Index to Volume LXII — 1978

ANTENNAS AND TRANSMISSION LINES

BASIC AMATEUR RADIO

CANADIAN NEWSFRONTS

CONTESTS AND OPERATING ACTIVITIES

EDITORIALS

HAPPENINGS

HINTS & KINKS

INTERNATIONAL NEWS

KEYING AND CONTROL CIRCUITS

MEASUREMENTS AND TEST EQUIPMENT

MISCELLANEOUS GENERAL

MISCELLANEOUS TECHNICAL

NEW BOOKS

OPERATING PRACTICES

PICTURE TRANSMISSION AND RECEPTION

PRODUCT REVIEW

PUBLIC SERVICE

RECEIVING

REGULATIONS

SATELLITES

TECHNICAL PRINCIPLES AND APPLICATIONS

TRANSMITTING

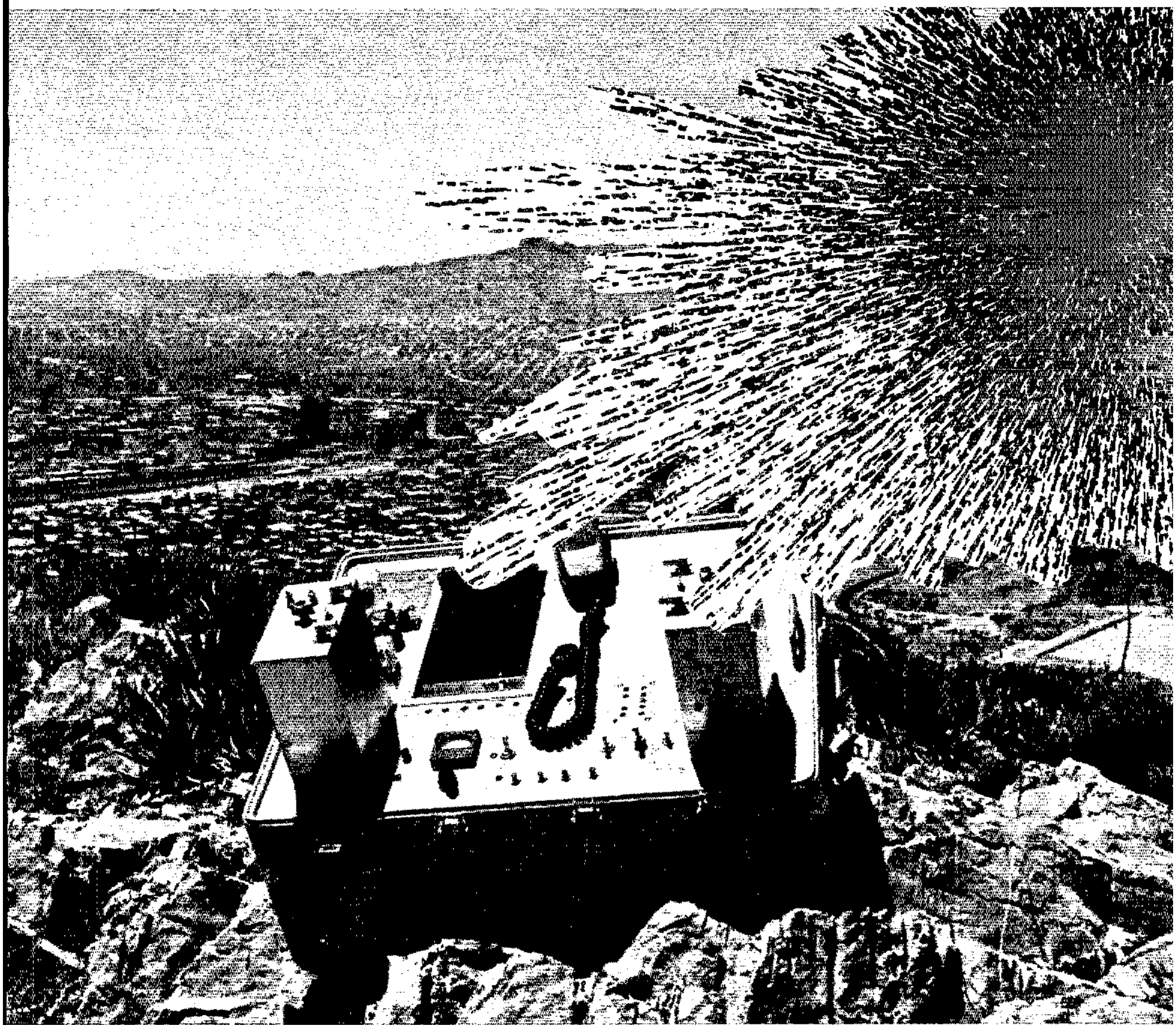
VHF AND MICROWAVES

WORLD ADMINISTRATIVE RADIO CONFERENCE

QST

devoted entirely to Amateur Radio

January 1978 $2.00



Energy from the sun powers El Paso repeater!

Page 11

January 1978
Volume LXII Number 1

Published monthly as its official journal by the American Radio Relay League. Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices
225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

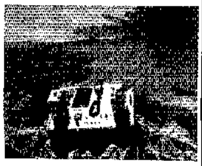
Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER



Solar energy keeps the El Paso repeater operating. See page 11.

Contents

Technical

Basic Radio

General

Organizational and Regulatory

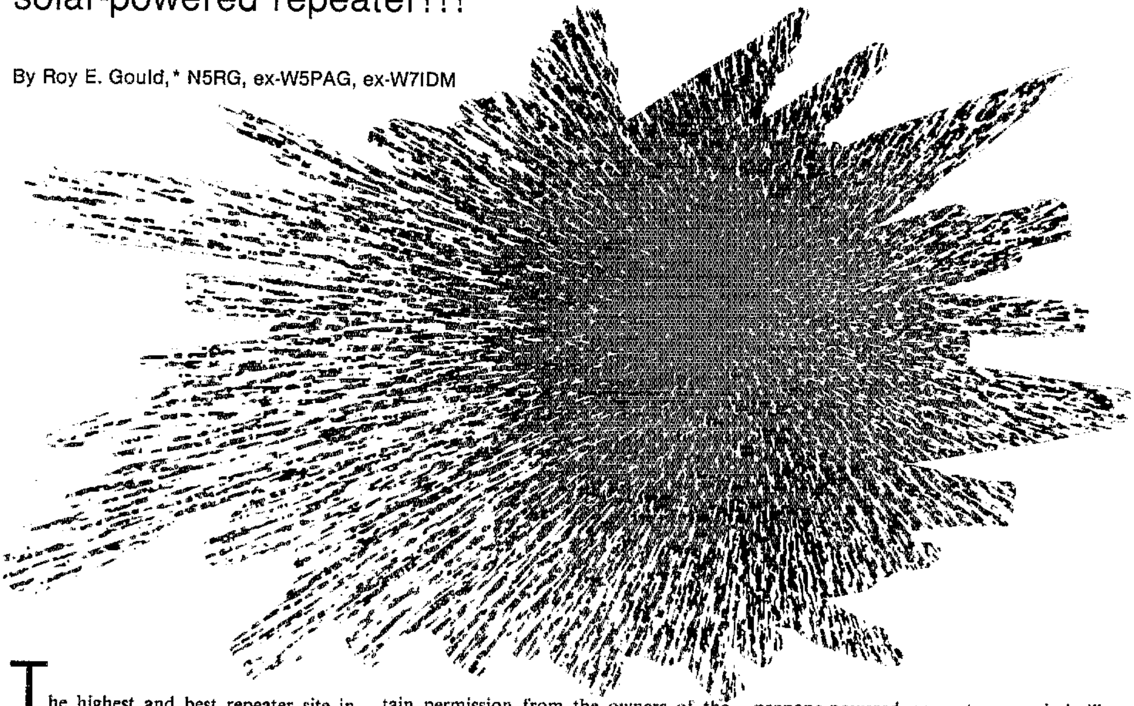
Operating

Departments

The El Paso Solar-Powered Repeater

Everybody is talking about solar power; its use will become more and more important in the future. The El Paso amateurs have already done something about it — a solar-powered repeater!!!

By Roy E. Gould,* N5RG, ex-W5PAG, ex-W7IDM



The highest and best repeater site in the El Paso, TX, area is the top of North Mt. Franklin. The summit is at an elevation of 7192 feet, more than 3100 feet above most of the city. It is located about 10 miles from downtown El Paso and only about three miles from the northeastern section of the city. Las Cruces, NM, is about 33 miles northwest and Alamogordo, NM, is about 66 miles northeast. A repeater at this location would provide line-of-sight coverage to virtually all of El Paso and the surrounding communities of Las Cruces and Alamogordo, tying the whole area together on one repeater. At the 1975 annual meeting of the El Paso VHF Repeater Association, it was decided to actively pursue construction of a 2-meter repeater at this site.

The first major hurdle to be overcome before a repeater could be built was to obtain permission from the owners of the top of the mountain to use it for a repeater site. A lawyer in our group, WB5LCN, began working on this and in a few months had obtained a license from the owners granting permission. We were now ready to begin seriously working on the repeater itself.

Unfortunately, the closest road is about 2-1/2 miles from the summit and there is *no* electricity anywhere near. A trail extends about halfway up. From that point you are on your own over moderately rugged, rocky terrain. The vegetation on this desert mountain consists mainly of various types of cacti and small bushes. It is not an easy location to build or operate a repeater.

Solar or Wind Power?

A basic decision that had to be made was to decide what power source to use. Among the possible candidates were a propane-powered generator, a windmill and solar cells. The windmill and solar cells quickly became the primary candidates. After considerable discussion, solar power was chosen.

Some of the reasoning that went into this decision was that while a windmill could generate considerable energy, a large amount of energy is not really required. A windmill would be difficult to transport to the top of the mountain. It would be susceptible to damage from the 100 mi/h spring winds. It would probably require periodic maintenance and would probably be by far the most *unreliable* component in the system.

On the other hand, solar panels can generate sufficient energy at an affordable cost. They are small and lightweight, require no maintenance and should have a very long lifetime. Also, solar power seems destined to become an important power source in the future and

*4752 DeBeers Dr., El Paso, TX 79924.

would be interesting to experiment with.

The Solar Panels

A set of six solar panels was ordered from Sensor Technology.[1] These panels are rated at 8 volts at 0.6 amperes when illuminated by 100 mW/cm² (1 kW/m²). This amount of illumination is apparently close to that present in El Paso during a typical hot summer day because the output from the panels equals their rated output under that condition.

The solar panels were connected in a series-parallel arrangement, Fig. 1, with a diode connected in series with each set of series-connected panels. This diode prevents the battery from being discharged by the panels during periods of darkness and protects the power source from loading by shorts or low voltage in one or more of the panels. A combination of six panels produces a power source capable of delivering 16 volts at 1.8 amperes when illuminated by bright summer sun. In winter, the current drops to about 1.2 amperes in bright sunlight. Heavy clouds can reduce output to as low as 50 to 100 mA.

As shown in Fig. 2, the solar panel looks electrically like a constant-current source. As illumination decreases, current output decreases, but the voltage decreases only slightly.

[1]Sensor Technology, Inc., 21012 Lassen St., Chatsworth, CA 91211.

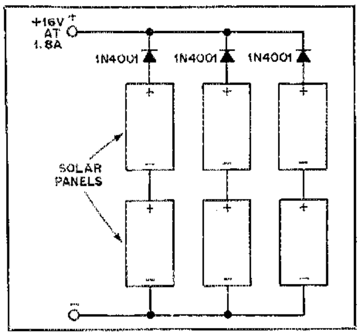


Fig. 1 — Series-parallel-connected solar panels with isolation diodes.

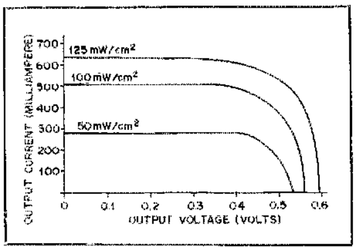


Fig. 2 — Typical solar-cell output. *(Courtesy of Sensor Technology, Inc.)*

The amount of energy collected in summer is higher than in winter both because the sun is brighter and because the days are longer. The amount of solar energy collected during the winter is the critical case if the repeater is to operate at full capacity the year around.

The amount of energy collected in winter is difficult to determine exactly, but an estimate can be made. The shortest day in El Paso in winter is about 10-1/2 hours long. With the panels mounted at 45 degrees from the vertical and facing south, the array supplies about 100 mA just after sunrise and just before sunset. At noon, the output will be about 1.2 amperes. The amount of energy collected can be approximated by integrating the curve shown in Fig. 3. Assuming a cloudless day, the solar panels should collect about 8.48 ampere-hours (Ah) per day in winter.

The collected energy is stored in a sealed automotive battery. If it is assumed that 85 percent of the energy input to the battery is recoverable from the battery, then about 7.2 useable Ah are collected on a typical cloudless winter day. Armed with this figure, it is now possible to describe the type of repeater that will be practical for use with the solar panel.

Repeater Requirements

The major user of power in the repeater is the transmitter. A typical 2-watt transmitter (output) draws about 500 mA.

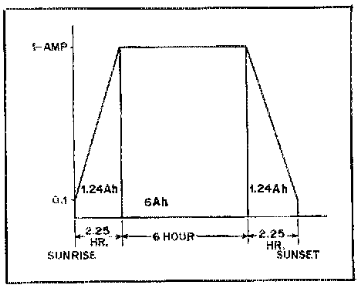
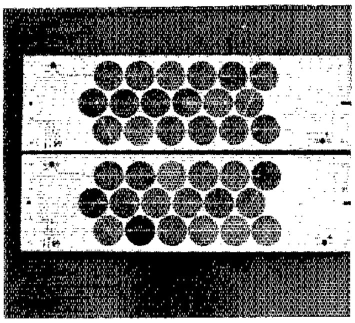


Fig. 3 — Approximate solar-collector output in winter.



This pair of solar panels from Sensor Technology can supply 16 V at 600 mA when connected in series. *(WA5FCV photo)*

With 10 hours use a day, the energy consumed by the 2-watt transmitter will be 5 Ah. This leaves 2.2 Ah to operate all other components in the repeater. A 2-watt output repeater therefore seems to be a practical power level.

If the combined energy consumption of the nontransmitter load can be kept below 2.2 Ah per day, the energy budget will be satisfied. A design goal of 20 mA was set for the average current consumption for the nontransmitter load in the repeater. This amounts to 0.48 Ah per day, well within the energy budget, leaving an excess to charge the battery to compensate for cloudy weather.

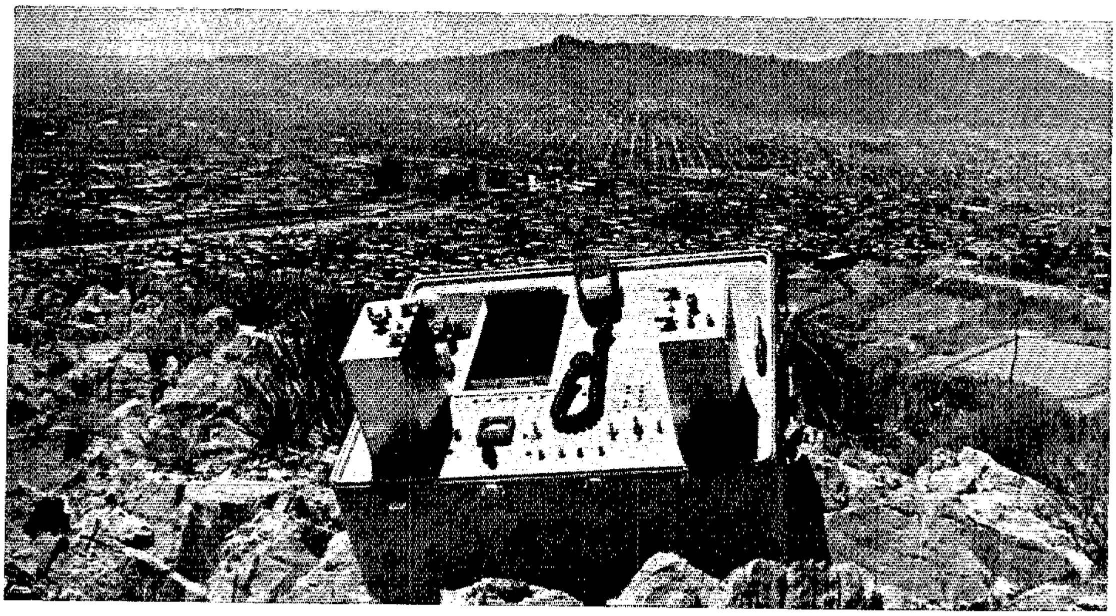
Build or Buy?

Partially because there does not seem to be a commercial repeater available that uses energy efficiently enough, it was decided to custom build a repeater just for solar power. Hallicrafters operated a manufacturing plant in El Paso until it was closed in 1974. A piece of equipment they manufactured was a two-channel vhf transceiver built for commercial and industrial use in both foreign and domestic markets. Factory fallout units were available and many are in use in this area. The repeater association already operates one repeater using two Hallicrafters boards. These boards contain a complete 2-watt transceiver. The receivers were designed for low-power consumption and draw only about 12 mA, very suitable for use in a solar-powered repeater.

To meet the design goal of 20 mA total nontransmitter current, the combined average consumption of the carrier-operated relay (COR), the identifier, the control and the telemetry circuits had to be kept below 8 mA. The primary methods used to achieve this goal were to use CMOS logic wherever possible and to shut off power automatically to sections of the system not in use.

The COR is the master controller of the system and consists mainly of logic and timers. CMOS was used throughout for logic, and unijunction transistors were used for timers. The repeater is VOX-operated to save power by reducing "kerchunking" from both intentional and unintentional sources. The VOX circuitry is included on the COR. When the op amps used in the VOX circuitry are not required, their power is disconnected. The COR draws only about 0.5 mA when in standby and about 3 mA when the repeater is transmitting.

Since a second receiver is available in the repeater on the transmitter board, it was decided to include a lockout receiver to satisfy the requirements of the FCC rules. The COR controls the lockout receiver. When a signal is first sensed at the repeater input, the lockout receiver is turned on to check for activity on the repeater output frequency. If no signal is sensed in 0.35 second, the transmitter is



Solar-powered repeater with downtown El Paso, TX, and Juarez, Mexico, in background. This photograph was taken at the Commanche Peak (4800-ft elevation) repeater site operated by the El Paso VHF Repeater Association. *(WA5FCV photo)*

turned on. A timer in the COR prevents lockout receiver activation for two minutes after the transmitter is turned off. Because the lockout receiver is only on for short periods, its energy usage is quite low.

A diode-matrix, cw identifier was designed and built using CMOS logic. The identifier was designed to perform the complete identification function and includes an i-d interval timer and an audio oscillator on the board. The matrix is large enough to hold a cw message of up to 126 bits in length. The identifier draws only 0.5 mA.

The control portion of the repeater could be quite a power hog, so the following scheme was adopted. A timer on the control board turns the control receiver on for one second once a minute. If a signal is detected, the control receiver remains on for the next minute and the type 567 tone decoders and control logic are turned on. The control operator has one minute to execute his commands. When the control receiver first senses a signal the control audio is broadcast over the repeater output for 10 seconds. This allows the control operator to determine when he has access to the control circuits and to determine the quality of his signal at the repeater. The control receiver being used draws about 15 mA. But because it is only on for one second every minute, the average control receiver current is less than 1/4 mA when the repeater is not being controlled.

A section of the control board monitors battery voltage. If the voltage drops below a preset limit, the repeater is automatically turned off and can only be turned back on by either remote or local control.

Telemetry and Monitoring

Because of the remoteness of the site and the desire to monitor the operation of the solar panels, telemetry is included in the repeater. A telemetry board, designed by VU2XP and WB5FKC, generates eight channels of tone-encoded commutated data. Two of these channels are used for calibration, one for ground and one for a reference. Data to be transmitted includes solar-panel current, battery voltage, transmitter current, rf-output voltage and ambient temperature. The telemetry is commanded on by the control link and transmits its data on the repeater output. The data is commutated so that each frame is available for about five seconds. It is received by measuring the frequency of the tone transmitted in each frame with a frequency counter connected to the listener's 2-meter receiver. The data is decoded by referring to a curve or solving an equation for each parameter.

Another telemetry section monitors battery voltage. If it drops below a preset level, the telemetry places a tone on the repeater squelch tail to signal that battery voltage is dangerously low. The frequency of this tone is the same as generated by the battery-voltage frame of the telemetry. Since most of the telemetry is not powered up unless specifically commanded on, it draws less than 2 mA average current.

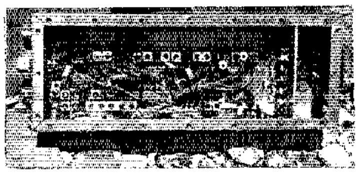
A repeater monitor board contains an audio power amplifier and an LED driver. The power amplifier can be switched on to monitor the repeater audio locally. Six LEDs are used to indicate repeater functions such as power on, repeater receiving signal, repeater being keyed by i-d, repeater is locked out, etc. The LEDs and audio amplifier are used only for testing and are not left on during normal operation.

A relay is needed to turn the repeater on and off from the control link. If a conventional relay were used for this function, considerable energy would be used to energize the relay. To avoid this source of power drain, a latching relay was used. Only a pulse of current is needed to change the state of a latching relay and no power is needed to maintain that state.

The power-saving techniques described have been effective and the 20-mA average current consumption goal for the nontransmitter load was easily met.

As stated earlier, a sealed automotive battery is used for energy storage. This battery has sufficient capacity to power the repeater for at least a week even if it receives no charge. This should be sufficient reserve to keep the repeater in operation during most periods of stormy weather.

Because the solar panel voltage is 16 volts in bright sunlight, it can overcharge the battery. To prevent this, a 13.8-volt shunt voltage regulator was designed using a Zener diode and a Darlington power transistor. The regulator is designed so that no usable energy is lost in the operation of the regulator. The voltage regulator module also contains an am-



An interior view of an rf module. Note rf shielding at right end made up of feedthrough capacitors and ferrite beads. *(WA5FCV photo)*

meter for monitoring solar-panel current and a voltmeter to monitor battery voltage, as well as fuses to protect the system.

Some Construction Notes

Because of the difficulty in reaching the repeater site and because it will be very difficult to service the repeater while on the mountain, the repeater is constructed in a modular manner. The repeater contains two rf modules: One serves as the repeater receiver and the other as the transmitter. These modules are identical to each other and each contains a complete transceiver. Their function in the repeater is determined by the socket into which they are plugged in the repeater. The modules are well shielded and each lead from the module has an rf filter. A third module has been built as a backup unit. In case of trouble, the spare module can be taken up to the repeater and simply plugged in. The defective module would then be brought down and repaired on the bench. It would then become the backup unit.

For easy servicing, the rf modules contain a metering switch to select various transceiver monitoring points such as the individual multiplier stages and the receiver discriminator. A meter built into the repeater allows easy checking of the operation of the repeater. A card cage holds the five cards making up the system logic as well as the control receiver. In case of difficulty a malfunctioning card can be replaced with a good one.

The repeater is built into a military surplus aluminum box. This box has dimensions of about 22 × 26 × 15 inches and has carrying handles. The lid snaps on securely and is tightly sealed by a rubber gasket. The box is rf-tight and makes a convenient enclosure for the repeater.

The solar panels will be enclosed in an aluminum box with a Lexan cover to protect the panels from the elements and vandalism. The panels will be mounted on the antenna tower at a 45-degree angle from the vertical. The optimum angle in winter is about 54 degrees, however use of a 45-degree angle will result in collection of 99 percent of the available energy in winter and improve efficiency at other times of the year.

With the exception of the Hallicrafters transceiver boards and the control receiver, the repeater has been designed and built by El Paso amateurs. This includes even the cavities which were beautifully built by WA5GGU from the plans contained in *FM and Repeaters for the Radio Amateur.*

Progress

At the time this is being written, the repeater has not yet been placed on top of North Mt. Franklin. Before this can be done some sort of enclosure will have to be built on the mountain to house the repeater. This structure will probably be small, perhaps about four feet square. The problem of transporting building materials to the top of the mountain still remains to be solved. This will probably be done using a helicopter or perhaps a mule train.

The repeater is still not quite finished as portions of the control and telemetry circuitry have yet to be completed and checked out. However, the repeater was placed on the air under local control on October 9, 1976, using solar power. We have not heard of another amateur repeater using solar power,* so claim the distinction of operating the first solar-powered amateur repeater. If you know of an earlier solar-powered repeater, please let me know.

Our thanks go to ARRL hq. and Lew McCoy in particular for assistance and advice in a response to our questions. It was very helpful and aided our successful completion of the project. Special thanks go to the many El Paso amateurs who contributed their time, equipment and money, thereby allowing this repeater to be built.

Bibliography

DeMaw, "Solar-Electric Energy and the Amateur," *QST,* August, 1977.

Gorman, "No-Fill, No-Fuss Batteries," *Popular Science,* June, 1977.

Noll, "Circuits and Techniques," *Ham Radio,* July, 1974.

Noll, "Wind/Solar Energy," Howard W. Sams and Co., 1975.

FM and Repeaters for the Radio Amateur, ARRL.

*[Editor's Note: On a recent visit to Los Alamos, NM, we found that a local group had installed, and had working, a completely solar-powered repeater. We'll be happy to hear of other groups using wind or solar power.]

Strays

IARU WHEELS

☐ This car and its owner, HB9AJU, are very well known in IARU circles. Located in Geneva, Switzerland, Gerald Lander and his Austin-Mini have provided transportation for one ARRL president, two IARU presidents, two IARU/ARRL secretaries, about a dozen European amateur society presidents, the entire International Working Group of the IARU, several ARRL and IARU vice presidents, the secretary and several other officials of Region 1 IARU, the president of Region 2, a couple of directors of Region 3 and a host of other IARU society staffers and employees.

HB9AJU holds no official position in IARU, but it would be difficult to find a single individual who has provided so much assistance so willingly and so frequently. After 11 years of yeoman service, the Mini is about to be retired — a number of us have shed a tear. — *W1RU*

QST Congratulates . . .

☐ Bill Osborne, K4LN, who was named the outstanding radio amateur in Tennessee for 1977 by the Tennessee Council of Radio Clubs.

I would like to get in touch with . . .

☐ participants for the International Ragchew-Relay Net for younger hams (old-timers and foreign hams welcome, too). John Purnell, WD9CYV, 405 Miller Ave., Madison, WI 53704.

The Groundshade Antenna

Tired of hanging those antennas from your living-room ceiling? Try this groundshade antenna for a light touch to your station.

By Spencer Allen,* KØREC

I call it a "groundshade." While it can't compare with the now-stored extended Ringo Ranger which graced the chimney of my former residence, the groundshade in the new QTH, a first-floor apartment, performs surprisingly well on 2 meters. It is adequate for the local repeater and for simplex operation around town. And I can raise the Jefferson City, MO, machine 30 miles away with 10 watts out.

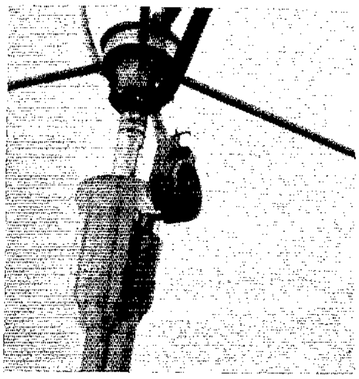
With no outside antenna privileges in my apartment complex, an indoor installation had to be devised. A convenient mount for a quarter-wave antenna appeared to be the cylindrical lampshade on the operating desk lamp. A metal bracket secures the shade to the lamp base, and a wire frame shapes and supports the parchment shade. (See Fig. 1.) This configuration, I calculated, should act as the groundplane for the quarter-wave radiator.

My first attempt at feeding the coax directly to the telescoping replacement antenna, with the radiator insulated from the lampshade, was a failure. The SWR was excessively high and no variation in the length of the radiator made an appreciable difference.

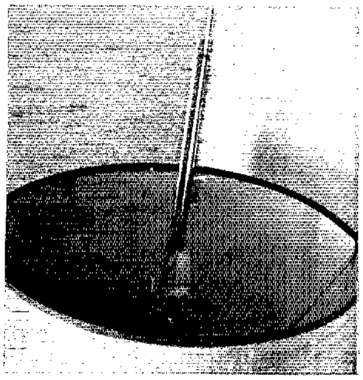
The second try was successful. This time, I secured the base of the radiator directly to the metal lampshade bracket and applied a gamma match, using a 1/4-inch rod as the stub. With three variables (the capacitor, the shorting bar, and radiator length) it is relatively easy to obtain a good match.

Starting with a radiator length of 19 inches (483 mm) and the shorting bar at nine inches (229 mm), I first adjusted the 5- to 25-pF ceramic capacitor for minimum SWR. This is critical as just a slight change in capacitance will cause the SWR to soar. After finding the minimum reading with the capacitor, I adjusted the sliding bar and radiator length for 1:1. These changes are not critical. Final radiator length was 20 inches (508 mm) with the shorting bar at 9-1/2 inches (241 mm). These dimensions probably will differ with various lampshades.

I checked the SWR with the lamp turned on, then off — no change. I have not investigated for RFI in my upstairs neighbor's quadraphonic monster. And I don't intend to.



Coupling and mounting detail of the groundshade antenna; the insulator/spacer is a polyethylene furniture caster insert.



A 1/4-inch rod is used as a gamma rod.

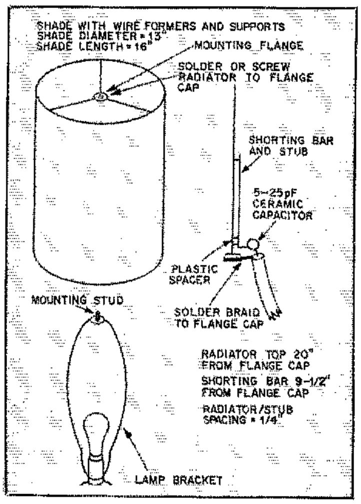
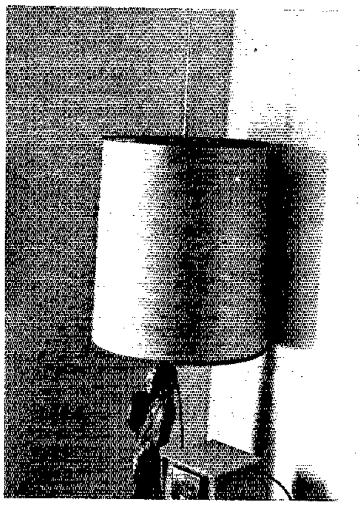


Fig. 1 — Construction details for the groundshade antenna.



The completed groundshade antenna; can you find it?

*2911-C Rollins Rd., Columbia, MO 65201

A 220-MHz Transmit Converter

Crowded bands bothering you? Try VHF! Recent FCC rulings have removed the immediate threat of CB invasion into the 220-MHz band, making it the next logical step up from 2 meters. Here's a way to get your signal on the wide-open stretches of 220!

By Fred J. Merry,* W2GN

If you're lacking vhf experience, don't let the high frequencies scare you. This well-proven straightforward design can provide an interesting way to get your feet wet. And those familiar with vhf-uhf construction techniques will find no unusual difficulties in duplicating this transmit converter.

All-mode transceiver availability has closed the equipment gap for complete utilization of the 2-meter band: ssb, cw, fm or what have you. But the next higher ham band has been conspicuously void of signals in the small-signal or "exotic mode" segments of the band. In the past, this situation developed because most hams were afraid to invest their money in gear for a band with a dubious future. Now the air has been cleared, and the menace to the 220 band is no longer!

For those who dove headfirst into the 2-meter scene with an ultra-sophisticated all-mode transceiver, 220 may prove to be more challenging! Lacking commercial equipment of this complexity at this stage of the game, the vhf man must be content with transmitting and receiving converters which are "state of the art" for 220. This article describes a 220-MHz transmit converter (TC) which is patterned after a 432-MHz TC originally made and sold by the Carmichael Communications Company, Carmichael, CA.

This converter is a compact unit built on a Bud CU247 chassis, utilizing a solid-state local-oscillator chain, a 6939 mixer and a 6939 amplifier. Power supply requirements are 250 V dc at 140 mA and 6.3 V ac at 3 A. Power output on 220 is a minimum of 6 watts with approximately one-watt drive on 28 MHz. The 15-volt supply for the transistor section is derived from a voltage-doubler circuit off the 6.3-V ac source. The dc bias for the 6939 amplifier is supplied in the same manner. The circuitry is similar to that published in various articles of the past, particularly on 432 TCs. The ARRL *Handbook* also has a description of a similar TC for 144 MHz; the difference is that the local oscillator drive is supplied by tubes. Many of these TCs are in use on 432 for uplinking to OSCAR 7 Mode B. They have been used under a wide range of conditions and

*35 Highland Drive, East Greenbush, NY 12061

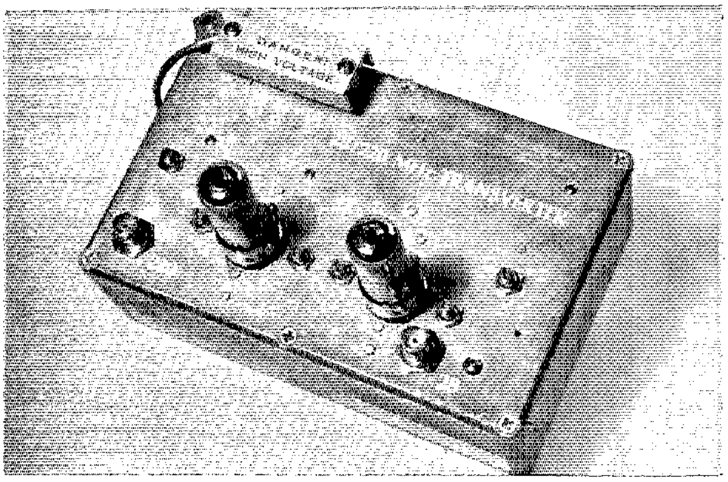


Fig. 1 — The 220-MHz transmit converter shown with the tubes in place. The 28-MHz drive enters at the right and the 220-MHz output is at the left. Note that an aluminum channel is used to cover the high-voltage terminals. This feature should be incorporated into the unit as a safety precaution.

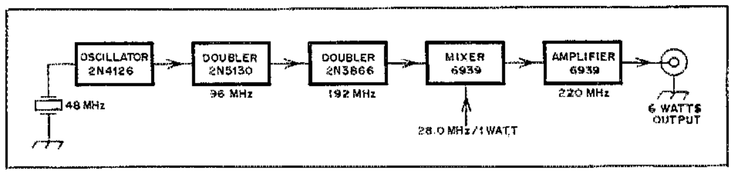


Fig. 2 — A block diagram of the 220 transmit converter. The oscillator, first doubler, and second doubler comprise the local-oscillator chain which is contained on the circuit board. The 192-MHz output from the LO goes to the first 6939 tube where it is mixed with 28-MHz rf from the hf exciter. The second 6939 tube is used to amplify the 220-MHz rf to a six-watt level.

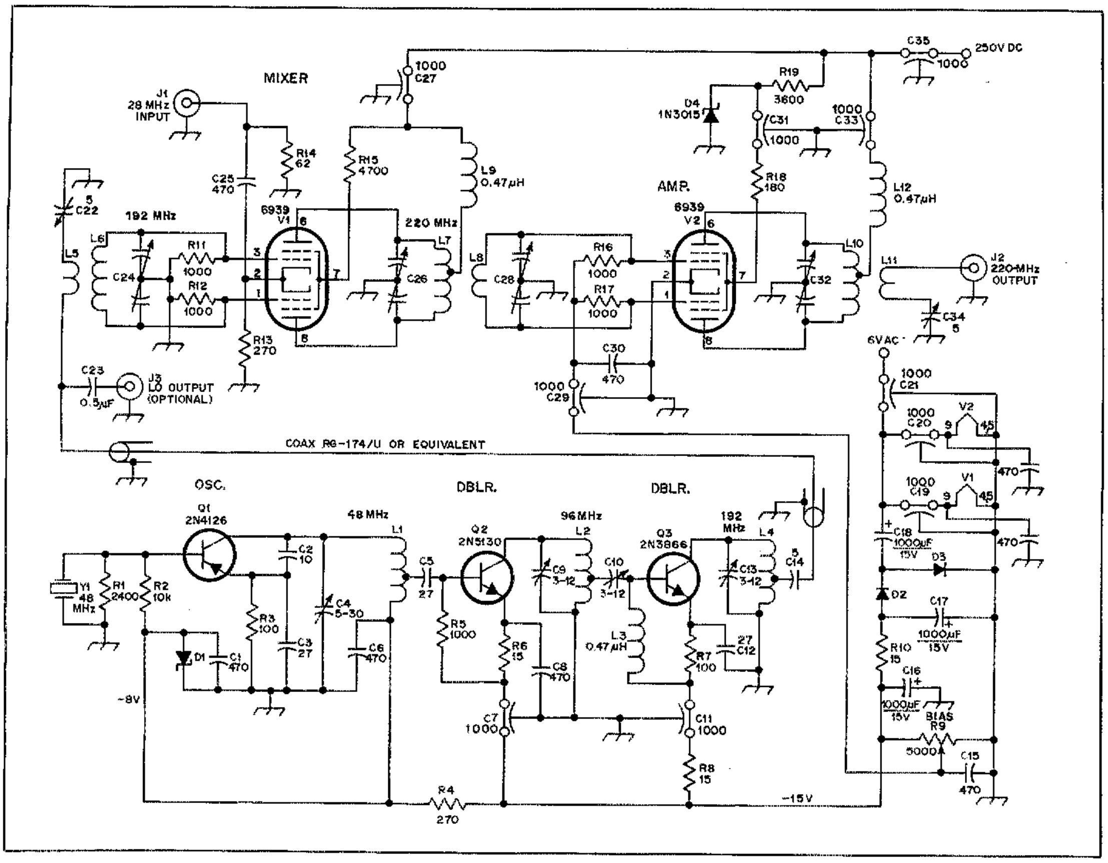


Fig. 3 — A schematic diagram of the 220-MHz transmit converter. Note that J3 is an optional LO output. It can be added if the builder wishes to use the LO in a receive converter also. All resistors may be 1/4 watt unless otherwise specified. All capacitors are in pF and resistors in ohms unless marked otherwise.

C1, C6, C8, C15 — 470 pF, low drift (ARCO MCA-C).
C2 — 10 pF, low drift (ARCO MCA-C).
C3, C5, C12 — 27 pF, low drift (ARCO MCA-C).
C4 — 5-30-pF variable (Johnson 275-0430-005).
C7, C11, C19, C20, C27, C29, C31, C33 — 0.001-µF 600-V feedthrough, circuit-board type (Erie 2404000).
C9, C10, C13 — 3 to 12-pF variable (Johnson 275-0112-005).
C14 — 5 pF, low drift (ARCO MCA-C).
C16, C17, C18 — 1000-µF 15-V electrolytic (Mallory TC1501B).
C21, C35 — 0.001-µF 600-V feedthrough, bulkhead type (Erie 2443007X5S0102M).
C22, C34 — 5-pF midget type, air variable (Johnson 189-0564-001).
C23 — 0.5 µF (optional — only used if LO output is installed).
C24, C26, C28, C32 — 8-pF butterfly type, air variable (Johnson 160-028-001).
C25, C30 — 470 pF, low drift, ceramic (ARCO MCA-C).
D1 — 8-volt, 1-watt Zener diode (G.E. ZD8.2).
D2, D3 — Power supply rectifier diodes (INT. R170 B).
D4 — 180-volt Zener diode (1N3015).
L1 — 12 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 1-3/4 turns.
L2 — 6 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 2 turns.
L4 — 3 turns No. 18 wire, 3/4 in. long, 1/4 in. diameter. Tap at 1 turn.
L3 — 0.47-µH rf choke (Miller).
L5, L6, L7, L8, L10, L11 — See Table 1.
L9, L12 — 0.47-µH rf choke (Miller).
Q1 — 2N4126.
Q2 — 2N5130.
Q3 — 2N3866.
R1 — 2400 ohm.
R2 — 10 kilohm.
R3, R7 — 100 ohm.
R4 — 270 ohm, 1 watt.
R5, R11, R12, R16, R17 — 1000 ohm.
R6, R8 — 15 ohm.
R9 — 5000-ohm circuit-board type potentiometer.
R10 — 15 ohm, 1 watt.
R13 — 270 ohm, 1 watt.
R14 — 62 ohm, 2 watt.
R15 — 4700 ohm, 2 watt.
R18 — 180 ohm, 1 watt.
R19 — 3600 ohm, 2 watt.
V1, V2 — 6939.
Y1 — Crystal, 48 MHz; HC-6/U (ARCOS).

Miscellaneous

Chassis box (drilled), Bud CU247 (ARCOS).
Tube sockets, Cinch 9JC2.
BNC bulkhead-type connector, Cannon DIC22497 (3 required if LO output is used; UG-657/U if 3/8-in. hole is used).
Circuit board (etched and drilled).
Brass partitions/hardware — see text. (ARCOS)
Wire — 3 feet No. 16 silver-plated; 3 feet No. 18 silver-plated.
Coaxial cable — RG-174/U.
Terminal strip, 2-point.

seem to be standing the test of time in good shape. (See Editor's Note, page 20.)

Those who are familiar with vhf-uhf construction techniques will find no unusual difficulties in duplicating this 220 TC. Others may find it an interesting way to get their feet wet with a well-proven straightforward design.

Fig. 2 shows the circuitry of the 220 TC in block form. The local oscillator chain develops about five volts of rf at the output of the 2N3866, just enough to drive the 6939 mixer. Although expensive ($17.50 to $22 each), the 6939 mixer and amplifier tubes offer an economical alter-

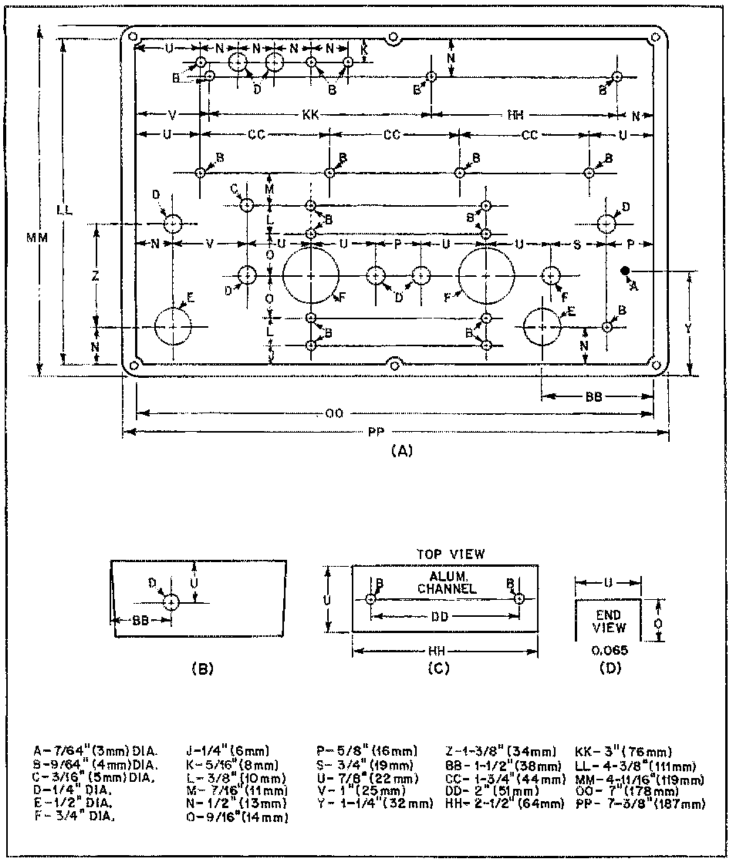


Fig. 4 — The drilling template for the lid of the Bud chassis is shown at A; B shows the hole location for bias adjustment on V2. The dimensions at C are for the aluminum-channel safety guard.

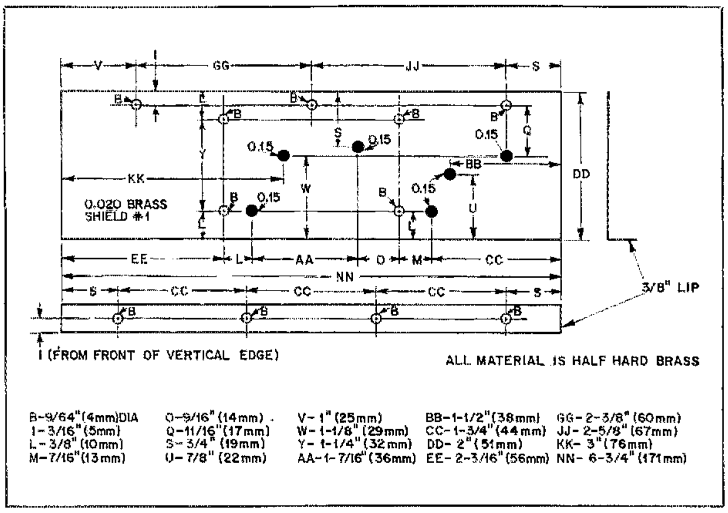


Fig. 5 — A template for the long brass shield used in the chassis construction. Material is half-hard 0.020-in. brass.

native to transistors for equivalent power, output, linearity and relative freedom from spurious responses. With only two stages for 6-watts output, this unit is possibly easier to duplicate than an equivalent solid-state mixer and amplifier chain. A study of the schematic will reveal the rest of the circuit details including the built-in low-voltage power supply.

Construction

A good place to start construction is to drill the top plate of the Bud CU247 box. A drilling chart is shown in Fig. 4A. Note that measurements are referred to the ridge on the underside of the cover — actually the inside dimension of the box. The two 1/2-inch holes toward the bottom of Fig. 4A will be 3/8-inch instead of 1/2-inch if you are using 3/8-inch type BNC bulkhead connectors. Also note that there is an optional hole to be drilled if you plan to use the local oscillator output to drive a receiving converter.

Fig. 4B locates the bias adjustment hole on the end of the box. Fig. 4C gives the dimensions and drilling for a piece of aluminum channel used as a cover over the feedthrough capacitors terminating the 250-V ac power leads.

The dimensions and drilling of the brass partitions are shown in Figs. 5 and 6A. Make five small brass angles which are used to ground the partitions to the bottom of the box. (See Fig. 6C.) The locations of these angles can be seen in the photos. The angles may be soldered or bolted to the partitions. Put a solder covering on the angle part that will be in contact with the bottom of the box.

Next, assemble the partitions and mount the tube sockets. Do the preliminary wiring as shown in Figs. 7 through 9. This will include the grounding of pins 4 and 5 of the tube sockets to the center pin which is in turn soldered to the brass partitions. Use a small piece of folded braid between the center pin and the brass partition to facilitate this connection. Pin 2 of V2 is also soldered to the brass partition. The feedthrough capacitors on the long partition are installed and wiring done as shown in Fig. 7 for the filament of V2. A 470-pF filament bypass capacitor is connected from pin 9 to the brass partition for each tube. These are not shown on the schematic or indexed in the parts list.

Mount capacitors C22, C24, C26, C28, C32 and C34, the input and output BNC connectors and the two-point terminal strip for L5. Make and mount inductors L5, L6, L7, L8, L10 and L11 using the dimensions of Table 1.

Note the position of the coils as shown in Fig. 8. The leads on L6 and L10 are pushed through the butterfly (variable) capacitor terminals to the tube socket pins. L7 and L8 are soldered to the stator terminals of their respective butterfly capacitors. L7 and L8 are connected to the socket pins with short pieces of No. 16 wire from the capacitor terminals. Try to follow the coil dimensions precisely. If you have an accurate grid-dip meter, check them out — remember that L6 is tuned to the local-oscillator frequency of 192 MHz.

Check the schematic to verify that all parts are installed and connected for the mixer and amplifier section. A review of Figs. 9 through 12 will reveal the assembly details of the local oscillator section of the converter. Note that the small brass partitions as shown in Fig. 6B are mounted on the circuit board to form a shield between the input and output of the two doubler stages. The circuit board is mounted with three small brass angles. Before mounting, however, it is best to check out the circuit-board operation. Connect 6.3 V ac to the board and verify that the power supply is operative by checking for proper voltages at the oscillator collector and the first and second doubler emitters.

Adjustments and Testing

Shut the 6.3-V ac source off. Using a grid-dip meter, set the oscillator-tuned circuit to the crystal frequency. Turn on the 6.3-V ac source and observe the oscillator output at the base of the first doubler with an rf probe and meter. Make sure the oscillator starts readily when power is applied.

Connect the rf probe to the base circuit of the second doubler and peak the collector circuit of the first doubler. Similarly peak the second doubler with the probe at the output cable connection point on L4. At this test point, a minimum of 4 volts of rf should be obtained after final peaking of the doubler tuning and coupling capacitors. Mount

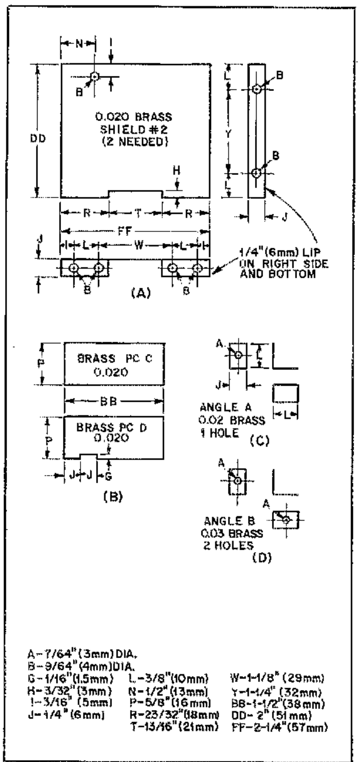


Fig. 6 — At A, the small shield used in the transmit converter chassis. Two of these 0.020-in. brass shields are used. The brass partitions, B, are used to isolate the input and output sections of the doublers in the LO chain. C and D show the brass angles used for mounting and grounding the partitions to the box bottom when closed. The angles with two holes are used to mount the pc board.

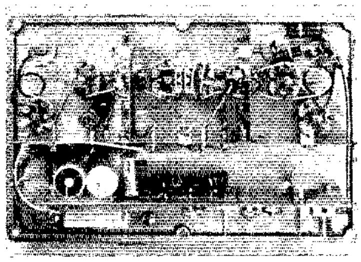


Fig. 7 — The inside of the transmit converter. Coil dimensions are given in the parts list and in Table 1.

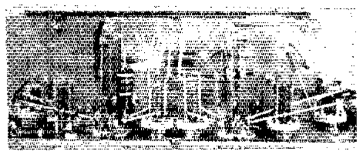


Fig. 8 — A side view of the tube section in the 220-MHz transmit converter. Note the position of the coils in the photo.

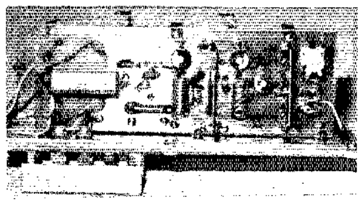


Fig. 9 — This photo shows the parts placement on the foil side of the converter circuit board. Dimensions for the coils are given in the parts list. Note the partitions used to shield the input circuits from the outputs, and the L brackets used for grounding the pc board and tube-section partitions to the chassis box bottom.

Fig. 10 — Shown here at actual size is the pc-board template for the local-oscillator chain of the 220-MHz transmitting converter. The template is shown from the foil side of the board, with black representing copper.

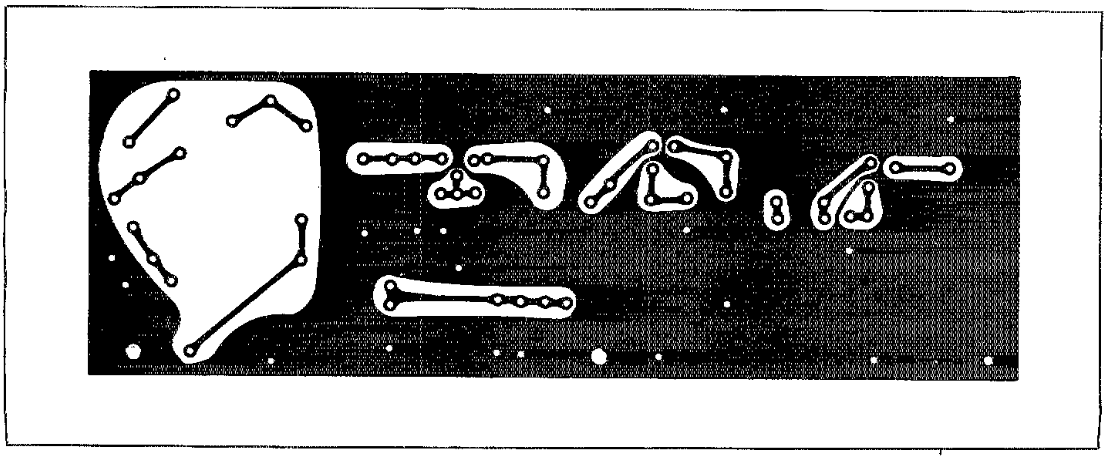


Table 1 — Dimensions for Winding Inductors. All Use an Air Core.

L5 — 1 turn, 1/2-in. dia, 3/4-in. leads; No. 22 insulated wire.
L6 — 1-1/2 turns, 1/2-in. dia, 1-in. leads; No. 16 wire.
L7 — 1-1/2 turns, 5/8-in. dia, 3/16-in. leads; No. 16 wire.
L8 — 1/2 turn, 5/8-in. dia, 3/16-in. leads; No. 16 wire.
L10 — 1-1/2 turns, 5/8-in. dia, 1-1/4-in. leads; No. 16 wire.
L11 — 1 turn, 1/2-in. dia. 3/4-in. leads; No. 22 insulated wire.

the circuit board and complete all power connections. The unit is now ready for test.

Hook up the power supply with a 150-to 250-mA meter in the B+ (250 V dc) lead. Adjust all tuning capacitors (C22 through C34) to minimum capacitance. Turn the power supply on and adjust the bias potentiometer for the total current of 65 mA. Connect the 28-MHz excitation (approximately one watt) to the mixer input, and a dummy load and rf indicator to the output circuit. Adjust C22, C24, C26 and C28, in that order, for maximum plate-current indication on the meter. Adjust C32 and C34 for maximum output power. Then repeak C22 through C28 for maximum output. C22, C24, C32 and C34 may require multiple adjustments for best results. The output power should be at least six watts. Spurs in the output of the converter are at least 45 dB down from the desired output. Do not run the 28-MHz drive up beyond where the output flattens out. Once the output has been maximized following a 10-minute warm-up, no further adjustment should be required unless tubes are changed or a change occurs in the input or output circuits.

Good luck on 220!

[Editor's Note: The circuit information and coil data for the 432 and 144 versions of this TC will be furnished by the author on request for an s.a.s.e. The converter and its 432- and 144-MHz counterparts are all available as assembled units from Amateur Radio Component Service, P. O. Box 546, East Greenbush, NY 12061. Circuit boards and all parts are also available individually from the same source. The 220TC package price for all parts except tubes at the time of this publication is $105.]

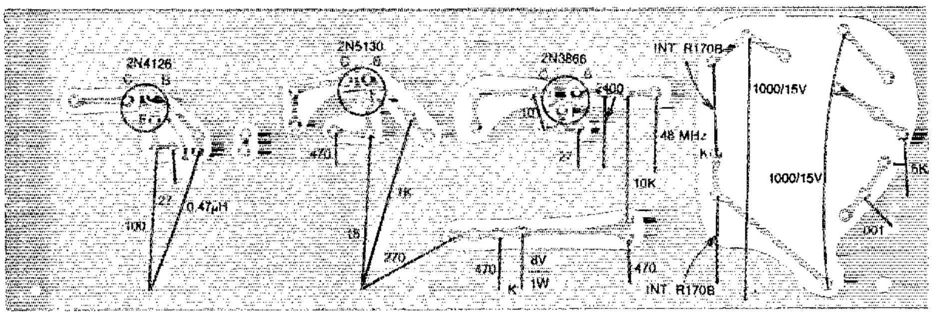


Fig. 11 — This parts overlay diagram is for the non-foil or component side of the pc board shown in Fig. 10. Parts are labeled here for convenience but the builder should refer to the schematic diagram and parts list for more specific information on component values. Gray represents the foil pattern on the opposide side of the board. K indicates the cathode end of a diode.

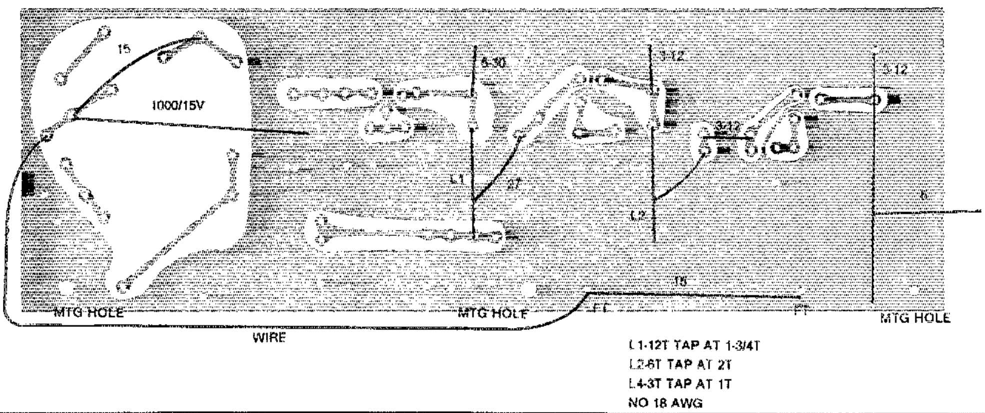


Fig. 12 — Parts placement for components which are placed on the foil side of the circuit board. Gray represents copper.

Twisted-Wire Quadrature Hybrid Directional Couplers

That title scare you off? Well, don't let it. Just read this and we'll make believers out of you.

By Reed Fisher,* W2CQH

In a previous article[1] it was shown how 3-dB directional couplers or quadrature hybrids could be used to effectively parallel two uhf amplifiers or attain circular antenna polarization. The quadrature hybrid is clearly a very useful circuit. Unfortunately, the uhf strip-line models cannot be scaled down to the high-frequency amateur bands since their dimensions could become prohibitively large. This article shows how compact, low-cost, lumped-element, quadrature hybrids can be easily constructed for use in the hf amateur bands.

Theory

Figs. 1 and 2 show, respectively, the circuit diagram and photograph of a twisted-wire hybrid suitable for use in the 40-meter band. The coupling transformer consists of two insulated copper wires tightly twisted together, thereby forming a bifilar pair. The pair is then wound around a small ferrite toroid (at vhf an air-core solenoid will be suitable). The transformer is then connected to the four BNC connectors along with two molded mica capacitors. The circuit is then placed in a suitable metal enclosure. This four-port (connector) circuit will function as a hybrid or directional coupler if constructed properly.

What should a hybrid do? Let's reiterate the hybrid functions given in Ref. 1. When the hybrid is driven by a generator and connected to matched (Z_0) loads, as shown in Fig. 1, it should perform as follows:

1) There is transfer (coupling) of power from port 1 to port 2.

2) There is transfer of power from port 1 to port 4.

3) There is *no* transfer of power from port 1 to port 3.

4)There is *no* reflected power back out of port 1 (VSWR = 1:1).

5) The voltage V_2 and V_4 differ in phase by 90 degrees, hence the name quadrature hybrid.

Conditions 3, 4 and 5, above, are *theoretically independent* of frequency. Thus, for certain applications, the hybrid can be used on more than one amateur band. The term *coupling*, which *is* frequency dependent, refers to the ratio of power leaving port 2 (or port 4) to that entering port 1.

$$\text{Coupling (dB)} = -10\log_{10}\frac{\text{Power leaving port 2 (or 4)}}{\text{Power entering port 1}}$$

Fig. 3 shows the coupling characteristics of the twisted-wire hybrid. Note that at frequency f_0 the coupling is 3 dB, meaning that equal power emerges from ports 2 and 4. Thus the hybrid, when operated near f_0, functions as a *matched power splitter*. This means that the loads connected to ports 2 and 4 not only receive equal power, but also see a matched (Z_0) generator. Therefore, when the hybrid is inserted into any transmission line, it will split the power into two parts without introducing any impedance mismatch.

Hybrid Design

A twisted-wire hybrid may be designed by considering Fig. 4, which shows the coupling transformer and capacitors removed from the baseplate and reconnected in two ways. In Fig. 4A, the connections are arranged such that the transformer "looks like" a simple inductor. The inductance, L, measured at points x-x, is found by connecting the circuits to an impedance bridge or using the grid-dipper technique described in the *Handbook.*[2] The capacitors are, of course, shorted out and can be removed for this measurement.

In Fig. 4B the connections are rearranged such that the transformer interwinding capacitance and external capacitors together "look like" a single capacitor. The capacitance C, at points y-y, can be measured by a 60-Hz capacitance bridge.

When reconnected as shown in Fig. 1,

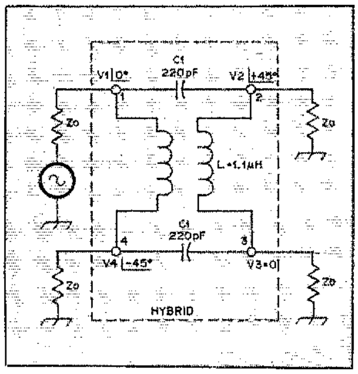


Fig. 1 — 7-MHz hybrid circuit.

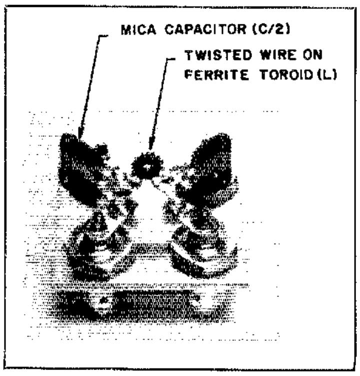
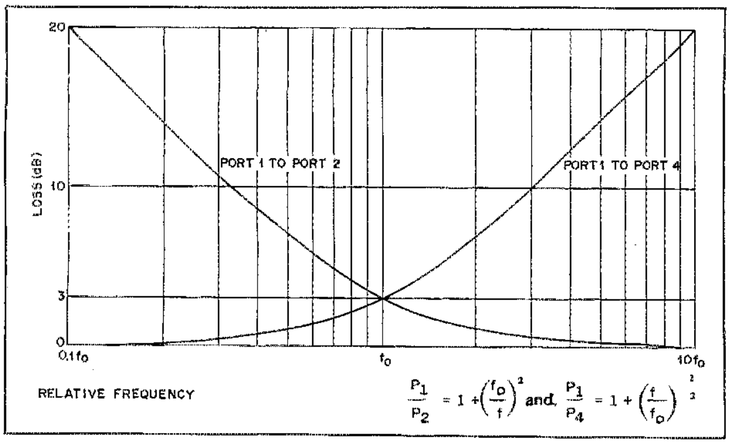


Fig. 2 — The 7-MHz hybrid.

*2 Forum Court, Morris Plains, NJ 07950

[1]References appear on page 23.



$$\frac{P_1}{P_2} = 1 + \left(\frac{f_o}{f}\right)^2 \text{ and } \frac{P_1}{P_4} = 1 + \left(\frac{f}{f_o}\right)^2$$

Fig. 3 — Quadrature hybrid theoretical insertion loss versus frequency.

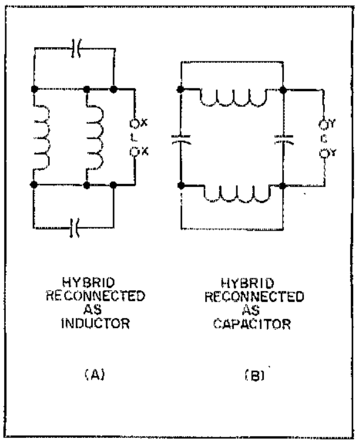


Fig. 4 — Measurement connections.

the hybrid will perform properly when

$$Z_o = \sqrt{\frac{L}{C}} \qquad \text{(Eq. 1)}$$

Equal power division (3 dB) between ports 2 and 4 will occur at a frequency f_o where

$$2\pi f_o L = Z_o \qquad \text{(Eq. 2)}$$

and

$$\frac{1}{2\pi f_o C} = Z_o \qquad \text{(Eq. 3)}$$

Eq. 2 simply means that the reactance of L (as measured per Fig. 4A) must equal Z_o (the desired load impedance) at the "3-dB" frequency f_o shown in Fig. 3. Eq. 3 means that the reactance of C (as measured per Fig. 4B) must equal Z_o at frequency f_o. The values of L and C necessary to obtain the required reactance also can be found by consulting a reactance chart.[3]

Example of Hybrid Design

Suppose we want to design the 7-MHz hybrid shown in Fig. 2. Then

$$Z_o = 50 \text{ ohms} \qquad \text{(Eq. 4)}$$

and

$$f_o = 7 \text{ MHz} \qquad \text{(Eq. 5)}$$

A reactance chart shows that to satisfy Eqs. 2 and 3,

$$L = 1.1\,\mu\text{H} \qquad \text{(Eq. 6)}$$

and

$$C = 450 \text{ pF} \qquad \text{(Eq. 7)}$$

The transformer is constructed by taking two strands of AWG No. 30 Formex magnet wire and twisting them tightly together to form a bifilar pair having approximately 10 twists per inch (the wire size and twist are not critical). It was found that when 12 turns of this pair were wound on a small ferrite toroid,* the inductance (measured as per Fig. 4B) was nearly 1.1 μH.

The measured capacitance between bifilar wire pairs was found to be 12 pF (typically 35 pF/foot). Therefore, the end terminal capacitors (C1 in Fig. 1) must each be

$$C1 = \frac{450 - 12}{2} = 219 \text{ pF} \qquad \text{(Eq. 8)}$$

When assembled as shown in Fig. 2, the hybrid functioned correctly the first time without requiring any trimming of inductance or capacitance.

Hybrid Applications

Fig. 5 suggests some applications for the quadrature hybrid. In Fig. 5B, two receivers are fed from a common antenna or vhf converter. If the 3-dB (f_o) frequency of the hybrid is near the output frequency of the preamplifier or converter, each receiver will receive an equal amount of power. If each receiver input impedance is Z_o, then no power will be lost in the Z_o termination connected to port 3 of the hybrid.

In Fig. 5B, the hybrid is used to obtain an *unequal* split in generator power. The generator frequency is at one-third the hybrid 3-dB frequency, f_o. Therefore, as indicated by Fig. 3, the power arriving at the load connected to port 4 of the hybrid will be attenuated by 0.5 dB, while the power emerging from port 2 will be 10 dB down. In this case, the hybrid is functioning as a directional coupler. If the detector and load impedances are near the value of Z_o, no power will be dissipated in the Z_o termination connected to port 3; also, the impedance looking into port 1 will be Z_o.

Fig. 5C shows the parallel operation of two amplifiers, a particularly useful application first mentioned in Ref. 1. This connection provides excellent amplifier isolation and virtually eliminates interaction between them, thus "taming" most tuned transistor amplifiers. The circuit is unique in that, if the amplifiers are identical, then the impedance seen looking into port 1 of the first hybrid and port 2 of the second hybrid will always have the value Z_o regardless of the amplifiers' input and output impedances.

Fig. 5D shows how an impedance-matched spdt switch can be constructed from two hybrids and two spst switches. When the spst switches (which can be semiconductor diodes) are open, all of the power from the generator will flow into load no. 2. When the switches are closed, all of the generator power will be diverted to load no. 1. In either case, the generator and both loads will always see an impedance of Z_o.

In Fig. 5E, the switches have been replaced by two identical band-pass filters. For frequencies that fall in the passband of the filters, all power from the generator will flow into load no. 2. However, for frequencies outside the filter passband the generator power will be diverted into load no. 1. As before, the generator and both loads always see impedance Z_o.

Hybrid Limitations

Fig. 3 implies that the twisted-wire hybrid is principally a one-band device since the coupling remains near 3 dB over a relatively narrow frequency region. A

*[Editor's Note: The toroid was part no. CF-101 Q2 made by Indiana General Corporation, Keasby, NJ. Outside diameter of toroid was 0.230 inch, thickness was 0.60 inch, and permeability approximately 100.]

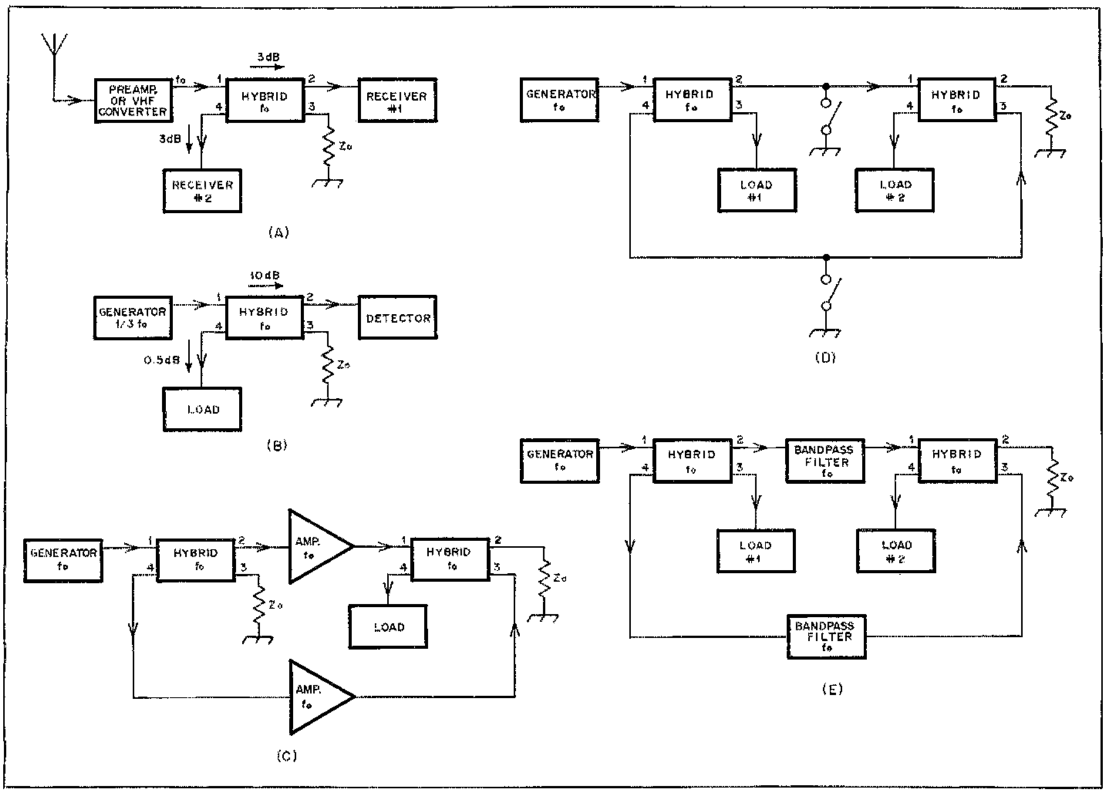


Fig. 5 — Various hybrid applications.

method of cascading two couplers to obtain wider bandwidth has been described in the literature.[4]

The upper frequency of operation is limited by the minimum value of capacitance C (Fig. 4B), which is the capacitance between turns of the bifilar winding. These hybrids have been made to operate successfully at 900 MHz.

Power-handling capability is limited by ferrite-core saturation and/or insulation breakdown in the bifilar section. The hybrid shown in Fig. 2 should be able to handle at least 10 watts. Higher power hybrids can be constructed by employing not only wire with thicker insulation, but also larger ferrite cores. It may be profitable to experiment with an air-core transformer by simply winding the bifilar pair into a solenoid. However, the design equations hold only for a "lumped network"; therefore, the length of the bifilar pair should not exceed perhaps one-tenth wavelength.

References

[1] Fisher and Turrin, "UHF Directional Couplers," *QST*, September, 1970.

[2] *The Radio Amateur's Handbook*, 1971 edition, p. 541.

[3] *The Radio Amateur's Handbook*, 1971 edition, p. 35.

[4] Fisher, "Broadband Twisted-Wire Quadrature Hybrids," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-21, No. 5, May, 1973, pp. 355-357.

Strays

I would like to get in touch with . . .

☐ teenage hams who would like to play chess, checkers, battleship, etc. on 80-, 40- or 15-meter cw or ssb. Please send an s.a.s.e. Dave Bullard, WB3CBG, 202 S. 4th St., Hamburg, PA 19526.

☐ anyone who knows where I can reach the daughter of Russell H. Tighe, W2ALH, a recent Silent Key. Jorge Perich, WA4GPC, 821 Barnett St. N.E., Atlanta, GA 30306.

☐ industrial electricians or members of large- to medium-size industrial maintenance organizations. Florentino Gonzalez, WA1LYS, 26 Lincoln Ct., Meriden, CT 06450.

☐ teenagers who would like to start a 15-meter ssb net for ragchewing and traffic. John Purnell, WD9CYV, 405 Miller Ave., Madison, WI 53704.

☐ other university-affiliated clubs concerning functions and services during the academic year. Rick Lewis, WBØUZI, University of Iowa ARC, Room 4900, Engineering Bldg., Iowa City, IA 52240.

☐ an amateur rose grower to share knowledge with a new rose enthusiast. Lyle Bickley, WB4VKW, 901 N. Washington, Tuscumbia, AL 35674.

An Inexpensive Morse Keyboard

Put that hand key, bug or electronic keyer on the shelf! Update your operating with this fine-performing Morse keyboard that sends perfect cw, yet requires little skill to use. Build it for under $30 and you'll have a ball!

By Al Helfrick,* K2BLA

Many radio amateurs who have used a keyboard for transmitting Morse code find the device most satisfying and delightful for communication. The near-perfect code sent by keyers of this type does much to reduce operator fatigue and increase accuracy of copy. Oddly enough, and over the objections of some purists, machine-sent code does tend to improve one's fist. Any device that improves the quality of radio communication deserves attention and use.

Until recently, the price of commercially available keyboards and the cost of many homebuilt units have made the keyboard keyer an expensive station accessory. But, with the explosive growth of home computers, large supplies of surplus keyboards and digital-logic material have been made available at reasonable prices. By careful shopping and acquisition of a used keyboard, the keyer described in this article costs less than $30.

After designing and building two previous keyboard keyers, I decided upon a few guidelines for any future construction. First, diode matrices for keyswitch encoding are to be avoided. With all sorts of LSI chips and dynamic systems for encoding switch closures, there is no justification for using literally hundreds of diodes. Secondly, CMOS logic is used. CMOS devices are widely available at reasonable cost. They have excellent noise immunity and allow the use of simple power supplies. Finally, any unnecessary frills will be avoided such as buffer memories, baudot operation, and canned messages.

*RD 1 Box 87, Boonton, NJ 07005

These extras, although often useful, are not worth the added cost and complexity to me. What evolved is an inexpensive, easy-to-build, keyboard keyer constructed from readily available parts. It includes a completely interlocked keyboard with two-key rollover. The unit has the capability to transmit all letters, numbers, punctuation and special symbols including $\overline{AR}$, $\overline{SK}$, $\overline{DN}$, $\overline{AS}$ and $\overline{BT}$.

The secret to the diodeless encoding scheme is the use of a scanned keyboard. The heart of the scanning circuitry is composed of three CMOS analog multiplexers. An analog multiplexer is comparable to eight electronic switches as shown in Fig. 1, arranged so that only one of the eight switches is closed at any time. The switch that is closed depends on the binary number presented to the decoder. For example, if binary 010 appears at the decoder, switch number two will be closed. If 000 appears, then switch number zero will be closed. If the input to the decoder is connected to the output of a binary counter, then the switches will close in succession (zero through seven and back to zero.)

If the analog inputs and outputs are reversed the device becomes a demultiplexer, allowing one common input to be applied to any one of eight outputs. The same monolithic integrated circuit is used in the keyboard keyer as a multiplexer and demultiplexer.

The Scanned Keyboard

Fig. 2 shows a simplified schematic diagram of a scanned keyboard. It may be viewed as an electronic maze or puzzle. If one of the keyboard switches is closed, the

The author operating his keyboard in its intended environment. For field operation, the Gonset twins have been "solid-stated," and run eight watts to an FET power amplifier.

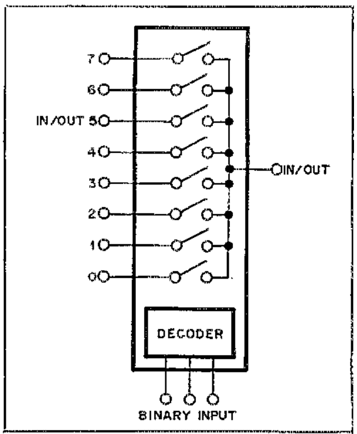


Fig. 1 — An analog multiplexer with an internal decoder. The decoder allows only one of the eight switches to be closed at a time.

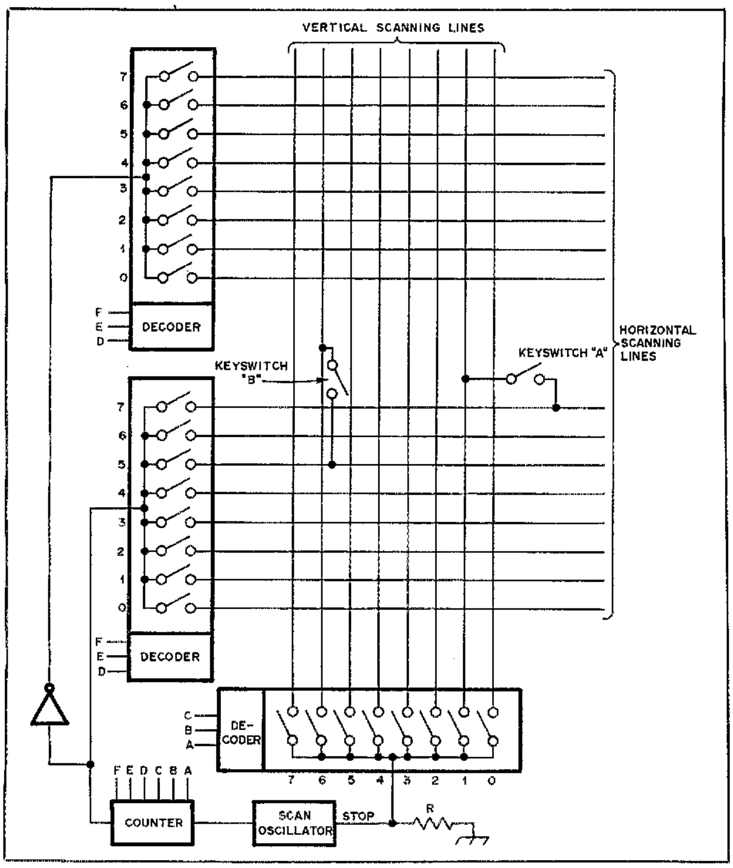


Fig. 2 — A scanned keyboard. Switches are connected between any horizontal wire to any vertical wire as desired. An intersection without a switch implies that these binary codes are unnecessary or invalid for the system.

Table 1

Keyswitch Connections

Connect keyswitches as indicated. Connecting wires are kept short to minimize rf susceptibility. The longest wire in the author's keyboard is about 200 mm (7-7/8 inches). It causes no difficulties.

	Connect			*Connect*	
Character	*From*	*To*	*Character*	*From*	*To*
A	A7	B1	X	A4	B6
B	A5	B6	Y	A4	B2
C	A5	B2	Z	A5	B4
D	A6	B6	1	A0	B1
E	A5	B5	2	A0	B3
F	A3	B3	3	A0	B7
G	A6	B4	4	A1	B7
H	A5	B7	5	A3	B7
I	A7	B3	6	A3	B6
J	A4	B1	7	A3	B4
K	A6	B2	8	A3	B0
L	A5	B5	9	A2	B0
M	A7	B0	0	A0	B0
N	A7	B2	$\overline{AS}$	A3	B5
O	A6	B0	$\overline{AR}$	A2	B5
P	A5	B1	$\overline{BT}$	A1	B6
Q	A4	B4	$\overline{DN}$	A2	B6
R	A6	B5	$\overline{SK}$	A9	B7
S	A6	B7	comma	A8	B5
T	A7	B4	period	A9	B1
U	A6	B3	?	A10	B3
V	A4	B7			
W	A6	B1			

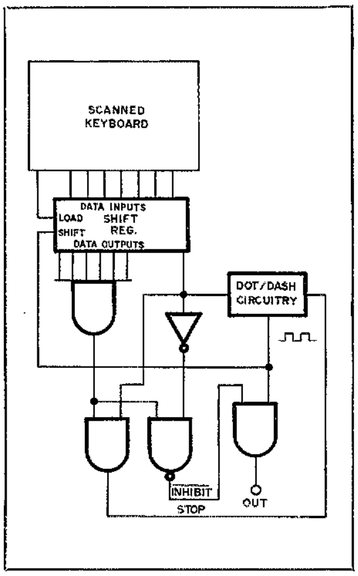
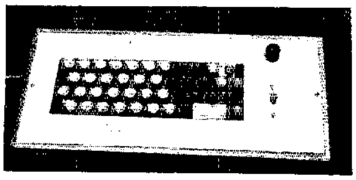


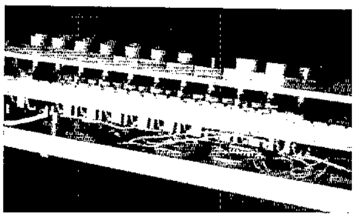
Fig. 3 — A simplified diagram of the Morse keyboard. Each Morse code character has a unique seven-bit binary number. The binary number encoded by a keyboard switch is determined by which horizontal and vertical scanning lines the switch is connected to.

scanning system must find it and generate the proper code assigned to that switch without being fooled by switch bounce or multiple switch closures. When a keyboard switch closes, there will be a current path from the demultiplexer to the multiplexers. The scanning circuitry attempts to find this current path by closing one electronic switch after another, going through all possible combinations until the circuit is completed.

The current flowing through the demultiplexer, the keyboard switch, the multiplexer and finally resistance R, in that order, causes a voltage drop across R and stops the scanning oscillator. The binary number contained in the seven-bit counter when the oscillator stops is the binary code assigned to the keyswitch. Since the counter is seven bits long, there is the possibility of encoding any binary number from 0000000 to 1111111 and producing 128 different combination possibilities. For example, if switch A in Fig. 2 is closed, the counter will stop at 1111001. If switch B is closed, then the counter stops at 1101110. If no switches are closed, then the circuit will continue to scan all 128 different possibilities until a closed switch is found. When this happens the counter will stop until the detected switch is released, whether or not any other keyboard switches are closed. This produces interlocking so that if more than one keyboard switch is closed, only the first will be decoded.



Operator's view of the Morse keyboard. The enclosure is home constructed. The top panel is made with 1/8-inch aluminum while the sides are wood. Some keys are relabeled to include noncomputer symbols such as AR, BT or SK.



The electronics are contained on a single 4- × 6-inch prototype board attached to a shallow aluminum channel. The keyboard frame, the panel and the electronic channel are secured with long machine screws and spacers.

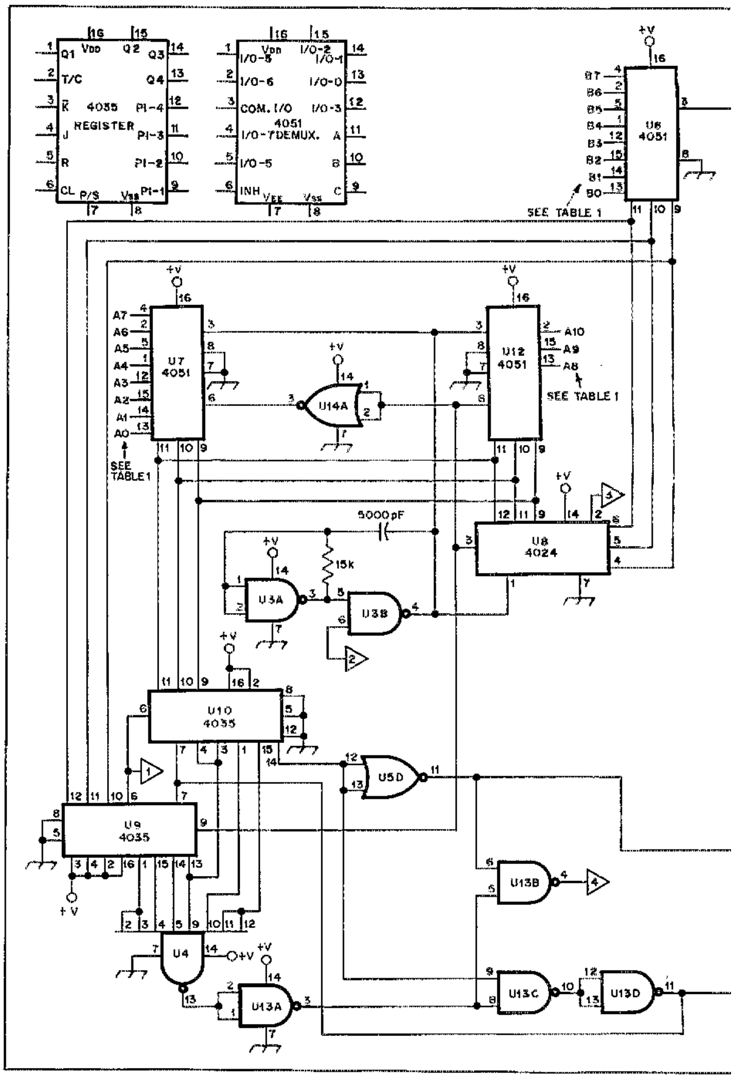


Fig. 4 — The inexpensive Morse keyboard using a diode-less encoding scheme. All capacitors

U1, U2 — Monolithic silicon digital MOS IC, dual J-K flip-flop type 4027.
U3, U11, U13, U14 — Monolithic silicon digital MOS IC, quad 2-input NAND gate, type 4011.
U4 — Monolithic silicon digital MOS IC, 8-input NAND gate, type 4068.
U5 — Monolithic silicon digital MOS IC, quad 2-input NOR gate, type 4001.
U6, U7, U12 — Monolithic silicon digital MOS IC, multiplexer/demultiplexer, type 4051.

The scanning oscillator in this keyboard keyer operates at about 64 kHz. At this frequency the operator has a feeling of instantaneous operation. This frequency provides a worst-case decoding time of about 2 ms. Although possible, operating the oscillator at a higher frequency is not desirable. The 2-ms time is fast enough for practically any keyboard action. Higher scanning frequencies tend to place stronger, low-order harmonics of the scanning oscillator in the hf radio spectrum, causing possible interference problems.

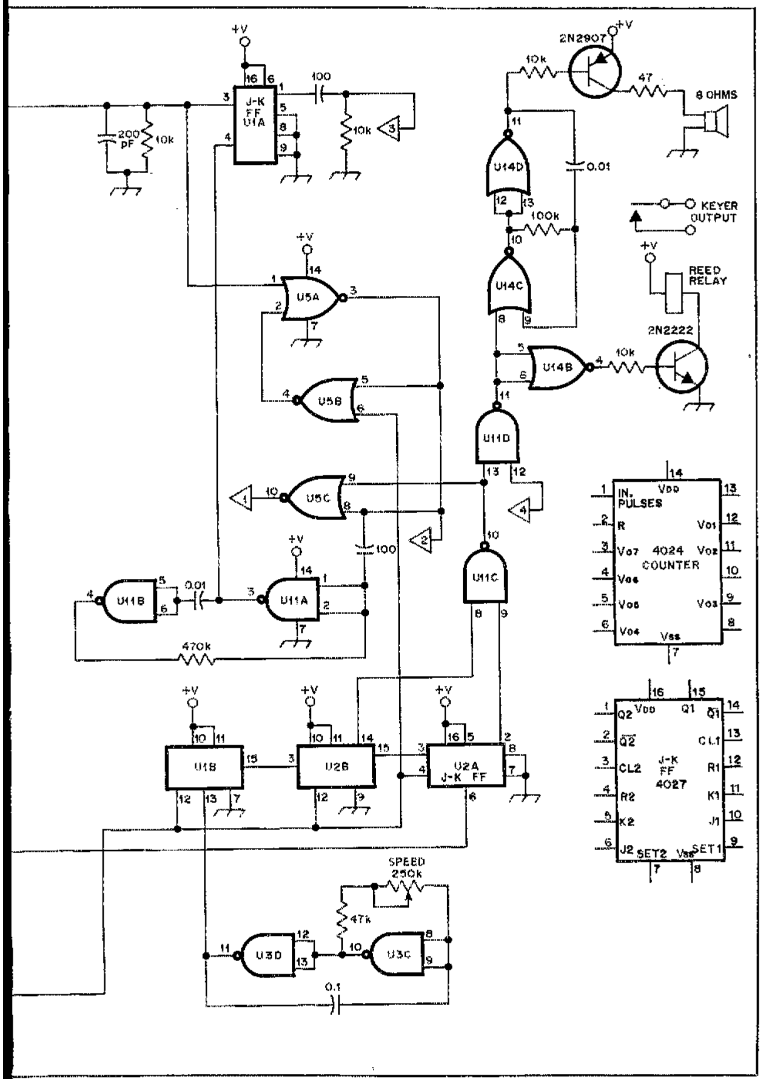
Because the keyboard scanner can only encode seven-bit binary numbers, some scheme is required to convert these binary numbers into valid Morse code characters. In this keyer, binary one represents the dot and binary zero the dash. An extra zero is added as an "end" bit and the characters are sent from right to left. All of the letters, numbers or special characters must be represented by seven-bit binary numbers where all of the unused bits to the left of the "end" bit are binary 1s. For example, the letter A is represented by 1111001. The right-hand digit, a one, represents a dot. The next digit is zero, representing a dash. The following zero represents the end bit and is not sent, but signifies the end of the Morse character. The remaining digits are ignored. To illustrate further, the letter B is thus encoded 1101110, and the number seven as 1011100.

The Shift Register

A shift register is used to temporarily store the decoded binary number and to shift the number to the right one digit at a time (see Fig. 3). The binary output from the keyboard scanning encoder is parallel-loaded into the seven-bit shift register. The state of the right-hand stage of the shift register will determine whether a dot or dash is to be sent by the dot/dash circuitry.

Presume that 1111010 has been parallel-loaded into the shift register from the keyboard encoder. Because the right-hand stage of the shift register contains a zero, the dot/dash circuitry will send a dash. The falling edge of the dash shifts the register one step to the right, and places a 1 in the left-hand stage. The number now in the register is 1111101, with the right-hand stage containing a one, the dot/dash circuitry sends a dot.

When the falling edge of the dot shifts the register again, the digital content is 1111110. The dot/dash circuitry generates a dash because the last digit is zero.



are Mylar or polystyrene, 20 V.

U8 — Monolithic silicon digital MOS IC, 7-stage binary counter, type 4024.
U9, U10 — Monolithic silicon digital MOS IC, 4-stage parallel-in/parallel-out shift register, type 4035.

However, the dash will not be sent because the inhibit line will go low and not allow the dash to appear on the output line. After shifting, the register now contains all ones. This causes the "stop" line to go high, indicating the end of the Morse character. In this example, the letter N has been sent and a space of one dash duration was generated. The shift register is now free to be parallel-loaded with the next encoded Morse character. Notice that the space of one dash duration, included between any two Morse characters, is required for letter spacing and is thus automatically generated.

About the Electronic Package

In the keyboard keyer constructed by the writer, these simplified circuits took on a somewhat different form in order to contend with problems of real hardware. See Fig. 4. Extra gating was required to suppress false decoding which resulted from switching glitches in the scanning circuitry. A flip-flop was added to allow automatic spacing of repeated letters.

If the reader wishes to understand thoroughly how the circuit functions, a careful study should be made of the data sheets for each device, especially the complex functions. By doing so, one may gain an in-depth understanding of the keyboard keyer from the moment a switch closure has been detected until the unit is ready for another key closure.

The entire electronics package is assembled on a universal DIP pc board. Wire-wrap techniques could be used, but would require the board to be deeper. Because of the noise immunity of CMOS devices, layout is not critical.

The scanned keyboard circuits are inherently debounced and interlocked. Therefore, almost any type of key contact or keyboard will work. No electronics are required for the keyboard. Consequently, the builder can save considerably by shopping around for a keyboard with nonstandard encoding, or no encoding at all.[1] These keyboards are the least desirable for the computer enthusiast, but are ideal for a Morse keyboard. If the keyboard has any circuit connected to it, the circuitry must be removed.

A Sidetone Oscillator and Key Switches

A sidetone oscillator was added and a switch was provided for turning off the sidetone to save power drain. A power drain problem exists for the keying stage. The use of a reed relay is the most foolproof keying method, but costs the most in terms of power drain. If an ac supply is used, power drain is no problem, allowing the use of pilot lamps, monitors and relays. The power supply voltage may range from 5 to 15 volts dc. A regulated supply is not essential. The writer's keyboard keyer is powered by six penlight cells. There is no keying stage because the keyboard is used with a portable transmitter having a CMOS-compatible key input.

In Conclusion

The keyboard is easy to use and requires very little skill to send perfect code. Being familiar with a typewriter keyboard is helpful.

Because the keyboard keyer automatically spaces each letter, the operator may press one letter and before the letter has been completed press another letter and still have both letters sent with correct spacing. For example to send CQ, press the C key and then immediately press the Q key. Hold the Q until the keyer starts sending Q. A perfectly spaced CQ will be transmitted.

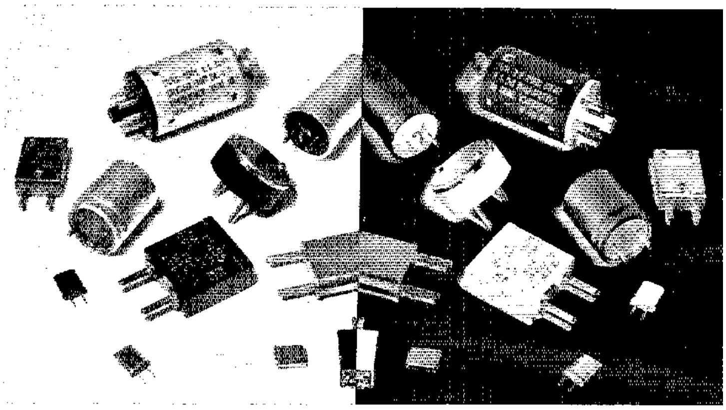
One word of caution is in order. Sitting in front of a keyboard is like sitting at the wheel of a Ferrari — one is tempted to go very fast. Remember that copying the keyboard with a pencil is like racing a Model A against the Ferrari!

[1] To purchase a keyboard, the builder should refer to Ham Ads in *QST* and advertisements for surplus equipment.

Crystals Inside Out

So you know what frequency to order . . . but what about load capacitance or tolerances? There's a lot more to crystals than what's stamped on the outside. Take a peek at the guts and learn what makes them tick — here's a dissection!

By Jim Bartlett,* WB9VAV



Without crystals, we'd be drifting like snow in a December storm, making communication much more difficult than it presently is. Piezoelectric crystals are very important to us as ham radio operators, because they maintain frequency stability in oscillator circuits. Since crystals play such a significant part in our hobby, it only seems fair that we should be interested in their history, design and theory of operation.

In 1880 the Curie brothers discovered the direct piezoelectric effect. They found that pressing a large piece of Rochelle salt on its surfaces produced a voltage between the surfaces, and that the charge produced was directly proportional to the pressure exerted. The converse piezoelectric effect was discovered a year later. In this effect, when submitted to a voltage at its faces, a crystal would be strained and bend due to the expansion and contraction inside the crystal.

The piezoelectric effect remained a scientific curiosity until the early 1900s, when Nicholson constructed and demonstrated speakers, microphones and phonograph pickups using Rochelle salt crystals. He was also the first to use crystal control in an oscillator, and obtained the primary crystal oscillator patent. G.W. Pierce also published an early oscillator circuit using crystal control, and the Pierce oscillator bears his name.

Today, quartz is the most widely used radio crystal material because it is less brittle than Rochelle salt and some of the other early crystal materials.[1] A crystal behaves much like an inductor-capacitor (LC) tuned circuit, and in fact simulates or looks like the tuned circuit shown in Fig. 1 when in the vicinity of its resonant frequency. Depending on the thickness and "cut" of a crystal, one frequency will exist at which the crystal will vibrate when a particular frequency of ac voltage is applied to its plates. This frequency at which the crystal oscillates is similar to the resonant frequency of an inductor-capacitor tuned circuit. One difference is that the crystal has a much higher Q than an LC tuned circuit does. When we speak of the "Q" of a circuit we are actually talking about *quality*, because that is what the Q stands for. But quality in electronic circuits means a combination of efficiency and selectivity. A tuned circuit with a high Q has very little dc resistance, and therefore very little energy is wasted or used up (dissipated) by the pure resistance. Result? High efficiency. This also means that almost all of the current is flowing through the capacitive and inductive elements of the tuned circuit. Consequently, they are more effective in their tuning and more selective! So the high Q helps make crystal-controlled oscillators more accurate and stable than the LC type.

Let's look at the crystal in an oscillator circuit. If we can apply an ac voltage to the crystal plates momentarily, the crystal will begin to vibrate. This physical vibration will, in turn, *generate* an ac voltage (identical in frequency to the original) which causes the crystal to continue vibrating. This circular process continues until the energy that was initially applied to the crystal plates is dissipated. This action is similar to that in an LC tank circuit.

Two schematic diagrams of a triode oscillator are shown in Fig. 2. Both forms of the circuit are of the tuned-plate, tuned-grid variety, but one contains an LC tuned-grid circuit, and in the other a crystal is substituted for the coil-capacitor combination. In both of these circuits the energy that is fed back from the tuned-plate circuit through C keeps the grid circuit oscillating. We said before that a crystal displays a greater Q than an LC circuit. Because of this high Q, the grid circuit of the *crystal* oscillator is much more selective, responding only to those frequencies very close to its resonance. The crystal tuned grid also requires less feedback energy (drive) from the plate circuit than an LC tuned-grid circuit does, because the crystal's higher Q means it dissipates the energy more slowly. This is important, because the strength of the crystal's vibration depends on the voltage being fed back to the grid circuit from the plate. If the feedback becomes too large (too large C), the vibrations may increase in magnitude until the crystal fractures.

Crystal Types

The resonant frequency of a quartz crystal is dependent mainly upon the

*Basic Radio Editor, *QST*
[1]Footnotes appear on page 32.

crystal thickness, its electrode configuration, and the angle of cut. The angle of cut is determined by the orientation of the crystal faces with respect to the X, Y and Z axes present in the natural crystal formation. Fig. 3 shows X-, Y- and AT-crystal cuts and their orientation in the quartz formation.

An X-cut crystal is cut perpendicular to the X axis. This type of crystal is usually thicker than Y or AT crystals all cut for the same fundamental frequency. The X also has a tendency to oscillate at many frequencies that are all fairly close together, making it difficult to pick out the desired mode. For this and other reasons, it was abandoned in favor of the Y-cut crystal which vibrates in shear rather than longitudinal mode (see Fig. 4). Unfortunately, the Y-cut crystal had problems too, the largest being that its resonant frequency would increase about 86 parts per million for every degree Celsius increase in the temperature. (A 5-MHz crystal would shift about 430 hertz per degree Celsius.) This highly positive temperature coefficient required close regulation of the Y crystal temperature in order to achieve good stability.

In order to improve the performance of quartz crystals, investigations were made that led to the development of the AT-cut crystal. The AT cut displays a low temperature coefficient, which means that its resonant frequency varies only a little with temperature change. Because of its large frequency range and its superior frequency stability, the AT-cut crystal is probably the most widely used at this time. These crystals are available from many sources and can be designed for operation on any frequency from approximately 500 kHz to 25 MHz in the fundamental mode, or from 10 to 200 MHz in overtone modes.

Overtone Crystals

So what is the difference between a fundamental and an overtone crystal both designed for 15 MHz? The difference is that the fundamental crystal is cut for 15 MHz and the overtone crystal is cut for some frequency lower than 15 MHz. If it were a third overtone rock, its fundamental frequency would be 5 MHz, and if it were a fifth overtone, 3 MHz. Thus, both 15-MHz crystals can operate at the same frequency, but are cut at different fundamentals. Fundamental mode is the operation of a crystal at the frequency for which it is cut. In an overtone mode, the crystal actually vibrates at a frequency that is harmonically related to its fundamental cut. This is called its *working* frequency. An overtone frequency is always an *odd* multiple of the fundamental.[2] *Even* multiples of the fundamental cannot be excited in a crystal, because the charge displacement inside the crystal does not result in a voltage potential at the electrodes when the crystal is stressed. In other words, the piezoelectric effects discussed earlier do not occur when a crystal is vibrating at an even multiple of its fundamental frequency. Consequently, oscillation cannot be sustained at the even harmonics. A crystal also cannot oscillate in its fundamental and overtone modes simultaneously. See Fig. 5. When a crystal oscillates on an overtone, it breaks down into separate layers. The number of layers depends on the specific overtone in use. There are three layers for a third overtone oscillation, five for a fifth, and so on. The layers are separated by nodes as shown in Fig. 5. Extreme care is used in the grinding and mounting of overtone crystals because the overtone layers are only a fraction as thick as the fundamental layer. Take a 7-MHz crystal about 0.014 inch thick, for example. The overtone layers for third mode operation would each be less than 0.005 inch thick. For fifth mode they would be less than 0.003, and for seventh, 0.002 inch thick! This doesn't leave much room for error in the grinding process. A small imperfection or scratch on the crystal surface could impair crystal efficiency or prevent operation in the overtone mode completely. The method used to mount the crystal, and the capacitance of the holder used, may also have considerable bearing on the perfor-

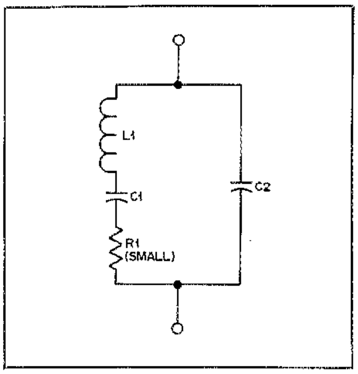


Fig. 1 — An electrical equivalent to the crystal in a circuit. The inductance of the crystal is symbolized by L1 and the capacitance by C1. The resistance of R1 is shown to signify that although the crystal has a very high Q, the value is not infinite. The capacitance of C2 is called shunt capacitance. This is added in parallel to the crystal (across the electrodes). This shunt capacitance is a combination of crystal holder and socket capacitances.

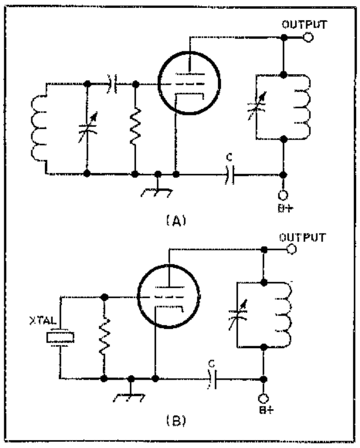


Fig. 2 — Shown in A is a tuned-plate, tuned-grid oscillator using an LC tuning combination in both the plate and grid circuits. Both circuits are tuned to the same resonant frequency. In B, the LC combination at the grid has been replaced with a crystal. In this circuit, if a fundamental crystal is used (one which is cut at the working frequency) then the plate circuit is tuned to the crystal frequency just as in A. But if an overtone crystal is used, then the plate circuit is tuned to the working frequency or overtone.

Fig. 3 — X, Y and AT cuts of quartz crystal in relation to the raw quartz formation. Notice the angle at which the AT cut is made. Other cuts are made from quartz using different angles of cut from perpendicular. For instance, a BT cut, is made at an angle of about 49 degrees to the opposite side of perpendicular from that of the AT cut.

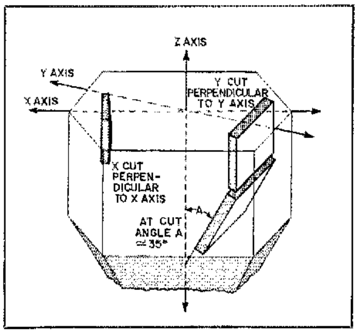
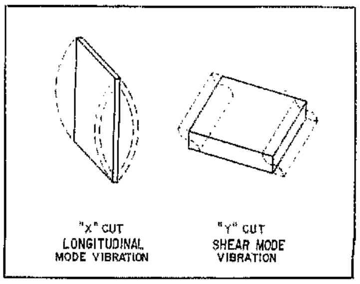


Fig. 4 — Longitudinal and shear modes of vibration are shown greatly exaggerated in this drawing. These both show fundamental operation of a crystal.



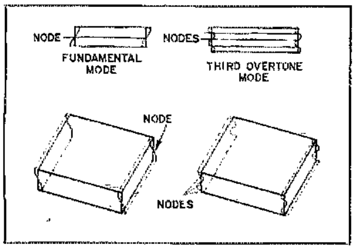


Fig. 5 — At the left is a fundamental-mode crystal oscillating at its "cut" frequency. At the right is an overtone crystal oscillating at an odd multiple of its fundamental or cut frequency. Note that there is a *node* for each multiple of the fundamental. Basically, each node is a point on the crystal where there is no movement when the crystal is vibrating. In a fundamental crystal or an overtone crystal operating at its cut frequency, there is only one node. But if an overtone rock is operating at its overtone or working frequency, there are nodes equal in number to the overtone number. Thus, the third-overtone crystal has three nodes.

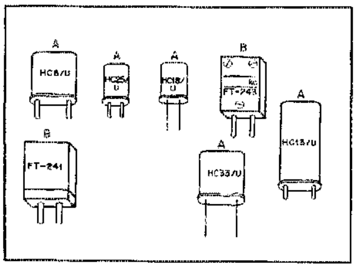


Fig. 6 — Some of the more common types of crystal holders found in amateur radio equipment. Those marked with an A are typical plated-electrode types. Those marked with a B are typical pressure-mounting types.

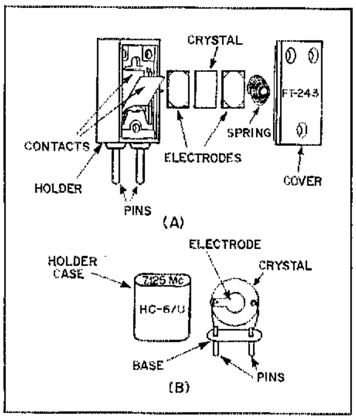


Fig. 7 — One type of pressure-mount crystal holder is shown in A. The crystal blank is sandwiched between two electrodes and then held in place between the contact plates by spring pressure after the case is screwed together. An electrode-plated crystal and holder are shown in B. This type of holder is usually evacuated or filled with dry air before being sealed.

mance of the crystal in the overtone mode.

One more thing that makes an overtone crystal different from a fundamental crystal is the circuit in which it is used. As we said earlier (see Fig. 2), an overtone crystal oscillator must return energy to the crystal at the overtone frequency. This encourages the crystal to oscillate at the overtone rather than the fundamental. Note that because of the need for feedback from a tuned circuit, an overtone crystal will not work in many crystal oscillator circuits. Common circuits such as the Pierce and crystal Colpitts cannot be used with a crystal that is to be operated in the overtone mode. The overtone crystal must be used in a tuned-plate, tuned-grid, or similar circuit as shown in Fig. 2B.

Holders

Because crystals are so delicate, they must be mounted in containers that protect them from the environment. These containers or holders come in various shapes and sizes, each designed to hold a specific type of crystal or one used in a certain application. The crystal holders most common in amateur gear at present are shown in Fig. 6. These holders can be broken down into two basic groups: those using pressure to hold the crystal between the electrodes, and those in which the electrodes are actually plated to the crystal and attached to the holder by wires. These are shown in Fig. 7. The plated type of crystal begins with a quartz blank that has already been ground to a frequency just above the one to be achieved. Then a plating of silver (or sometimes other metals) is applied to the crystal surfaces. This plating thickens the crystal and brings the blank closer to its final operating frequency (fundamental). After plating, the blank is mounted on a base and the plated-on electrodes are attached to the base pins. The mounted blank is then calibrated to its final frequency, after which the base and cover are joined and sealed together. The plated crystal has the advantage over the pressure mounted type of being more mechanically stable, permitting the crystal to have closer calibration and temperature tolerances. In general, plated crystals also tend to work better in overtone modes than the pressure mount types, and therefore they are more widely used than the older pressure-mounted ones.

The plated crystal has one disadvantage: its inability to dissipate as much internal heat as the pressure-mounted crystal. Consequently, plated crystals must be operated at lower drive levels than the pressure-mounted ones.

How to Order Your Rocks

Some of you are probably saying, "But how do I order the crystal for a specific application?" First of all, in order to know what type of crystal to order, you must know what kind of equipment or circuit it is going to be used in. For most crystals that might be ordered, you would include some of the following information: (1) holder type (as per Fig. 6), (2) load capacitance, (3) intended use (type of equipment), (4) fundamental frequency (cut frequency), (5) working frequency (if other than fundamental), (6) the overtone to be used (if it is an overtone crystal), (7) calibration tolerance required, (8) temperature coefficient required, (9) temperature range over which crystal will be used (room temp. — nonoven or oven), (10) final transmit or receive frequency of rig, and (11) any other information that may be helpful to the crystal manufacturer, such as the transmitter or receiver strip numbers on old commmercial gear.

For old Motorola gear, give the Motorola crystal type number if possible (RN-1 for transmit and RM-10 for receiver, for example). The *most important* items to include when ordering are frequency, holder type, and load capacitance.

Finding the Frequency

First, let's discuss the procedure for obtaining the crystal frequency. This depends somewhat on the type of equipment, because of the numerous transmitter and receiver designs. Dozens of conversion schemes and intermediate frequencies (i-fs) exist for receivers, and there are probably as many ways to multiply or heterodyne signals to the final frequency in transmitters. All of these designs require different crystal frequencies to fit into the various circuits being employed.

Let's take a 2-meter transmitter, for example. Pretend we have a circuit diagram which shows that the output of our transmitter should be 144 MHz. But the crystal isn't going to be at 144 is it? No, the three doubler circuits on the schematic tell us that the crystal oscillator must be putting out a frequency only 1/8 of 144 MHz, or 18 MHz.

$$\text{Three doublers} = 2 \times 2 \times 2 = 8$$

$$\frac{144}{8} = 18 \text{ MHz}$$

Now we know that the crystal is oscillating at 18 MHz. But to find out whether it is a fundamental or overtone crystal, we must look at the transistor oscillator circuit. The crystal in the base circuit is labeled 6 MHz but the collector tuned circuit is labeled 18 MHz. This indicates that the crystal is a third overtone cut for 6 MHz and designed to oscillate at 18 MHz — its working frequency![3] Now we know the frequency that the crystal must be cut for and that it is a third overtone, but we've also found out something else that is important: the number of multiplications between the crystal working frequency and the transmitter output frequency. Knowing this can help us determine the calibration tolerance needed for our crystal.

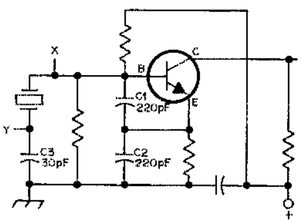
Calibration: How Exact Is the Frequency?

To begin with, we must agree that no crystal is going to be *exactly* on the frequency that you want it to be, even if you had it cut specifically for that frequency. For instance, a 7.125-MHz crystal might actually be 7.12529 or 7.12472. This would mean it was plus or minus 0.004 percent correct, or had a calibration tolerance of 0.004 percent. "Well, that's close enough for anybody on 40 meters" you might say, and you'd be right! That's where knowing the equipment comes in. What if you had a 6-MHz third overtone rock that had the same tolerance but was used in the 2-meter transmitter we discussed earlier? Would you be on 144 MHz? Let's find out. The third overtone crystal is designed to oscillate at 18 MHz, so the 0.004 percent calibration is at that frequency. A plus or minus 0.004 percent gives us 18.00072 and 17.99928 MHz respectively. That's not too far off, but we haven't multiplied the error yet: 18 × 8 = 144 but 18.00072 × 8 = 144.00576 and 17.99928 × 8 = 143.99424 so at 2 meters, you are off by plus or minus 5.76 kHz. Not so good, huh? Actually, you would be able to adjust the frequency some amount by using the trimmer that is in parallel with the crystal, but can you adjust it that far? This would depend on the circuitry in the rig, and the value of the trimmer capacitor. So we're back to *knowing the equipment* in which the crystal is to be used. It can get pretty complicated, that's for sure! The best way to guarantee that any crystal you order will be close enough for your purposes is to specify the rig that it will go in. Then the crystal manufacturer will make the crystal "to specs" for the rig, and you should have no problems. If you are converting an old commercial rig to amateur frequencies, then you should specify whether the equipment originally had oven or nonoven crystals, and what type you want as a replacement. As a rule, nonoven crystals are plenty accurate for amateur use, and they're energy efficient too!

Temperature Tolerances

The next item on our list of crystal-ordering parameters is temperature. Although a crystal is cut for a certain frequency and is calibrated to within a fraction of a percent, it can still deviate from this frequency when the ambient temperature changes. The best way to determine how much deviation might occur in a particular crystal, and how much temperature change would be required to cause the frequency drift, is to check the crystal's temperature coefficient or tolerance. Two methods are used by crystal manufacturers to denote a crystal's temperature tolerance. One method is to list the tolerance as a percentage of the crystal frequency (0.002 percent) as the calibration tolerance is. The second method gives the tolerance of the crystal as a parts-per-million (ppm) figure accompanied by a temperature range over which the figure is accurate (±30 ppm from −30 to +60 degrees Celsius). The relationship between these two methods is not always direct or constant, but depends on complex curves drawn by plotting frequency drift and temperature change against time. Therefore, it is desirable for the amateur to be familiar with both methods and their use in ordering crystals.

Let's revive the 2-meter transmitter example used earlier and discuss frequency tolerance with respect to the 18-MHz transmit crystal. The crystal is a third overtone type, cut for 6 MHz but operated at 18 MHz. The temperature-tolerance information is referenced to the working or operating frequency, so we can disregard the 6-MHz figure and concentrate on the working frequency of 18 MHz. Pretend that we have two crystals both cut to operate at exactly 18 MHz. While we are pretending, let's also say that for the purpose of this example the calibration tolerance on both crystals is zero. Now the only *variable* that is left is the temperature coefficient. If crystal A has a temperature tolerance of ±0.002 percent, and crystal B has a tolerance of ±30 ppm from −30 to +60 degrees Celsius, which is the better crystal? Here are the figures for crystal A: 0.002 percent of 18 MHz is 360 Hz, multiplied by 8, to get a figure at 144 MHz, gives us 2880 Hz (360 × 8 = 2880). So crystal A will vary a maximum of 5.76 kHz, or more specifically 2.88 kHz above or below the 144-MHz transmitter operating frequency. For crystal B, ±30 ppm from −30 to +60 degrees Celsius means that for every million hertz (and we have 18) there will be up to 30 hertz of deviation above or below the crystal working frequency: 30 × 18 = 540, and 540 × 8 = 4320 Hz. So at 144 MHz the frequency could vary by as much as 8.64 kHz, or 4.32 kHz above or below the "ideal" 144-MHz transmit frequency, depending on the temperature. Which is better? Crystal A? Not necessarily, because comparing these two crystals with different temperature tolerance notations is like comparing apples with oranges! Crystal A *could* be better, but you can't be certain without more information. For instance, there was no



$$C = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}} \qquad \text{Eq. 1}$$

$$C = \frac{1}{\frac{1}{220} + \frac{1}{220} + \frac{1}{30}} = \frac{1}{0.0045 + 0.0045 + 0.0333} = \frac{1}{0.0423} = 23.6\ \text{pF} \qquad \text{Eq. 2}$$

Fig. 8 — A typical crystal-oscillator circuit using an npn transistor. The load capacitance can be figured by determining the amount of capacitance that is placed across the crystal by the rest of the circuit. The direct capacitance of C1, C2 and C3 is figured by the formula shown in Eq. 1, because the three capacitors are in series. The values shown in the diagram are plugged into the formula as shown in Eq. 2. The 23.6 pF is directly between points X and Y, and therefore across the crystal. But to obtain an accurate load capacitance figure, we must also take into account the stray capacitances present in the circuit wiring and pc board, and the emitter-base junction capacitance of the transistor. For the moment, we will assume the stray capacitance value to be about 7 pF. Actually, in a small-signal transistor such as this one, the junction capacitance is almost impossible to determine, because it depends upon operating frequency, signal amplitude, and operating voltage. However, for our purposes it can be anything up to 150 pF without changing the load capacitance value more than a fraction of a picofarad! This is because the junction capacitance of the transistor is in parallel with C1, and consequently is going to be almost negligible in the final analysis. With junction capacitance out of the way, we can obtain the load capacitance by simply adding 23.6 pF of straight capacitance and 7 pF of stray capacitance arriving at 30.6 pF. This would be rounded off to 31 pF.

Table 1 — Sample Crystal Order

One (1) crystal HC-25/U holder, load capacitance: 32 pF nonoven type.
Frequency: Third overtone — 18.2925-MHz crystal working frequency. Transmit freq. — 46.34MHz.
To be used as a transmit crystal in a Schmaltzberg 144Q 2-meter transceiver, serial no. 0123456A.
Calibration tolerance: ±0.002 percent*.
Temperature tolerance: ±30 ppm from —30°C to +60°C.

A sample crystal order for a 2-meter transmitter. Note that both calibration and temperature tolerances are given. Keep in mind that these tolerances are additive. This means that when variations in both tolerances occur simultaneously, they can combine making a larger change in crystal frequency than either could create individually. Realizing that this can happen, some crystal manufacturers combine their tolerance figures to arrive at a more practical figure, and one that will more accurately predict the crystal's behavior in the circuit. In these cases, the calibration tolerance *only* will be listed, but will contain a qualifying temperature statement (from —30 to +60 degrees C).

*Unless the crystal is to be used in an oven, this calibration tolerance will be measured at room temperature, or 26°C.

temperature range given for crystal A's figures. Actually, both crystals would probably be fine for use in the 2-meter transmitter we used as an example provided crystal A was rated from —10 to +60 degrees Celsius. "But those things would be off frequency by a mile," you're probably saying. Yes, left as they are they would be off by as much as 4.32 kHz except that we haven't taken into consideration the temperature-compensating components that may be inside the rig! These devices are placed in the oscillator circuit to compensate for frequency drift which occurs when the temperature changes. If the frequency of the crystal goes up when it gets colder, a component is used which has the opposite effect. Thus, when the circuit gets colder, the crystal wants to oscillate faster, but the value of the compensation component changes also so as to make the oscillator run slower. The two effects tend to cancel each other and the change in frequency is held to a minimum. But each piece of equipment is designed differently, so you must know the equipment in order to take temperature compensation components into account. As mentioned earlier, this can become quite complicated, consequently the best way for a beginner to assure himself of getting the proper temperature tolerance for his crystal is to specify the rig or circuit in which it will be used.

Finding Load Capacitance

One of the most important items to include when ordering a crystal is the load capacitance. The load capacitance is just what its name implies: a load in the form of capacitance that is presented to the crystal by its associated circuitry. When a crystal is manufactured, its frequency and tolerance figures are all calculated for a specific load capacitance. In other words, each crystal is designed to operate properly with a predetermined amount of external capacitance across its terminals. This value is usually somewhere between 20 and 50 pF, the most common figure being 32 pF. To determine the load capacitance for a particular circuit, look at the components surrounding the crystal (see Fig. 8). The load capacitance value will consist of all direct capacitances across the crystal terminals, the transistor junction capacitance (or tube interelectrode capacitance), and any stray capacitance in the circuit wiring or pc board. All this figuring can be somewhat difficult for the beginner. Therefore, it may be easier when ordering crystals for commercially manufactured gear to simply state the rig (make, model and serial number) rather than chance a mistake in the calculations. Let the manufacturer send the proper crystal for that piece of equipment. If you are ordering a crystal for a homemade rig, then you might want to send a copy of the schematic diagram to the crystal manufacturer along with your measurements of load capacitance.

Now that we've covered all the design parameters that should be included when ordering amateur crystals, let's look at an example of a typical crystal order. See Table 1. In this crystal order, we have listed the number of crystals we want, the frequency, holder type, load capacitance, type of equipment, and calibration and temperature tolerances. We also have specified a nonoven or room-temperature type of crystal.

With the advent of VFOs, digital synthesizers, and PLL, crystals are slowly consuming a smaller and smaller chunk of the amateur's budget . . . but even synthesizers need crystal oscillators or "clocks" to make them tick. Therefore, the quartz crystal may still be the most important item in our radios for years to come — until someone finds something better.

Assistance in the compilation of data used in this article was given by ARRL Technical Advisor Paul Freeland, W5ZVB, vice president of International Crystal Co.

References

McCoy, "Crystals Where You Want Them," *QST*, June, 1958.
Tilton, "Overtone Crystals — How and Where to Use Them," *QST*, March, 1955.
The Radio Amateur's Handbook, ARRL.

Footnotes

[1]Tourmaline, another crystal material, is sometimes used instead of quartz in very-high-frequency applications due to its superior strength, which allows it to be sliced extremely thin.

[2]An overtone frequency is not an exact multiple of the fundamental, but is always higher than the true multiple frequency. For example, a 6-MHz crystal operating on its third overtone would not be exactly at 18 MHz, but could be 3 to 10 kHz higher depending on the frequency.

[3]Although we are using an overtone crystal for our transmitter in the example, most transmitters use fundamental modes because the circuits include trimmers to zero the crystals. Receivers use both fundamental and overtone crystals. The use of the fundamental is prevalent in equipment utilizing temperature-compensated crystal oscillators (TXCO), because compensation is easier and there is trim range. When overtones are used, it is almost impossible to trim more than a few hundred hertz.

Strays

TRANSATLANTIC CROSSING A BUST

☐ When two balloonists prepared to attempt a transatlantic crossing from the Boston, MA, area last September, radio amateurs were among those providing support. For three hours K1FB and WA1LJB used WR1ACO, 19-79 Repeater Association and WR1ABV, Waltham Repeater Association, to relay weather updates from the tracking center in Bedford, MA, to the launch site in Marshfield, MA. The *Double Eagle* reached as far as the west coast of Iceland before deteriorating weather forced it down. — *WB1CTZ*

It's never too late: K4AI, of Morganton, NC, displays his new ARRL life member plaque along with a 50-year membership award. — *W4WXZ*

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

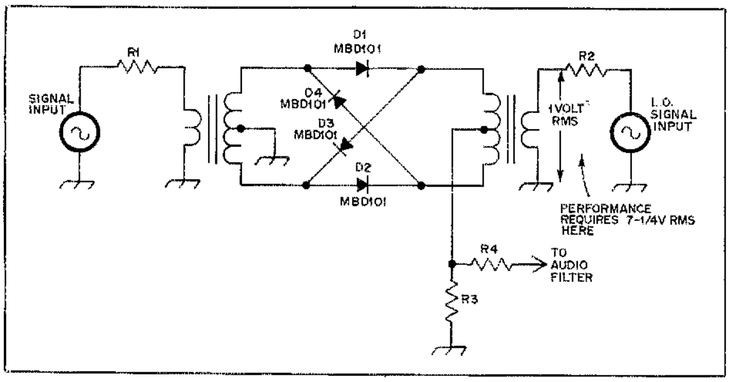


Fig. 1 — W9NZB's direct-conversion product detector scheme.

DIRECT-CONVERSION RECEIVING NOTES

☐ W1FB's article, "Understanding Linear ICs" (*QST*, January, 1977), was received with interest here. Direct conversion is one way we can put the "amateur" back in ham radio.

An important shortcoming of direct conversion is the poor ability of the product detector to reject strong a-m or ssb signals. It is very useful to give this quality a quantitative value so that product detector designs may be compared. This quality could be called a-m rejection ratio, or AMRR. This is the ratio, stated in dB, of the a-m signal required to cause the same audio output as a reference cw signal. The a-m signal would be a few kHz away from the receiver's tuned frequency (I use 100 kHz). The a-m signal gives an audio output proportional to the power in its sidebands. I am currently using this formula

$$AMRR = 20 \log (0.707)(0.01)(\%\ \text{modulation}) \frac{V_{carrier^{a\text{-}m}}}{V_{carrier^{cw}}}$$

As a-m detection is often a threshold effect I always use 1 μV as the cw carrier reference level. The same audio frequency should be used on cw and a-m because of the receiver's audio passband. With a frequency-selective voltmeter I have measured peak carrier voltages in the range of 5 to 10 μV for Radio Moscow in the 40-meter band and WWV at 15 MHz. Others have reported similar problems. This means that the practical direct-conversion receiver would have an AMRR in the range of 70 to 80 dB.

The best product detector for direct coversion that I have built so far is the double-balanced, hot-carrier diode type as first described by Hayward and Bingham in *QST* for November, 1968. The real tricks to getting performance out of this configuration are to terminate all ports in a resistance of 50 to 150 ohms and drive it hard. Fig. 1 illustrates what I mean.

The hot-carrier diodes used in the mixer respond very fast and during the design I had problems with a periodic "clicking" in the audio output at about one-second intervals. I first suspected it to be some sort of relaxation oscillation in the audio amplifier. However, DeVry Tech is just down the block from me and they have an old (WW II) pulsed radar they use for educational purposes. The pulsing came from that direction, so I managed to cut it off with a piece of aluminum sheet!

All this makes me think that direct conversion is practical for vhf/uhf, using the same mixer but changing the broadband transformers. A 2-meter transceiver would be quite possible, and dsb might be more welcome on 2 meters than it is at hf. If I do anything along those lines I'll let you know. — *Wayne R. Openlander, W9NZB, Direct Conversion Technique, 3132 North Lowell Avenue, Chicago, IL 60641*

A HIGH-PERFORMANCE RTTY BAND-PASS FILTER

☐ The filter described here is designed to be used ahead of the limiter in any good-quality 170-Hz-shift RTTY receiving converter. All of the filters I have seen for this purpose are of the capacitive-coupled, tank-circuit kind, using Butterworth design. While these circuits have the advantages of simplicity and ease of tuning, they exhibit very sharp lower skirts at the expense of poor high-frequency skirts. The high impedance dictated by the 88-mH toroids generally used in this application can be easily transformed to the desired 600-ohm level, but since this will do nothing to even out the skirts an entirely different circuit is indicated.

The circuit described here is the "mesh" configuration and uses a 0.1-dB-ripple Chebyshev design (Fig. 2). This circuit allows much lower impedance (73 ohms in this case) and the freedom to choose the couplings at will. An inductor to ground sharpens the lower skirt while a capacitor coupling sharpens the upper skirt. The one-inductor, two-capacitor scheme shown yields good symmetry. The two 0.33-μF capacitors (C1 and C6) are not couplings but rather are part of an L network that matches the filter to the desired 500-600 ohms.

Tuning of this type of filter can be very involved if the parts used have poor tolerance. Only one prototype of this filter was built and 10-percent tolerance capacitors were used. Measurements beforehand, however, revealed that the four 0.1-μF capacitors (C2 through C5) were all very nearly matched. When the filter was built the passband was smooth with no signs of "hanging sections," but it was centered about 40 Hz low in frequency. Pulling 12 turns off each inductance section (L1 through L4) moved the passband to the right frequency, indicating about 3.5 Hz per turn is a good rule of thumb.

High-Q capacitors should be used for best results; Sprague 715P is a good choice but they are difficult to obtain. If you are forced to use standard Mylar capacitors as I was, try to get five-percent tolerance or at least buy a large quantity and pick out four closely matched ones for C2, C3, C4 and C5.

Performance of the filter is excellent, as may be seen from Fig. 3. Insertion loss is a bit high at 6.6 dB but the 3-dB/60-dB shape factor of 5.1 as compared to the theoretical 4.5 is impressive. The 3-dB bandwidth is 225 Hz, putting the mark and space tones only 1.5 dB down. — *Albert J. Klappenberger, K3KWX, Rte. 1, Box 227, Westover, MD 21871*

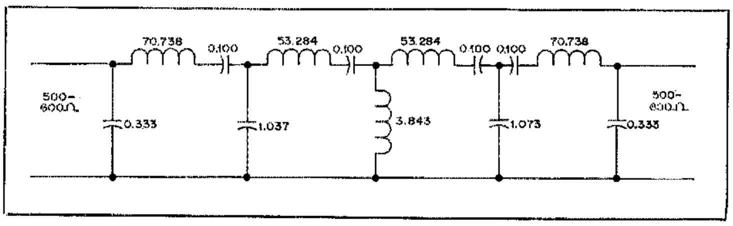


Fig. 2 — Schematic of the Klappenberger RTTY band-pass filter.

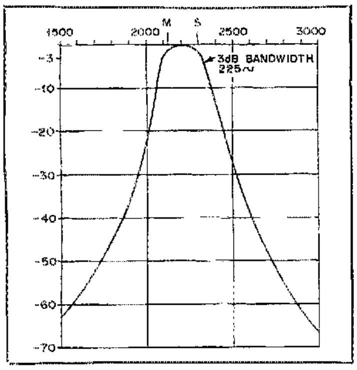


Fig. 3 — RTTY filter response curve (2100-Hz center frequency).

STANDARDS FOR FM AUDIO

☐ Edward Avilla's article about repeater audio in the June, 1977, issue of *QST* was a much-needed contribution to the amateur art. Many repeaters *do* sound bad for precisely the reasons given in the article — a lack of understanding of the technical standards for amateur fm audio. In the interest of completeness and accuracy, I would like to make a correction to the article, and then argue that standards for fm audio do exist, and should be published in the ARRL *Handbook* and recognized as such.

First, the correction. The 75-microsecond preemphasis mentioned and described in WB6DSW's article is the standard for commercial fm broadcasting, not amateur fm. Amateurs on vhf fm use the same standards as the Land-Mobile Service: phase modulation. In equipment where a frequency modulator is used, it is preceded by a preemphasis circuit consisting of a series capacitor and a shunt resistance with a time constant of RC = 53 microseconds. The de-emphasis circuit following the receiver discriminator consists of a series R and a shunt C with a time constant of 530 microseconds.

There is an important distinction to be noted between the commercial broadcasting standard of 75 microseconds and the land-mobile standard. In commercial broadcasting, starting at the lowest modulating frequency, the response is flat until the turnover frequency of 2100 Hz is reached. From there, the response rises at 6 dB per octave up to the highest modulating frequency. In the land-mobile standard, the one we amateurs follow (whether we realize it or not), the response rises at a rate of 6 dB per octave, ***starting at the lowest modulating frequency***, all the way up to the highest modulating frequency. Further clarification of this point may be found in "Modulation Standards for VHF FM" by Les Cobb, W6TEE, in the June, 1970, issue of *Ham Radio.*

My second point about standards is that there aren't any in the *Handbook;* amateurs building gear according to the 75-microsecond standards used by commercial fm broadcasters would find their homemade gear incompatible with the majority of hams operating on vhf fm. The *Handbook* should clearly spell out the phase modulation standards in use by hams today and show how to design receiver and transmitter audio circuits to meet those standards. — *Mark Wharton, KØLO, 1344 Scrub Oak Circle, Boulder, CO 80303*

GROUND-FAULT-INDICATOR PRECAUTIONS

☐ Reference K4AAL's comments on possibly bypassing ground-fault indicators (*QST*, August, 1977, page 42): I strongly suggest that any amateur having problems with GFI devices contact the vendor of the unit for information concerning EMI problems. The use of bypass capacitors introduces leakage paths which may, under certain conditions, defeat the whole purpose of ground-fault detection — especially around swimming pools.

Unless one is totally familiar with safety and leakage standards, and GFI systems, it is wiser to ask the product engineering division of the manufacturer for advice than to attempt home remedies. — *John Czap, WB2LGS, 938 E. 5th St., Brooklyn, NY 11230.*

☐ K4AAL's suggestion that RFI may cause GFI systems to operate is probably true; however, bypassing the GFI can be dangerous. Most amateurs assume that a neutral connection on power tools represents a zero-impedance path to dc ground. My experience, in three years in the electric distribution trouble area, shows otherwise. Power company employees find several cases daily where the jumper connection from the electric service panel (the main fuse panel) to the cold water pipe (as required by the electric code) has become disconnected or has developed a high-resistance connection. This factor, combined with a significant amount of resistance in the electric extension cord, and the amount of fault current that can exist when a device such as a power tool fails, can cause a significant amount of current to flow in a person's body if he is holding the faulted device and is standing on a good ground such as damp soil.

The hand-to-foot path is very dangerous in that the heart is frequently in series with this circuit. Heart stoppage or fibrillation is likely. Death often occurs as the individual cannot release the faulted device yet the current produced is not detected by the circuit breaker for some time. Because 0.07 ampere can produce a heart stoppage, there is no room for error. The GFI will operate on as little as 0.005 amps of ground current, thus offering considerable protection.

At present, GFI is required only on outlets above 300 volts to ground and on all outside receptacles. Because of the danger involved, the GFI portion of the house circuit breaker must *not* be bypassed. Frozen water pipes are not as serious as Fried Ham. — *Tom Kulas, KØTK, 221-17th Ave. N.W., New Brighton, MN 55112*

CIRCUIT BOARD MOUNTING TIPS

☐ Since June, 1976, there has been an alert published by the U.S. government to all their vendors about high failure rates of 1N914 and 1N4148 type diodes. It seems they will open when subjected to a six-pound axial pull and cycled in temperature. The use of 1N914 and 1N4148 diodes is now forbidden in government equipment.

The failures seem to stem from a method of construction called thermal compression bonding. This is where the diode chip is placed between two metal plugs and held there by compression forces caused by the glass outer case. The metal plugs and glass case have similar thermal expansion coefficients; if an axial pull is applied and the device is subjected to temperature cycles of 100°F, the diode is likely to open due to loss of compression on the chip.

This mode of failure has been reduced greatly by using a construction technique called metallurgical bonding. Here the chip is bonded or "welded" to the end plugs. Otherwise, construction is the same.

Lower failures were also obtained by using a heavier glass case for thermal compression bonding, while some manufacturers are successfully using a small "C" spring to take care of any mechanical movement. Diodes now approved for military and/or government use are designated 1N914-1 and 1N4148-1. These use a metallurgical bond and exhibit acceptable failure rates.

Before you throw away all your diodes I should say that the reliability of ordinary diodes for amateur use is good except for high-vibration or high-temperature-variation applications. Keep in mind also that the failures usually occur when the diodes are pulled down tight against a circuit board. Since the pc board has a different coefficient of thermal expansion than the diodes, an axial pull is exerted on the diodes under conditions of changing temperature. Vibration causes the pc board to bend, causing the same forces. The accompanying drawings illustrate better ways to mount diodes.

Failures in electronic assemblies have also been traced to potting techniques. If a potting compound is allowed to cure unevenly, as in an oven, the outer surface of the epoxy will harden before the middle, creating a hard, inelastic shell. Then, as the middle hardens, it expands slightly (or tries to), putting a tremendous force on components. Some can be crushed. No cheap fix has been found for this problem except to keep the epoxy coating thin.

One more thing a home constructor can do to increase the reliability of his projects involves soldering of components to boards. Usually, component leads are stuck straight through the hole, soldered, and the excess lead clipped off. This results in a very small soldered surface area, leading to bad solder joints, oxide formation and solder land failure. The preferred method is to bend the component lead over the solder land, clip it off about 1/8 inch from the hole and then solder. This results in a much more reliable solder joint.

The foregoing are a few of the things I have run across where I work; the last idea is probably the most useful to amateurs but the others are certainly interesting food for thought. — *Lee Sumner, WB3BCF, 75 E. King St., Dallastown, PA 17313*

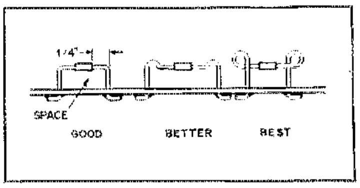


Fig. 4 — Suggested circuit board mounting techniques.

Product Review

ETO Alpha 76 Linear Amplifier

With the introduction of the Alpha 76 linear amplifier, Ehrhorn Technological Operations now offers a "full line" of hf power amplifiers for the amateur service. Several years ago the Alpha 374 set new standards for small, full kilowatt linears (*QST*, April, 1975) and the 76 is a logical spinoff from that unit.

The main differences between the 76 and the 374 are manual tuning only (no band-pass operation) and two 8874 tubes in the 76 instead of three. Actually, we are speaking now of the standard model 76: Also available is the Alpha 76P which includes three final tubes and the 76C which boasts three tubes plus a special 2.4-kVA Hypersil transformer. Both provide for greater power input than the Alpha 76. Options available in the standard model 76 include the Hypersil transformer (about 20 pounds lighter than the standard transformer) and a relay arrangement, front panel switched, for either high or low plate voltage.

Typically excellent ETO construction techniques are evident in the 76; the cabinet is natural finish aluminum. The top cover and right-hand panel are easily removable for installation of the transformer, which is shipped separately. Mating of two pairs of multi-pin connectors, which hook up the control circuitry with the "business end" of the amplifier, completes assembly.

Physical layout of the 76 is similar to the 374: bandswitch, tuning and loading controls are on the left of the front panel while all control and metering switches are on the right. Metering functions include HIGH VOLTAGE, GRID CURRENT, PLATE CURRENT, FORWARD POWER and REFLECTED POWER. Two small lamps, mounted behind the meter on the control circuit board, illuminate the meter: amber during warm-up time and while transmitting, and green for "ready."

The ETO Alpha 76 Amplifier

Power input: 2000 watts PEP for ssb, 1000 watts for cw (amateur service).
Amplifier tubes: Two 8874 triodes.
Plate dissipation: 800 watts for the two tubes.
Frequency range: Amateur bands, 1.8-30 MHz.
Metering: Plate current, grid current, plate voltage, reflected and forward power (in watts).
Power requirements: 240 V at 10 A or 120 V at 20 A.
Rear-panel terminations: Relay, rf output, rf in and alc adjust.
Dimensions: 7-1/2 × 17 × 14-3/4 inches (191 × 432 × 375 mm) (HWD). Weight: 75 pounds (34 kg).
Price class: $995; $1045 with high-/low-plate voltage relay.
Manufacturer: Ehrhorn Technological Operations, Industrial Park, P. O. Box 708, Canon City, CO 81212.

The Alpha 76 cabinet is divided into two rectangular compartments, one for the rf section and one for power supply and control circuitry. One small bare corner indicates where the third 8874 is placed in the 76C and 76P models. All control circuitry is on one board, approximately four by eight inches, mounted above the six filter capacitors. They are, incidentally, computer-grade, factory-matched electrolytics, totalling 30 μF at 2.7 kV.

RF Circuits

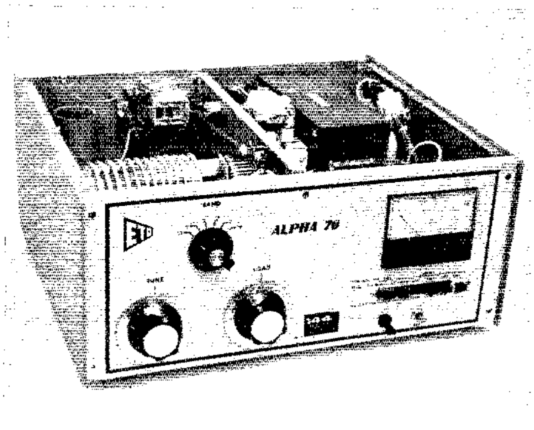
The 8874 tubes are parallel-connected in a grounded-grid configuration. They require forced-air cooling, which is accomplished by a squirrel-cage blower, pressurized anode compartment and rubber chimneys which direct the air through an outlet on the top of the cabinet. ETO recommends four to six inches of clearance for both the back and top panels. During normal operating with the 76, the exhaust air was observed to be no more than lukewarm.

A built-in timing circuit precludes operation of the amplifier (i.e., application of drive power) until the 8874's indirectly heated cathodes have reached operating temperature. When the meter light switches from amber to green the unit is ready to run. Warm-up takes about 30-45 seconds. Switching functions are the normal "straight-through" in standby and external shorting at the RELAY connector on the back panel to enable the amplifier during transmit.

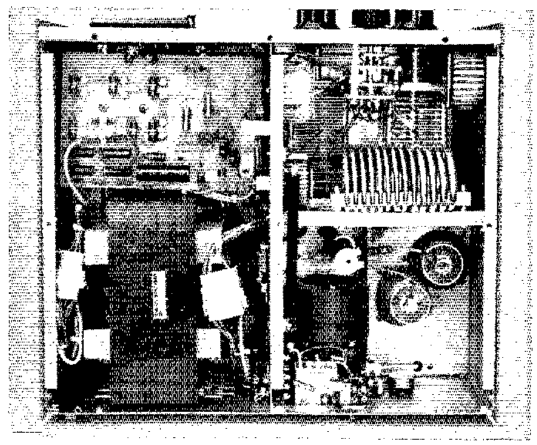
Drive is applied to the cathodes of the 8874s via a broadband, toroidal, matching transformer; the output circuit is of the pi-L variety. ETO recommends use of antenna systems providing a VSWR of 2:1 or less (50 ohms). One hundred watts PEP or 60 watts carrier are required to drive the Alpha 76 to the legal amateur limit.

Power Supply and Control Circuitry

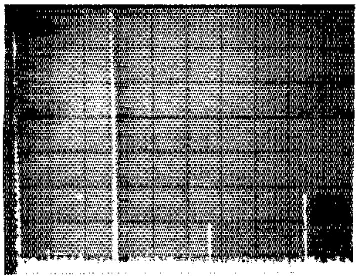
The transformer in the 76 is a 1.5-kVA continuous-service unit; high voltage may be reduced from the normal ssb level of 2.4 kV to about 1.5 kV by changing the transformer tap. The optional high/low-voltage relay does this via a front-panel switch. The design feature of reducing the plate voltage when going to the 1-kW cw input provides excellent efficiency at the lower power level. Output efficiency as measured in the ARRL laboratory, was better than 60 percent for both the 2000-watts PEP



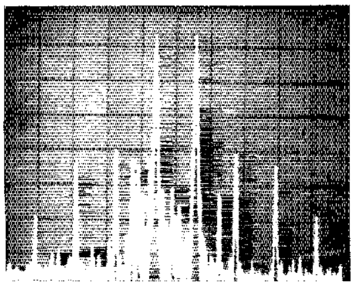
This shows the neat front-panel arrangement of the Alpha 76.



Peering down into the amplifier shows the clean appearance of the unit.



This spectral analysis photograph shows the 14-MHz signal and the second and third harmonics. The tall pip at the far left is generated in the analyzer. Each horizontal division is 5 MHz and each vertical 10 dB. The Alpha 76 more than exceeds harmonic attenuation for spurious signals.



This photograph shows the two-tone IMD test. Third-order products are approximately 40 dB down from the PEP output level. The driver unit used to test the Alpha 76 was a TS-820 exciter.

and 1000-watts cw inputs on all bands.

Approximately 95 volts are applied to the blower, reducing its noise level with only a slight reduction in blower speed. As in other ETO amplifiers, a cover-interlock switch prevents the main power from being applied to the unit with the top cover off. A safety "crowbar" discharges the filter capacitors when the top cover is removed. A plate overcurrent relay disables the amplifier by removing ac power in the event of a high-voltage problem or excessive drive. Main-power switching and metering are both similar to those functions in the model 374; a self-latching relay controls application of power to the unit, and a time-delay relay takes care of amplifier tube warm-up.

General and Operating Notes

The very extensive operating manual provides installation and operating instructions, including detailed tune-up procedures for maximum efficiency. In actual use the Alpha 76 tunes "smoothly" and tuning is not particularly critical, so long as the operator always adjusts the load control first, then the tune.

The unit runs cool and quiet, fits on the operating desk rather than having to take up an entire corner of the room, and most parts are easily accessible for service despite the small size of the amplifier. "Dial-a-number" tuning is possible for quick band changing during contests. — *K1TN*

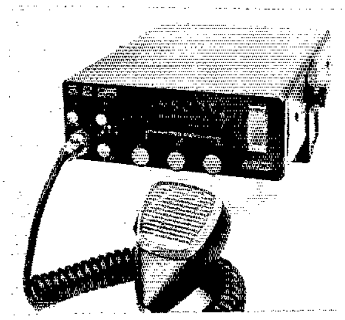
THE AMCOMM S225 SYNTHESIZED TWO-METER FM TRANSCEIVER

It seems unlikely that any active ham has not been exposed to the burgeoning phenomenon we call "2-meter fm." From scanning the parking lot at a hamfest, it appears that everyone has a mobile whip on his car. Fm is truly the most universal amateur operating mode. Most fmers find that four or five sets of crystals will fulfill their needs when they're close to home. But when traveling, it always seems that the one repeater you want to use is one you're not "crystalled-up" for. Sticking to 600-kHz offsets, there are 78 standard repeater channels, including 15-kHz "splits," and 12 standard simplex channels. Assuming your rig needs two crystals for each repeater or simplex channel, you'd need 180 crystals to cover all of them. This hefty investment still wouldn't permit operation on the die-hard repeaters using 1-MHz offsets, nor could you operate on a nonstandard simplex channel.

Military communicators ran into similar problems in the past. Operation on one particular military vhf band required equipment that could cover a whopping 1750 channels! Early synthesized gear designed for this application used intricate mixing schemes and mechanical switching drives that gave the repairman nightmares. The gross inefficiency of these radios and their high cost made them unsuitable for amateur use. Thanks to the development of digital integrated circuits, synthesized vhf radios may be constructed that are comparable in size and efficiency to crystal-controlled radios. Amateurs now have the convenience of multichannel communications equipment that fits beneath the dashboard of a compact car and doesn't require the electrical system of a tank to power it.

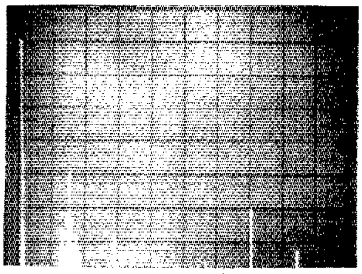
Rather than use a rack full of crystals, most synthesized rigs (the S225 included) require only one crystal oscillator, called the reference. Miniscule integrated circuits slice up the ouptut of the reference oscillator. The divided frequencies are mixed with harmonics of the reference in combinations selected by the front-panel-mounted frequency controls. When transmitting, nominal synthesizer output at 124 MHz is mixed with the 22-MHz reference to yield an output at 146 MHz. In receive, the 124-MHz signal is shifted by 600 kHz when simplex operation is desired, and mixed with the incoming signal to produce the first i-f of 21.4 MHz. With all this frequency dividing, multiplying and mixing going on in an 187-cubic-inch (3064-cc) enclosure, the designer must take great pains to prevent harmonics and spurious mixing products from appearing at the output port. In the past, harmonics of the oscillator in a vhf transmitter were the only concern. These could be located with a sensitive wavemeter, an accurate communications receiver and patience. This simple approach is no longer permissible. In order to properly evaluate a modern amateur transmitter, a spectrum analyzer is absolutely essential. While scanning the rf spectrum from bottom to well into the microwave region, spurious outputs are readily observed. A spectrum analyzer also permits the reviewer to study the transmitter output close to the desired transmit signal. Properly used, the spectrum analyzer tells no lies and keeps no secrets.

The spectral-response photograph shows the displayed spectrum of the AMCOMM transceiver at 25-watts output. To prevent the fundamental output of the transmitter from overloading the spectrum analyzer mixer stage, a two-cavity notch filter is connected between the transmitter and the analyzer. The horizontal lines on the graticule correspond to 10-dB steps of decreasing amplitude, with the top line calibrated at 0 dB. Spectral response from nearly 0 to 1000 MHz is displayed, with each vertical line on the graticule a 100-MHz increment. The tallest "pip," at the far left edge of the screen, is a marker signal generated inside the spectrum analyzer. It represents 0 MHz. The fundamental output of the transceiver at 146.52 MHz may be seen attenuated 49 dB by the notch filter. FCC requires that the out-of-band spurious emissions of an amateur transmiter in the 25-watt-output class be suppressed 60 dB. The most powerful spurious output of the S225 is at 700 MHz and is suppressed over 60 dB. Second-harmonic energy is suppressed 68 dB. Other spurious outputs resulting from the 22- plus 124-MHz mix are suppressed more than 66 dB. In-band spurious emissions are all suppressed more than 62 dB.



The AMCOMM S225 cabinet is finished in black, presenting a sleek appearance.

The transceiver tested did not initially comply with FCC specifications regarding spurious outputs. An image caused by mixing the synthesizer output with the reference oscillator was suppressed only 56 dB, 4 dB less than what FCC requires. Inability to resolve this problem would have required ARRL to refuse AMCOMM advertisements. The presence of this spur was puzzling because the transceiver tested for advertising approval last year did not show any spurs suppressed less than 60 dB. AMCOMM was contacted and two representatives of the company flew up to Hartford from Florida the next day, bringing with them another transceiver. After comparing the two units, the review model was subjected to a minimum of tweaking, which knocked the spur down to 66 dB below the fundamental output. A discussion ensued on ways of insuring against a recurrence of the problem and it appears AMCOMM has the situation well in hand. It was apparent that a synthesized radio could not be aligned by looking at a field-strength meter and tuning for maximum output; the complexity of the procedure requires the aid of a spectrum analyzer. The user should keep this fact in mind, though it may go across the grain of some old-timers: *Unless you know what you're doing and have the proper test equipment, don't fiddle with a synthesized transceiver.* Modern rigs are sturdily built and should remain properly aligned for long periods of time if not physically abused. Just as our modern automobiles require periodic trips



Spectral display of the AMCOMM S225 transmitted signal. Transmitter output was 25 watts at 146.52 MHz. The vertical axis is calibrated in steps of 10 dB per division; the horizontal axis is 100 MHz per division. The fundamental is attenuated 49 dB using a two-cavity notch filter. The most significant spurious output, at 700 MHz, is down 61 dB from the unnotched fundamental, which exceeds FCC specifications. Other spurious outputs are the second harmonic, attenuated 68 dB, and unwanted mixing products down 66 and 69 dB. The S225 complies with FCC specifications regarding spurious emissions.

to the shop for renewal, it is not unreasonable to expect that occasionally our modern radios will need touching up.

AMCOMM has included several features in the S225 which are worthy of mention. Instead of discrete transistors, the transmitter power-amplifier stage is a hybrid power module. PA output is passed through a multistage low-pass filter. The power module is immune to damage from open or short circuits in the antenna system. This feature was confirmed by the reviewer, at one time inadvertently! Power output is continuously adjustable from 1-25 watts* with a front-panel-mounted control concentric with the volume control. This feature allows reduced input for local work or selection of the proper drive level for an external power amplifier. A potentiometer concentrically mounted with the squelch control may be used to adjust the brightness of the LED digital display and the meter-illuminating lamp. The digital display is recessed from the panel and this, in combination with the dimming feature, allows the display to be read in all but the brightest incident light.

While most synthesized rigs display received frequency, AMCOMM has chosen to display transmitted frequency. This feature will help prevent the operator from accidentally transmitting outside the amateur band. Another front-panel control selects either simplex, plus or minus 600 kHz, or plus or minus 1-MHz receiver offset. The offset feature allows the receiver to tune from 143 to 147.995 MHz, while the transmitter covers 144 to 147.995 MHz. Tuning is in 5-kHz steps.

Audio quality is an all-but-forgotten area in communications equipment. Many mobile rigs have receiver audio outputs barely capable of being heard when the vehicle is in motion. Not so with the AMCOMM. Audio output is rated at 4 watts. Not only was the audio level more than adequate, but the *quality* of the output was startling. For the first time, stations worked sounded like humans were operating, rather than tinny-sounding computers. The hefty microphone shown in the photograph comes as standard equipment with the unit. In combination with some audio filtering in the transmitter, this mic accounted for several unsolicited comments on the fine audio quality of the rig.

This reviewer could go on and on telling the virtues of the S225, but in the interest of space will just touch briefly on a few more features. A search for spurious responses in the receiver failed to turn up any, nor was image response a problem. Two LEDs are mounted next to the frequency display. One indicates the synthesizer is "locked" and the other is illuminated while the unit is transmitting. The panel meter is calibrated in S units and power output. The power meter calibration could have been better; it reads slightly high. When the meter read 25 watts out the measured output was 19 watts.* Full output was obtained with the power-level control fully advanced while the unit operated from a stable 13.5-volt supply. When the supply voltage was reduced to 12 volts, power output was 20 watts maximum. At the 13.5-volt level, with the display at full brightness and power output at maximum, the unit drew 6.7 amperes. Frequency display was compared with that indicated on a frequency counter and maximum error was measured at 60 Hz. This leads one to believe that the owner of an S225 would be very popular whenever a crystal-controlled rig needed "netting." Because of its accuracy, a discriminator meter is not required in the receiver, but one would be useful when helping other stations get on frequency.

An accessory Touch-Tone encoder pad plugs into a jack mounted on the rear panel. A delay circuit in the pad keeps the rig transmitting for one second after a key is pressed to prevent the transmitter from turning off between digits. The transmitter is automatically keyed when an encoder button is depressed. Also mounted on the rear panel is an external speaker jack. Transmitter deviation adjustment, the only one which should be attempted without a spectrum analyzer, is easily accomplished by removing the top cover of the all-aluminum cabinet. A gimbal bracket for the transceiver and slip-in brackets for the mic and optional tone encoder are provided. The transceiver measures 7-1/8 × 2-5/8 × 10 inches (181 × 67 × 254 mm) and weighs 4-1/2 pounds (2 kg). The S225 is available from AMCOMM, 730 West McNab, Ft. Lauderdale, FL 33309. Price class is $400. — *W1XZ*

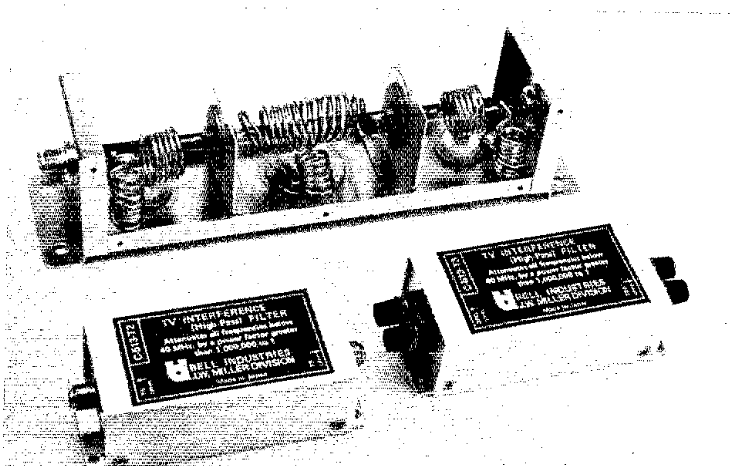
*Measured in the ARRL lab.

TVI FILTERS FROM J.W. MILLER

There's hope that the time will come when *all* home-installed, RFI-suppression devices will be a thing of the past. And it's doubtful if any hams will grieve over their absence. But until the day arrives when newcomers ask, "What's that?" when they see a high-pass filter on a flea-market table, supplemental suppression techniques will be required.

In the meantime, J. W. Miller has offered some assistance with their filters for audio and rf home-entertainment equipment. For those not familiar with the company, J. W. Miller has a very excellent line of components such as capacitors and coils. The review items are of similar quality. Of particular interest to amateurs are the high-pass (for receiving) and low-pass (for transmitting) filters. A frequency-response curve for the C-514-T low-pass filter is shown in Fig. 1. Field tests confirmed that this filter was effective in rejecting transmitter harmonic energy that would otherwise be conducted to the antenna and radiated. A noticeable decrease in interference level was observed with the filter installed in the transmitter transmission line. Response of the high-pass filter models was checked in a 50-ohm system, even though a 75-ohm measurement setup is required. Rejection appeared to meet the manufacturer's specification in spite of the mismatch.

Many TV sets derive their operating voltages



Interior view of the C-514-T low-pass filter. Also shown are the C-513-T2 high-pass filter (75-ohm type F connectors) and the C-513-T3 high-pass filter (300 ohm). The C-514-T is designed to handle 1000 W (2000 W PEP) at 50 ohms impedance.

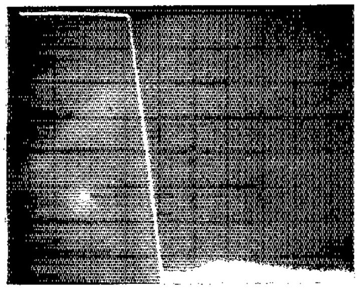


Fig. 1 — Frequency response of the C-514-T low-pass filter. The vertical scale represents 10 db/division while the horizontal scale is 10 MHz/division. Rejection is better than 70 dB above 40 MHz.

directly from the ac line. While this is an "el cheapo" way of doing things, it represents poor design procedure, particularly from a safety point of view. *Consequently, never attempt to connect a grounded device* (such as a high-pass filter) *directly to the chassis of a TV set!* Sparks may fly if you do! (To compound the confusion, some sets have a filament transformer but still get the other voltages directly from the line. The filament transformer can easily be mistaken for a power transformer.)

The obvious question is, "But what about the antenna: Is there a 75-ohm coaxial input for CATV in newer sets which would have 117 V ac on the outer sheath?" In order to get around this problem, the outer shield of the coaxial cable is broken inside the TV set between the 75-ohm input and the tuner, then a capacitor is inserted. Since the capacitance is small (on the order of 0.001 μF), it presents a high impedance at 60 Hz while permitting rf energy to pass. However, the ability of the outer conductor to shield the system from unwanted rf energy is also decreased by the break. Consequently, high-pass filters connected at the antenna input are not as effective as a filter built into the tuner itself.

One happy note in this regard: A few manufacturers are beginning to get their act together and have improved the immunity of their tuners to unwanted rf energy. Faced with the reality that RFI is not just a problem in a "few isolated cases" perhaps the rest will do the same. The manufacturer of these filters is Bell Industries, J. W. Miller Div., 19070 Reyes Ave., P. O. Box 5825, Compton, CA 90224. Price class of the C-514-T is $27 and all high-pass units are $10. — *K1FM*

GEM QUAD ANTENNA

The Gem Quad three-band antenna has been around for about 10 years, but it is not well known in the U.S. Patented by the late VE4RA, the quad originally used gamma-match feed. Subsequently redesigned to provide greater matcing convenience, the antenna is now fed directly with a single 50-ohm coax line.

The Gem Quad antenna is unusually complete. The shipping package, a very tough cardboard tube with wooden end-inserts, contains eight fiberglass arms (more about them later), four 80-inch tie rods, six spools of wire (three each for the directors and reflectors), 16 stainless-steel clamps, 24 tension tubes (attach wire to each arm), a toroid balun kit, an all-aluminum welded spider, a packet containing 64 self-locking nylon straps, a packet containing a spool of wire for the stubs, a length of nylon cord, and seven spacers (insulators) for the stubs (two spacers for each band) and one for the common driven-element tie point.

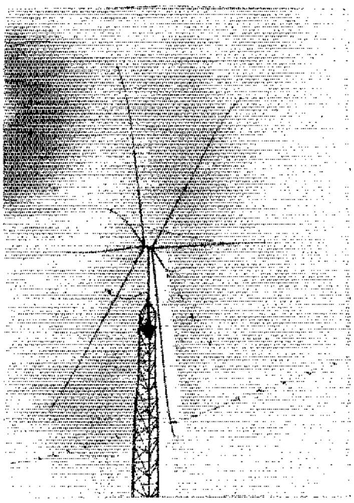
The fiberglass arms are perhaps the most significant feature which sets the Gem Quad apart from other quads. Each arm is an assembly; an assembly not unlike a tower. Gem Quad calls them "tridetic" arms. Each arm consists of three fiberglass rods conically spaced, and wound with fiberglass material to form what appears to be a very strong structure. Since it has been known to survive winters even worse than those commonly found in New England, there is every expectation that these arms will make it through this one.

The assembly of the antenna is straightforward, despite some ambiguities in the instructions. One would think that in 10 years these would have been eliminated. As a result, one must know at least what a quad looks like to be able to successfully complete the installation and assembly. If not, there could be some trying moments.

In an otherwise excellent design, there is one weak point that may be avoided in the assembly of this antenna. The stub spreaders (the insulator at the common tie point of the driven element is made of the same material) are made of a low-temperature plastic that melts just as soon as heat is applied to the connection to be soldered. As a result, the wires melt through the plastic immediately. To avoid this anguish, in advance it is suggested that just about any material be substituted. It's a simple matter to make up the seven insulators needed. Masonite would be better from a structural standpoint, and should have little effect upon the performance of the antenna as the insulators appear at low-voltage points.

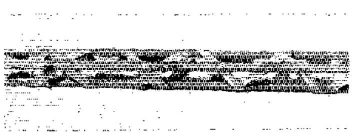
The information in the instructions about pruning the feed-line length perpetuates some fallacies that were supposedly laid to rest more than 20 years ago by W1DX ("My Feedline Tunes My Antenna," *QST*, March, 1956 or April, 1977) and the information about the antenna "link coil" is certainly dated in this era of pi-network finals and Transmatches. However, the physical construction of this antenna has much to recommend if you have ever suffered having your quad fold up like so much straw in a wind or ice storm.

The antenna is available from Gem Quad Products, Transcona, MB R2C 2Z5, Canada. Price class, including U.S. duty, but FOB Transcona, is $129. — *W1SE*



The design of the Gem Quad antenna provides for optimum element spacing.

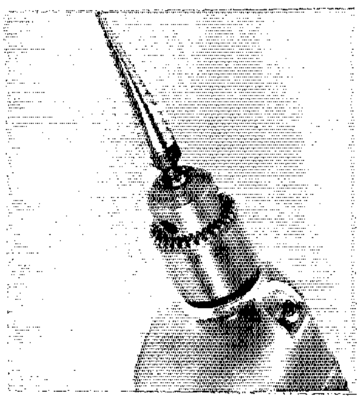
A close-up view of a section of the fiberglass tridetic arms. Exceptional strength is achieved using this method of construction.



UNIBIT

The sum of $7.95 will buy quite a few individual drill bits, so there must be more to the Unibit than price alone. And there is. Unibit is a drill bit capable of drilling 13 different hole sizes, from 1/8- to 1/2-inch diameter. As the card it comes on says, it cuts metal, wood, plastic, doesn't need a centerpunch start, and automatically deburrs its own holes. That pretty well sums it up, and it's convenient, especially when you don't know exactly what size hole you need to make. The Unibit will handle just about any kind of drilling requirement amateurs have, short of quarter-inch plate for antennas. And it really does work! The patented Unibit is made by Unibit Corporation, Wyoming, NY 14591, and is distributed by Amidon Associates, 12033 Otsego Street, North Hollywood, CA 91607. — *K1TN*

Thirteen bits in the drill simultaneously.



Hints and Kinks

A SIMPLE COIL-WINDING TOOL

Winding a coil with a large number of turns is a chore few experimenters look forward to with anticipation. And if a fixed spacing is required, the task is all but impossible. A few turns may go on the form successfully only to have them loosen as more are put on. Special equipment such as a lathe or a coil-winding machine is necessary if a professional appearance is desired. But the cost of such gear can hardly be justified if it is to be used only occasionally.

The tool shown in Fig. 1 and the accompanying photograph is the answer for those one-of-a-kind projects. It is made from a piece of 0.058-inch aluminum stock, 1-1/4 × 15 inches (32 × 381 mm). This model is suitable for coils of approximately 3-1/2 inches (89 mm) in

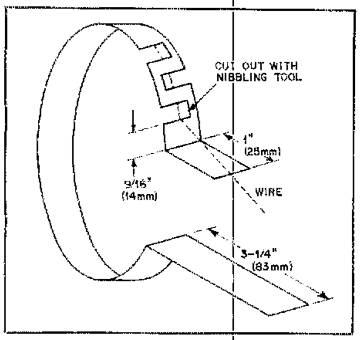
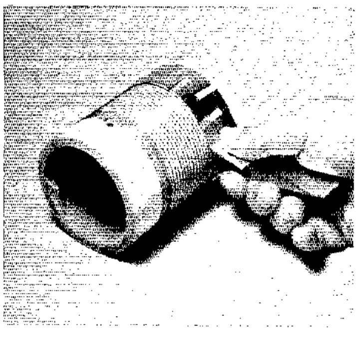


Fig. 1 — Construction details of the coil-winding tool.

diameter. Versions can be made for other coil sizes by bending the metal strip on a suitable form such as a can or bottle. Leave a slight spacing between the upper lip and the lower handle so that pressure can be applied on the coil form during the winding process. Slots are cut into the sides with a nibbling tool in order to guide the wire and examine the winding as it is being made. This winding tool is best suited for wire sizes up to about No. 22 or so. Larger wire sizes don't bend as easily. Also, a larger wire tends to retain its shape once it is formed, so different methods can be used.

To use the tool, first mark a line around the winding form where the winding is to begin. This can be accomplished by placing the form on a flat surface next to a pencil positioned at the proper elevation. Rotate the form and mark the line. It is also advisable to make other lines at different locations in order to assure that the windings are going on uniformly. Then attach the wire to the form securely since considerable tension is applied during the winding process. Inserting the wire through a hole drilled in the form should suffice. Next, position the winding tool over the wire as illustrated in the photo. Rotate the form while guiding the wire so that it follows the line made previously. With a little practice, it is possible to get uniform spacing or even a variable-pitch coil as shown in the photo.


Winding evenly spaced coils or variable-pitched ones is simplified considerably with the method illustrated.

By applying pressure to the winding as it is being formed, even minor kinks or bends in the wire are straightened out. After the coil is completed, the windings are tight enough so that they won't unravel before a coat of coil dope is applied. — *K1FM*

MOUNTING BRACKET FOR SMALL CIRCUIT BOARDS

A handy mounting bracket for small circuit boards can be fabricated from terminal strips such as H. H. Smith nos. 3002-3013. These are available in various sizes and are the type where a piece of phenolic containing the terminals is pressed into a U-shaped channel. Merely remove the phenolic strip and replace it with the circuit board. This method has been used at K1THP to mount crystal calibrators and other circuits such as preamps. For commercial gear where a minimum of drilled holes is desirable, this way is convenient. — *Dave Karpiej, K1THP*

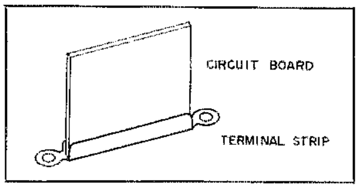


Fig. 2 — A terminal-strip mounting bracket is used to hold a small circuit board.

ALTERNATE RECEIVING ANTENNA MODIFICATION

Often the use of a low-noise receiving antenna for the 160- and 80-meter bands will reduce atmospheric-noise levels sometimes associated with vertical, sloper and inverted-V antennas. Popular low-noise receiving antennas include the Beverage, loop or random-length wires mounted close to the ground. To switch such an antenna to and from a transceiver may require an expensive coaxial relay, a not-so-handy manual switch or a simple modification that requires 30 minutes and an expenditure of 45 cents. Credit for the idea goes to K1PBW, a well-known, 16-meter DXer.

I modified my FT-101EE according to the illustration shown here. The idea can be used for similar transceivers. In the FT-101 series, RL-2 is the transmit-receive relay. A normally closed, miniature phone jack is installed between the receive side of the transmit-receive relay and the protective bulb fuse. I installed the phone jack on the rear of the FT-101EE using a hole vacated by removing the AF IN jack (RCA type). Many miniature phone jacks will fit directly into the hole without drilling. At trade-in time restoration is quick and easy.

Feeding the alternate receiving antenna input to this jack through the matching plug removes the main antenna from the receive circuit. Simply pull the plug for normal reception through the transmit-receive relay. — *Bill Smith, W5USM*

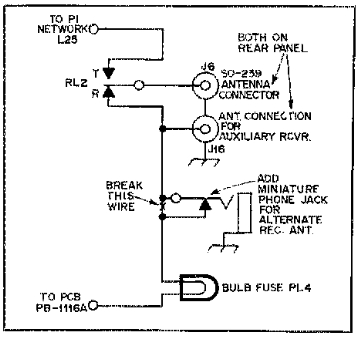


Fig. 3 — An arrangement for using a separate low-noise receiving antenna with the FT-101E/EE transceivers.

A MOD FOR THE MICODER

Do you like the convenience of an encoder at your fingertips but find that the local 2-meter repeater at times fails to decode the tones from your Micoder? I overcame such a difficulty by installing a Data Signal encoder, available for about $16 from Data Signal, 2403 Commerce La., Albany, GA 31707.

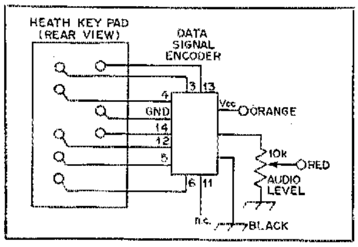


Fig. 4 — Dialing capability of the Micoder may be improved with the use of this encoder.

To install, remove the old pc board from the microphone housing. Epoxy the keyboard on the back corners to secure in place. Connect the new encoder as in the drawing. Wrap the pc board in foam to hold in place. Adjustment of the tone level can be made externally if a small hole is made through the housing and the 10-kΩ potentiometer is epoxied in such a way as to be accessible through the hole. — *Bill Atkins, WD4ASB*

COIL IMPROVEMENT FOR OFF-CENTER-LOADED ANTENNA

I followed a suggestion about using epoxy to beef up the insulating strips on the coils for my off-center-loaded dipole antenna (*QST* for September, 1974). I also changed the configuration of mounting the coils in order to take the strain off the first turn on each end of the coils. The result is shown in the drawing.

I made these changes on my old coils and was able to salvage them very well in spite of one loose coil end and considerable crazing of the insulating strips. Repairs turned out well and the old coils have been in use for several months with no appreciable effect from weathering. — *Fred Oldendorf, W6RPO*

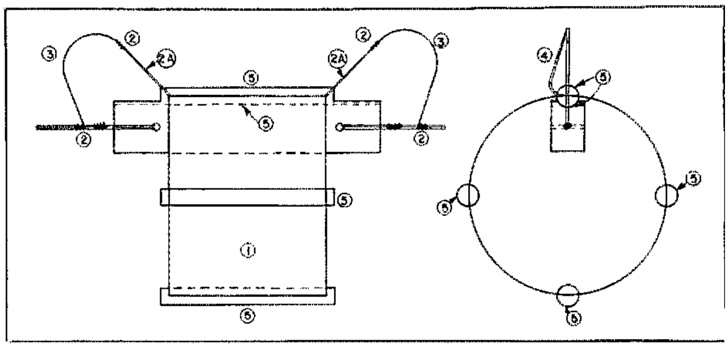


Fig. 5 — Coil modifications for the off-center-loaded dipole (*QST*, Sept., 1974). Coil parts and instructions: (1) Coil body. (2) Wrap and solder wire. Use pliers at points 2A on wire for heat sink when soldering ends of coil. (3) Flexible stranded wire. (4) Only one end view is shown — other end has opposite take-off from coil. (5) Epoxy applied at these areas.

SLIDING FERRITE BEADS

While assembling the Heath IO-4510 oscilloscope one may have some difficulty in sliding ferrite beads over the insulated green wire depicted on page 89 of the instruction manual. I found that the wire diameter is too large to fit into the ferrite bead hole. My solution: With a pair of pliers, grasp the end of the uncut green wire (both conductor and insulator) and then slowly heat the wire over the kitchen stove until the wire is reasonably hot to touch. Next, while holding the end with the pliers, squeeze the hot insulation with your fingers, moving the insulation toward the free end. The insulation is slowly stretched and moved over the free end, thus reducing the diameter. The heating and stretching may have to be done more than once to reach a diameter compatible with the hole in the ferrite beads. — *H. C. Patterson, WA1ZMV*

ABOUT RIT FOR THE HW-8

In regard to "Full Break-In and RIT for the HW-8 QRP Transceiver," *QST* for July, 1977, readers should note that the ability to copy ssb is lost if the wide-selectivity switch is removed. While using my HW-8, I have enjoyed several QSOs with Canadian hams who were on ssb, a pleasure that would have been denied me by removal of the switch. — *Andy Thall, WD8EOI*

A LIGHTWEIGHT FIELD DAY ANTENNA

A Field Day, fun-day antenna that performs well on 10 and 15 meters can be made for under $10. With a Transmatch we have used a 15-meter version for contacts on 10, 15 and 20 meters. The drawings illustrate the construction of this lightweight antenna which may be constructed as an inverted or horizontal V. The assembly can be folded flat for easy transportation atop a car or in a van.

The boom pivots at the plywood plate. When the antenna is removed from the mast, the insulators are easily detached and the boom can be folded parallel with the crossarm. When assembled the antenna wires act as guys for the crossarm. It will bow slightly under tension. For the 10-meter band, the boom is approximately 5-3/4 ft (1.75 m) long as is each of the two pieces which form the crossarm. For 15-meter operation, the boom is approximately 7-3/4 ft (2.36 m) long as is each member of the crossarm. While the design is mainly for portable use, we have one version permanently mounted on the roof of our shack that is doing very well for itself. — *Terry and Mark Sinclair, WB1AJD and WB1AJE*

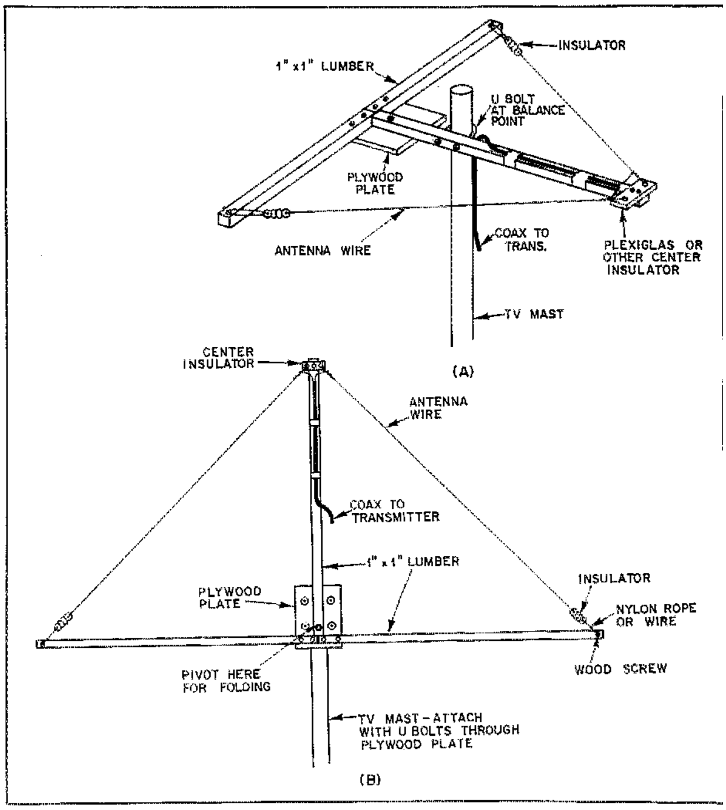


Fig. 6 — Simple construction of these horizontal (at A) and inverted (at B) V antennas make them useful for Field Day activities.

QST

devoted entirely to Amateur Radio

February 1978 $2.00

Radiosport Championship stresses Olympic ideal of world brotherhood.

Page 72

QST

February 1978
Volume LXII Number 2

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $1.50. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalant amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

Playing the radio game at sunset in Curacao in the first run of this "everyone-works-everyone" contest. See page 72 for results.

Contents

Technical

Basic Radio

General

Operating

Organizational and Regulatory

Departments

The W9TO vacuum-tube keyer (never published in amateur literature but manufactured by Hallicrafters) was one of the most popular keyers ever designed. Its successor, Chet Opal's Micro-TO keyer, was an all-solid-state version with ICs which appeared in QST *for August, 1967, and gained equal popularity. Now Chet goes one step further, to an all-CMOS keyer with message memory. With its fine ancestral line, this latest entrant in the "most-memory-for-the-least-parts" competition should prove to be a winner.*

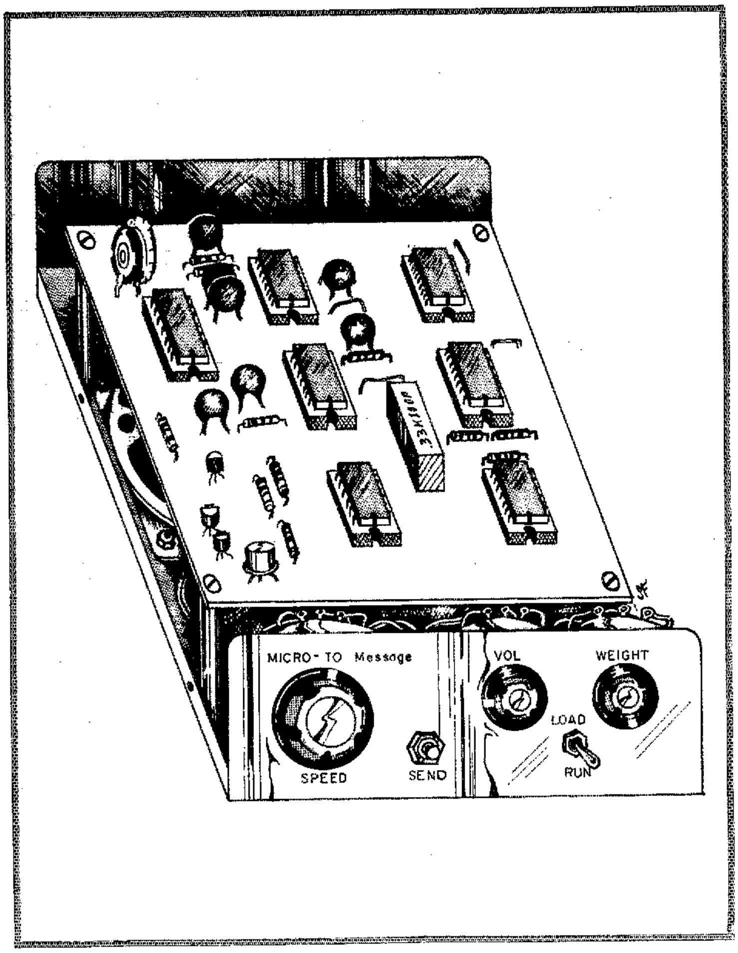
The Micro-TO Message Keyer

By Chet B. Opal,* K3CU (ex-K3CUW)

Since the advent of semiconductor read/write or random-access memories (RAMs), it has been possible to design cw keyers with convenient message-sending capabilities (for example, the Accu-Memory keyer[1]). To operate such a keyer all you do is throw some switches and send the message you want to record. Afterward, the message or messages can be called at the push of a button.

The circuit described here has two advantages over previous designs: It is very simple (only seven ICs, fewer than many nonmessage keyers), and it uses all-CMOS circuitry. Because the CMOS circuits draw so little power, battery operation is practical, which means that the recorded message can be stored indefinitely, independent of the power line (great for Field Day!).

The keyer can be hooked up in parallel with your favorite keyer to provide message capability, or some of the ideas can be applied to existing designs. However, the unit described here has been designed so that it can function as a stand-alone unit. It includes a monitor, a simple weight control, and both positive- and negative-keying outputs. Message loading is very convenient. On playback it can be interrupted by closing either paddle contact. The memory can hold two runs of the alphabet, two sets of numbers, and a punctuation mark or two. The keyer is readily expandable to include multiple-message capability.



Both front-panel and interior simplicity of the Micro-TO Message Keyer are evident in this illustration. A complete keyer with monitor, weight control, and 1024 bits of memory!

The Circuit

The basic idea is quite simple and similar to some previous designs: The message is recorded as a series of 1s and 0s in consecutive locations in a memory. (A dot is a 1 followed by a 0; a dash is three 1s followed by a 0.) On readout, the message is fed back in parallel with the normal keyer output. The design can be adapted to almost any keyer; one requirement is that a free-running clock must be used so that spaces will be recorded and so that the message can be clocked out on playback. In some keyers a free-running clock will generate endless dots which must be inhibited.

Fig. 1 is the schematic of the keyer described here. Circuits U1, U2 and U3 form the basic keyer. U4, U5 and U6 provide memory functions, while U7 and the transistors are associated with the monitor and keying circuits. The keyer portion is essentially a Micro-TO MK II circuit[2] with a few changes. The clock has been modified to include an external "run" input, and a J-K flip-flop has been substituted for the original D flip-flop so

*5414 Old Branch Ave., Camp Springs, MD 20031
[1]Footnotes appear on page 14.

that dots can be inhibited. The message (actually, its complement) goes to the memory from U2C and is fed back and merged in U1C. Basically, by grounding pin 1 of U2A and connecting pin 8 of U1C to the positive supply, one would have an ordinary TO keyer.

The heart of the memory circuit is U6, a 1024-bit CMOS RAM chip. The memory location is addressed by lines A0-A9. The address is latched onto the chip during the falling portion of $\overline{STR}$ ("not strobe"). On the rising edge of $\overline{STR}$, the data at D_I will be stored at that location if $\overline{WE}$ ("not write enable") is low or, if $\overline{WE}$ is high, read out from that location and placed on the D_O output line. Since D_O is often in an undefined open state, a pull-up resistor (R9) is used to define it to "1," i.e., a blank. (Remember we store the complement of the message.) Also, the $\overline{MSG}$ latch flip-flop is used as a buffer between D_O and the output gate, U1C, in order to eliminate glitches while the memory output is changing.

Addresses to the memory chip are generated by U5, a 12-bit binary counter. This chip counts upward by one on each negative transition at the C input whenever it is not held in the reset mode. The clock pulse is derived out of phase with that applied to U6 and delayed by R6 and C4 so that the addresses are set up at the correct times to be accepted by U6. The counter is normally held in the reset mode, with all outputs 0 by the Q output of the $\overline{MSG}$ flip-flop U4B, which is set in the standby mode (this flip-flop is sort of upside down).

The counting circuitry and memory are activated when the $\overline{MSG}$ flip-flop is reset. That can happen in two ways. In the recording mode (S1 thrown to LOAD), a "0" is applied to the D input of U4B. When either paddle is depressed, the output of U1D changes to a 1; this signal is applied to the clock input of U4B, causing the 0 at the D input to be transferred to its Q output. This starts the clock and also takes the binary counter out of the reset mode, so that it starts counting upward. It also enables U6, which records the signal at D_I at successive memory locations following each clock pulse. When the counter gets to the 1024th clock pulse, output 2^{10} changes state; this feeds the S input of U4B, setting it again and terminating the process.

In the playback mode, U4B can be reset by tapping the SEND button. In this case, since $\overline{WE}$ is high, the input is not recorded, but instead played back via D_O. The message normally ends as above, when 2^{10} changes state. In addition, the D input of U4B now has a 1 on it, so that if either paddle is tapped this 1 is transferred to the Q input of U4B, resetting everything. In this way it is possible to terminate a CQ when, as often happens, you hear someone come back to a previous CQ just as you have started the current one.

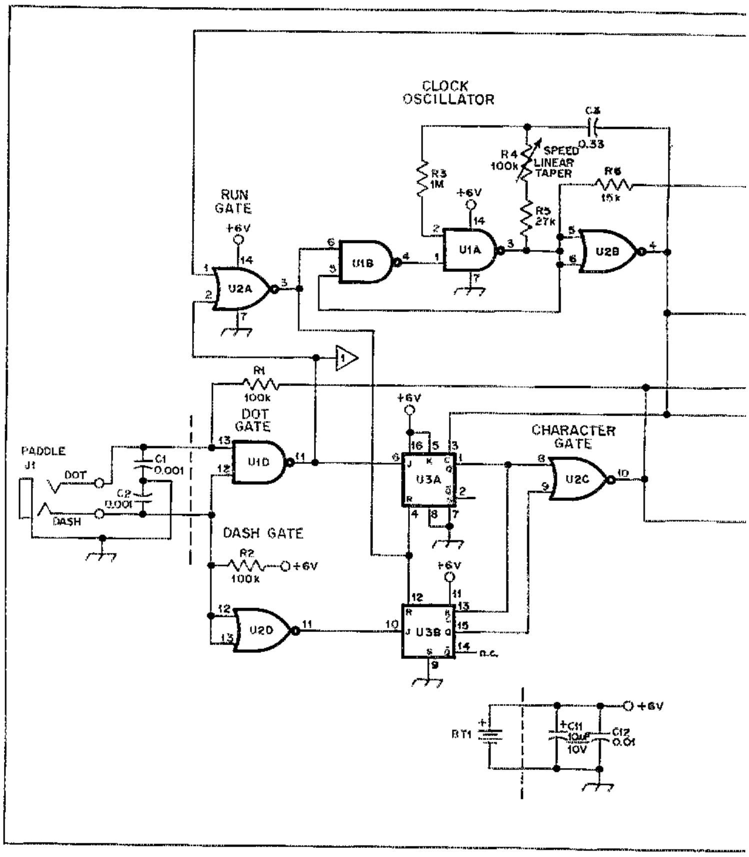


Fig. 1 — Schematic diagram of the Micro-TO Message Keyer. Unless noted, resistors are 1/4 W, 10 percent; capacitors are ceramic, 50 V. C1, C2 and C5 are mounted where their associated signal leads enter the cabinet.

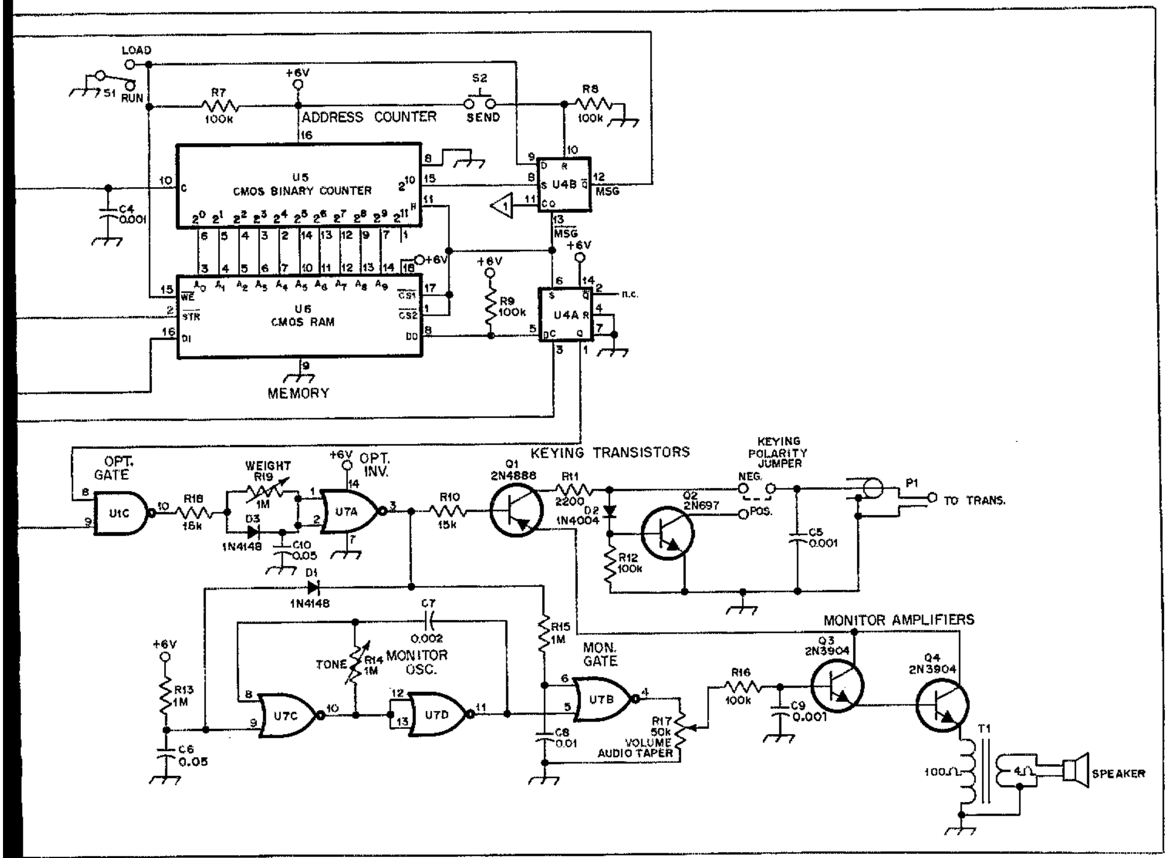
BT1 — 4 to 7-volt battery, four AA cells of any type in series.
C3 — Polyester (Mylar) dielectric capacitor.
C11 — Low-leakage electrolytic, 10 V or higher (tantalum recommended).
D1, D3 — Silicon, signal diode (1N914I, 1N4148, etc.).
D2 — 200-PIV, silicon diode (1N4003, 1N4004, etc.).
J1 — Two-circuit, 1/4-in., phone jack.

The output of U1C contains the message coming from the paddle or the memory. At this point the dot "mark" duration is exactly equal to the "space." In order to compensate for transmitter delays (or to add a little "meat" to the dots, which some operators like) a simple network consisting of R18, R19, D3 and C10, has been installed at the output of U1C. At the beginning of each character C10 charges rapidly through R18 and D3 but at the end it discharges slowly, depending on the setting of weight control R19, extending the "mark" period. The time added is independent of keying speed, so if the weight control is used mainly to make the dots heavier, it will have to be changed whenever the speed is changed.

The monitor is the same circuit as used in the Micro-TO MK II. An additional monitor amplifier is included to provide sufficient drive to the speaker at the lower voltage used here. Also, an npn transistor has been added to provide positive-to-ground keying, which is needed by some of the newer solid-state rigs. The transistor shown will sink about 50 mA of keying current.

Construction

I built my unit using a pc board, the layout for which is shown in Fig. 2.[3] If you use this pattern, be sure to install all the jumpers (18 of them). IC sockets were used everywhere for checkout purposes; this isn't really necessary although it might be worthwhile for U6. I used a Radio Shack no. 270-253 cabinet (5-1/4 × 3 × 6 in. or 133 × 76 × 152 mm), which is attractive and quite inexpensive.



LS1 — 2-1/2-in.(62.5 mm), permanent-magnet speaker,4 to 10 ohms.
P1 — 1/4-in. phone (or other suitable) plug.
Q1 — 200-volt, silicon, pnp transistor (2N5414, 2N4888, MM4002).
Q2 — Medium-current, medium-voltage, silicon switching transistor (2N697, etc.).
Q3, Q4 — Npn, general-purpose, silicon transistor (2N2222, 2N3904, etc.).
R4 — 100-kΩ, linear-taper, 2-W, carbon pot.
R14 — 1-MΩ Trimpot.
R17 — 50-kΩ, audio-taper, 2-W, carbon pot.
R19 — 1-MΩ, linear-taper, 2-W, carbon pot.
U1 — Quad, CMOS, two-input, NAND gate (CD4011AE, SCL4011AD, etc.).
U2, U7 — Quad, CMOS, two-input, NOR gate (CD4001AE, etc.).
U3 — Dual-CMOS, J-K flip-flop (CD4027AE, etc.).
U4 — Dual-CMOS, D flip-flop (CD4013AE, etc.).
U5 — CMOS, 12-bit binary counter (CD4040AE, etc.).
U6 — 1024 X 1-bit CMOS RAM (Intersil IM6518CJN).

Everything will fit into the next smaller size, but I wanted room for future expansion. The speaker is mounted on the floor of the cabinet over an array of holes and the circuit board is mounted on standoffs above it. The battery holder could also be mounted under the board, but I glued it to the cover for easy access.

Most of the parts can be obtained from stores like Radio Shack or Lafayette, which are proliferating everywhere as a consequence of the CB boom. I plan to make available the memory chip, the high-voltage pnp transistor and perhaps other parts, depending on demand. The choice of the push button is important: It must have a soft touch so that the cabinet doesn't walk across the table every time it is pushed. I used an inexpensive, miniature, unenclosed unit and bent the contacts for a feather touch.

Checkout and Operation

A warning: Never install an IC with power connected. Applying voltage to a signal pin before the chip is powered can cause an internal breakdown which persists after power is applied. The CMOS RAM in particular, with thousands of transistors in it, can get "toasty." This doesn't lead to permanent damage if caught in time, but it can be rough on batteries.

Set the WEIGHT control to minimum resistance (fully counterclockwise), the other controls to midrange, and the LOAD/RUN switch to RUN. Hook up the batteries and keying paddle, and close the thumb contact on the paddle. This should lead to a series of dots; the index finger should produce dashes. Adjust the PITCH, VOLUME and SPEED controls to suit. Practice sending for awhile. Now throw the switch to LOAD and send a CQ. You may notice that it is a little harder to send in this mode, since the clock is running continuously, and your timing must be more accurate. After waiting to load blanks into the remainder of the memory, throw the switch to RUN and hit the SEND push button. Out should come an exact replica of what you sent. Determine whether you have a positive or negative voltage at the transmitter key terminals, and patch the keyer output accordingly. Put the top on, plug the key in, and have at it.

Power Considerations

The keyer draws virtually no current in

the standby mode. The actual drain is highly variable, determined primarily by the temperature, the characteristics of the particular memory chip, and potentially leaky components such as the transistors and C11. Actually, C11 is used only to hold power to the keyer while changing batteries. A good test of leakage is to disconnect the batteries, wait a few minutes, then reconnect them. If the message remains intact, there are no serious leakage problems.

The main power drain during operation is from the keying and monitor circuits. Turning the volume control all the way down shuts the monitor off. Another power-saving possibility is to increase the value of R11 until the transmitter barely keys, then substitute about half this value.

I would be pleased to correspond with anyone having difficulties and would also like to hear ideas on what features would be desirable in future versions of the keyer (a stamped reply envelope would be much appreciated). On the latter point, the emphasis here has been on simplicity. Obviously desirable additions would be multiple messages, auto-repeat, iambic operation with dot and dash memories, Morse-to-Baudot conversion, automatic logging . . . . QST

Footnotes

[1]Garrett and Contini, "The Accu-Memory," *QST*, August, 1975.

[2]Opal, "The Micro-TO MK II Keyer," *QST*, September, 1975.

[3]As a convenience to those wishing to avail themselves, ready-made circuit boards may be obtained from the author, as may some of the harder-to-find components. The boards are the same size as the one pictured but have been altered to provide an optional dual message capability. Since prices will depend on demand, the author requests you send a self-addressed stamped envelope for the latest list of prices. (The memory ICs are $7.50 each at this printing date.)

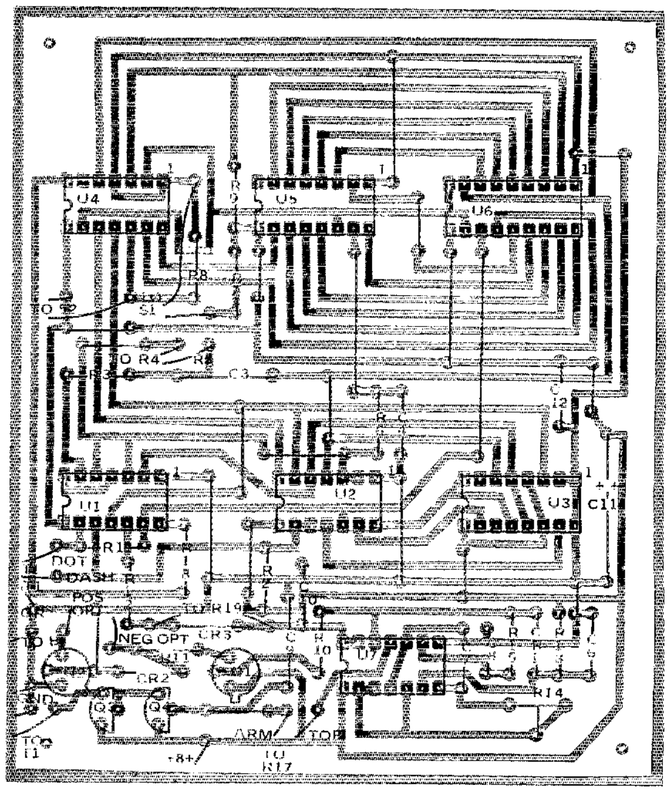


Fig. 2 — Circuit-board etching pattern for the Micro-TO Message Keyer. The pattern is shown at actual size from the foil side of the board with gray representing copper. Refer to schematic and accompanying parts list for identification of components; all components are mounted on the nonfoil side of the board.

Strays

PRACTICE FIRST ON P76-5

☐ OSCAR 8 fans can practice tracking and tuning up their 435-MHz converters with the P76-5 satellite. This Stanford Research Institute spacecraft transmits continuously on 435.974 MHz, with a power of about 200 mW. Its 1000-km (600-mile) altitude corresponds well with the projected orbit of OSCAR 8. So you can debug and Murphy-proof your ground station, and even check for possible transmitter-receiver interaction problems, with this bird. (Warning: The third harmonic of the uplink frequency is close to the downlink frequency and may desense your receiver or converter.)

The accompanying table contains reference orbit information for February. To determine equator crossings of future orbits, add the period (105.729 minutes) and the orbital progression (26.432 degrees per orbit) to the given figures. The orbit crossing marks on the OSCAR 8 OSCARLOCATOR will introduce an error of about 10 degrees per day. For more precise tracking of the P76-5 satellite, see Thompson, *QST* for November, 1975, and the data below.

By the way, the P76-5 satellite transmits on many different frequencies, all in phase, as part of an ionospheric propagation study. The satellite is often off on Sunday evenings, local time. — *WB2CHO*

The P76-5 Satellite

Period: 105.729 minutes
Inclination: 99.655°
Apogee: 1025.968 km
Eccentricity: 0.045°
Progression: 26.432° per orbit
Reference orbits for February, 1978:

Day	*UTC*	*°W Long.*	*Day*	*UTC*	*°W Long.*
Feb. 1	0020	188	Feb. 15	0036	196
Feb. 2	0042	198	Feb. 16	0116	206
Feb. 3	0122	208	Feb. 17	0011	190
Feb. 4	0017	192	Feb. 18	0051	200
Feb. 5	0057	202	Feb. 19	0131	210
Feb. 6	0137	212	Feb. 20	0026	194
Feb. 7	0032	195	Feb. 21	0106	204
Feb. 8	0112	205	Feb. 22	0001	188
Feb. 9	0006	189	Feb. 23	0041	198
Feb. 10	0047	199	Feb. 24	0121	208
Feb. 11	0127	209	Feb. 25	0015	191
Feb. 12	0021	193	Feb. 26	0056	201
Feb. 13	0102	203	Feb. 27	0136	211
Feb. 14	0142	213	Feb. 28	0030	195

A Universal Crystal Oscillator

Do you like weekend projects? This gadget will test any crystal from 50 kHz through vhf without tuning — and it will drive a counter for checking crystal frequency.

By Fred Brown,* W6HPH

One doesn't have to be in amateur radio for very long before he discovers that crystal-controlled oscillators are the most stable kind of circuits one can use. When you start experimenting with circuits, and all hams do sooner or later, you'll probably acquire a junk box. With that comes a collection of surplus crystals. Take our word for it — it will happen.

My own crystal collection is so extensive I can nearly always find a rock close enough to any desired frequency. This makes it possible to test out a circuit and continue working on a project without stopping to await delivery of an ordered crystal for the exact frequency.

But, unfortunately, the frequency of surplus crystals is not always what is marked on the holder. Some are marked with a transmitter-output or a receiver-input frequency, and some are marked only with a meaningless channel number. Some are not marked at all. There is a need for a crystal tester that would oscillate with *any* crystal without the need for fussing with tuning adjustments or impedance matching. The output of the test oscillator should be capable of driving a frequency counter directly for display of the actual crystal frequency. In the past I have often improvised by link coupling to a grid-dip oscillator, but this expedient is awkward, tricky and does not readily drive a counter.

All About the Circuit

In developing the UCO, several oscillator circuits were tried, some quite complicated. But the old, dependable Pierce proved more surefire and worked over a wider frequency range than any of the others. In fact, I have yet to find a usable crystal that will not oscillate in this circuit. The circuit oscillates readily at 50 kHz (the lowest frequency rock in my collection), and continues right on up through the 25-MHz upper frequency limit of fundamental-mode crystals.

A 2N4220 n-channel JFET is used in a straightforward Pierce oscillator with the crystal between drain and gate. See Fig. 1. Output to the counter is taken from a capacitive voltage divider, C1 and C2, in the drain circuit. Rf voltage on the FET drain is detected by the 1N914 diode and is indicated on a 0-100 microampere meter. The meter reading is a rough indicator of what, in the old days, was called crystal "activity." If your rock is so inactive that it does not produce any reading, the odds are it will not oscillate in any circuit. The 1N645 diode (any silicon diode will work) across the meter begins to conduct at about 1/2 volt and prevents the meter from going off scale, no matter how vigorously the FET oscillates. A 0-1 mA meter could also be used in the UCO if R1 and R2 are reduced in value to about 1/10th of those given.

By using a one-inch meter and miniature components, the UCO can be built in a 1-1/2 × 3 × 4-inch (38 × 76 × 102-mm) box. Parts layout is not critical but rf leads should be kept reasonably

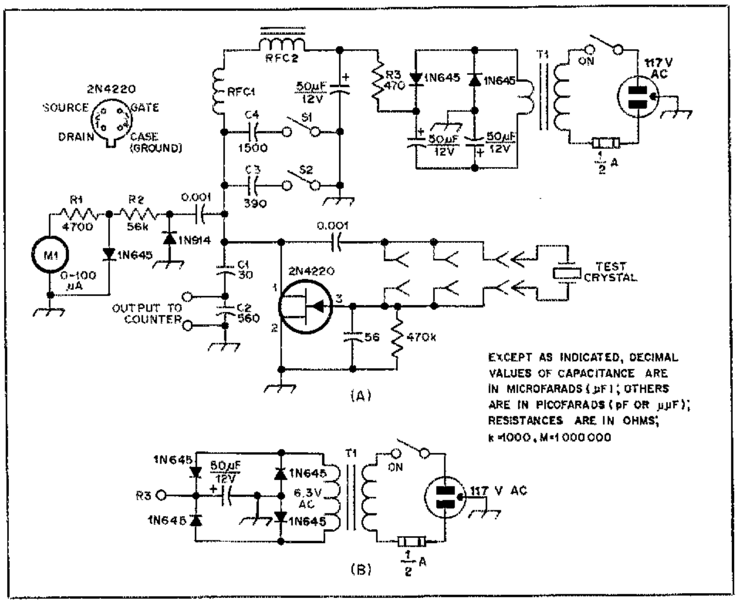


Fig. 1 — Circuit diagram of the crystal tester is shown at A. An alternative power-supply circuit using a conventional 6.3-V ac filament transformer is shown at B.
RFC 1 — 2.5-mH, rf choke, four pi.
RFC 2 — 150-mH, miniature toroid, 30-ohms dc resistance.
T1 — Plate-to-voice-coil type, 33:1 turns ratio, see text. (Stancor A4748).

*Box 2053, Rancho Santa Fe, CA 92067

short and direct. The three crystal sockets shown accommodate HC-6/U, FT-243 and FT-241 as well as the older CR-1A type crystals. Other crystals, such as those with wire leads, are taken care of by a pair of alligator clips mounted on the prongs of a cut-down, CR-1A holder. In this unit I used a terminal pair rather than a coax fitting for connection to the frequency counter since my counter terminates in a pair of alligator clips.

Putting It All Together

A 9-volt battery will power the UCO, but a power supply was included since my shack already has too many battery-powered gadgets. (I'm getting to be battery poor.) The transformer, T1, can be a small plate-to-voice-coil output transformer of approximately 33:1 turns ratio. Such transformers can be salvaged from defunct, tube-type TV sets and radios.[1] The full-wave voltage doubler provides about 9 volts output. The FET drain current is about 4 mA, not oscillating, and drops to about 2 mA when a crystal is plugged in.

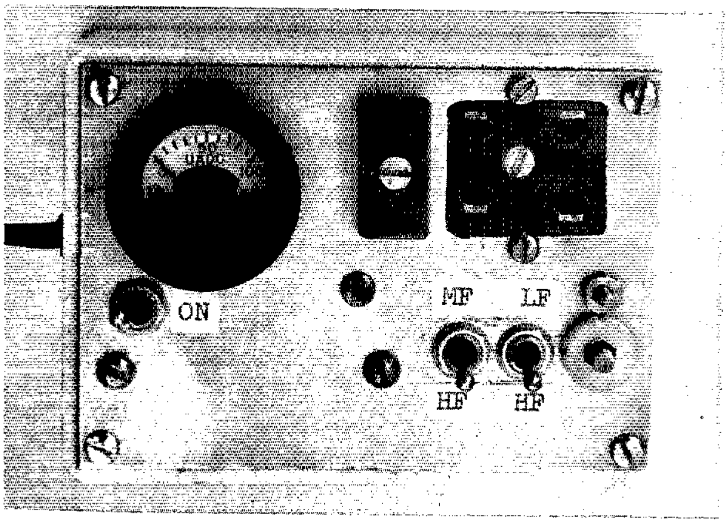
To get the UCO to oscillate with some mf and lf crystals, it was necessary to switch in extra capacitance between the drain and ground. This is handled by the two toggle switches, S1 and S2, and C3 and C4. If you are only interested in hf crystals, you will not need these capacitors or switches; most mf crystals will oscillate without them also. Neither will you need RFC2, a miniature toroidal 150-mH inductor. A single, three-position rotary switch could have been used in place of S1 and S2, but a rotary was not used in this particular unit for lack of space.

With S1 and S2 open, the oscillation frequency of the UCO will be at the parallel-resonant frequency of the crystal, as shunted by about 20 pF. Closing S1 or S2 will effectively shunt the crystal with an additional 30 pF, or about 50 pF total.

VHF Crystals

Fundamental-mode crystals are used for frequencies up to a maximum of about 20 or 25 MHz. At higher frequencies third-, fifth- or seventh-overtone modes are employed. The UCO will test vhf crystals, but they will oscillate on the fundamental, not the overtone frequency. The oscillation frequency will be very close to, but not precisely one-third, one-fifth or one-seventh the vhf frequency, since the overtone is seldom an exact integral multiple of the fundamental. The discrepancy is not large, however, typically about 0.1 percent, or 150 kHz at 2 meters.

[1]The audio transformer may not be on hand, but a 6.3-V, filament transformer can be substituted. See Fig. 1B for the substitution.



All the UCO components are mounted on the 3 × 4-inch (76 × 102-mm) cover plate of a small utility box.

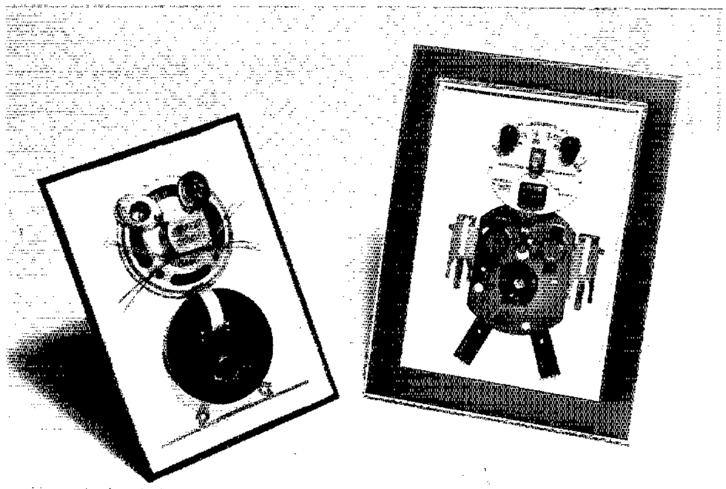
Strays

JUST AN INCONVENIENCE

☐ What may be an insurmountable obstacle for one person can be merely a hurdle for another. Frank Wagner, WB6FQM, of Napa, CA, made the climb from Technician to Extra Class in just four months despite partial blindness. And his enthusiasm for amateur radio continues: He now teaches Novice courses at Silverado Junior High School in Napa. It is difficult for him to see like you or I, but as he says, "It really isn't a serious handicap . . . it's a little inconvenient!" — *Ronald G. Martin, W6ZF*

QST congratulates . . .

☐ Douglas Zwiebel, WB2VYA, a Geraldine Rockefeller scholar at the University of Pennsylvania, School of Veterinary Medicine.



A creative member of the Society of Wireless Pioneers, Hyman Wallin, of Silver Spring, MD, produces electronic art from parts salvaged from various and sundry junk boxes. Hearing of Hq. staffer W1YL's penchant for cats, he constructed the design shown here especially for her.

A Long-Delayed Echo Revisited

Long-delayed echoes — what causes them? They have been one of amateur radio's longest standing and most intriguing mysteries.

By Nathaniel Cohen,* N1IR, Jonathan Davis,** WA1TCL and Franklin Davis,*** WA1TCK

Long-delayed echoes have been an exciting topic of conversation among radio amateurs for years and reports of several score observations have appeared in *QST*.[1,2,3] But major problems in explaining LDEs have prevented any viable scientific analysis. For example, almost all LDEs have occurred on the low bands, where large antenna beamwidths and the possibility of hoaxes have frustrated efforts in defining the region where the echo happens. Fortunately, there is one unique case of an LDE which yields valuable insight into the nature of the phenomenon which is discussed here.

OZ9CR Revisited

On July 7, 1974, Hans Rasmussen, OZ9CR, noted a "ghost echo" during his EME tests.[4,5] The echo occurred two seconds after the return of his EME signal. Hans' setup and discovery are pertinent to the study of LDEs for several reasons:

1) The use of 1296 MHz made it unlikely that a hoax was perpetrated because of the paucity and ardency of EME buffs.

2) At 1296 MHz the ionosphere cannot reflect signals.

3) A lower limit of electron density in the extraterrestrial reflector can be found.

4) Beam size was quite narrow (1.67 degrees subtended), which pinpoints the vicinity of the reflector.

5) The bandwidth of 500 Hz sets stringent limits on the Doppler frequency shift.

In point three, we mention an "extraterrestrial reflector." Why is this true? Why can't the signal be a bounce from the moon to ionosphere to the moon to the earth? Quite simply, the physics is not correct. Every vhfer knows that skip is not the best at 1296, with good reason. For good and especially *direct* reflection, the transmitted frequency must be on the order of the electron plasma frequency, f_p, where $f_p \approx 5.6 \times 10^4 n_e^{1/2}$ Hz. Here, n_e is the electron density in number per cubic centimeter.

Transmit *above* the plasma frequency and no skip, *below* and you are doing fine. Typically, the ionosphere reflects up to 30 MHz, which corresponds to an n_e of 3×10^5 electrons/cm^3. With reflection at 1296 MHz, the electron density must be 5.4×10^8 electrons/cm^3 or greater. This means that the ionosphere would be at least 1000 times its normal density for moon-ionosphere-moon reflection! Combining this with the geometry and signal loss makes it apparent that the echo arose from an extraterrestrial reflector about 700,000 kilometers distant.

Solar Cloud Hypothesis: Untenable

Solar physicists have shown that storms on the sun can produce ejection of dense, ionized plasma clouds if these clouds have high velocities in addition to internal magnetic fields for self-confinement.[6] OZ9CR has taken the usual value of 1000 km/s in attributing his LDE to a nearby, but extraterrestrial, reflecting plasma cloud ejected from the sun. This is incorrect for three reasons. First, a *close* cloud moving at this velocity would produce very prominent radiation in the form of QRN on the hf bands. Second, the bandwidth of 500 Hz sets a Doppler upper limit of 0.11 km/s for any v_e, the velocity of the cloud toward the observer on the earth. With v_e = 1000 km/s, a large Doppler frequency shift of 4.3 MHz would result.[7] Yet the cloud would have been ejected *radially* from the sun. Thus, it would have only a negligible Doppler velocity if it were passing the earth at a position approximately perpendicular to the line of sight with the sun, along with a correction for the earth's orbital velocity of 30 km/s. And third, the clouds are short-lived and soon dissipate without forming stable orbits.

The question of Doppler velocity is *not* trivial and indeed strongly refutes the ejection hypothesis. In Fig. 1 we show the relative arrangement of the sun-earth-

The Echo Mystery

Everyone loves a mystery story, especially one based on personal experience. What could be more mysterious than hitting your key and then listening to your own signal in your receiver a second or two later? This has happened on and off for as long as amateurs have been transmitting and has remained a mystery ever since the first *QST* mention of the subject in 1934.

The pages of *QST* reported some 90 long-delayed echo (LDE) occurrences as of 1971 in an article by three California scientists. Their call for additional reports produced several dozen in succeeding years, but the subject boiled up most heatedly in 1976, when Hans Rasmussen, OZ9CR, was quoted in the May issue of *QST* as having heard his own echoes at 1296 MHz. The significance of that event was that previous explanations of LDEs, such as ionospheric scattering and multipath propagation via the F layer, just fall apart at 1296 MHz.

Footnotes in the two accompanying articles refer mainly to letters from amateurs reprinted in "Technical Correspondence" in the past 18 months as the LDE controversy swirls and swarms. Cohen and Simpson present two of the best possible explanations seen to date. ARRL headquarters welcomes your reports of LDEs as well as *your* proposed explanations of the phenomena; whoever turns out to be right will certainly achieve everlasting fame and glory, if not riches! — *K1TN*

*Space Sciences Building, Room 206, Cornell University, Ithaca, NY 14853
**37th and Spruce Sts., Philadelphia, PA 19174
***Physics Department, Oberlin College, Oberlin, OH 44074

[1]Footnotes appear on page 18.

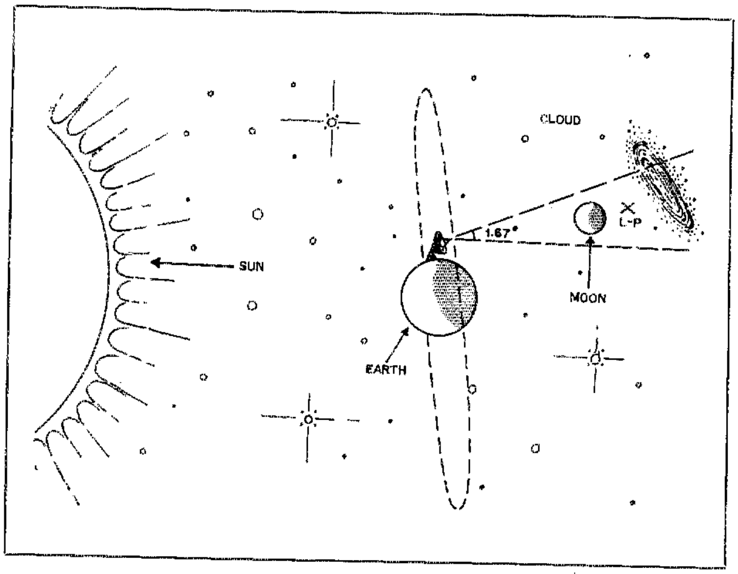


Fig. 1 — The sun-earth-moon-cloud system during the time OZ9CR received long delayed echoes. This view is taken with respect to the observer's horizon. Distances, sizes, etc. are not to scale. The great circle represents the points at which this cloud would have had small Doppler velocities if it were ejected from the sun. The X, identified L-P, indicates a semi-stable, earth-moon, Lagrange point about 600,000 km from the earth.

moon-cloud system. By noting the position of the sun and moon on July 7 we also obtain the position of the reflecting cloud within the antenna beamwidth. At this position a traveling cloud ejected from the sun would have a Doppler velocity vector of 0.87 times its true velocity, resulting in a substantial frequency shift. Small Doppler shifts occur on the great circle defined by the points perpendicular to the line of sight with the sun as is also shown in the diagram.

Dust Swarms and the Solar Wind

The possible significance of the zodiacal light and Gengenschein with LDEs has been discussed in *QST.*[8] Although LDEs are not associated with these optical phenomena, they have much in common. Simply stated, there are large areas containing many small sized (1/2-micron) particles often ascribed to a meteoric or cometary origin. In other words, these are dust swarms which can form semi-stable orbits and last about 1000 years before disintegrating. Can OZ9CR's LDE have resulted from a swarm of these particles? We say yes, but with some reservations.

There are two problems with LDEs and dust swarms. First, why is there such a high electron density in a dust swarm? Second, why isn't the swarm at an earth-moon-system Lagrange point[8] (located near the earth at distances of about 600,000 km)? Here, the forces acting on a mass cancel, and the orbit is stable and synchronous with that of the earth's orbit.

Since the reflection cloud was not at a Lagrange point, how do we explain the cloud in terms of a high-density dust swarm? Fortunately, this problem has already been studied and it has been noted that high particle densities in interplanetary dust streams can occur in perturbations seen *near* the Lagrange points[9]. In addition, it seems likely that the reflection cloud would be a dust swarm not in synchronous orbit to the earth, but whose v_e cancels with the earth's orbital velocity. The perpendicular velocity of the cloud is not readily obtainable from OZ9CR's observations but seems likely to be small since internal turbulance would cause substantial Doppler broadening with large velocities resulting in garbled echoes with bandwidths greater than 500 Hz.

Now problem one: How can there be such a large electron density? The answer is found in the solar wind. When the solar wind hits these dust swarms it erodes away layers of the particles in a mechanism called *sputtering*. The layers are ionized, producing a local electron density. But a density of 10^8 electrons/cm^3 is unusual; why is this sputtering so intense? The cause lies in the salience of solar activity during the week of July 1-7, 1974. Particularly on July 5, many energetic solar flares were recorded which created a strong solar wind with an average velocity of 1000km/s.[10] This was capable of producing intense sputtering for a short time, easily producing an effect on a large dust swarm. For the echoes of OZ9CR the cloud-swarm must have had an angular size at least on the order of the beam size and greater than 20,000 km across, consistent with this view. Thus, OZ9CR's LDE seems to be the result of a large, dense, dust swarm and a strong solar wind.

Searching for LDEs

Clearly much work remains to be done to yield greater understanding of the LDE phenomenon. Unfortunately, the problems mentioned for hf LDEs complicate attempts at learning more about the dust swarms. We suggest that more LDE work be done at uhf and vhf and during known times of pronounced solar activity. Searches at 2 meters may prove the most ideal because of the lower electron density necessary while still maintaining narrow beamwidth. Although the Lagrange points need not be the only place to look, they are good places to begin. The organized involvement of moonbouncers may enhance our understanding of LDEs in addition to demonstrating a new and possibly viable means of radio propagation.

Acknowledgements

The authors are grateful to D. Stinebring, J. A. Pierce and R. Hohlfeld for their comments. Cohen acknowledges the support of an NLC Trust Fellowship and the National Astronomy and Ionospheric Center, Cornell University.

Footnotes

[1]Villard, Graf and Lomasney, "Long-Delayed Echoes . . . Radio's Flying Saucer Effect," *QST*, May, 1969, p. 38.
[2]Villard, Fraser-Smith and Cassam, "LDEs, Hoaxes, and the Cosmic Repeater Hypothesis," *QST*, May, 1971, p. 54.
[3]Villard, Graf and Lomasney, "A Long-Delayed Echo AR," *QST*, February, 1970, p. 30.
[4]Rasmussen, "Ghost Echoes on the Earth-Moon Path," *Nature, 257,* p. 36 (1975).
[5]Rasmussen, "Ghost Echoes on 1296 MHz," *QST*, June, 1976, p. 36.
[6]Kundu, *Solar Radio Astronomy*, Interscience, New York, 1965, p. 577.
[7]Fletcher, "Ghost Echoes Again," *QST*, March, 1977, p. 43.
[8]Clark, "Two Possible Explanations for LDEs," *QST*, November, 1971, p. 40.
[9]Roach and Gordon, *Light of the Night Sky*, Reidel, Boston, 1973, p. 40.
[10]NOAA, *Solar Geophysical Data*, CRPL FB-135, 361, July, 1974.

Strays

TOGETHERNESS

☐ Not a few family members have received consecutive calls when going for their licenses at the same time. But how many get calls with the same suffix? Bob and Judi Goldschmidt, of Stanton, CA, took their tests together and wound up with the call signs WA6SKE (his) and WB6SKE (hers).

More Reflections on LDEs

Solar wind? Plasma clouds? Here are other thoughts about long-delayed echoes.

By Richard Simpson,* W6JTH

The observations of long-delayed echoes by Rasmussen[1] have received rather piecemeal discussion in *QST*.[2,3] The original statement and cover letter[4] remain the most useful sources of information for evaluating this phenomenon. The published explanations, however, including Rasmussen's own, do not stand up well under close examination.

Rasmussen originally reported peculiar 1296-MHz echoes during moonbounce tests in the summer of 1974. The character of these signals was somewhat similar to the lunar echoes except that they were "hoarse" and delayed by an additional two seconds. Their presence did not appear to be highly dependent on antenna pointing and they had no noticeable Doppler shift. After considering the evidence, Rasmussen proposed that the ghost signals may have been reflections from a solar streamer located some 400,000 km beyond the moon and moving toward the earth at 1000 km/s.

Garibaldi[2] has correctly noted that time delay and Doppler shift should be very noticeable if the proposed reflector were moving at 1000 kilometers per second. With this velocity, time delay should decrease 0.4 second during each minute of observation. This compares with the fixed, 2.6-second, round-trip time for a lunar echo. Rasmussen observed his ghost for at least 20 minutes and detected no change whatsoever in its position with respect to the lunar echo. One infers from this that the reflector was stationary with respect to the observer.

A rather high Doppler shift is expected from a rapidly moving reflector.[2] At 1296 MHz a 1000 km/s target should impart 8.64 MHz of shift (Fletcher[3] is low by a factor of two). Since Rasmussen's receiver passband was only 500 Hz and the Doppler offset due to earth-moon motion and earth rotation amounts to only a few kHz, it is unlikely that he would have detected an echo from a plasma cloud such as the one he hypothesizes. Thus, from Doppler considerations (which are not independent of time-delay shifts) one also concludes that the source of the echo was stationary with respect to the observer.

Fletcher postulates a plasma cloud that was moving so that its velocity with respect to the earth was zero. This is certainly a possibility, but other problems remain. Any connection between the stationary cloud and the radio blackout which occurred on the day following must (under such circumstances) be considered entirely fortuitous.

A recent review article, "Waves in the Solar Wind"[5] describes the usual flow of plasma from the sun. Most movement is radially outward, meaning that the strongest radio reflections from a solar-wind "wavefront" would occur when the antenna is pointed directly toward the sun. Rasmussen's geometry is such that his antenna was aimed away from the sun and opposite to the direction of the earth's motion in its orbit. Only a turbulent or otherwise irregular front to the cloud could then scatter energy back toward the earth. Both are possible, especially considering that a major solar disturbance was taking place. A disturbance, however, would not be likely to produce the very stable signal which was reported.

In addition to being Doppler shifted away from 1296 MHz, the echo from a turbulent moving cloud likely would be Doppler spread owing to the wide distribution of velocities within the cloud. Similarly, the echo time delay would depend on which of many parts of the cloud responded to the transmitted signal.

The reflection mechanism within the cloud poses additional problems. If we imagine that the cloud behaves as the ionosphere does, then its critical frequency can be found from $F_C = 9000\sqrt{n}$, where n is the density (in electrons per cubic centimeter) of the plasma. For typical D and F2 layers above the earth, n has values of 10^3 and 2×10^6, respectively. These give critical frequencies on the order of 300 kHz and 13 MHz. To reach a critical frequency of 1296 MHz one must have an electron density of 2×10^{10}. When one compares this with the ambient solar-wind density at the earth[6] of n = 10, it becomes obvious that the ionospheric-reflection analogy is not satisfactory.

Incoherent scatter, such as that associated with aurora, is a second possibility. Incoherent echoes, however, are much weaker than those returned via ionospheric reflection at hf. At the distance of the moon or beyond, they would very likely be undetectable.

The foregoing does not in any way explain Rasmussen's observations. The time-delay and Doppler-shift arguments strongly suggest, however, that the echo mechanism is fixed with respect to the earth and is not connected with a moving plasma cloud. Recent theoretical work and systematic attempts at LDE detection by Crawford, Sears and Bruce[7] do not seem to apply here because of Rasmussen's much higher operating frequency. Clearly, more observations and good reporting will be needed before phenomena of this sort can be explained.

*2339 Santa Catalina, Palo Alto, CA 94303

References

[1]Rasmussen, "Ghost Echoes on 1296 MHz," *QST*, June, 1976, p. 36.
[2]Garibaldi, "Ghost Echoes, Phase 2," *QST*, September, 1976, p. 31.
[3]Fletcher, "Ghost Echoes Again . . . Echoes Again," *QST*, March, 1977, p. 43.
[4]Lorenzen, "Long Delayed Echoes on EME Circuit," *QST*, June, 1976, p. 36.
[5]Gosling and Hundhausen, "Waves in the Solar Wind," *Scientific American*, March, 1977, p. 36.
[6]Glasstone, *Sourcebook on the Space Sciences*, D. Van Nostrand Co. Inc., Ch. 8, 1965.
[7]Crawford, Sears and Bruce, "Possible Observation and Mechanism of Very-Long-Delayed Radio Echoes," *J. Geophysical Research*, Vol. 75, No. 34, pp. 7326-7332.

The Long-Boom Quagi

What, you're not on 432 yet? If it's the need for an antenna that's stopping you, you've got the green light now — this 15-element quagi.

By Wayne Overbeck,* K6YNB/N6NB

No, a quagi is not the sound made by a certain species of duck found only in northern California and southern Alaska. A quagi is merely one of the most interesting amateur antenna designs to come down the pike in recent years. The author first described this combination of cubical quad and Yagi-Uda design techniques about a year ago[1] and the response from amateurs seemed to demand further work on the design. The result is a quagi for 432 MHz, a band of ever-increasing interest among vhf operators working direct, moonbounce and through the OSCAR 7 satellite.

What does the quagi have going for it that makes it an attractive alternative to both the quad and Yagi-Uda arrays? Easy, noncritical construction, for one thing, as well as simple matching of the feed line to the driven element. Also, quagi fires have been fed by recent discussions of the advantages of quad loops over rod-type driven elements (such as used in straight Yagi-Uda designs).[2] Not that there has been any doubt about that, as attested in past work by acknowledged experts Orr and Lindsay.[3,4]

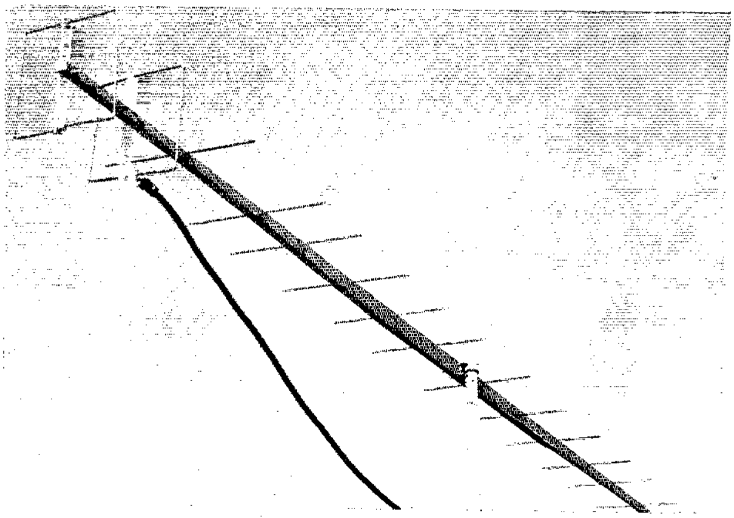
Finally, Danish scientist Appel-Hansen has produced results[5] indicating that while quad loops make excellent driven elements and reflectors, rods seem to be superior directors. Thus, the quagi, for your 432-MHz pleasure.

The vhf quagis were designed by amateurs, using amateur methods. Although developed independently of Appel-Hansen's work, they are a practical application of the principles he demonstrated. The effectiveness of the original quagi design is well known, and numerous amateurs have asked if the quagi principle could be applied to a super-long antenna for 432-MHz work.

The answer is the 15-element array to be described. It is just as easy to reproduce as the smaller eight-element quagi, but it offers nearly 15 dB gain over a dipole (dBd). Boom length of the antenna is 5λ (11.5 feet or 3.51 meters for 432 MHz). Obviously, this boom length makes such an antenna impractical for use on the lower amateur frequencies, but at 432 MHz it fits nicely on a 12-foot (3.66 meter) length of 1 × 2-inch (25 × 50-mm) lumber.

Long-Boom Performance

The 15-element quagi has been tested repeatedly against other long-boom antennas, including the 16-element, log-periodic Yagi described by Holladay[6] (made commercially by KLM Electronics), and the 21-element, F9FT Yagi. When the 15-element quagi was designed,



The long-boom quagi is elegant in its simplicity. Tapering the boom lends greater rigidity to the structure. The most difficult part of this project may be obtaining lumber straight enough for accurate alignment of the elements.

*Pepperdine University, Malibu, CA 90265
[1]References appear on page 21.

the KLM long Yagi was used as a reference standard against which to test the new array. In several test-range experiments the quagi's gain was found to be comparable to that of the 16-element, log-periodic Yagi.

To confirm the new design's performance and reproducibility, a second 15-element quagi was built directly from the dimensions that appear in Table 1, with the original antenna out of sight. This "cookbook" quagi was taken to the three major vhf antenna gain competitions in the United States in the spring and summer of 1977. In all three measurements, the quagi's performance was very similar to that of the larger, more expensive, commercial antennas. At the Central States VHF Conference, the 15-element quagi and 16-element KLM antenna were rated at identical gains, with the 21-element F9FT array about 1 dB greater than both. On the other hand, the quagi outperformed both the F9FT antenna and the KLM in the sun noise measurements at the East Coast VHF Society's session. When the same antennas were measured with a nearby signal source, however, the best F9FT and KLM antennas topped the quagi by 0.8 to 1.0 dB. That result was closely duplicated at the West Coast VHF Conference.

The consensus of all these measurements seems to be that all of these long-boom antennas are very good performers, with none holding a decisive advantage over any other in gain. Whether an amateur buys a long 432-MHz Yagi or "rolls his own" will depend on his budget, schedule and personal preferences. With this quad-driven array, gone are the days when first-rate, 432-MHz Yagis could be built only by those having special skills and elaborate test equipment. No longer must a builder match impedances and struggle with critical baluns to get a 432-MHz Yagi to take power efficiently. To duplicate this antenna, all the builder need do is cut the rods and wire loops to within about 1/32 inch (0.8 mm) of the dimensions given in Table 1.

As with any uhf project, the quagi builder should use the materials specified or expect to do some extra "tweaking." Any sort of 1/8-inch (3-mm) rod stock will do for the directors, but the quad loop must be no. 12 AWG (2-mm) TW *covered* copper wire (available from electrical suppliers). If you use bare wire (or any other diameter wire) for the loop elements, be prepared to adjust the lengths. A wood (or other nonconductive) boom is used. The quad loops are supported by Plexiglas strips while the director rods pass through the boom.

As with the smaller eight-element quagis, the long-boom 15 should be fed directly with 52-ohm coaxial cable. A type N connector is soldered into the midpoint of the bottom side of the driven loop. The feed-line coax is brought perpendicularly to the antenna feed point, running along the boom or (preferably) directly to the supporting mast.

Like the smaller quagis and other antennas, long-boom 15s can be stacked in pairs, fours, eights or 16s for additional gain. With this much gain over a dipole for each bay, a stacking distance of six to seven feet is recommended at 432 MHz. Since these antennas can be built of much lighter materials than the 16-element, log-periodic Yagi, they represent a practical as well as economical approach for moonbounce work. Allowing for normal feed-line losses, 16 long-boom quagis should deliver nearly 26 dB gain over a dipole, while about 23 dB would be attainable with only eight bays. Even the larger 16-bay array would be only about 20 × 20 feet (6 × 6 meters) in size, not that big by EME standards!

However, any EME system consisting of long-boom antennas poses special mechanical problems because all bays must track accurately enough so that they all point at the moon at once. As the author learned during an Alaskan moonbounce DXpedition, this can be difficult under adverse environmental conditions.[7]

Conclusion

There you have it, a long-boom version of the quagi antenna that offers very high gain without high cost or undue construction complexity. Anyone who takes reasonable precautions to follow the listed dimensions should be able to achieve the same results! The author again wishes to thank WB6RIV for his antenna-range assistance! QST

About Building Quagis

Since the original "VHF Quagi" article appeared in *QST* for April, 1977, hundreds of hams have successfully reproduced these antennas. However, several builders have written the author that they were having difficulty getting their quagis to work. These difficulties stem from three causes:

1) *Failure to observe correct polarization* — The photos in *QST* show *horizontally polarized* arrays, but vertical polarization is standard in fm and repeater work. Several builders have written complaining that they built quagis and put them up "just like you showed it in *QST*" only to find that their groundplanes would get into the local repeater better! For fm service, the quagi must be vertically polarized. That means the directors must be vertical and the feed point must be on the side of the driven element. Despite its square shape, a quad-type loop is not universally polarized — it is vertical or horizontal, depending on where it is fed.

2) *Failure to allow for overlaps at joints* — The dimensions given for the driven element and reflector are *net* dimensions. The builder must allow excess length for any overlap when the loop ends are soldered.

3) *Failure to use the specified wire type* — While any conductor of the proper diameter (1/8 inch or 3.2 mm) is fine for the directors, the driven element and reflector loops must be made of no. 12 TW wire *with its insulation in place.* Use of bare wire — or any other size wire — will require a correction in loop length. One builder used brazing rod for his driven element and had to increase the length 1.7 percent to get the VSWR down to a normal 1.2 at resonance. But once he made that correction, his eight-element quagi was measured at 13.8 dBd gain at the West Coast VHF Conference last May!

Table 1
432-MHz, 15-Element, Long-Boom Quagi Construction Data

Element Lengths — Inches (mm)		*Interelement Spacing — Inches (mm)*	
R — 28" loop (711)	D7 — 11-3/8 (289)	R-DE — 7 (178)	D6-D7 — 12 (305)
DE — 26-5/8" loop (676)	D8 — 11-5/16 (287)	DE-D1 — 5-1/4 (133)	D7-D8 — 12 (305)
D1 — 11-3/4 (298)	D9 — 11-5/16 (287)	D1-D2 — 11 (279)	D8-D9 — 11-1/4 (286)
D2 — 11-11/16 (297)	D10 — 11-1/4 (286)	D2-D3 — 5-7/8 (149)	D9-D10 — 11-1/2 (291)
D3 — 11-5/8 (295)	D11 — 11-3/16 (284)	D3-D4 — 8-3/4 (222)	D10-D11 — 9-3/16 (233)
D4 — 11-9/16 (294)	D12 — 11-1/8 (283)	D4-D5 — 8-3/4 (222)	D11-D12 — 12-3/8 (314)
D5 — 11-1/2 (292)	D13 — 11-1/16 (281)	D5-D6 — 8-3/4 (222)	D12-D13 — 13-3/4 (349)
D6 — 11-7/16 (291)			

Boom — 1 × 2-inch × 12-ft (25 × 51-mm × 3.66-m) Douglas fir, tapered to 5/8 inch (16 mm) at both ends.
Driven element — No. 12 TW copper-wire loop in square configuration, fed at center bottom with type N connector and 52-ohm coax.
Reflector — No. 12 TW copper-wire loop, closed at bottom.
Directors — 1/8-inch (3.2 mm) rod passing through boom.

References

[1]Overbeck, "The VHF Quagi," *QST*, April, 1977.
[2]Belcher and Casper, "Loops vs. Dipoles — Analysis and Discussion," *QST*, August, 1976.
[3]Orr, *Quad Antennas*, 2nd ed., Radio Publications, Inc., Wilton, CT 1970.
[4]Lindsay, "Quads and Yagis," *QST*, May, 1968.
[5]Appel-Hansen, "The Loop Antenna with Director Arrays of Loops and Rods," *IEEE Transactions on Antennas and Propagation*, July, 1972, p. 516.
[6]Holladay, "High Gain Yagi for 432 MHz," *Ham Radio*, Jan., 1976.
[7]Overbeck, "Moonbounce Boondoggle," *QST*, Feb., 1977.

BC-Band Energy — A Rejection Filter

Strong bc-band signals can spoil amateur reception. Build this high-pass filter and protect your receiver front end.

By Edward E. Wetherhold,* W3NQN

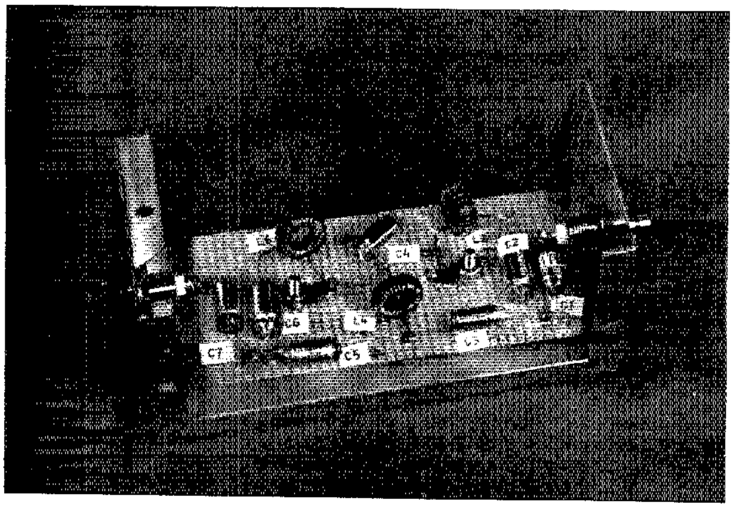
How does your receiver front end stack up against strong, broadcast-band signals in the 550- to 1600-kHz range? Inadequate front-end selectivity, or bipolar-transistor rf amplifier and mixer stages which perform poorly, can result in unwanted cross-talk and overloading from adjacent commercial or amateur stations. A simple cure for this problem is to install between the antenna and receiver a filter that will sufficiently attenuate the out-of-band signals but pass those signals of interest with little or no attenuation. If the receiver is designed for reception of frequencies below *and* above the broadcast band, a 550- to 1600-kHz band-stop filter will be required. However, if reception is desired only below *or* above the broadcast band, then a less complex low *or* high-pass filter will suffice. Because a majority of ham receivers are used for reception above 1600 kHz, a high-pass filter will generally be preferable to the band-reject filter. For the same number of components, the high-pass filter performance is superior to that of the band-reject type.

*Honeywell Inc., Defense Electronics Div., Annapolis Operation, P. O. Box 391, Annapolis, MD 21404

Since the power level of broadcast stations can be quite high, the stop-band attenuation of the high-pass filter should also be high, preferably in excess of 60 dB. The cutoff frequency should be selected so less than 1 dB of attenuation occurs above 1800 kHz, the start of the 160-meter band. Receivers are generally designed to present a 50-ohm load to the antenna, and the filter should also be designed for the same impedance level. The rate of attenuation rise, VSWR, pass-band ripple, and number of filter components are all interrelated and many design choices are possible. In the high-pass design to be discussed, the maximum VSWR of the filter was selected to be 1.353. To obtain adequate stop-band attenuation and a reasonable rate of attenuation rise, a filter of 10 elements was considered necessary. Finally, to simplify construction, only those designs permitting the use of standard-value capacitors were considered.

Of the two filter-design procedures now used, the image-parameter and modern-filter design (or network synthesis), the modern-design procedure was used because of its greater preciseness and versatility. The modern-filter design procedure was first explained for the amateur in the pages of *QST* [1] and *Radio Communication*[2] in 1969 and 1971, respectively. These articles should be used for background information and an explanation of any unfamiliar filter-design terms. From the many different types of modern-filter responses (Bessel, Butterworth, Chebyshev, elliptic, etc.), the elliptic type (referred to as "Cauer parameter" type in ref. 3) was chosen because it provides the fastest rate of attenuation rise. A disadvantage of the elliptic filter is that it

[1]References appear on page 24.



The filter is built on perfboard in a 2 × 2 × 5-inch Minibox. The filter can be made smaller if desired, and phono connectors can be used in place of the BNC fittings shown here.

requires tuning, but if this can be accomplished with the use of close-tolerance, standard capacitor values, the tuning should present no problem. One of the design parameters of the elliptic filter is A_s, the value of the minimum stop-band attenuation in dB. In the references used,[3,4] the A_s ranges from 2.65 to 133 dB in increments of several dB. For this particular application, the C0715 filter-catalog listings between A_s = 52 to 90 dB were of interest. The "C0715" of the filter catalog heading signifies a filter with Cauer (or elliptic) parameters of degree "n" = 7, and a reflection coefficient of 15 percent (equivalent to a VSWR of 1.353). The degree n = 7 is equal to the number of elements in the Chebyshev filter to which the Cauer filter is related. All Chebyshev filters are Cauer filters with A_s = infinity. Consequently, the Chebyshev filter has no stop-band ripples as does the Cauer. To obtain stop-band ripples and a finite value of A_s, three capacitors are added to series tune inductors L2, L4 and L6 of the filter shown in Fig. 1. The total number of elements in the Cauer filter is thus 10.

In the C0715 catalog, there are 25 normalized filter value listings between A_s = 52.8 and 91.7 dB. The extremes of this range were considered as the minimum and maximum acceptable values of A_s. A computer data file (no. 1) was assembled in which the normalized values of C1-C7, inclusive, and L2, L4 and L6 were listed for each of the 25 values of A_s. Another data file (no. 2) was assembled containing the capacitor values of the Mallory SXM polystyrene series (2.5 percent at 160 V). A computer program was then used to evaluate each normalized catalog listing in data file no. 1 for a cutoff frequency of 1.6 to 1.75 MHz in increments of 0.1 MHz. The computer was programmed to print out only those designs in which all capacitor values were within ± 3 percent of the standard values in data file no. 2. Of those designs printed out by the computer, the one design believed to be most suitable was selected for construction. The parameters of the selected design are listed in Fig. 1 along with the calculated component values. Although the A_s value was less than the desired 60 dB, it was high enough (58.3 dB) to be adequate for the application.

Building the Filter

The filter layout, schematic diagram and response curve, the component values used, and the toroidal-inductor winding specifications are all shown in Fig. 1. The design parameters and the calculated filter component values and other calculated parameters are shown in the upper right-hand corner of Fig. 1. The standard-value capacitors used are listed under the filter schematic diagram. Note that all standard values are within 2.8 percent of the design values. Since the maximum deviation between the actual capacitance used and the design value will be only 5.3 percent, there should be little or no difficulty in obtaining the desired response. If the attenuation peaks (f2, f4 and f6) at 0.677, 1.293 and 1.111 MHz are not obtained, a slight squeezing or separating of the toroidal-inductor windings should be all that is required to tune the series-resonant circuits. Note that series circuit C6-L6 should resonate at f6 = 1.111 MHz, but from the response curve it actually resonated at about 1.130 MHz. This frequency error of about 2 percent is small enough to ignore. The A_s value was selected to be 58.3 dB, and examination of the response curve shows the measured filter response to be in good agreement. The measured values of cutoff frequency (at the attenuation

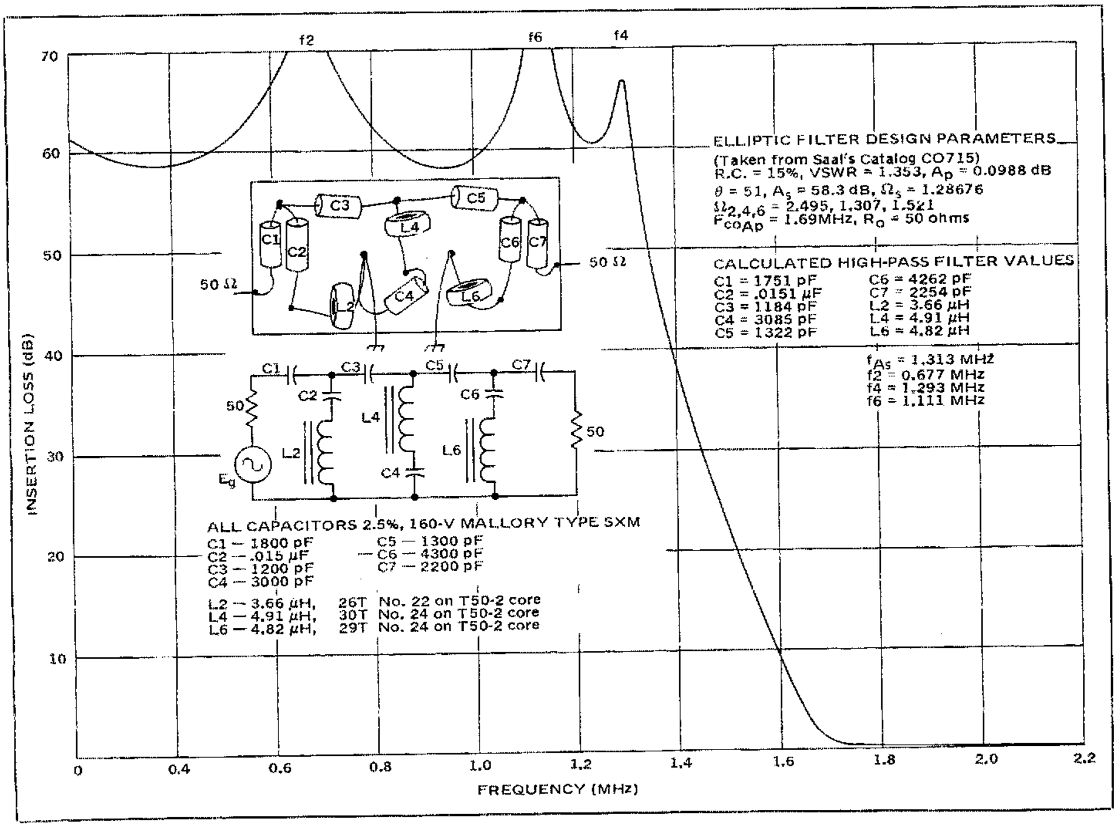


Fig. 1 — Filter-response curve, insertion loss, layout and schematic diagram. Terminal impedance is 50 ohms for this 1.7-MHz, high-pass filter.

level of 0.0988 dB) and the measured value of fA_s (the frequency where A_s is first reached) are also in good agreement with the calculated values. The measured pass-band loss was less than 0.8 dB from 1.8 to 10 MHz. Between 10 and 100 MHz, the insertion loss of the filter gradually increased to 2 dB. The measured input impedance versus frequency was in good agreement with the calculated input impedance between 1.7 and 4.2 MHz. (The frequency range above 4.2 MHz was not tested.) Over the range tested, the input impedance of the filter remained within the 37 to 67.7 ohms input-impedance window (equivalent to a maximum VSWR of 1.353).

Final Comments

Construction of the filter is relatively simple, as shown in the photograph, and no difficulty should be experienced if the Mallory SXM polystyrene capacitors are used. These capacitors have a standard tolerance of 2.5 percent and are available through all Mallory distributors. The Micro-metals iron powder T50-2 toroidal cores are available through either Amidon,[5] Palomar Engineers,[6] or G. R. Whitehouse[7]. Write to these distributors for prices or see *QST* ads for January, 1977, pages 108 and 160, and *QST* for February, 1977, page 126.

The performance of this filter is a good example of what can be expected when the modern-filter design procedure is used. The designer has a wide choice of filter catalogs from which to choose (reflection coefficients from 1 to 50 percent for 5- to 13-element elliptic filters) and has the assurance that the finished design will perform as intended. As the advantages of the modern-design procedures are more frequently demonstrated and this design procedure becomes more familiar to the amateur, it will eventually replace the less versatile image-parameter design procedure. For your next filter requirement, why not try a modern-filter design?

References

[1]Wetherhold, "Modern Filter Design for the Radio Amateur," *QST* for September, 1969.

[2]Allen, "Modern Filter Design for the Radio Amateur," *Radio Communication* for August, 1971 (journal of the RSGB).

[3]Saal, "The Design of Filters Using the Catalog of Normalized Lowpass Filters," *Telefunken Gmbh*, Western Germany, 1966.

[4]Zverev, *Handbook of Filter Synthesis*, John Wiley and Sons, Inc., New York, 1967.

[5]Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607.

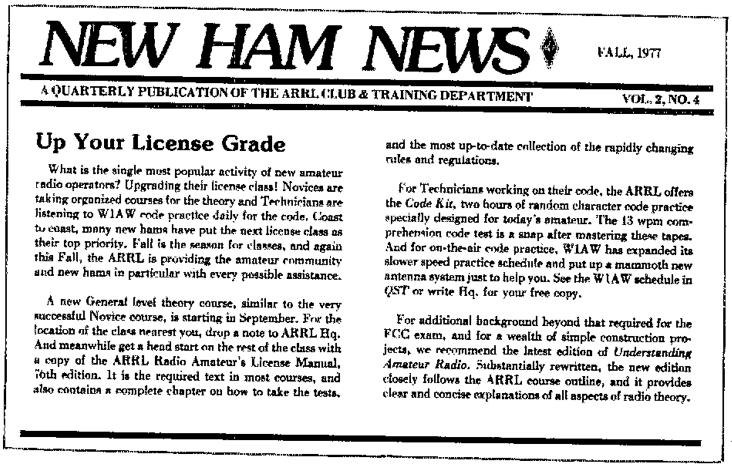
[6]Palomar Engineers, Box 455, Escondido, CA 92025.

[7]G. R. Whitehouse, 11 Newbury Dr., Amherst, NH 03031.

Strays

DO YOU READ *NEW HAM NEWS?*

☐ *QST* isn't the only publication for beginners that comes out of League hq. Written for newly licensed amateurs, *New Ham News* is chock full of timely articles of special interest to new hams. You'll find such pertinent topics covered as Novice antennas, humorous experiences that we can all learn from, operating and upgrading tips, and more. The quarterly newsletter is mailed free of charge to all Novice members of the ARRL, as well as to all new licensees. The latest issue, Winter, 1978, is hot off the presses. If you do not normally receive *NHN* and would like a free copy, send a self-addressed, stamped envelope to ARRL hq. Have a tale to tell or some secrets to impart to newly licensed amateurs? Send it to Editor, *New Ham News*, ARRL Hq. — *WB2CHO*



NEW HAM NEWS

FALL, 1977

A QUARTERLY PUBLICATION OF THE ARRL CLUB & TRAINING DEPARTMENT — VOL. 2, NO. 4

Up Your License Grade

What is the single most popular activity of new amateur radio operators? Upgrading their license class! Novices are taking organized courses for the theory and Technicians are listening to W1AW code practice daily for the code. Coast to coast, many new hams have put the next license class as their top priority. Fall is the season for classes, and again this Fall, the ARRL is providing the amateur community and new hams in particular with every possible assistance.

A new General level theory course, similar to the very successful Novice course, is starting in September. For the location of the class nearest you, drop a note to ARRL Hq. And meanwhile get a head start on the rest of the class with a copy of the ARRL Radio Amateur's License Manual, 76th edition. It is the required text in most courses, and also contains a complete chapter on how to take the tests, and the most up-to-date collection of the rapidly changing rules and regulations.

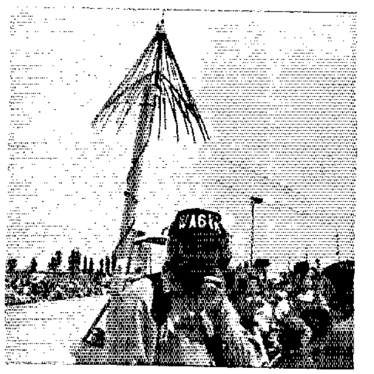
For Technicians working on their code, the ARRL offers the *Code Kit*, two hours of random character code practice specially designed for today's amateur. The 13 wpm comprehension code test is a snap after mastering these tapes. And for on-the-air code practice, W1AW has expanded its slower speed practice schedule and put up a mammoth new antenna system just to help you. See the W1AW schedule in *QST* or write Hq. for your free copy.

For additional background beyond that required for the FCC exam, and for a wealth of simple construction projects, we recommend the latest edition of *Understanding Amateur Radio*. Substantially rewritten, the new edition closely follows the ARRL course outline, and it provides clear and concise explanations of all aspects of radio theory.

It's informative, it's lively and it's free! Write ARRL hq. for your first copy of *New Ham News*.

AMATEURS ASSIST AT WHEELCHAIR EVENT

☐ The National Wheelchair Games, held last summer at San Jose, CA, presented unique possibilities for Santa Clara Valley amateurs, and they rose to the occasion in unique ways. Roy, WA6VRK, for example, used an unusual rig consisting of two lead-acid motorcycle batteries built into a backpack. The rig was an ICOM 211 into a modified discone antenna that strongly resembled a broken umbrella. In all, more than 40 amateurs provided communications for the five-day event.



The unique portable operation of WA6VRK at the 21st annual National Wheelchair Games at San Jose, CA.

JET PROPULSION LAB TOURS

☐ Most amateur radio groups are busy enough with their own projects, but the Jet Propulsion Laboratory Amateur Radio Club of Pasadena, CA, goes further by inviting other clubs for tours of the JPL complex. The visitors see a multimedia presentation, full-sized spacecraft models, assembly and test areas, and the W6VIO club station. Interested groups should contact Norm Chalfin, K6PGX, JPL ARC, 4800 Oak Grove Dr. (180/302), Pasadena, CA 91103. Tel. 213-354-6833.

A Spectacle-Mounted Code Blinker

Want a neat idea for the handicapped amateur? This one is invented by a handicapped amateur, so you know the idea is tested and true!

By D. W. Conover,* WA6MJZ

This flashing cw-assist device will offer considerable utility for many deaf amateurs, as well as enhancing their code-speed learning potential. Such a unique means of simplifying the visual flash technique for cw operation could lend further support to amateur radio by adding to its ranks many deaf people. Otherwise, they might be denied ready entry into a fascinating hobby.

A spectacle-mounted LED can be especially attractive to the hard-of-hearing person who needs a visual method for receiving code rather than a vibratory means. Even for the experienced amateur who has recently become deaf, this device will allow the operator to watch the code while writing it down. A general view of the device is shown in the drawings and the photo.

As a person who became deaf very recently, I also found this device to be a definite help in essentially eliminating the usually temporary, but always annoying, double-vision phenomenon that often accompanies a stroke to the central nervous system. For the deaf person with double vision, imagine — if you haven't already experienced it — keying a dash ("T") and knowing it, only to see a space flash in two slightly offset places! The sender — at least when he is first learning cw — is very apt to interpret this signal as two dashes ("M").

The Concept

By using the modified spectacles in the sketch, the operator can eliminate the double-vision handicap and can improve his efficiency with very little interruption in his hobby. Fig. 1 shows how a pair of ordinary prescription spectacles can be fitted with a L-shaped boom to hold an LED in the proper position. In this specific application, the boom (a hammered piece of copper wire about 10 inches long), was attached by small bolts to the left temple piece of the spectacle frame. Of course, the boom can be attached to either side in order to meet the user's preference or special physiological needs.

For the person with no double vision or other visual acuity problems, the spectacles can be used without lenses in them. The empty frames merely serve as a convenient mount for the L boom and LED while still permitting the light source to

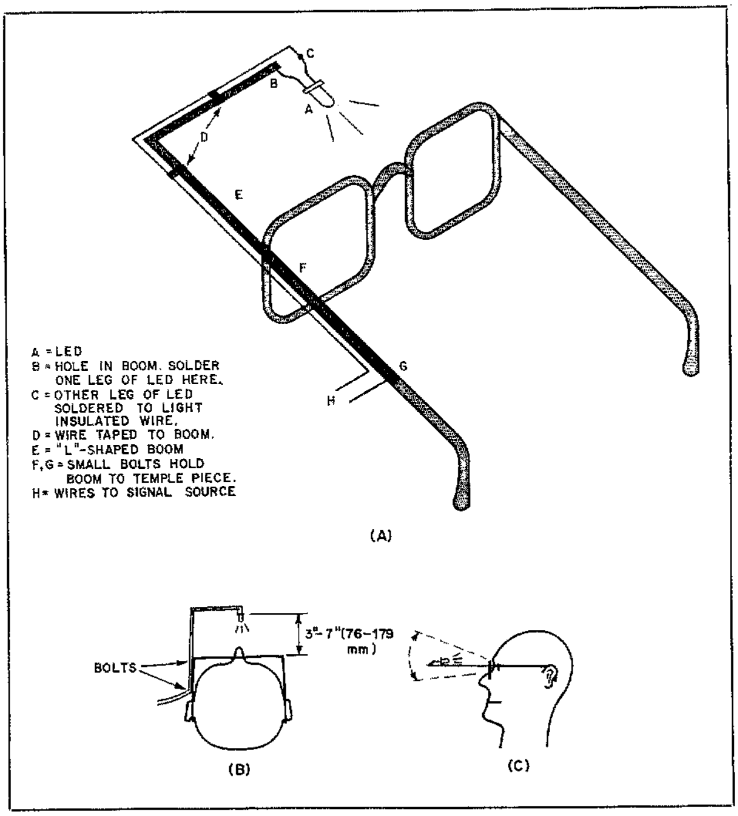


Fig. 1 — A sketch of spectacles with boom and LED flasher attached. At B, a top view and at C, a side view.

*4270 Alta Mira Dr., La Mesa, CA 92041

move in synchrony with head movements, thus keeping the LED in a constant position in front of the eyes.

Whatever type frames are used, it is strongly suggested that fairly substantial plastic temple pieces be employed to minimize possible breakage and provide an insulation base for the boom. There may be a more technical optometric term for the so-called "temple pieces." However, most users of eye glasses will consider the temple pieces as those parts of the frames which fit along the sides of the head and hook over the ears.

Frame Construction

A simple boom can be made out of readily available piece of No. 8 or No. 10 copper wire, or any functionally similar material. If round wire is used, simply hammer the LED end flat for about 1/2 inch,(13 mm), and drill a small hole about 1/32 inch,(1 mm), dia. through the flattened part to accept one of the LED "legs." An LED will be soldered in place later in the construction process.

The length of the temple end of the L boom should be about three or four inches. It should be hammered flat in two places in order to accept two small bolts which secure the boom to the plastic temple pieces. See Fig. 1A. The long leg of the boom must project straight out past the temple pieces from about three to six inches, depending on many factors, the most important of which is a need for monocular or binocular viewing. If you are monocular (because of double vision), the bent portion of the boom should begin at about three inches in front of the lens plane and extend to the right (or left, depending on which side the boom is anchored) about 1-1/2 inches (38 mm). This arrangement will place the LED light source in front of the left (or right) eye and just outside the visual field of the other eye, thus avoiding double vision (diplopia).

By placing the LED about three inches in front of the lens plane it is generally within the near-point range of the eye. This is the distance within which most people can no longer cause the eye muscles to converge. For binocular viewing with normal eyes or for individuals with just one eye, the bent portion of the boom *can* be as far out as seven inches in front of the lens plane. With most viewers, the LED at seven inches will appear as a reasonably bright source about 1/4-inch (6 mm) in diameter and at an indeterminate distance. The lighted LED can be seen under ordinary ambient lighting conditions.

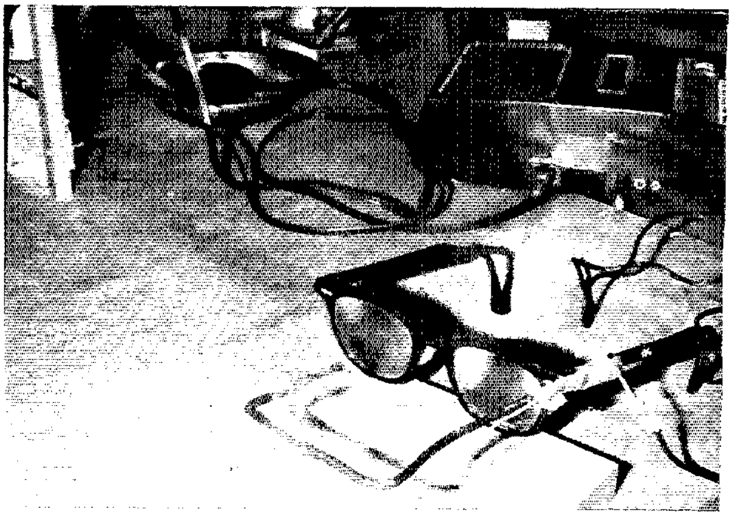
Additional Thoughts

So much for mechanical construction of the basic spectacle mount to hold the LED. Now for some general comments on LEDs as they apply to the cw flasher. For this application, it was found that a red jumbo unit was the most satisfactory of a number of LEDs tested. Other colors, however, may be more satisfactory for certain people. But this again requires a bit of trial and error by the individual builder.

Available in a variety of shapes and sizes, LEDs are generally driven by a dc source, with 20 to 50 mA current required. Depending upon the cw signal-source voltage, it will again be up to the user to determine what value of series resistor to use with the LED to keep the driving signal close to 3 volts or less. As a precaution, the author used a small Zener diode (1/4 watt, 3.5 volts) across the LED terminals to minimize possible damage by minor voltage spikes in the cw-producing signal.

Signal Sources

For cw practice, Fig. 2 shows the circuit designed by the author for use with a HAL DKB-2010 dual-mode keyer/keyboard. This keyer generates near-perfect signals, making it ideal for code practice. Actually, almost any cw oscillator, tape cassette or receiver could be utilized. Also, the author has used his Drake R-4C receiver for the signal source. The LED flasher was connected directly



This photo gives the prospective constructor an idea of how the flasher is mounted to the glasses.

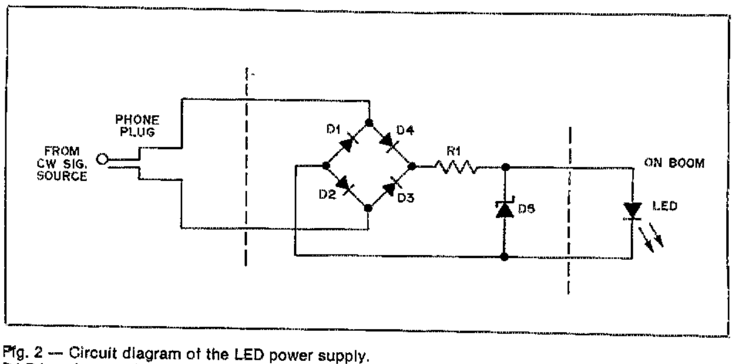


Fig. 2 — Circuit diagram of the LED power supply.
D1-D4 — Any small-signal diode.
D5 — 3.5-V, 1/4-watt Zener diode.
R1 — 10 to 300 ohms, 1/4 watt (see formula below).

A simple formula for determining the value of the series resistor R1 is

$$R1 = \frac{V_{source} - V_{LED}}{I_{LED}}$$

where: V_{source} = ac voltage measured at signal source.

V_{LED} = rated LED forward peak voltage.

I_{LED} = rated LED forward current in amperes.

to the headphone jack.

Another reason for using the headphone jack on the author's R-4C may be a bit humorous to some readers. To the XYL or other passive listeners exposed to hours of annoying (to them) chirps and clicks, the resulting silence of using the headphone jack which mutes the speaker is most welcome. Probably most hard-of-hearing enthusiasts are rarely aware of the severe annoyance to others that they create with close to full audio gain for either LED flashes or vibratory cw-reception methods. The deaf operator may be forgiven — as was the author — by his non-cw-oriented friends. But often, unless muted by some means, this crashing code could ultimately become the objective of, at least, unwished-for mayhem!

The red jumbo LED finally used in this system has a maximum forward drop of about 3 volts. A typical value of forward current for a light-emitting diode is 50 mA, or 0.05 A. Assuming the source voltage is 10 volts, then the theoretical value for R_s is

$$R_s = \frac{10 - 3}{0.05} = \frac{7}{0.05} = 140 \text{ ohms}$$

If the calculated value of the series resistor is not available, one can readily substitute the next closest value, plus or minus 20 percent or so. Actually the value of R_s used by the builder will depend entirely on the cw signal-source voltage and so may vary from about 10 ohms to 300 ohms.

With the author's DBK-2010, a 20-ohm resistor was used. The jumbo LED used with this signal source has lasted for over eight months. If one drops much below 20 ohms for the HAL keyer, the LED will show a much brighter dot symbol. This is quite desirable, but the LED life is shortened considerably.

If the circuit shown in Fig. 2 is used between the cw signal source and LED, the likelihood of a damaged LED is further reduced because of the additional small voltage drop in the bridge rectifier. Four HEP-154s or equivalent rectifier diodes would be quite satisfactory, although the author used four small diodes of unknown value salvaged from the components of a surplus board. The reader will note that a series resistor and a low-voltage Zener are shown. This joint provision (series resistor and Zener) in the final circuitry was probably a bit of unnecessary sophistication. The Zener alone is all that is actually necessary. An occasional signal voltage spike might destroy an LED protected only by the series resistor. As was mentioned previously, the signal source from most units that the operator may use will be a small ac voltage, generally on the order of 10 volts or less.

The potential user of this device might as well face it at the beginning: Each cw signal source will be somewhat unique in output voltage value and impedance. There are about as many signal sources (receivers, transceivers, oscillators, keyers and cassettes) as there are operators. Fortunately, LEDs are quite inexpensive so one can have a bit of fun while experimenting.

The author would be remiss in not giving much of the credit for the novelty of this device to his mentor, technical helper and patient adviser, W6MNO. It was he who initially suggested the LED application trials for faster cw learning as well as routine use by the deaf operator. Success in amateur radio by deaf and blind operators is due largely to amateurs with the same spirit shown by Chuck in helping and encouraging those of us who are handicapped and by pushing us into a challenging source of much satisfaction — ham radio. Others do care! Good luck and happy experimenting to those of you who might try to build this gimmick. QST

Feedback

☐ With reference to the WA2FIJ modification of the "PEP Wattmeter — a la Heath" (Hints and Kinks, *QST* for July, 1977), R1 will effectively control the positive output if pin 7 of the positive IC regulator (type 723) is connected to ground. — *K5HHE*

☐ In "Full Break-In and RIT for the HW-8 QRP Transceiver" (*QST* for July, 1977), author K6TG advises that he left the decimal out of R104 in Figs. 4 and 5. The correct value of R104, 4.7k ohms, will increase the RIT frequency spread to about 5 kHz on each side of the zero mark.

☐ The article, "Public Service Begins with You" (*QST* for January), stated that names of amateurs who assist during emergencies or in public service capacities must be listed in *QST* before a Public Service Certificate can be issued. In fact, the only prerequisite is an article or mention of the event in *QST*.

☐ The call sign of Wade Mitchell, father of 5-year-old Novice Guy Mitchell, should be WDØCFW (*QST* for November, page 79).

☐ There was a mix-up with the photo caption on page 54, *QST* for November. W6BWM appears at left, not K6SKA. Let's face it — W1RU blew it! — *W1RU*

☐ In "Crystals Inside Out" (January, 1978, *QST*), an error appears on page 28. With reference to Fig. 2 on page 29, the text states that "in both of these circuits the energy that is fed back through C . . ." keeps the grid circuit oscillating. The "C" value should be indicated in Fig. 2 as being the interelectrode capacitance between the grid and plate of the tube, not the capacitor shown. In both circuits, the capacitor shown as C functions as a bypass capacitor, preventing any rf energy generated by the oscillator from entering the power supply through the B+ line.

In Fig. 4, page 29, the vibration modes shown as "longitudinal and shear" should be more accurately stated as "longitudinal *flexure* and shear.'

The final transmit frequency in Table 1, page 32, should have read 146.34 MHz, not 46.34 MHz.

Strays

SILVER JUBILEE AWARD OFFERED

☐ To celebrate the Silver Jubilee of Queen Elizabeth II, the Greater Manchester County Council is sponsoring a special award for contacting amateurs in the newly formed county. To qualify, licensed amateurs outside the British Isles must contact 25 county residents. The 250 to 300 amateurs who reside there will add "in the county of Greater Manchester" to their call signs. Any band and any mode may be used, except land-based repeaters. A special award will be issued for five contacts through OSCAR. No QSLs are required, but a duplicate copy of the log, certified by a radio club or two amateurs, must be submitted. The fee for the award is three IRCs. Deadline for submitting applications is June 30, 1978. Write Don Aitchison, G3BSA, 28 Avondale Dr., Astley, Tyldesley, Manchester, M29 7ES, England.

SHORTEST CALL

☐ From among the proliferation of new two-letter calls has come the shortest in the U.S. — N5EE. It's held by Fredrick Walworth, ex-K5CK, of Dallas, TX. In fact, a check of the *callbook* shows that it ties with EI5I for the world's shortest call, with both being a mere 25 bauds in length.

W1AW GETS OUT

☐ The regular listening audience of Hq. station W1AW has grown noticeably during the first year that the new antenna system from the estate of Ralph Thetreau, W8FX, has been in operation. In fact, not only are "locals" tuning in, but people in some rather distant locations. Among the participants in the Code Proficiency program is Bill Norris, VK2WN, who qualified for his 25 wpm endorsement over a distance of 11,000 miles.

Calculating Capacitor Values

There's nothing mysterious about the proper values for blocking and bypass capacitors in rf circuits. These simple guidelines can help the homemade-equipment designer.

By Doug DeMaw,* W1FB

In response to a number of inquiries concerning correct values for blocking and bypass capacitors, we offer this information for your use. We have attempted to simplify the procedure in this presentation by providing a rule-of-thumb approach to capacitor type and value determination.

Our first example is the plate blocking capacitor of a typical rf power amplifier (Fig. 1). We will presume that the amplifier is for the bands from 3.5 to 29.7 MHz. Blocking capacitor C1 should be selected for the lowest operating frequency, which is 3.5 MHz. In an ideal circuit the reactance of C1 would be negligible or nonexistent in order to prevent a mismatch and subsequent power loss in the circuit. However, a slight reactance presented by C1 could be tuned out by adjustment of C3 and L1. This would lead to a small change in tank-circuit Q_L (loaded Q) which could be ignored for the most part. However, since a properly designed pi network is intended to transform the plate impedance to the load impedance (4000 to 50 ohms in this example) at a specified Q (12 to 15, typically) it is desirable to select a C1 value that does not require the pi network to compensate for unwanted reactance.

A practical guideline is to allow the reactance of C1 to be 1/100 of the plate impedance of the amplifier tube. In Fig. 1 we have specified 1 kW of dc input power. An efficiency of 60 percent is common for a Class B or Class AB2 linear amplifier, so we can assume that approximately 600 W will be present at C1 and the pi network. With a plate voltage of 2000 and a plate current of 500 mA, our plate impedance is 4000 ohms. Therefore, $X_{C1} = 0.01 \times 4000$, or 40. To obtain from this number the value of C1 in µF:

*ARRL Senior Technical Editor

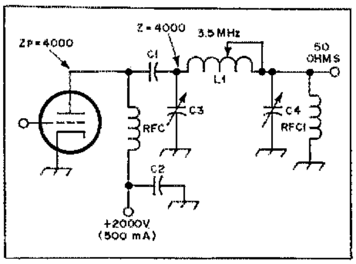
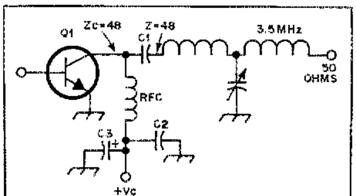


Fig. 1 — Tube amplifier used as an example for calculating C1 and C2 values (see text).



$$Z_C = \frac{V_C^2}{2P_O} \text{ and}$$

$$C1 = \frac{1}{\pi f X_{C1}} = 0.095\ \mu F$$

Fig. 2 — Circuit example related to determination of C1, C2 and C3 values. $X_{C1} = 0.01 Z_C$.

$$C1 = \frac{1}{2\pi f X_{C1}} = \frac{1}{6.28 \times 3.5 \times 40} = 0.0011\ \mu F \quad \text{(Eq. 1)}$$

where f = MHz and X = ohms.

In this case a 0.001-µF capacitor will be entirely suitable, permitting the use of a standard value. The voltage rating of C1 should be $2V_p$ or 8000 V. This will allow adequate safety margin for the dc path through the pi network, then to ground via RFC1. We need not be too concerned about the rf-voltage rating because the impedance at each end of the capacitor is the same — 4000 ohms, assuming that the pi network is designed correctly. Therefore, the matter of rf-voltage drop across the capacitor is a minor one provided the pi network is not grossly misadjusted while full power is applied. The Q of the capacitor should be high at the operating frequency, and it should be noninductive in nature. A ceramic capacitor satisfies the requirement.

A final consideration remains: ability of the capacitor to pass the rf current without overheating (which can cause a change in capacitance value or destruction of the component). Because we are using C1 at a fairly high impedance point in the circuit, the current passing through it will be relatively low. This can be determined by

$$I_{rf} = \frac{W}{Z_p} = \frac{600}{4000} = 0.39\ A \quad \text{(Eq. 2)}$$

where I = current in amperes, Z_p = plate impedance, and W = watts.

If the same capacitor were used at a 50-ohm point in the circuit, we would have considerably more rf current to deal with (3.46 A) and heating would occur if we used a physically small ceramic capacitor. It would become necessary to place several capacitors in parallel in order to distribute the current among them, reducing the heating in any one capacitor of the combination. The 600-W power figure used in Eq. 2 was derived from the 60-percent efficiency we assumed for the amplifier.

Fig. 2 illustrates the principle we are discussing, but as applied to a solid-state amplifier.

Bypass Capacitors

Plate bypass capacitors should have a

very low reactance at the lowest operating frequency if they are to be effective in creating an ac ground. We are not as concerned about C2 being ideal for rf applications as we are in the case of C1. Therefore, it is less difficult to locate a capacitor with high C and adequate voltage rating for our bypassing job. Conversely, a high-C plate blocking capacitor with a suitable dc-voltage rating and a high Q might be expensive, or even impossible to purchase from ordinary amateur supply stores.

In view of the foregoing it is practical to use a factor of one for X_{C2} of Fig. 1. We can assume a theoretical B+ bus impedance of zero, although in practice this is seldom true. If such a condition did exist, we would have no need for a bypass capacitor. To calculate the value of C2

$$C2 = \frac{1}{1(2\pi f)} = \frac{1}{1 \times 6.28 \times 3.5} = 0.045\ \mu F \qquad \text{(Eq. 3)}$$

where f = frequency in MHz. The voltage rating of C2 should again be $2V_p$, or 8000 volts. A ceramic or mica capacitor will be suitable for use at C2.

Another Consideration

At Fig. 2 we have a solid-state rf amplifier. It is commmon practice to bypass the collector circuit at low frequencies as well as at rf. This is because transistors tend to self-oscillate at low frequencies because of the extreme gain they exhibit in that part of the spectrum. C2 is chosen in accordance with Eq. 3, but C3 requires a much larger value. We should make it effective at, say, 1000 Hz and higher. Once more we will assume a reactance factor of 1, and the value for C3 will be determined by

$$C3 = \frac{10^6}{1(2\pi f)} = \frac{10^6}{1 \times 6.28 \times 1000} = 159\ \mu F \qquad \text{(Eq. 4)}$$

where f = hertz. A third bypass capacitor is used frequently at the point where C2 and C3 of Fig. 2 are joined. It is smaller in value than C2, and is intended as a vhf/uhf bypass element. It helps prevent unwanted self-oscillation above the hf range, and is calculated in accordance with Eq. 3. C2 and C3 not only provide an ac ground for Q1, but discourage rf currents from flowing along the collector-supply bus to other stages in the circuit. This helps prevent feedback which could cause unstable operation. C3 can be the nearest standard capacitor value — 150 µF, at twice the supply voltage potential.

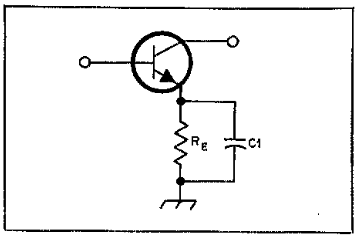


Fig. 3 — Circuit showing emitter bypassing (see text).

If a 12-volt collector supply is used, C3 should have a 25-volt rating (dc).

Emitter or Cathode Bypassing

Fig. 3 shows a typical transistor emitter circuit. The value for C1 can be determined by

$$C1 = \frac{10^6}{2\pi f R_E} = \frac{10^6}{6.28 \times 300 \times 470} = 1.1\ \mu F \qquad \text{(Eq.5)}$$

where R_E = emitter bias-resistor ohmage and f = lowest frequency in Hz.

A 1-µF capacitor will suffice as the nearest standard value. Here we have effectively bypassed the emitter resistor at 300 Hz, providing maximum stage gain above that frequency. Gain below 300 Hz will fall off markedly. It can be seen from this that the lower the operating frequency, the larger the value of C1. The same principle applies for cathode-resistor bypassing.

For determining the value of an emitter or cathode bypass capacitor at rf, say, 3.5 MHz:

$$C1 = \frac{1}{2\pi f R_E} = \frac{1}{6.28 \times 3.5 \times 10} = 0.0045\ \mu F \qquad \text{(Eq. 6)}$$

where f is in MHz and R_e is in ohms. In this equation we have specified a 10-ohm emitter resistor. The voltage rating of the emitter or cathode bypass capacitor should be twice the developed dc voltage across R_E. For audio amplifiers an electrolytic or tantalum capacitor can be used for C1. A ceramic capacitor is recommended for rf bypassing work.

Strays

A NOVICE AT 79

☐ Earning a Novice license was an extra-special achievement for Red Dozier, WD4JDL, of Wake, VA. At age 79, he is nearly blind and had to convert from American Morse code to international Morse for his first amateur license. During the 1920s, Red worked as a telegraph operator for Western Union in Norfolk. The experience has paid off, as he can now receive code at speeds up to 30 wpm. In fact, he wants to arrange high-speed contacts, particularly with other old-time telegraph operators. Contact him at Box 14, Wake, VA 23176. — *Len Dozier, Jr., WB8ZFI*

Once a Western Union telegrapher, 79-year-old Red Dozier oprates his first amateur station from his home on the Rappahannock River near Urbanna, VA.

FLAMINGO NET COMMEMORATIVE

☐ In celebration of its 25th anniversary, the Flamingo Net of Miami, FL, offers a special seal for attachment to the net certificate. Present certificate holders qualify by working 10 other certificate holders, while all others must work 20 holders. All contacts must be on 10 meters during calendar year 1978. Log the certificate number, call sign, name and location. Send the application, with $1 for handling, to Walt Dixon, W4DWN, 820 N. E. 123rd St., Miami, FL 33161.

SPRECHEN SIE DEUTSCH?

☐ Dale Lally, WØOWF, director of the Arts & Sciences Learning Lab at the University of Louisville, is involved in an unusual on-the-air experiment. He meets with Ed Richmond, W4MGN, of Georgia Tech, at noon Wednesdays (Eastern Time) on 7235 kHz so that students of both universities can practice German. Amateurs conversant in German, French or Spanish are invited to check in to the gathering. If the enthusiasm of the students (and the amateurs!) continues to run high, more languages will be added. Inquiries should be sent to Dale at the Arts & Sciences Learning Lab, University of Louisville, Louisville, KY 40208. — *WA6IDN*

Product Review

Cushcraft 2-Meter Collinear Array

Is this antenna really new? Is it different? Well, the truth of the matter is that the DX-144 and its DXK-140 stacking kit have been Cushcraft products for a few years. That doesn't qualify them as new, but because of the rekindled interest in 2-meter DX types of antennas, it seemed worth testing the system and reporting the results in *QST*. Now that more and more "import" boxes are being sold in the USA as all-mode 2-meter transceivers, activity on the "low end" of 144 MHz has increased notably. The cw and ssb modes are so popular in specific regions that some long-term operators are heard complaining about the QRM!

The DX-144 basic package consists of two 20-element, collinear bays. Each is a conventional 16-element collinear, as many of us knew it in bygone times. But a parasitic director has been added in front of each driven element to provide 20 elements. The DXK-140 stacking kit contains the cable harness, vertical tubing supports (two each), rugged horizontal bars (two each), matching transformer and all necessary assembly hardware. All the buyer needs is a tower, rotator, feed line and some elbow grease.

Assembly was a backyard project which took two evenings (approximately six hours). The putting together could have been cut by an hour had the writer not coated each of the nuts and bolts with GE Silastic compound. Cushcraft supplied cadmium-plated iron nuts and bolts, and rather than have the antenna become a "rustcraft" type later on, it seemed prudent to encapsulate the hardware at the offset. Previous experience with Silastic has proved that it remains intact for several years.

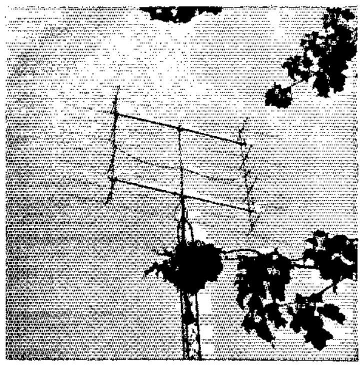
The written instructions which are supplied with the antenna system are somewhat vague in spots. This caused a small slowdown in assembly at the beginning, as there were some parts that weren't shown in the data sheets. However, a bit of common sense can be applied to solve minor problems of that variety! The quality of the materials is excellent. The aluminum tubing is very sturdy, and the antenna elements are made from solid aluminum rod. Each insulator is made from solid polystyrene rod, except for the phasing-line spacers (four each), which appear to be made of Bakelite or similar material. Without some additional protection, however, the plated iron bolts, nuts and U clamps would be subject to rust from salt air and pollutants found in most metropolitan areas.

Each bay of the array was adjusted for an SWR of 1:1 by pointing the antenna skyward while it was four feet above ground. Bringing the SWR down to a 1:1 level was a simple matter of setting the transmitter on 144.1 MHz and spreading or compressing the adjustable fitting across the phasing lines at the point where the harness is connected (see photograph). The SWR was checked at 146 MHz after being optimized at 144.1 MHz. The reading on a Bird wattmeter was 1.3:1, indicating the excellent bandwidth of collinear antennas.

Installation was a two-man job. The array took one hour to affix at the top of the 50-foot, unguyed tower. Owing to the weight of the composite array (fairly heavy) a Ham-II rotator is being used.

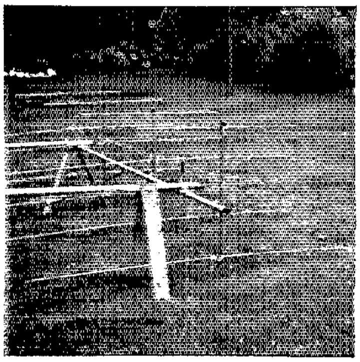
From a less-than-ideal vhf location in Newington, performance has been good. The effective daily communications range (cw and ssb) with 10 watts of power output is approximately 125 miles (200 km). A power amplifier would serve nicely as an "equalizer," because many signals are heard which can't be worked in solid fashion. Such stations are without exception using 100 watts or more of power output.

A 40-element array of this type should have a theoretical gain of approximately 17 dB, although in practice it may depart from that number slightly. The ARRL has no test range with which to verify the gain or radiation pattern of any antenna. In practice, the DX-144

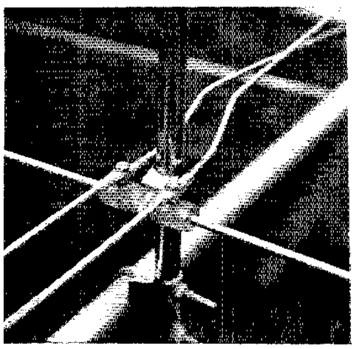


The DX-144 collinear array is shown in place atop the 50-foot tower at W1FB.

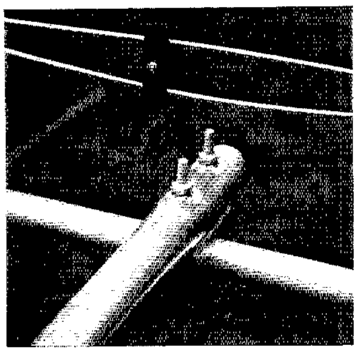
One 20-element bay of the antenna shown on the assembly stands prior to erection.



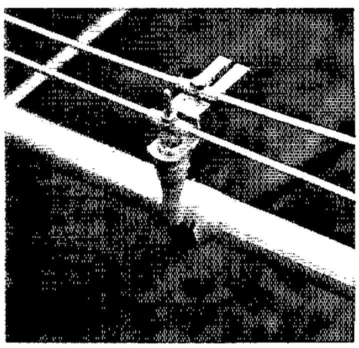
View of one of the insulators and the phasing bars.



View of one end of the rugged H frame from the DXK-140 stacking kit. These bolts and all others in the system have been coated with GE Silastic compound to prevent rusting.



The adjustable U slot for obtaining an SWR of 1:1 is shown here. At this point in the system the phasing lines are moved together or apart until a 50-ohm match is secured.



has a very sharp discrete frontal lobe, with a rather broad overall major lobe. The front-to-back ratio over a fairly stable 25-mile (40-km) path (measured with a Tektronix step attenuator) checked out at 28 dB. This side nulls weren't measured, but were quite deep.

During the ARRL VHF QSO Party of September, 1977, and under casual operating conditions, W1FB worked 18 ARRL sections, 12 states and 85 QSOs. Transmitter power output was 10 watts. W8IDU (Michigan) and VE1ASJ were worked by means of aurora during the contest. It is worth adding that the operating site is boxed in by small mountains to the south, west and north!

The total system is in the $150 price class. The manufacturer is Cushcraft Corporation, Box 4680, Manchester, NH 03108. — *W1FB*

VHF ENGINEERING SYNTHESIZER II

"W1NJM and WA1JHZ, move to WR1AZZ to pass the 25 through messages."

"Sorry, I don't have that pair in my rig."

"How about 'AZY?"

"Sorry, no crystals for that repeater either."

Stocking up on crystals does have its limitations with today's rate of repeater growth unless you have a large interest in crystal companies' stocks. On the other hand, acquiring a fully synthesized rig might require hocking the cat as well as the kids. Besides, you just don't want to part with your faithful rig, do you?

VHF Engineering has produced a kit that gives a feasible alternative — their Synthesizer II. It is a unit that is compatible with virtually any 2-meter fm equipment normally using crystals. Direct-reading thumbwheel switches select any multiple of 5 kHz across the entire band. Not only are the standard plus-and-minus 600-kHz transmitter offsets available, but the user may program up to three more offsets of his choice.

Circuitry

Only one crystal and TTL ICs are used to derive a 6-, 8- or 12-MHz output for the transmitter. On receive, 15 MHz is produced. Among the unique features of the circuit is a provision, by diode programming, to adapt it to any receiverr i-f between 100 kHz and 30 MHz. For example, Standard uses 11.7 MHz in their radios instead of the usual 10.7 MHz. Similarly, diode programming of the divide-by-N counter allows transmitter offsets in any increment of 100 kHz. In the New York City area, for instance, 1-MHz splits ae supplementing the 600-kHz-split repeaters.

Any power supply voltage from 10 to 18 volts may be applied to the synthesizer. It is preregulated to +9 volts by a 2N6576 while an LM309K provides a regulated 5 volts for all logic circuitry. At 12.5 volts, the unit draws about 750 mA.

Construction and Interface

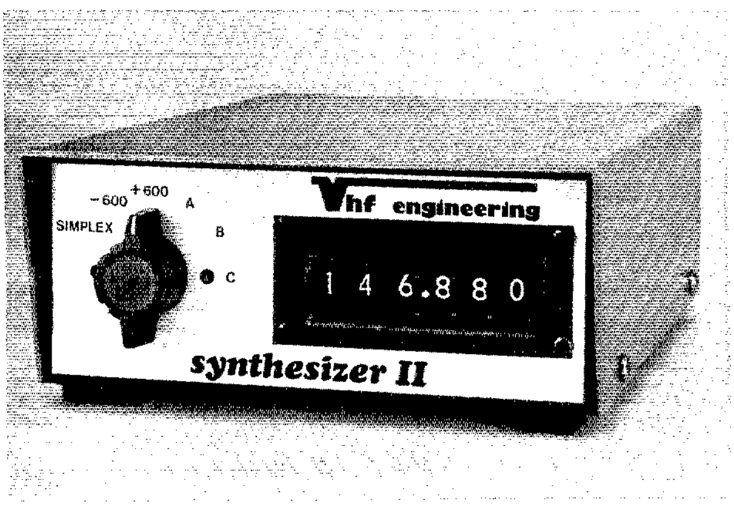
Most components are mounted on a double-sided drilled and plated-through pc board. Since that single board has more than 700 solder connections, the kit builder would be well advised to review the instructions thoroughly. Sockets might also be considered for the 20 ICs that go on the board. Indeed, a soldering error did creep in during one late-night session. Bad readings on the VCO led to finding tranposed 1-kΩ and 10-kΩ resistors. The mistake was corrected with the aid of the troubleshooting guide and, fortunately, the synthesizer was most forgiving. All the instructions are straightforward. Priority and careful attention should be given to the VCO coil. Because of its location in a corner, it should be assembled and mounted first. Both voltage regulators are mounted on the back of the anodized aluminum chassis. They should be securely seated because of their heat dissipation requirements.

Tune-up was very easy. Only a VTVM and frequency counter are required during initial tuning. Further adjustments are made on the receiver output filter when it is mated to the receiver input. For complete interface between the Synthesizer II and a transceiver, four leads are required — two 50-ohm leads, a PTT lead, a 12-volt lead, and ground return. Matching networks are constructed at the crystal sockets to compensate for the high-impedance inputs. This consists of a 47- or 51-ohm resistor to ground and a 0.001-μF capacitor in series. On transmit a resistor is also placed in series to limit the drive. With an HR-2B, for example, a 100-ohm resistor was required. Such phase-modulated rigs do not need any more modification. If a direct-fm type is used, however, the transmitter modulation must be applied directly to the synthesizer. Details of that are given in the manual.

The Synthesizer II approximates an average transceiver in size, so consideration might be given to placing the transceiver in a remote location for a mobile installation if space is at a premium. Using RG-174/U, the 50-ohm cables can run up to 30 feet without serious loss.

The unit measures 2-1/4 × 5-1/2 × 8 inches (57 × 140 × 203 mm), and weighs about 1-1/2 pounds (0.68 kg). The Synthesizer II may be obtained from dealers or directly from VHF Engineering, 320 Water St., P. O. Box 1921, Binghamton, NY 13902. Price class for the kit is $170, or $240 for a wired and tested unit. — *KH6HQG*

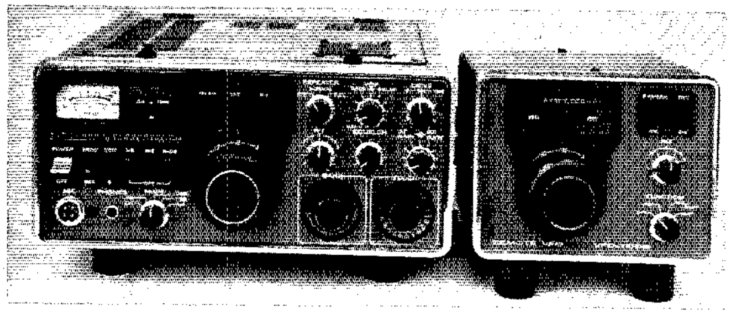
The Synthesizer II makes a neat package. The switch at the left selects the various outputs required for standard and nonstandard transmitter offsets.



TRIO-KENWOOD TS-700S 2-METER TRANSCEIVER

Notable among the more prominent changes in character, the latest version of Kenwood's a-m, ssb, cw and fm box, the TS-700S, is the digital frequency counter and display. Bright, easy-to-read blue LEDs post the approximate operating frequency plainly at the upper center of the front panel. The word "approximate" is used in the preceding sentence because the local-oscillator frequency is sampled by the counter instead of collective sampling of the BFO, local oscillator and heterodyne oscillator. (The latter scheme is used in the TS-520S and TS-820S hf-band transceivers.) Despite this change in format, frequency readout is entirely suitable in terms of accuracy. Observations show that a minor display offset exists in the fm part of the band when the TS-700S is set for the fm mode; the display indication is lower than the actual frequency. This reviewer has not checked the readout accuracy for ssb and cw operation, but for all practical purposes it is close enough to being *on the nose* for serious weak-signal work on 144 MHz. It is probably as accurate, or more so, than many receiver-converter combinations in use by 2-meter DXers. The fine-frequency analog readout has been disposed of in the TS-700S. This could present a problem if ever the digital display ceased to operate. The 100-kHz, coarse-frequency analog marks have been retained, however. No spurious signals from the counter circuitry have been observed during transmit or receive. Frequency stability of the TS-700S is excellent.

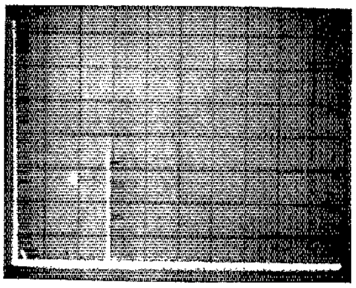
A major complaint among TS-700A users was inadequate receiver sensitivity (overall gain). Most owners of the early model bought or built preamplifiers and installed them at the receiver front end. The new model TS-700S contains an additional preamplifier which can be switched in from the front panel. Measured gain of this selectable preamp was between 6 and 7 dB for both units tested at ARRL. Kenwood informs us that the transistors used in the extra preamp are graded out before installation to ensure a noise figure of 2 dB. Although the actual receiver noise figure has not been checked in the ARRL laboratory, on-the-air in-



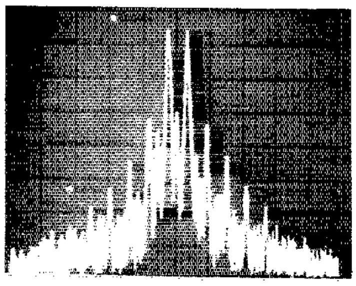
What's new in this classy-looking gray box? How do the "works" differ from those of the earlier version, Kenwood's TS-700A? Both are fair questions for the prospective buyer and are answered in this review, which begins where the TS-700A review ended when it appeared in *QST* for March, 1976.

Kenwood TS-700-S 2-M Transceiver

Dimensions (HWD) and weight: 5-3/8 × 11-1/2 × 15 inches (137 × 292 × 391 mm), 23 pounds (10.5 kg).
Power requirements: 117/220 V ac, 95 W; or 12 to 16 V dc at 4 A (transmit).
Frequency range: 144 to 148 MHz, a-m, fm, cw and ssb.
Power output: 1 watt or 10 watts, minimum (3 W a-m).
Receiver i-f bandwidth: 12 kHz for fm and 2.4 kHz for other modes.
FM transmitter deviation: ±5 kHz.
Price clas: $700.
Manufacturer: Trio-Kenwood Communications, Inc., 1111 West Walnut, Compton, CA 90220.



Spectrum-analyzer display of the TS-700S transmitter output. The vertical line near the left is the carrier. It actually reaches to full scale, but has been suppressed by means of cavity filters to prevent overloading of the analyzer front end. The vertical scale is 10 dB per division and the horizontal scale is 50 MHz per division. Measurements made at 10 watts output.



Spectral display of the transmitter. The horizontal scale is 2 kHz per division, and 10 dB per division for the vertical scale. Third- and fifth-order IMD products down approximately 32 dB.

dications are that the receiver does indeed have a very low noise figure.

The dynamic range of the receiver seems to be very good, even when strong local signals are close to the operating frequency. As is the case with most receivers which have a noise blanker, some degradation of the receiver dynamic range occurs when the blanker is actuated. This effect is not observed unless the interfering nearby signals are very strong, indicated as 25 dB or more over S9. A strong signal entering the receiver when the blanker is turned on tends to sound distorted when the receiver is tuned to the frequency of the loud signal, a fairly common trait of a blanker. However, the TS-700S blanker is perhaps the most effective one for its purpose that this reviewer has operated. At W1FB there are times when local power leaks deflect the S meter to 10 dB over S9. The noise can't be heard when the blanker is actuated, and the meter reading drops to less than S1!

Cw and ssb operators should be especially interested to know that semi-break-in delay and VOX have been added to the new model. A side-tone oscillator has been added, also. The VOX controls are located on the front panel of the rig for convenience of adjustment.

The TS-700S has a low- and high-power switch on the front panel. The instruction booklet specifies that the low-power mode (approximately 1 watt) should be used only on fm, as distortion may result when low power is employed during ssb transmissions. Several checks were made to verify this, but in all cases the ssb signal was reported to be very "clean."

A spectral analysis of the transmitter output brought startling results. The accompanying spectral photographs show that the two-tone transmitter IMD products are approximately 33 dB below peak carrier value. But of even greater interest is the reduction of harmonics and spurs. All unwanted energy is —75 dB or greater from the fundamental value! This is by far the cleanest spectral characteristic seen for commercial vhf equipment by ARRL laboratory personnel. It more than conforms to the recent FCC requirement that spurious output must be —60 dB or greater at this operating frequency. A two-resonator, high-Q band-pass filter is used at the transmitter output. No doubt this greatly aids the reduction of spurious output energy. This filter is switched into the receiver front end during the receive mode — a very clever engineering trick!

One feature that is worthy of mention is that the cw mode is operated on lower sideband, while ssb on 2 meters is normally carried out on the upper sideband. This presents a slight inconvenience to the operator who, under weak-signal ssb conditions, decides to switch to cw for better readability. The change in modes requires that the receiver be retuned, which could under very adverse conditions result in losing the station being worked. Perhaps future models of the TS-700 will have the cw mode changed to the upper sideband position, or mayhap a modification kit could be offered to those desiring it at a nominal cost.

On-the-air use of the transceiver has been enjoyable and satisfactory. Numerous contacts have been made, including cw DX near 144.1 MHz. Audio-quality reports on fm and ssb have been excellent. The cw note is hum- and chirp-free, but nearly 2-meter amateurs report a slight click on the cw note. The keying is a bit on the "hard" side with both the TS-700A and TS-700S models. It should be an easy matter to add some shaping to the keying circuit.

It is this writer's opinion that the TS-700S *is* an excellent buy for the price being asked. Anyone who is interested in DX work on 2 meters should enjoy owning this equipment. If fm is part of the vhf operating routine, the flexibility of frequency selection with continuous band coverage for fm repeaters and simplex should be an appealing feature.

An external VFO, the VFO-700S, is available as an accessory. This unit was tested with the TS-700S and proved to be stable and reliable. It is a handy device when the operator wishes to keep the transceiver on a specific frequency, but wants to monitor or operate in some other part of the band. In areas where there is considerable activity near 144 and 145 MHz, the VFO is a useful item, especially during vhf contests. — *W1FB*

TOLTEC WIRE-WRAPPING SUPPLIES

Let's say you're wanting to build a project which uses a couple of dozen integrated circuits and a handful of other parts. There is no circuit-board etching pattern available, and anyway you may want to experiment with the circuit a bit to improve its operation. How do you go about wiring it up? Soldering point-to-point lengths of wire is one way, sure. Would you consider wire wrapping? As the saying goes, try it, you'll like it! Wire-wrap techniques permit placing several conductors at one pin of an IC with no pain, no strain, no solder. And if you decide to move or remove a conductor later, unwrapping the wires is not difficult. A tool for wrapping by hand and a separate unwrapping tool are not expensive. Or for "the person who has everything," electric wrapping tools are available.

The problem for the amateur, though, is where to buy the wire. Of course you can purchase a spool of no. 28 or smaller solid-copper, tinned, plastic-covered hookup wire, and you can cut and strip each length as you need it. That gets a bit tedious, though. Besides, hookup wire is rather brittle and usually doesn't take kindly to more than one or two wrap and unwrap jobs. A different alloy of wire is commonly used for production wire-wrap runs, and precut, prestripped lengths are available — *in quantity*. Still not much help for *the* amateur wanting to purchase small amounts!

Here's where Toltec Corp. comes in. Now, to aid those amateurs wanting to do modest amounts of wire wrapping, Toltec offers a wire kit. At a price class of $44 you get 2300 lengths of wire ranging from 1.5 inches (38 mm) to 11.25 inches (2867 mm). Each length is packaged separately with 100 wires per package (200 for commonly used lengths), 14 packages in all. Both ends of each wire are stripped of 1 inch of its green Kynar insulation, the correct amount for a proper wire wrap. The wire itself is no. 30, solid, silver plated. If you prefer, this wire may be purchased from Toltec in 100- or 1000-ft spools. Toltec also offers hand- and electric-operated wrap tools and an unwrap tool. That's Toltec Corp., 21342 Washington, N.E., Albuquerque, NM 87110. Try it; you *will* like it! — *K1TD*

THE 5534 OP AMP

The 5534 is a recently introduced high-performance general-purpose operational amplifier. It is a plug-in replacement for 741 types in many applications and offers greatly improved specifications. The slew rate is 13 V/μs and the power bandwidth is 200 kHz. Capable of directly driving 600 ohms with 10 V rms, this device promises a reduced parts count in new designs. An additional feature of the 5534 is low noise, with an audio noise figure of about 1 dB. The op amp is internally frequency compensated for closed-loop gain greater than three. An external compensating capacitor may be used for unity gain and other special conditions such as capacitive loading. The high slew rate of the 5534 means reduced IMD. This feature, combined with the low noise figure, makes this op amp particularly attractive for use as the principal gain block in a direct-conversion receiver. Speech processing is another application that could benefit from an improved op amp such as the 5534. The device is available in a mini-DIP (suffix N) or TO5 package. The single-quantity price class is $3. Manufacturer: Signetics Corp. — *W1RN*

THE SSM 2020 COMPANDER AND 2040 VOLTAGE-CONTROLLED FILTER

The SSM-2020, from Solid State Music, Inc., is a low-noise, wide-dynamic-range amplifier designed for electronic musical instruments. The device functions as a two-quadrant, transconductance multiplier. Gain control is achieved by employing the 2020 as a variable feedback element in an op-amp circuit. The 2020, when used this way, is capable of lower distortion over a wider dynamic range than simple JFET voltage-controlled resistors. This device appears to have numerous potential applications to ham radio, particularly in direct-conversion receivers. For example, in conjunction with good op amps and rectifier and time-constant circuitry, the two sections can be used together to achieve 120 dB of agc range, a feature not usually found in direct-conversion receivers. As a compander, the 2020 should provide very predictable performance in speech processors, possibly at a reduction in parts count over some existing designs. The SSM-2020 comes in a 16-pin, dual-in-line package.

Also from Solid State Music, the SSM-2040 is a four-section, filter control element whose cutoff frequency can be exponentially voltage controlled over a wide range. This device can be used as a building block in virtually any type of active filter. The flexibility of the chip is somewhat limited, however, in that pin-out constraints dictate a single control input, thereby precluding independent control of the four poles. This one objection notwithstanding, amateurs should find the SSM-2040 worthy of consideration for use in new equipment designs. The data sheet features several applications with simple design equations and values of essential parameters in "cookbook" form.

Price class of the SSM-2020 is $8 in single-lot quantities. Data sheets are available from the manufacturer, Solid State Music, Inc., 2102A Walsh Ave., Santa Clara, CA 95050. — *W1RN*

Strays

PR PAYS

☐ With a little advance planning, your club can do what the Pennroyal Amateur Radio Society, Hopkinsville, KY, did recently. Provided with advice and materials by the ARRL Club and Training Department, club members spoke at civic clubs, showed "Moving Up to Amateur Radio," convinced local radio stations to air the Dick Van Dyke public service announcements, and held a very successful display at a local shopping mall. In addition, a detailed and favorable article on amateur radio featuring K4DMW was published in the local newspaper. In all, a worthwhile effort that caused a good number of people to look twice at amateur radio and its benefits to the community.

Tom Westerfield, WA4ZVL, operates the portable club station at a shopping mall during the Pennroyal ARS' week-long effort to attract attention to amateur radio.

I would like to get in touch with . . .

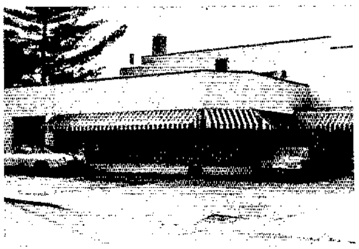
☐ other amateurs who live in remotely located, unusual structures (such as geodesic domes and yurts) and who would like to establish contests or awards for QRPp contacts. Hunt Turner, KØHT, Box 101, Berthoud, CO 80513.

☐ Navy Chief Frank Beldon, John Gibson and others from the Treasure Island Radio Club, K6NCG, who donated their Christmas, 1964, leave to the cold and flooded northern California areas, helping disaster-stricken victims. Vern Hajek, K6UGS, 1924 Packard St., Concord, CA 94521.

☐ anyone with a QSL from W1BL prior to 1968. Al Blank, W1BL, 727 Pine St., Bristol, CT 06010.

☐ hams who are in or retired from the lithographic or photoengraving industries, to form a net. John A. Peterson, WB9RPY, 466 Dover Dr., Des Plaines, IL 60018.

Brazilian foreign exchange student Lillian Block talks with friends and family back home via the North High and Farnsworth Junior High club station, Sheboygan, WI. Teacher Jim Burns, K9ERO, uses amateur radio to help students learn about Latin American countries. The club operates solely on contributions.



This former Edsel dealership may not look like a busy federal building, but on this site of a Civil War battle a staff of 80 persons handled about 5,000,000 license applications last year. In fact, every U.S. amateur has had contact with it at least once during the past five years. It is, of course, the FCC building in Gettysburg, PA. Known officially as the Facilities Branch of the Safety and Special Services Bureau, they also process licenses for such other radio services as aviation and marine. *(WB2CHO photo)*

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

WINDMILL INTERFERENCE?

☐ Windmill generation of electric power may be a mixed blessing — this is the message that the September, 1977, *Electro-Optic Systems Design* note on Professor Thomas Senior's work (at the University of Michigan) seems to carry. Professor Senior calculates that the giant (more than 100 feet in diameter) windmills planned by the Energy Research and Development Administration (ERDA, now part of the new U.S. Department of Energy) will cause significant television interference at two miles from the windmill location. This interference would be caused by variable reflections from the metal blades, and would depend on the locations of the TV station, TV receiver, windmill and probably on wind velocity.

The ERDA is to be congratulated for funding this study, for the effect has long been known. Military and civilian pilots know that "talking through the props" puts a burble (modulation) on the voice. This rumble depends on engine (and therefore propeller) speed.

The B-29 of WW II used propeller modulation of the tail-gun radar signal as the "friend or foe" identification. The propeller blade rate (number of blades passing near the radio wave per second) of the B-29 was different from the enemy propeller blade rates. If the radar echo modulation was in the B-29 blade rate range, the radar would turn on a red light and the tail gunner wasn't supposed to fire.

The effect is caused by the radio-wave reflections setting up standing waves. When the standing waves change, the received signal will change phase and strength. TV receivers may not be able to handle the changes without momentary effects on the reception.

Changing standing waves may not be undesirable in other cases. In the early days of microwave ovens (ca. 1950), Raytheon found that the standing waves in ovens tended to cook foods in peculiar patterns, part raw and part overdone. The cure was to have a fan blade rotating through part of the oven, shifting the standing waves and sweeping the cooking energy across the food.

Ham rigs have also been affected. Doug DeMaw, W1FB, speaks of his early 2-meter final having a fan within the cabinet causing reports of "unusual modulation" because of the changing standing waves (causing rapid tuning changes) in his resonant-line tank circuit.

The Electro-Optic System Design article suggests the ERDA cure may lie in making windmill blades of either nonconducting or absorptive material. Nonconducting materials have dielectric constants different than air, and radio waves will reflect off any differing dielectric constant material. Perhaps a fiberglass-air honeycomb material would cause little reflection, but some interference would probably be noticeable for a thousand feet or so.

Absorptive materials pose two problems — such materials (unless shaped either conical or pyramidal) tend to have a narrow-band response. So what frequencies are to be absorbed? Frequencies which *are* absorbed will cause repetitive shadowing of receivers behind the windmill. Total absorption may cause near-total loss of signal when the blades are momentarily in the "worst position." Of course, signals *not* absorbed will experience the changing reflections.

Another subject to ponder is that local TV disruption is far from the worst possible consequence of windmill reflections or absorption. Conceivably, the communications in a microwave link could be disrupted at a critical time, with dire results. Professor Senior's suggestion that "windmills in their present form will have to be sited with great care" sounds prudent. — *David T. Geiser, WA2ANU, Technical Advisor, ARRL*

OUT-OF-THIS-WORLD EXPLANATION OF LDEs

☐ It has been over a year since Hans Rasmussen's report in *QST* of ghost echoes on the earth-moon path. I have noted the subsequent comments by W6NWO in September, 1976, *QST*, those of K4KCK in March, 1977 and I have read the original article by Rasmussen published in *Nature* for September, 1975. [Also see two *more* articles in this issue of *QST*. — Ed.]

Rasmussen's explanation of the echoes as a result of a sun-generated cloud of ionized particles seems unlikely. Similar instances of this phenomena certainly should have been noticed by others considering the vast amount of rf that has been emanating from our planet for many years. It does not seem reasonable that such ionization would be frequency specific. While there have been other long-delayed echo reports, these have been sparse, quasi-apocryphal, and not as clear cut as Rasmussen's.

As an alternative explanation, I want to suggest the possibility, admittedly miniscule, that Rasmussen was in contact with an orbiting interplanetary probe. Professor Ronald Bracewell, in his book, *The Galactic Club*, mentions that a probe is probably the way interplanetary communications will occur. Bracewell speculates that an orbiting device would echo back TV signals. I disagree. Rather, I propose that the contact would more likely be made in just the manner Rasmussen describes — by cw signals in that frequency range.

An extraterrestrial group probably will have no direct evidence from anywhere of technological activity of the radio level (as we have none) and hence, they would have to probe many points. Economics would dictate simple, energy-conserving units. Cw fills this requirement. First, they would reason that any society reaching radio skills would quickly fill the spectrum and would be using narrow-band systems themselves. Second, cw is more of a two-way commmunications mode than TV. Anyone using it would probably be listening for a reply, thereby enhancing the chances for discovery of the probe. Third, a cw signal could be reported back to base at low speed, using a very narrow bandwidth to reduce noise and to minimize spectrum coverage for the receiving scanners.

The 1296-MHz frequency is well within the bandwidth requirements for a small probe using 1420 MHz, the hydrogen natural frequency, as the center. This frequency is in the low-noise band and also would have the bonus of using a 1420-MHz sensor to search out likely star systems for life. The frequency range would also allow employment of small, yet broadband, high-gain steerable antennas that could track any likely signal, much in the manner that Rasmussen's signal seemed to be followed.

I recognize that the odds against there being such a probe are astronomical (no pun intended) but this seems to be just the sort of project that radio amateurs could attempt. Such an endeavor would be too chimeric for professional scientists and their funding managers. Therefore, if someone would compute a family of possible orbits from Rasmussen's data, EME amateurs could conduct an organized search for similar "echoes."

A probe would probably be programmed to do nothing but repeat signals until it was sure it was recognized. This could require identical interrogations from widely separated points or at regular intervals to denote orbital acquisition by the interrogators.

Some coordination of this effort would be required. If anyone is interested, I will volunteer to assist. — *Forrest O. Burke, K4SK, 353 Coral Dr., Cape Canaveral, FL 32920*

MOSFET GRID DIPPER

☐ A friend of mine sent me a copy of my article, "A Dual-Gate MOSFET Dip Meter" (*QST* for January, 1977); There are still problems in getting printed matter here in Lebanon. I would like to make one elaboration on the presentation as it appeared in *QST*.

My dipper operates according to a heretofore unused principle; the dipping depends on the S shape of the transconductance curve which gives rise to a nonlinear relationship between voltage and current of the tank circuit. This effect is known since B. van der Pol derived, in 1920, his famous equation, but no device existed to fit the theory. I have been waiting for the MOSFET to be invented and then several more years before I could get one here. When tried, the dual-gate MOSFET performed exactly as the theory predicted.

With this FET the Q of the tank circuit is not affected and the sensitivity to dipping may be very large. I believe that the present circuit is fundamentally superior to any dip meter produced thus far. That this is not mentioned in the article does not really matter very much because, if the dipper is really good, this will become apparent anyway. I am surely happy and proud to have my circuit in the journal. — *Dr. Frans Bruin, Observatory, American University of Beirut, Beirut, Lebanon*

WIND POWER, MINNESOTA-STYLE

☐ WØMCN's fine article on wind power (*QST* for July, 1977) inspired me to jot a few notes about my own experiences with harnessing the wind. My goal was a functional unit, simply constructed, with easily obtainable parts. The unit pictured is the result of much trial and error, and could be duplicated for less than a hundred dollars.

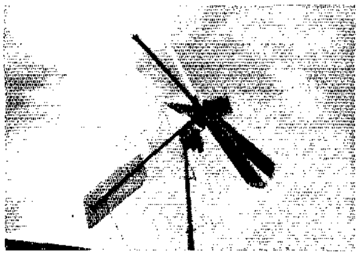
The bearing and blade-mount assembly is the front spindle, hub and wheel from an automobile. The ratio between wheel and alternator is about 4.7:1. I devised a simple, but effective horizontal and vertical pivoting point; the main assembly "jackknifes" vertically when gusts occur, by simple mechanical balance. The unit rides on the wind when the output reaches around 30 amperes.

The alternator is a "surplus" unit (available from various surplus outlets) and is rated at 60 A, 28 V. It is watertight, and produces 12 V and up in moderate winds (low RPM). I charge two 12-V auto batteries in parallel.

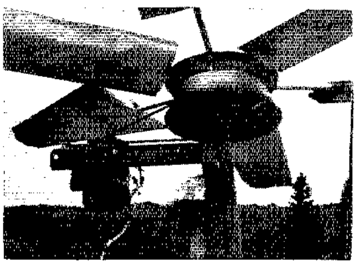
The blades measure 1 × 4 feet (0.3 × 1.2 m) and are made of 1/4-inch plywood with an airfoil stapled to the wood. The airfoil is made of aluminum flashing and the shape was just a guess but is much more efficient than a flat blade.

Early experiments with simple propellers revealed awesome tip speeds and a tendency to self-destruct. The multiblade unit is much more stable and less prone to vibration, which is important if one intends to mount the unit "in the open" for most constant winds.

In closing, I would like to say that I consider commercial power to be the cheapest commodity I pay for. I doubt very much that I will ever be capable of producing all my own electric power. It is fun to fire up my Drake TR-4 and tell contacts that I'm running it from wind power, though! — *Bud Graham, WAØWXL, 194 Poplar Rd., Duluth, MN 55804*



The WAØWXL fan tips up in a strong wind to prevent damage to the structure.



Close-up view of the WAØWXL wind power machine, showing the vertical "jackknife" pivot point.

SIMPLIFIED ANALYSIS OF RF CIRCUITS

☐ In the article, "Designing Solid-State RF Power Circuits" (*QST* for August, 1977) the author uses a very complex method of analyzing an rf circuit. Smith Charts, conversion to admittance, susceptance and normalized impedance can be very confusing to the newcomer [not to mention many old-timers! — Ed.].

A simpler approach is to replace the impedance of the inductor by $j\omega L$, and that of the capacitor by $1/j\omega C$. Then the circuit can be solved by means of simple algebra, where all impedances are treated as though they were resistors. For the problem presented in Fig. 10 we write the equation $(10 + j\omega L) \times (1/j\omega C) = 50$, which states that the series combination of the load and inductor in parallel with the capacitor is to be the input impedance.

Using $j^2 = -1$ and ordinary algebra gives:

$C = (25\omega)^{-1}$; $L = 20\omega^{-1}$ or

$X_C = 25$ and $X_L = 20$.

This seems to be considerably easier and cheaper than using the Smith Chart method. — *Louis C. Graue, K8TT, 624 Campbell Hill Rd., Bowling Green, OH 43402*

☐ The recent *QST* article, "Designing Solid-State RF Power Circuits," brought to mind two simple algorithms for converting impedances to admittances and vice-versa. These can be used on any calculator that has polar/rectangular conversion capabilities. Scientific or engineering notation is necessary in the calculator since typical admittances are much smaller than unity.

The theory behind the two conversions is very simple. A complex impedance $(Z = R + jX)$ can be represented as a vector $(Z = |Z|\angle\theta)$. To convert an impedance vector to an admittance vector, or vice versa, the sign of the angle is changed and the reciprocal of the magnitude is taken. Once the desired vector is obtained, it is converted back to rectangular form. This is basically what is done in the standard formula. But the polar/rectangular conversion done by the calculator reduces the amount of button pushing when using the vector approach, particularly when the circuit has several series or parallel elements.

Two examples are shown in Tables 1 and 2, with calculation key sequences listed. The calculators used were Hewlett-Packard models HP-21 and HP-25, so other types may require slight modification if reverse Polish notation (RPN) and memory stacks are not used by the machine. From the examples it can be seen that converting between parallel and series equivalents can give some additional insight into design problems. Looking at the series circuit $(Z = 25 - j25\ \Omega)$ as an antenna impedance, we might be tempted to add a series inductor to cancel out the capacitive reactance, and then add a transformation network to convert the resistance from 25 ohms to 50 ohms to match a feed line. If the parallel equivalent is looked at, you see at once that the parallel resistive component is 50 ohms; 1/0.02 mho = 50 ohms. To match this load to the 50-ohm coaxial line, only a parallel inductor is required to cancel the capacitive susceptance.

These algorithms have been used for designing antenna-matching networks and rf-amplifier impedance-matching problems, and have proved to be very helpful. — *Mal Crawford, K1MC, 19 Ellison Rd., Lexington, MA 02173*

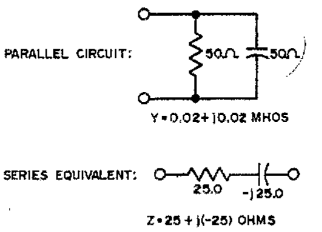


Table 1
Converting Susceptance to Reactance

Operation	*Keystrokes*
00 Enter Susceptance	[20] [EEX] [CHS] [3]
01	[Enter]
02 Enter Conductance	[20] [EEX] [CHS] [3]
03 Convert to Polar Form	[P]
04 Reciprocal of Magnitude	[1/X]
06	[CHS]
07	[X⇄Y]
08 Convert to Rectangular Form	[R]
09 Read Resistance	(display) 25.0
10	[X⇄Y]
11 Read Reactance	(display) —25.0

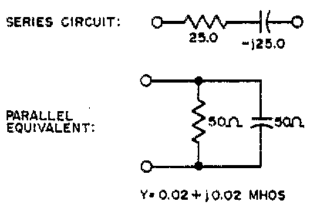


Table 2
Converting Reactance to Susceptance

Operation	*Keystrokes*
00 Enter Reactance	[25] [CHS]
01	[Enter]
02 Enter Resistance	[25] 0
03 Convert to Polar Form	[P]
04 Reciprocal of Magnitude	[1/X]
05 Change Sign of Angle	[X⇄Y]
06	[CHS]
07	[X⇄Y]
08 Convert to Rectangular Form	[R]
09 Read Conductance	(display) 20 —3
10	[X⇄Y]
11 Read Susceptance	(display) 20 —3

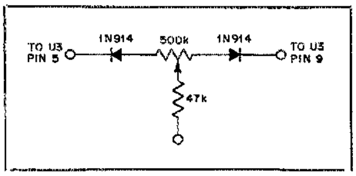
Hints and Kinks

A WEIGHT CONTROL FOR THE ACCU-KEYER

The WB4VVF Accu-Keyer (*QST* for August, 1973) and The Accu-Memory (*QST* for August, 1975) are without doubt the most-built construction projects ever to appear in *QST*. The Accu-Keyer is a first-class device, yet economical to build. It provides sending that contains a precise dash-to-dot length ratio of 3:1 suggested by Samuel Morse many years ago.

Nevertheless, many seasoned operators have found the apparently unalterable 3:1 ratio, as set up by the keyer logic, a disadvantage. For instance, a T may be mistaken for an E or part of a letter preceding it. Miscopying a 4 as a 5 has driven many a Southeasterner up a wall during cw contests. A weighting larger than 3:1 accentuates the difference between dots and dashes, alleviating such problems at high speeds and under poor conditions.

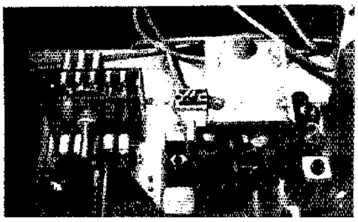
Changing the weighting at the keyer may also compensate for unwanted weighting changes caused by transmitter operation or a keyed antenna relay. The change is accomplished by altering the clock speed slightly by different amounts during the dot and dash intervals. This is done by feeding the Accu-Keyer dot-present and dash-present lines back to the clock-speed-determining components through appropriate diode steering. The keyer logic continues to count out what it perceives to be a perfect 3:1 ratio, but is fooled by having the counting rate altered by adjustment of the clock frequency. Although the circuit shown is for the Accu-Keyer, the principle is applicable to most electronic keyers which use a single clock. A weight control may also be added to the Accu-Memory. — *Hal Kennedy, N4GG*



A weight control addition for the Accu-Keyer. References are to the original Accu-Keyer schematic diagram.

A TRIMMER CAPACITOR FOR THE DRAKE 4 SERIES

Some owners of the Drake R-4A and R-4B receivers have experienced difficulty keeping the transmitter and receiver on the same frequency while in the transceive mode. Drift of the receiver carrier oscillator is responsible. Separate-frequency operation easily leads to signal leapfrogging with each operator trying to zero beat the other station.



Alignment of either the Drake R-4A or R-4B receiver is simplified by means of this small variable capacitor.

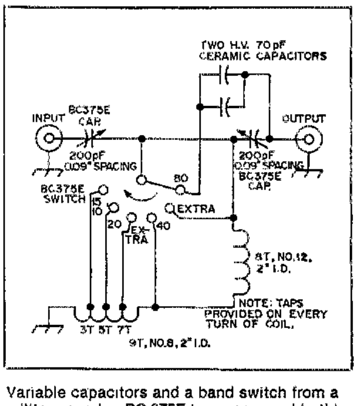
Aligning the Drake receiver is rather awkward. I simplified the procedure by installing a small variable capacitor (1-10 pF) in parallel with C61. The trimmer, visible in the photograph, is soldered to the VFO cabinet by means of one leg. The other leg is connected to a lead that passes through a nearby grommet and terminates at the ground side of C61. The trimmer may be reached by a small screwdriver inserted through a hole in the cabinet.

Place the receiver and transmitter in the transceive mode with the function switch on. Depress the microphone button. Adjust the trimmer so that the birdies become a single tone, indicating that the two oscillators (transmitter and receiver) are zero beat. — *Stan Dicks, WB8HAT*

AN INEXPENSIVE ANTENNA TUNER

Roller inductors and differential capacitors can be quite costly. A suggestion in one of Walter Maxwell's *QST* articles encouraged the construction of the tuner illustrated in the circuit diagram shown on these pages. It eliminates the shunt part of the differential capacitor used in *The Radio Amateur's Handbook* Universal Transmatch, and uses junkbox parts from an old BC-375E tuner and two homemade coils. The unit has been used with 2 kW PEP ssb and 1 kW cw with no voltage breakdown.

Although only six switch positions are available, extra coil taps permit changes to enable matching a particular antenna system to a transmitter. At this station, the six taps used have permitted the matching of several different types of antenna systems with SWR values varying from 1.0 to not over 1.5. The most regularly used antenna is a 107-foot dipole, fed with 30 feet of 300-ohm, TV line. A 4:1 balun at the bottom of this line permits a short length of coaxial cable to be brought into the shack. Lengths of RG-8/U up to 50 feet have been tried with satisfactory results. — *William L. North, W4BX*



Variable capacitors and a band switch from a military surplus BC-375E tuner are used in this inexpensive antenna-matching system.

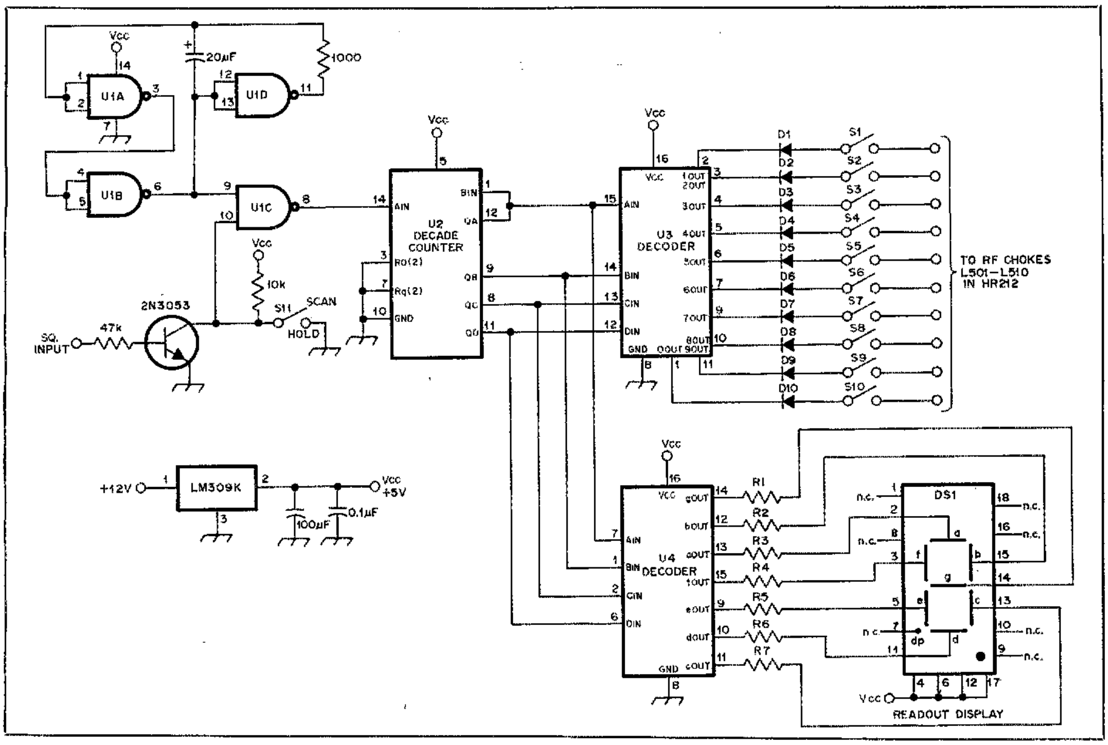
MICROPHONES AND THE TS-520

This information is primarily for amateurs who are not fully satisfied with microphone performance in conjunction with their TS-520 transceiver. My Turner +3 preamplified microphone gives sufficient gain but, like some other microphones, it tends to provide more low-frequency response than high.

A simple modification to increase the high-frequency response is to insert a 0.001-μF capacitor in series with the hot lead from the microphone. If an even higher frequency response is desired, the series capacitance should be decreased in 100-pF steps until a desirable response is reached. — *Edward G. Harris, WA2INE*

FM BCI ON THE MFJ CW FILTER

My MFJ CWF-2 cw filter picked up fm-broadcast interference from a station less than a half-mile away, even though shielded cable was connected between the filter and the receiver. The problem ended after I connected a lead from the ground terminal on the back of the filter to the terminal strip mounting screw, providing a direct chassis ground. With the original wiring, the filter ground terminal was connected to chassis ground by way of filter wiring. Now everything is fine. — *John E. McKeen, W1TN/W1BDK*



Circuit for a 10-channel scanner designed for use with the Regency HR-212, 2-meter transceiver. Resistors are 1/4 watt.

D1-D10 incl. — Silicon switching diodes, type 1N4154.
DS1 — Seven-segment readout display, Litronix type DL-747 or Radio Shack no. 276-056.
R1-R7 incl. — 220 ohm.
S1-S10 incl. — Spst switch.
U1 — Quad 2-input positive NAND gate, TTL type 7400.
U2 — Decade counter, TTL type 7490.
U3 — BCD-to-decimal decoder, TTL type 7445.
U4 — BCD-to-seven segment decoder, TTL type 7446.

10-CHANNEL SCANNER FOR THE REGENCY HR-212

Looking for a scanner for the Regency HR-212 2-meter transceiver? Would you like one that not only scans 10 channels but also has an IC-regulated power supply, large LED seven-segment readout, and features automatic stop, start, and stop of the scanner? Then consider this unit which may be built in a Radio Shack utility cabinet (no. 270-254). All parts should be readily available from local radio supply stores. The circuit diagram shows the relatively simple design.

These few construction points should be mentioned. To use the automatic-stop-and-start feature, unsolder the wires on the channel-12 selector switch of the HR-212. Tape these wires because they will not be used. Tie all the grounds, except the ones for the LM309K, the 100-µF capacitor and the 0.1-µF capacitor, to a terminal that is insulated from the chassis. Connect a wire from the channel-12 selector switch to the terminal to which the grounds are tied. The other three ground leads are connected to the chassis of the HR-212.

With this arrangement, the 5-volt power supply runs continuously. When one switches to channel 12, the ICs are grounded and the scanner starts operation. When switched to another channel, the scanner stops.

Diodes should be connected in series in the leads to the HR-212. These prevent the voltages of the HR-212 from reaching the scanner circuit. The squelch voltage is taken from the white jumper located near Q105 and C137 in the HR-212. These two components are on the i-f board. A connection may be made to the on/off switch for the +12 volts.

Finally, when connecting the 10 wires leading to the chokes in the HR-212, one should make sure that they are connected to the sides of the chokes wired to the channel switch. The 10 spst switches in series with the oscillators are for switching out the channel that one does not wish to monitor. — *Richard A. Little, K9EEH*

Pin Connection, Top View

Pin	*Function*
1	No Pin
2	Cathode — a
3	Cathode — f
4	Anode*
5	Cathode — e
6	Anode*
7	Cathode — dp
8	No Pin
9	No Pin
10	No Pin
11	Cathode — d
12	Anode*
13	Cathode — c
14	Cathode — g
15	Cathode — b
16	No Pin
17	Anode*
18	No Pin

*Common redundant anodes

2-METER MOBILE ANTENNAS

Fm enthusiasts interested in inexpensive 2-meter mobile antennas should note that Sears sells both the magnetic-mount type and one for trunk lid attachment. Both are in the $15 price class and are available through the catalog service. — *Neil F. Dunn, W1WFV*

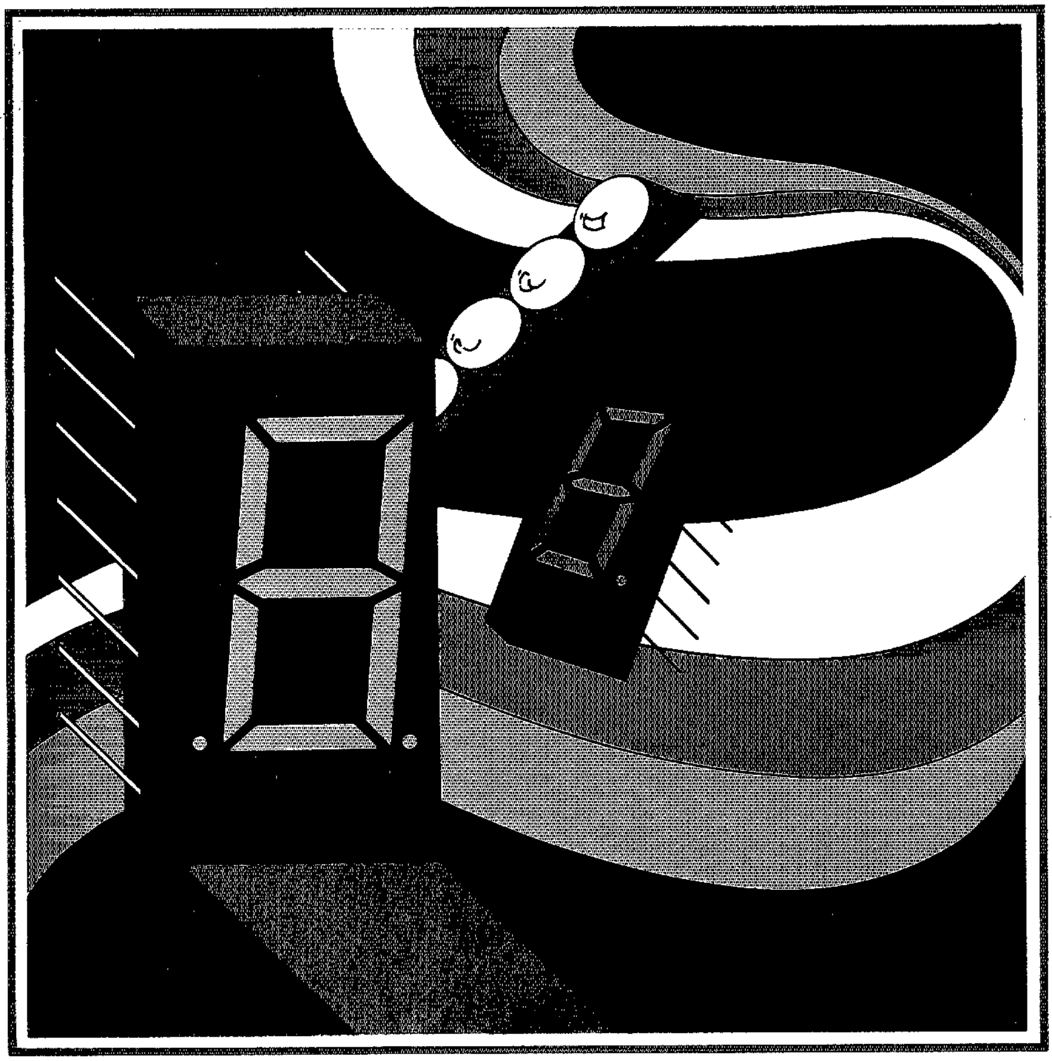
NEW FEET FOR THE HAM-KEY HK-1

I was somewhat disgruntled when my new Ham-Key Model HK-1 would slide around the operating desk when I became tired and a bit careless. My remedy was to replace the three round feet with four self-adhesive square feet such as those used on the Heath HW-8. The increase in surface area of the feet ended the wandering. — *John S. Jolly, WA7NWL*

QST

devoted entirely to Amateur Radio

March 1978 $2.00



What's behind those alluring numbers?

Page 11

QST

March 1978
Volume LXII Number 3

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $1.50. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

We've all seen them, but few of us really know what makes them shine. Delve into LEDs and LCDs, beginning on page 11.

Contents

Technical

Basic Amateur Radio

General

Operating

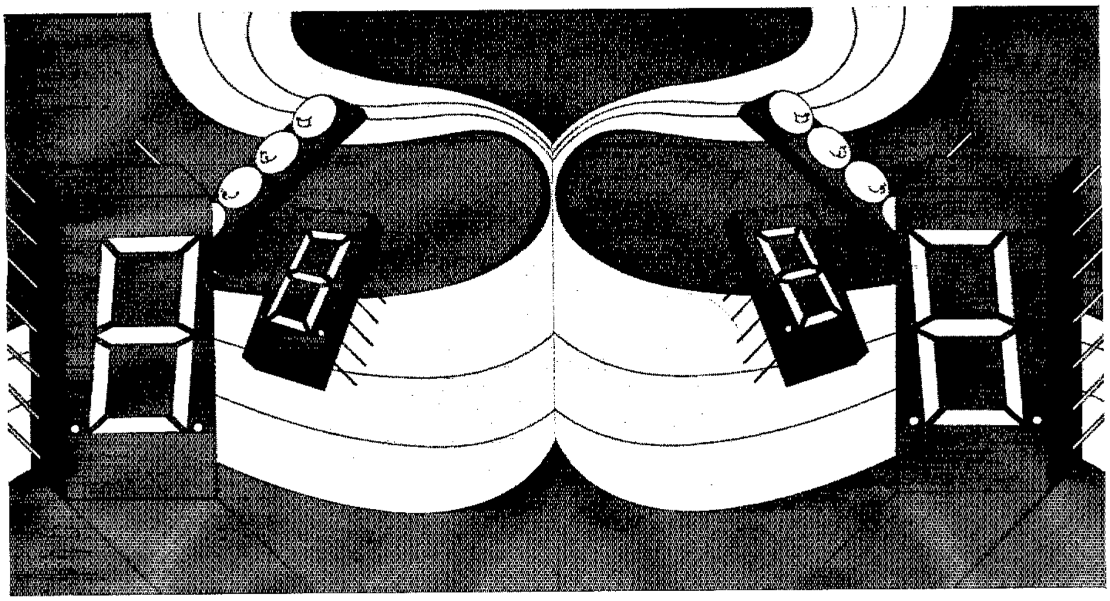
Organizational and Regulatory

Departments

How Visual Displays Work

Hardly a month goes by that another "digital-dial" radio isn't introduced. Read this for a clearer understanding of the chemical and electrical concepts behind those numerical readouts.

By Patrick A. Dreher,* WB1AJN



Almost six years have passed since *QST's* Doug Blakeslee introduced readers to the families of solid-state devices known as light-emitting diodes (LEDs) and liquid-crystal displays (LCDs).[1] Now those "readouts" have become commonplace items seen in almost every household. They can be found in myriad consumer devices, as well as amateur radio equipment of all kinds.

Amateurs are becoming less and less familiar with mechanical tuning devices (some readers may never have the "pleasure" of restringing a dial cord), while they struggle simultaneously with becoming more at home with LEDs and LCDs. In this article some useful data are provided on how the devices work in equipment which may already be on the workbench or operating table, while at the same time giving some guidelines to designers and home builders as to the use of displays, both light emitting and liquid crystal. We hope the reader will be looking at his or her watch, transceiver or microwave oven in a different light in the course of the next few pages.

*P. O. Box 475, Bantam, CT 06750
[1]References appear on page 15.

The Light-Emitting Diode

The process of extracting light from certain materials has been known for over a half century. It was discovered by an electrical engineer named Henry J. Round in 1907 when he connected two wires from a battery to a piece of silicon carbide and observed that the crystal emitted a yellowish light. However, it was not until the advent of solid-state components in electronics that the light-emitting diode began to appear to have commercial possibilities. The familiar technique of "doping," or introduction of a slight amount of foreign substance to semiconductor materials, was adopted in attempts to mass-produce LEDs.

Researchers experimented with various amounts of doping in different materials in hopes of producing useful LEDs in the visible range. To attain these goals they required the resultant emitted light from the LED to be restricted to the very small portion of the electromagnetic spectrum to which the human eye is sensitive. Fig. 1 shows the spectral response of the human eye to color as a function of wavelength, and the relative sensitivity to different colors. Depending on the design goals for a particular LED, the doping process could be either very helpful or completely disastrous. Hence, research work proceeded slowly in fabricating and constructing suitable material and in manufacturing processes for production of visible LEDs. (There is also a series of LEDs that operate in the infrared range of the electromagnetic spectrum but because these wavelengths are longer than those to which the human eye is sensitive they cannot be used in visual displays.)

Visible LEDs

During the course of research with these solid-state lamps a number of infrared

LEDs and visible LEDs were successfully produced. The first practical visible LED emitted a red light at approximately 660 nanometers. (It was constructed of gallium arsenide phosphide.) At about the same time another material (gallium phosphide) was found to emit red light at approximately 690 nm with an overall brightness of 2.4 times that of the first

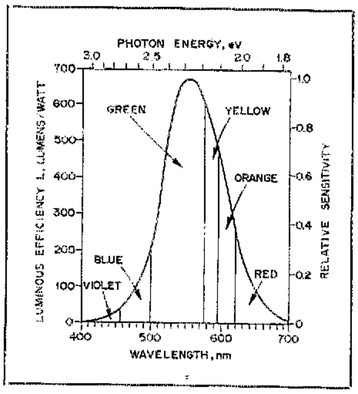


Fig. 1 — Spectral response of the human eye. A 500-nm wavelength is the same as 5000 angstroms.

diode. However, this wavelength at 690 nm translated into a resultant luminous efficiency of only three percent compared to the six-percent figure for the 660-nm LED. (Photometric definitions and terms are of critical importance in evaluating the characteristics of visible LEDs; see the appendix.)

Although the LEDs emitted light in the red part of the spectrum, red is not the ideal color for a visible-light-emitting diode. It would be much better if yellow or green LEDs could be produced, as the human eye is more sensitive to these colors. Research into green LEDs has produced some progress; the red LEDs, however, remain the most popular, inexpensive, solid-state lamp.

Multidigit LED Displays

Light-emitting diodes are finding increasing application in frequency-measuring devices and visual displays in amateur radio. What are some of the requirements and limitations that are placed on the LEDs that are used in these multidigit display devices?

Gerald Hall and Charles Watts in their series of articles, "Learning to Work with Integrated Circuits,"[1] extensively discuss digital readout displays using integrated circuits. The articles focused on constructing a seven-segment numeric display, showing the necessary integrated circuits needed and their function in the overall construction, whether it be a frequency counter or digital voltmeter. Fig. 8 of Part 4 (*QST*, April, 1976, page 20) shows the block diagram containing the clock, inputs, BCD counters (SN7490), data latch storage registers (SN7475), and the decoder/drivers (SN7447) necessary to finally display the correct digit to the LED.

As more digits are added to the visual display this block diagram for construction of digital readouts may suffer from financial problems. The total cost of the integrated circuits for these multidigit displays becomes prohibitive and an alternative technique known as multiplexing is used. This process uses one decoder-driver which is sequentially time-shared with each of the LED displays individually. All of the segments of the display devices are wired in parallel, thereby providing a simple system for shifting the character-enable voltage from one display digit to the next. (Only a connection to the anode of each position is required to activate a single display.) A single BCD-to-seven-segment decoder provides the appropriate segment connections. Does this new circuit arrangement have any effect on the operation of the LED?

In order to maintain the brightness of each digit, the current to each LED segment must be increased. A typical display should be operated at a peak current of 100 mA for each segment, with a pulse cycle of 50 to 250 microseconds at a duty cycle of 20 percent. Not *all* LEDs can perform satisfactorily under these conditions, however. For example, the light output from the 690-nm LED saturates at relatively low current densities and cannot

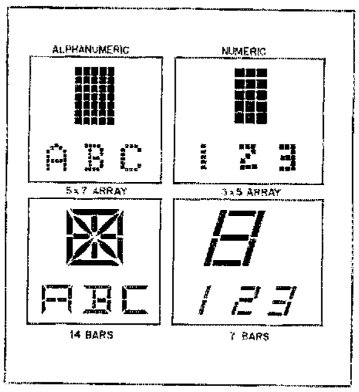


Fig. 2 — Various formats for symbolic displays.

be used in numeric or alphanumeric displays. The 660-nm LED does not have this problem and it is also inexpensive. Hence, it is the most widely used LED for visual displays.

In addition, not all LEDs are the seven-segment numeric type. Fig. 2 illustrates other numeric and alphanumeric LEDs that are manufactured. Each of these re quires its own decoder-driver systen which may entail a bit more expense thaı the seven-segment system. Similarly, thes LEDs may also be multiplexed. In fact, i is essential to multiplex these LEDs wheı they are used in large multidigit display because of the expense of constructing ; full set of integrated circuits to drive eacl LED individually.

Suggestions When Using LEDs in Construction Projects

A large number of manufacturers nov market LEDs which operate in the visibl region. However, before purchasing an specific brand, consider a few points.

First, the specification sheets for dif ferent LEDs from the same manufacture

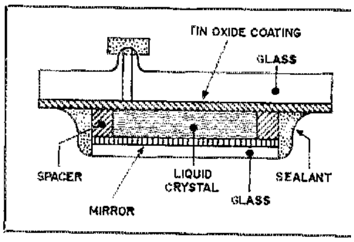


Fig. 3 — A cross section of a typical reflection device (LCD).

and for the same LED from different manufacturers are, in general, very difficult to compare. This problem arises when dealing with the photometry characteristics of each diode (see appendix). Basically, two types of diodes are manufactured: point-source diodes, and area-source diodes. The point-source diodes are used as indicators or status lights and the area-source diodes are used for numeric and alphanumeric displays. When considering which area-source LED you should use for your visual display construction project, the following factors must be considered: the character height, width, ambient lighting conditions affecting the contrast ratio, and the ease of visibility of the LED at various angles.

The size of the characters and the ease of visibility must be chosen so that the display output meets the needs of the user. Do you require the display output to be seen for a large distance? If not, the smaller characters may suffice. The larger the characters, the more difficult it is to maintain a uniformly bright output. Do you require that you be able to view the output at some angle other than perpendicular to the output face? Then be careful which LED you purchase!

Many LEDs have a limited viewing angle for very definite reasons. Some of the first commercial LEDs were packaged in a clear epoxy lens. When tested in a dark room the LED output was plainly visible, but in bright light the LED output could barely be observed. The output of the diode seemed to be "washed out" by the ambient lighting conditions. The reason for this was that the bright ambient light was reflected from the shiny internal parts of the diode such as the connection leads, the evaporated metal contact regions on the chip, and the chip itself. The resultant situation was that the surrounding light conditions either equalled or exceeded the power density of the LED output.

Two methods were used to correct this problem, some of which restricted the viewing angle. Some manufacturers corrected the problem by producing LEDs with blackened reflective metal connections and mounted the entire display behind a barrier with viewing slits. These steps helped mask most of the reflecting surfaces with only a minimal decrease in the effective viewing angle of the LED itself. The other technique to reduce the problem of ambient lighting was for the manufacturer to package the chip in a dye which is transparent only to the particular wavelength of the LED output.

If the requirements for your construction project still necessitate clear-lensed LEDs that must be used in bright light, don't despair. Manufacturers of clear-lensed diodes will usually offer a compatible filter that can be used with the LED. Either a red filter or a circularly polarized filter placed in front of the LED can correct an ambient-lighting problem. These filters only decrease the output of the LED by a small amount while trapping the reflected light from the internal parts of the LED, thereby preventing the display from being washed out. Finally, certain manufacturers may encase alphanumeric-display diodes in integral or bubble-cylinder lenses. These lenses are designed to increase the apparent size and viewing angle of the display through magnification. Although these techniques allow the output to be viewed from a wider angle, any imperfections in these bubble lenses will produce distortions in the LED output display.

So what LED should you buy? That depends on the requirements for your project. Dozens of companies presently market many different types of LEDs. A partial list might include General Electric, Fairchild, Texas Instruments, Hewlett Packard, RCA and Monsanto. Perhaps the best information that can be given about using LEDs in your construction projects is just to shop around, know exactly what you will require from your visual display, and match those needs to the different products on the market. There is no specific LED display that covers the builder's needs in every situation.

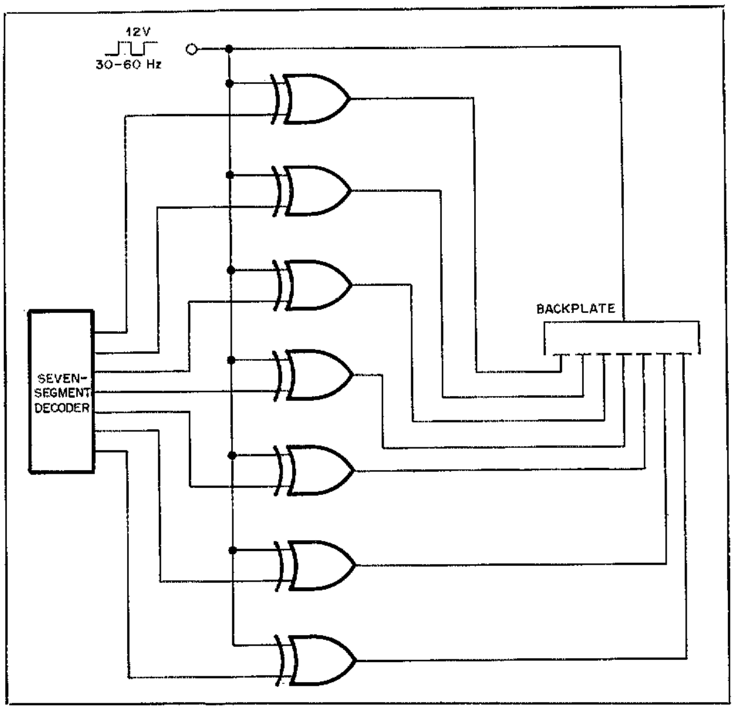


Fig. 4 — Phase-shift addressing commonly used to drive a typical seven-segment LED.

The Liquid Crystal

The liquid crystal, like the light-emitting diode, has a long history. Liquid crystals were discovered in 1888 but it wasn't until 1936, when the first patent was approved for a device using these materials, that liquid crystals were considered to have commercial possibilities. The original patent was for a device called an optical shutter, an invention that established the basic principles of modulating light by means of liquid-crystal materials. In the years which followed, though, interest in electro-

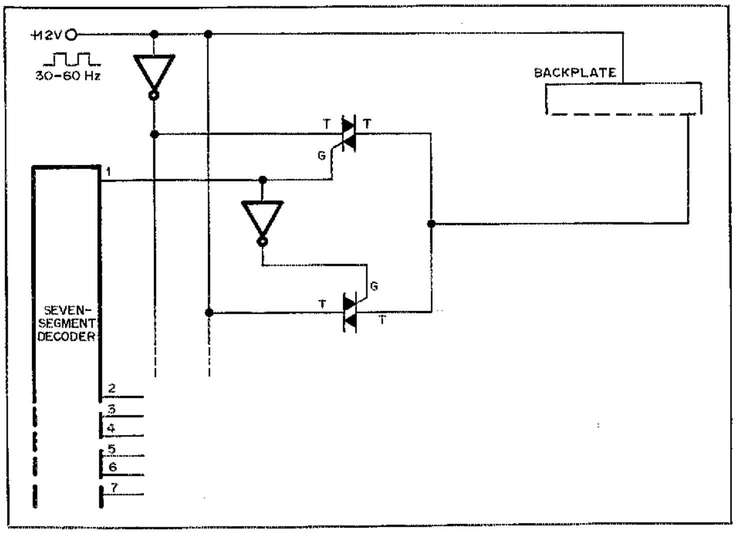


Fig. 5 — Phase-shift addressing using bidirectional switches requires less circuitry to drive an LED.

optical devices waned. It wasn't until the late 1950s that Westinghouse and RCA began investigating the possibilities of using the liquid crystals for slow-speed switching and memory applications. From this work evolved the idea for the liquid-crystal display in the 1960s, and research work with these devices has progressed steadily since that time. But what is a liquid crystal, and how does it act as a visual display?

There is a very small group of organic materials that have the peculiar characteristics of simultaneously exhibiting some of the properties of a crystal and some of the properties of a liquid. What!? The liquid crystal maintains the properties commonly attributed to a liquid, but in addition displays something called "long-range orientation" commonly found only in solid materials. This long-range orientation allows the molecules to act in harmony and produce large responses to electric fields applied to these materials. This produces something called an anisotropy in the material. It is this process which is responsible for enhancing reflection and scattering of light incident on the liquid crystal.

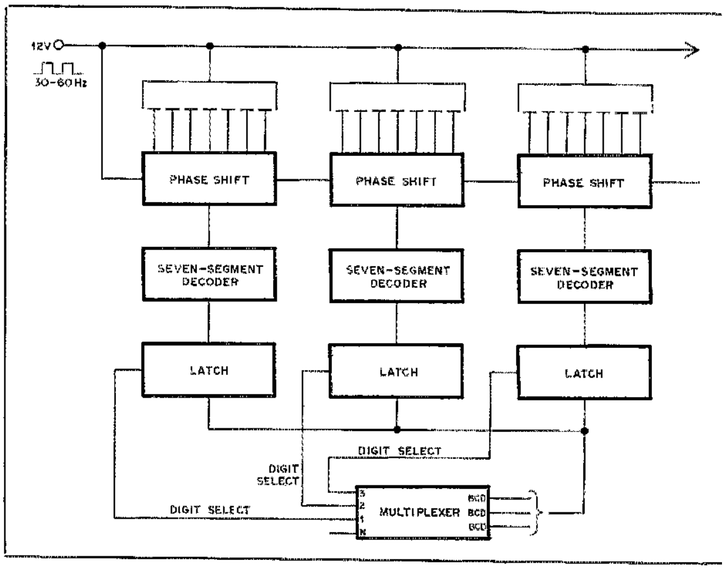


Fig. 6 — Block diagram of phase-shift addressing a multidigit LCD using a multiplexer.

Liquid-Crystal Displays — How Do They Work?

The most common LCD in use today is the nematic liquid crystal which uses dynamic scattering (reflection and transmission). The term dynamic scattering describes the strong, wide-angle light scattering that is produced when light hits the liquid crystals mounted in their cells. But what is the difference in producing an LCD output by reflection or transmission?

In reflective display (Fig. 3) the scattered light must have a high contrast with the background. This is accomplished by placing the mirror in the LCD cell so that it faces into a dark background. In transmission displays a visual output is produced when an enable voltage is applied to the liquid crystals set between parallel electrodes in the cell. This voltage randomizes the polarization of the LCD and enables a bright image to be displayed in contrast to the normally dark background. (The dark background is produced when the liquid crystal cell is placed between crossed polaroids.) Do these reflection and transmission devices actually work? Yes, in spite of some difficulties shared with the LED family.

The reflection device runs into the same problem that plagues the LED — the viewing angle. Reflective dynamic scattering gives rise to spurious reflections which destroy the readability of the device at certain angles. The transmission LCD has troubles, too. Although this LCD has a high contrast ratio (display to background) it suffers from the drawback that it requires some type of light behind the liquid crystal to produce the output, thus canceling its only advantage over the reflective devices — its low power requirement.

How to Drive LCD Displays

Liquid-crystal displays, like the LEDs, can be driven by using a standard BCD counter, data latch storage register and a seven-segment decoder-driver, with each LCD needing a set of these integrated circuits to generate an output. Again the question arises — what if I want to build a multidigit display using LCDs? Do I have to invest in all these ICs or can I multiplex the display? The answer is yes, liquid crystals can be multiplexed, but not in the same manner as an LED. The current cannot be increased to produce a stronger applied field against the liquid-crystal segment. When this "conventional" multiplexing technique is used, sneak paths develop in the LCD, producing activation of unwanted segments. An alternative method must be developed. Before we see in detail how LCDs are multiplexed, let's look at another method of driving a single LCD and see if we can adapt it to multidigit displays.

The technique is known as phase-shift addressing and is illustrated in Fig. 4. Square waves of equal amplitude and frequency are connnected to the backplate (anode) and the segments (cathode). The relative phase between the two square waves determines the state of each segment. The LCD segment is switched on when the square-wave outputs are exactly 180° out of phase; it is switched off when the relative phase of the square waves at the segment again matches that of the backplate.

A similar method of phase-shift addressing which is also used to drive LCDs is called a bidirectional switch (transmission gate) and is illustrated in Fig. 5. To construct such a switch, an n-channel transistor and a p-channel transistor must be connected in parallel. By adding a control inverter, a single-pole single-throw switch is formed which can conduct in both directions. The switch is turned on and off by either a high- or low-positive level at the control input. Each LCD segment is connected to a pair of these bidirectional switches with the decoder output being the control mechanism governing the on/off states of the segment.

Multiplexing LCDs

Let's take a close look at exactly what happens to a liquid crystal when it is driven by a multiplexing circuit. Dynamic scattering occurs in LCDs when turbulence in the liquid crystals overcomes their long-range orientation, producing either a reflection or transmission of light. In order to control this turbulence and enhance the contrast ratio between liquid-crystal segments that are on or off, a magnetic field may be introduced to help maintain the long-range orientation of the molecules. In practice, however, it is very difficult to construct such a device. An alternative method is to introduce high-frequency electric fields. This technique has the same effect on the liquid crystals as does the magnetic field, while having fewer construction problems. This procedure, using both high- and low-frequency square or sine waves to drive the LCD segments, is called two-frequency addressing. By addressing the segments with two frequencies the threshold for dynamic scattering is increased, thereby increasing the threshold voltage and enabling matrix addressing to be used to drive the visual display.

What is important to realize is that a high contrast ratio must be maintained in the LCD segments. The decay time of the liquid-crystal material must be sufficiently long to prevent any significant change in the state of the LCD segment before it has been rescanned.

Finally, there is another technique which may be used to multiplex liquid crystals. This technique will not save the builder construction time or money in ICs, but it seems to be the easiest way to construct an LCD display capable of being multiplexed from the original parts of an LED display with the standard BCD counter, data latch, and decoder-driver for each digit. Fig. 6 shows this approach. The input is multiplexed and then a phase-shift addressing scheme using exclusive-OR gates is used to drive the LCD.

What to Expect in the Future

Visual displays are only the "tip of the iceberg" in optoelectronics. As developments in LEDs and LCDs occur, they will find applications not only in visual displays, but in a host of other areas that haven't even been mentioned here such as optical isolators, light-sensitive FETs, light-activated SCRs, photoresistive detectors, PIN photodiodes and phototransistors. Only the limits of an amateur's cleverness in applying these optical devices to amateur radio will determine the extent of their development in our hobby.

Appendix

The following are definitions and terms used in optics to characterize the properties of an LED.

Incident flux density is defined as the amount of radiation per unit area (expressed as lumens/cm^2 in photometry; watts/cm^2 in radiometry). This is a measure of the amount of flux received by a detector measuring the LED output.

Emitted flux density is also defined as radiation per unit area and is used to describe light reflected from a surface. This measure of reflectance determines the total radiant or luminous emittance.

Source intensity defines the flux density which will appear at a distant surface and is expressed as lumens/steradian (photometry) or watts/steradian (radiometry).

Luminance is a measure of photometric brightness and is obtained by dividing the luminous intensity at a given point by the projected area of the source at the same point. Luminance is a very important rating in the evaluation of visible LEDs.

While luminance is equated with photometric brightness, it is inaccurate to equate luminance as a figure of merit for brightness. The only case where this rating is acceptable is when comparing *physically* identical LEDs. Different LEDs are subject to more stringent examination. Manufacturers do not use a set of consistent ratings for LEDs (such as optical flux, brightness and intensity). This is because of the dramatic differences in optical measurements between point- and area-source diodes. Point-source diodes are packaged in a clear epoxy or set within a transparent glass lens. Area-source diodes must employ a diffusing lens to spread the flux over a wider viewing area and hence have much less point intensity (luminance) than the point-source diodes.

References

[1] Blakeslee, "By the Light of a Diode," *QST*, May, 1972.

[2] Hall and Watts, "Learning to Work with Integrated Circuits," *QST*, January-July, October, 1976, and June, 1977.

Feedback

☐ Herbert Stevens, W6RSP, advises that in his simple cw QSK ("Hints and Kinks," *QST* for December, 1977) item, insertion of relay K1 in the coaxial line *does* serve to inhibit hash and backwave.

☐ In "Hints and Kinks" for January, 1978, the drawing for the "Alternate Receiving Antenna Modification" should have shown the two leads attached to the additional miniature phone jack in reverse position for correct operation.

☐ When WB9RXV contacted WA1YJF during his amateur radio demonstration (January, *QST*, page 58), he wasn't speaking to a YL, as he had thought. WA1YJF is a 15-year-old OM, whose new call is W1YE.

☐ "Silent Keys" in January 1978 *QST* incorrectly listed WØHQE. The correct call is WBØHQE.

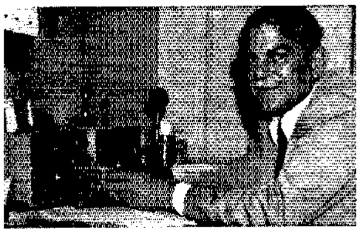
☐ The weight-control drawing appearing in "Hints and Kinks" for February, 1978, should have indicated that the 47-kilohm resistor is to be connected to C1, R4, CR1 and Q1.

Strays

***QST* congratulates . . .**

☐ John F. Kienzle, WA2UON, who has been included in the 1976-77 edition of *Notable Americans* as well as the current editions of *Community Leaders and Noteworthy Americans,* and *Dictionary of International Biography.*

☐ Bill O'Kain, K4LTA, named Tennessee Insuror of the Year by the Insurors of Tennessee.



During a recent business trip to the U.S., Martin Aitken, G2ACK, visited amateur friends in New York, New Jersey and Indiana, renewing acquaintances made over the air from England. G2ACK is shown at the station of Ron Stier, W9ICZ.

For only a few seconds once every 36 days, OSCAR 7 is in a common window to both Hawaii and Washington, DC. Nevertheless, Lee Wical (left), KH6BZF and Earl Skelton (right), N3ES, were able to copy each other through the satellite after many months of effort.

An FET Volt-ohmmeter with Linear Ohms Readout

Good test equipment is a must for any ham shack. But most are also expensive. Not this handy electronic volt-ohmmeter. Build it, and save money.

By Jay Rusgrove,* W1VD

Ask a dozen hams what piece of test equipment is most valuable around their shacks, and most would probably respond, "My vacuum-tube voltmeter." Why a VTVM? Because this one instruments allows measurements of, to some degree of accuracy, ac voltage, dc voltage, and resistance. An important feature of the VTVM is the high impedance it presents to the circuit under measurement. This is particularly important with dc-voltage measurements. An instrument that has a low impedance (as is common with inexpensive VOMs) tends to load down the circuit being measured and disrupt normal circuit operation. Fig. 1 illustrates how normal circuit voltages are changed by connecting a low-impedance instrument to the circuit. The lower the impedance of the instrument, the greater the error introduced by the meter.

Typical VTVMs have an input impedance on the order of 10 megohms. As can be seen in Fig. 1D, this type of meter has little effect on the circuit. An instrument with a specification of 1000 ohms/volt will often make it appear that a circuit is working improperly when in fact it is functioning normally. This likely brings up another question, "Why are VOMs so popular?" The answer to this is simple. VOMs are small, inexpensive and portable, not requiring the ac mains as a power source. The circuit to be described here blends the attractive qualities of both the VTVM and the VOM — measurement accuracy and portability.

Circuit Details

The circuit shown in Fig. 2 makes use of two field-effect transistors in a balanced circuit. Since no two active devices have exactly the same characteristics, some means must be incorporated to balance

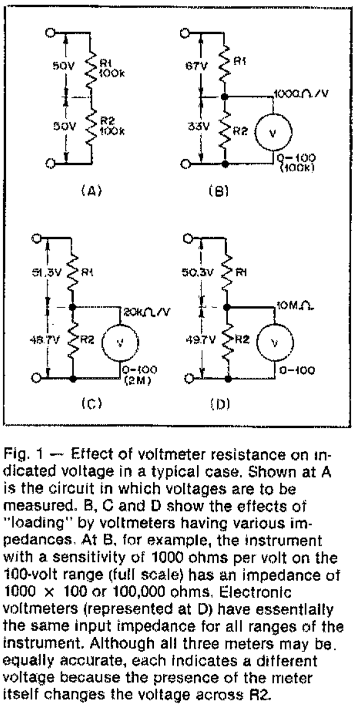


Fig. 1 — Effect of voltmeter resistance on indicated voltage in a typical case. Shown at A is the circuit in which voltages are to be measured. B, C and D show the effects of "loading" by voltmeters having various impedances. At B, for example, the instrument with a sensitivity of 1000 ohms per volt on the 100-volt range (full scale) has an impedance of 1000 × 100 or 100,000 ohms. Electronic voltmeters (represented at D) have essentially the same input impedance for all ranges of the instrument. Although all three meters may be equally accurate, each indicates a different voltage because the presence of the meter itself changes the voltage across R2.

the circuit under static conditions. The zero potentiometer does just that since the meter will read exactly "0" when the circuit is balanced. Any imbalance causes the meter to deflect, the amount of deflection proportional to the degree of imbalance.

Voltage scales for both ac and dc are 0-0.5, 0-5, 0-50 and 0-500. A series of dividers (R2 through R5) feed a portion of the voltage being measured to the bridge circuitry. A 1-megohm resistor is used in the tip of the dc probe bringing the total input impedance to approximately 7 megohms. The use of potentiometers in the divider alleviates the need for precision, special-value resistors, thereby reducing the cost of the unit considerably.

Measurements of ac voltage are facilitated by rectifying the ac and reading the resulting dc directly. Two 1N34 diodes, a 22-megohm resistor, and a 0.05-μF capacitor form the rectifier circuit. R1 is used to calibrate the instrument for ac measurements.

Resistance measurements are made in ohms using five ranges: 0-50, 0-500, 0-5000, 0-50k and 0-500k. This circuit makes use of a linear ohms-readout system. Conventional VTVMs and VOMs use scales that are cramped on the high end and expanded on the low resistance end. This logarithmic system is impractical for a home-constructed instrument since special meter faces are not generally available. Linear readout of resistance allows the user to read the value of resistance directly from a standard meter face. With this system a single meter scale can be used for resistance and voltage measurements.

Potentiometers R6 through R10 are used in place of precision, nonstandard-value resistors. Each potentiometer controls the voltage division for its associated range.

Under normal circuit conditions with the instrument placed in the ohms position, the meter will rest gently against the peg, off scale at the high end. When the ohmmeter leads are connected together, the zero potentiometer is adjusted so that the meter indicates 0 resistance. Separating the leads causes the pointer to return to its position resting against the high-end peg. D1 is used to limit the voltage fed to the bridge so that the pointer does not slam against the peg.

Construction

The enclosure is made from pieces of

*Senior Assistant Technical Editor, ARRL

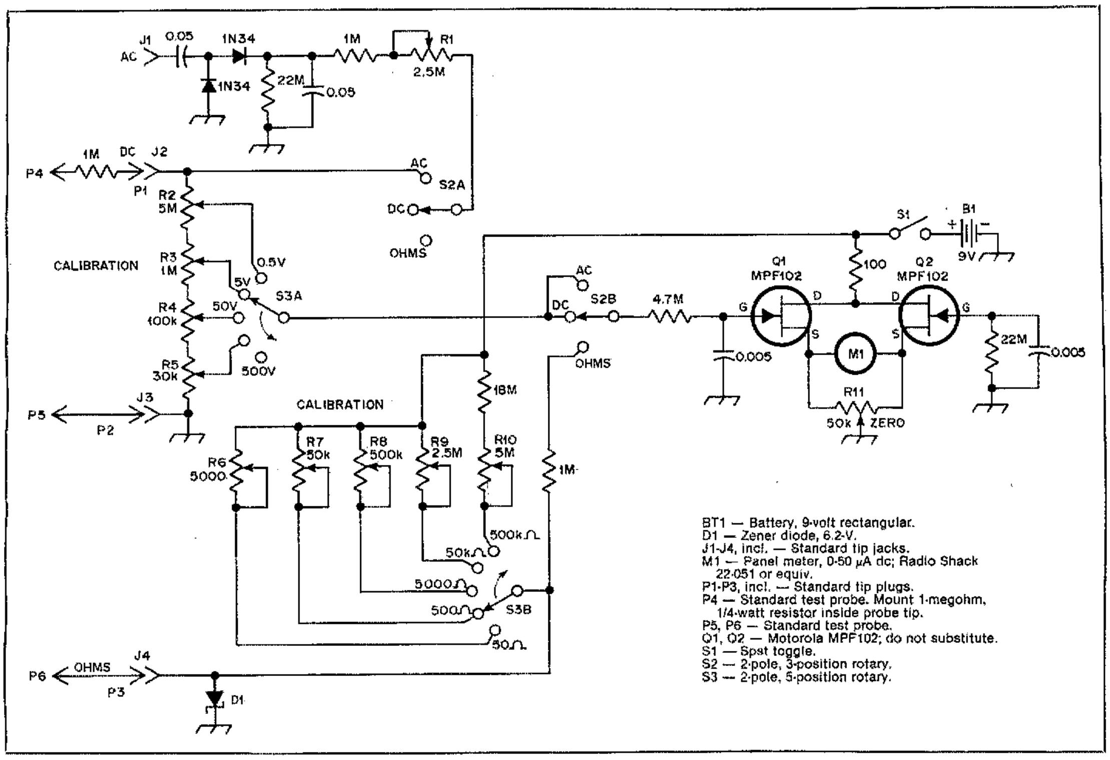
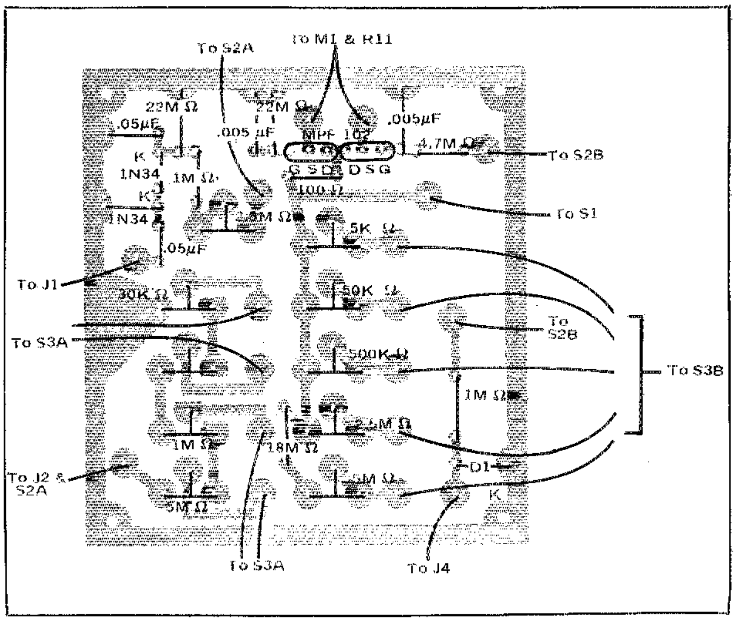
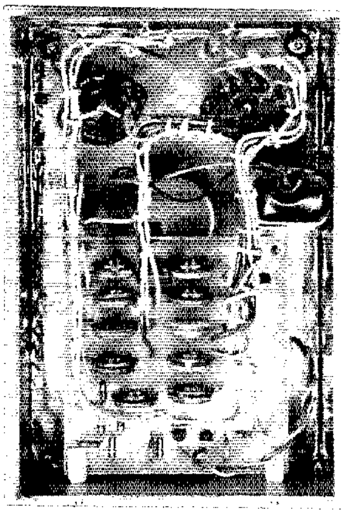


Fig. 2 — Schematic diagram of the FET VOM. All resistors are 1/4-watt carbon types except for the potentiometers. Numbered components not appearing in the parts list are for text callout only. All controls except R11 are for calibration.

This inexpensive FET volt-ohmmeter can be built with easily obtainable parts. Accurate ac, dc and resistance measurements are made quickly with this high-impedance device, without loading down the circuit being measured.

Fig. 3 — Circuit-board layout with parts overlay for the FET VOM. Shaded areas represent unetched copper areas of circuit board. This view is from the foil side of the board.





The inside of the FET VOM. Leads are dressed with wire-tying twine to provide a neat appearance.

double-sided, glass-epoxy circuit board material with the overall dimensions measuring 4 × 6 × 2-1/4 inches (100 × 150 × 60 mm). All seams are soldered together along their entire length to ensure a rigid construction. The battery is held between two pieces of circuit board material soldered to the sides at several locations.

All components other than the meter, switches, battery and zero potentiometer are mounted on a circuit board that measures 2-7/8 × 3-1/8 inches (73 × 79 mm). A suitable foil pattern with parts layout is shown in Fig. 3.

The schematic shows a number of connections to ground. In this particular circuit, ground is not the cabinet of the instrument but rather a "floating" ground. By not connecting any of the circuitry to the cabinet there is no chance of having dangerous voltages on the case. *This means that the circuit board ground foil should not be allowed to contact the cabinet.*

Although the unit shown in the photographs was left natural (tarnished copper) with a clear acrylic coating, there is no reason why the builder should not paint the finished VOM. Treat the copper like any other metal surface when painting. Any type of labeling that suits the builder's fancy may be used. Dry transfer type labels were used on the unit shown.

Calibration

Adjustment of the completed FET VOM is simple. However, it does require the use of a calibrated meter and a source of variable-voltage dc. The dc ranges should be adjusted first. Connect the calibrated voltmeter in parallel with the FET VOM and attach these connection points to the variable-voltage dc supply. Start with the lowest range (0-0.5) and set the supply voltage for a midscale reading (0.25 volt). Adjust R2 so that the FET VOM reading conforms with the reading on the calibrated meter. Do the same for each of the other ranges using a voltage that will allow the meter to read near midscale. Should 250 volts not be available for the high-range calibration, 50 volts could be used, yielding only a small difference in accuracy. *Care should be taken to touch only the plastic insulation on the potentiometers since potentially dangerous voltages are present in the circuit.*

Ac calibration is somewhat simpler since the basic voltage dividers have already been calibated. The ac line voltage should be used for calibration, again conforming the reading on the FET VOM with the calibrated meter. R1 is provided for this adjustment.

Calibration of the ohmmeter circuitry is done in a similar manner. A resistor that will allow the meter to read approximately midscale for each range will be required. If the resistors are of the precision variety, a calibrated ohmmeter will not be required. However, if the resistors used for calibration are of five-percent tolerance or greater, it would be wise to use a calibrated meter. For example, a 27-ohm precision resistor could be used for the lowest frequency range. R6 would be adjusted for a reading of exactly 27 ohms on the FET VOM. A 10- or 20-percent tolerance resistor could be used provided a calibrated meter is available. In that case the FET VOM reading should be made the same as the calibrated meter. Simply do the same for the remainder of the resistance ranges. That completes the calibration of the instrument, and it is ready for use in those many applications around your shack. QST

Strays

***QST* congratulates . . .**

☐ Dr. Robert Reed, vice president, engineering, of the John Zink Co., Tulsa, named Inventor of the Year by the Oklahoma Bar Association.

ACQUAINTANCES RENEWED

☐ Despite knowing each other for more than 32 years after meeting in the Solomon Islands during World War II, Allan Papworth, ZL1PA, of Warkworth, New Zealand and James Hanson, W1NQO, of Haddam, CT, had made successful on-the-air contact only twice. Late last summer they finally had a chance to really catch up on old times when Papworth took an extended vacation to North America. Ironically, both men's wives are named Irene.

☐ Prior to departing for Europe on a long-delayed honeymoon last summer, Steven Decho, WB6ZFI, of Canoga Park, CA, happened to make a 20-meter contact with Henry and Yvonne Meier, DF1KM and DJ∅JF, near Aachen, Germany, and was immediately invited to spend a weekend there. They did enjoy the hospitality and with a reciprocal permit Steve worked back into the L.A. area between pileups on the DL repeaters. The Dechos were similarly hosted by another on-air friend, Carlo Bugnano, I1BGJ, in the Italian Alps.

Worldwide, total strangers in amateur radio can easily become good friends. Shown in the photo at left, DF1KM (left) and wife DJ∅JF hosted WB6ZFI and his wife, while at right, ZL1PA (left) visited W1NQO (right).

New Tasks for the Digital Voltmeter

The versatility of the QST IC-course digital voltmeter/frequency counter expands with this compact, easy-to-build adapter. Use it to measure R and C values.

By Robert Shriner,* WAØUZO

With diligence you completed the course on ICs (*QST* for January through July and October, 1976, and for June, 1977). Resting amid your sparkling amateur radio equipment is that versatile digital voltmeter/frequency counter, a product of the course trail that led you through the mysteries of ICs.[1] Perhaps you went the distance and even added some 14 TTL ICs as suggested in my article, "The DVM/Frequency Counter Becomes a Clock," which appeared in *QST* for January, 1977. Satisfied with your accomplishment, you might lean back in your swivel chair and ask, "So, what else is new?"

This, the second of what I am sure will be many adapters for the DVM/counter, is an answer to that question. The usefulness of a device for measuring unknown resistances and capacitances stands without reservation. Any amateur who likes to build and service his own equipment knows the desirability of being able to take such measurements. Then, where does the DVM/counter come into the picture? Well, right here.

Back at my drawing board, determining what would be required to adapt the DVM/counter for measuring such parameters, provided an interesting challenge. With a "black box" approach, a prototype evolved that permitted the adapter output to be fed to the DVM by means of the DCV and DC10 range. When constructed, the black box responded like a genie evolving from a magic lantern.

Overall design objectives called for a compact device with solid-state construction and a self-contained power supply. Not only would the finished product be able to measure resistances and capacitances as shown in Table 1, but also additional capability would be incorporated whereby there would be two auxiliary ranges for capacitance testing and one auxiliary range for resistance testing. A regulated power supply would provide the +6, +12, −6 and −12 voltages needed for operation. Two rotary switches would

Table 1 — RC Adapter Range

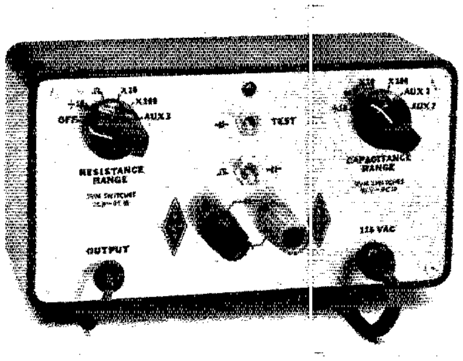
Capacitance	S1A Position
0-1 µF	÷10 (B)
0-10 µF	MF (C)
0-100 µF	×10 (D)
0-1000 µF	×100 (E)
Resistance	*S2A Position*
0-1000 Ω	÷10 (H)
0-10 kΩ	Ω (J)
0-100 kΩ	×10 (K)
0-1 MΩ	×100 (L)

B through L are switch positions shown on schematic diagram.

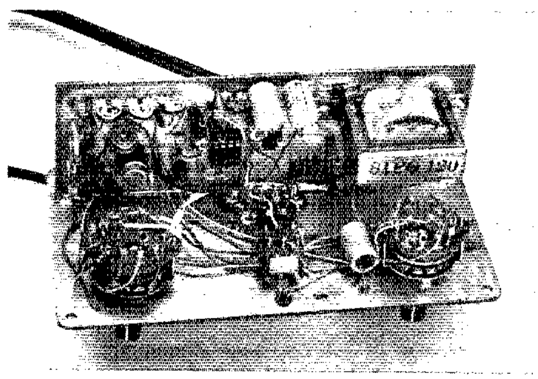
*1740 E. 15th St., Pueblo, CO 81002

[1] [Editor's Note: The entire series, all nine parts, has been reworked and is now available in a 48-page booklet format with an attractive cover. A shopping list and index have been added, and printing errors in the earlier *QST* parts have been corrected in the booklet. These booklets are available from the Circulation Department of ARRL hq. for $2 per copy ppd. in the U.S., $2.50 elsewhere.]

The resistance/capacitance adapter designed for use with the *QST* IC-series DVM/frequency counter.



Inner construction of the RC adapter. The chassis, constructed from pc-board material, is protected by a rugged plastic utility box having outer dimensions of 5-7/8 × 3-1/16 × 2-1/8 inches (149 × 78 × 54 mm).



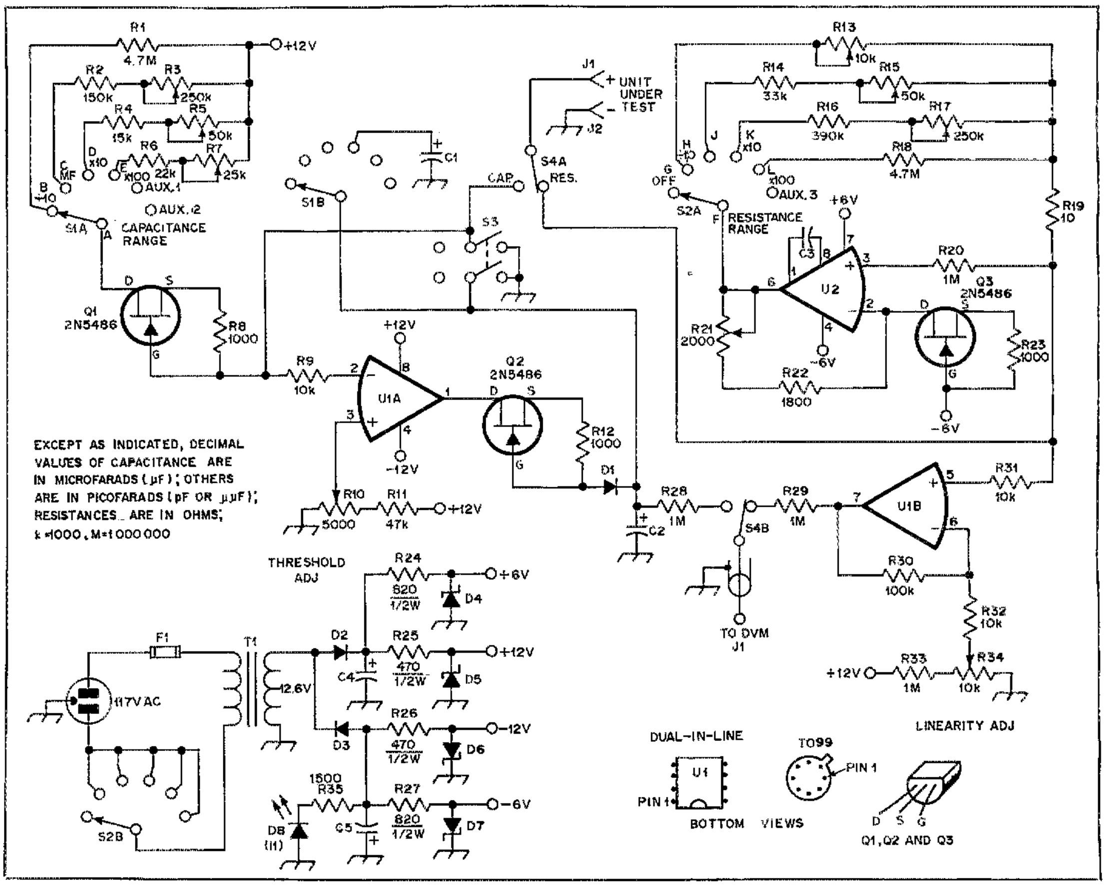


Fig. 1 — The resistance/capacitance adapter. Resistors are 1/4 watt except as noted. R1-R7 and R13-R17 are calibration resistances. Potentiometers are linear-taper pc variables. Circuit boards and components are available from Circuit Board Specialists, Box 969, Pueblo, CO 81002. Tel. 303-542-5083.

C1, C4, C5 — 220 μF, 16 V, Sprague 227G016CG or equiv.
C2 — 22 μF, 16 V, Sprague 226G016AS or equiv.
C3 — 130-pF disk, Sprague 1CC0G131X0100C4 or equiv.
D1 — Silicon small-signal diode, 1N914 or equiv.
D2, D3 — Silicon rectifier diode, 200 V, 1 A; 1N4003 or equiv.
D4, D7 — Zener diode, 6.2 V, 400 mW, 1N753 or equiv.
D5, D6 — Zener diode, 12.0 V, 400 mW, 1N759 or equiv.
D8 — 3/16-in. red LED, Motorola MLED50 or equiv. (I1 on pc board).
F1 — 1/2-A pigtail fuse, Buss MDV 1/2 A, 250 V.
J1, J2 — 5-way binding post. (Radio Shack package no. 274-661 includes red and black posts.)
Q1, Q2, Q3 — N-channel JFET, 2N5486 or equiv.
S1, S2 — 2-pole, 6-position rotary switch, CTS no. T206 or equiv.
S3 — Dpdt momentary toggle switch, Alco no. MTA206T or equiv.
S4 — Dpdt toggle switch, Alco no. MTA206P or equiv.
T1 — 12.6-V, 100-mA power transformer, Mouser no. 81PG120. Mounting centers 1-13/16 inch.
U1 — Dual operational amplifier, National Semiconductor type LM1458. Interchangeable with IC type 5558.
U2 — Linear IC operational amplifier, RCA type CA3130.

enable the device to cover the resistance and capacitance test range.

The Capacitance Section

To explain the functions of the adapter as an accessory for the DVM/counter, let us examine the capacitor test section first. The main principle behind this part of the adapter is that when a voltage is applied to a capacitor, a specific time period will be required to bring the capacitor to full charge. The time period of course depends on the value of the capacitor. One must note, however, that charging will not take place normally in a linear fashion unless some special arrangement is made. If a capacitor is charged with a constant current, then charging will take place linearly. This fact of electronic life forms the basis for operation of the capacitor testing section of the adapter: For this project, an n-channel, depletion-mode 2N5486 JFET was pressed into service as Q1, a constant-current source.

If you refer to Fig. 1, you will observe that the supply voltage for Q1 is fed through S1A, the capacitance-range rotary switch. R1 through R6 are the current-limiting resistances for the four range steps normally used in capacitance testing with the adapter. For the moment, we will not consider the auxiliary ranges.

As you look across the schematic

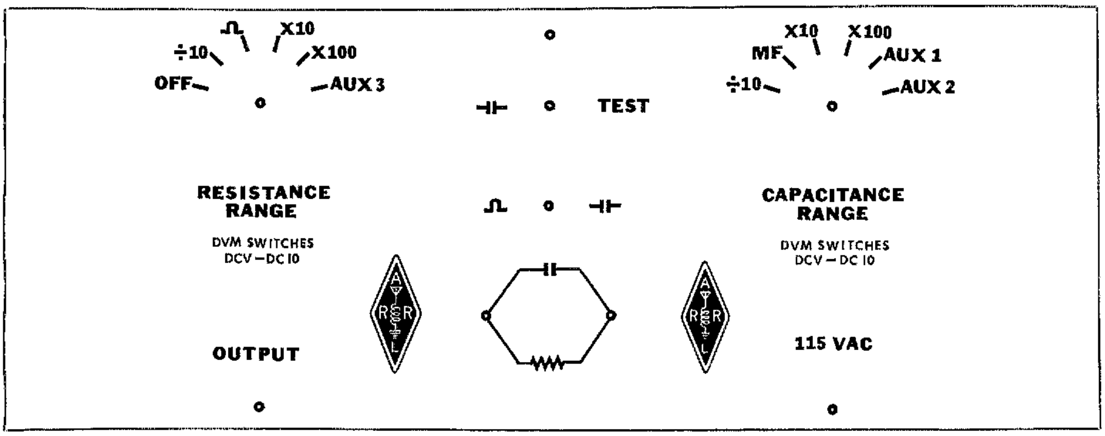


Fig. 2 — Faceplate template at actual size. Black represents copper. Epoxy pc-board material is used for the faceplate and the circuit board. The Ω and the MF switch positions are direct-reading positions without a multiplier.

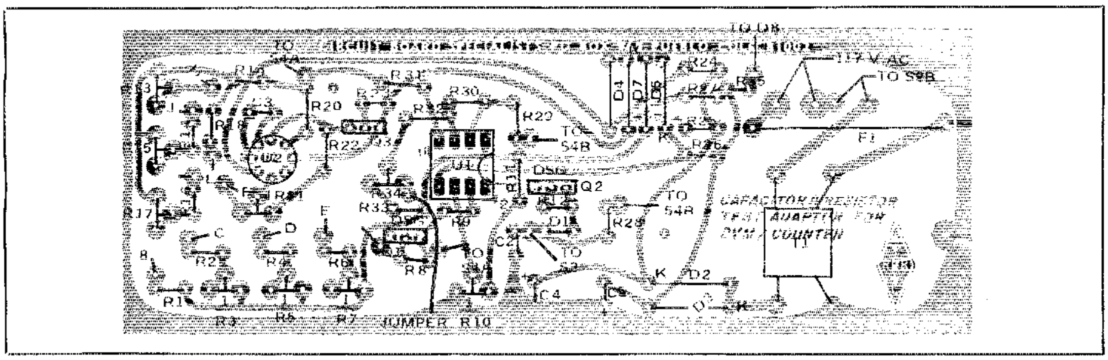


Fig. 3 — Actual size circuit-board template and parts placement guide. Black represents copper. A jumper is to be connected between the foil common and R34.

diagram, U1A comes into view. This LM1458 operational amplifier, with which you might be well acquainted from other projects, stands as a traffic director for this part of the adapter. It is equivalent to the 5558 operational amplifier. Section U1A functions as a dc switch, the purpose of which is to call a halt to the charging at a specific voltage point. Q2, another 2N5486, provides an additional constant-current source. And D1 is the one-way guard that prevents C2 from discharging back into U1A.

Now, let's view this area a little more closely. Presume for instance, that we have an unknown capacitor, the value of which we wish to determine. We connect the capacitor to be checked across terminals J1 and J2. S4, the selector switch for either resistance or capacitance tests, is placed in the capacitance position. S3 is used to short out the capacitor under test and also C2. The output lead is plugged into the DVM/counter on which the controls are set for DCV and DC10. Observe in Fig. 1 that the output lead to the DVM is connected to S4B. Back at U1, pin 1 is standing high (+12 V) and supplies voltage to Q2.

As we open S3, two things begin to happen. The unknown capacitor starts charging up as well as C2. When the unknown capacitor reaches a voltage that causes U1A to switch from positive to negative, then C2 stops charging. Diode D1, being unidirectional, prevents C2 from discharging into U1A.

Once the charging process is ended, we have a voltage standing on C2 that is proportional to the value of the unknown capacitor. We then proceed to feed this voltage into the DVM where it will be indicated. There is something to be said for the adage that seeing is believing. So, let us see for ourselves.

For an example, set the capacitance-range switch (S1) to the MF position and connect a capacitor to the jacks, J1 and J2. Press the capacitor test switch into the test position and observe the reading on the DVM. Suppose, then, you see 4.70 volts appearing on the meter. Such a reading indicates that the capacitor under test has a capacity of 4.7 μF. This becomes a direct reading. In other words 1 volt on the DVM means 1 μF of measured capacitance.

A reading over 10 volts on the DVM indicates an overvoltage. Therefore, we move the capacitance range switch S1 to ×10. Should the meter indicate 4.70 volts, the value of the unknown capacitor would be 4.70 × 10 or 47 μF. On the other hand if the reading appears to indicate less than 1 volt, the procedure to be followed is to set the capacitance range to ÷10 and remeasure. Now, if the meter shows 4.70 volts, the value of the unknown capacitor would be 4.7 divided by 10 or 0.47 μF.

As you scanned the schematic diagram, perhaps you noticed C1 resting adjacent to S1B. This capacitor comes into play when measurements require the high range. By means of S1B it is switched into the circuit to parallel C2.

The Resistance Section

The nature of the resistance measurement section should seem fairly obvious as one looks over that portion of Fig. 1. The linear integrated-circuit operational amplifier, CA3130 (U2), is incorporated as a voltage-to-resistance converter. Very simply stated, the output (at pin 6) is fed back to pin 3 through a range resistor. The unknown resistor is connected at J1 and J2. The lower the value of the unknown resistor, the less the voltage available through R31 to pin 5 of U1B and consequently, the lower the voltage at pin 7, which is fed to the DVM. Because of the high input impedance of the CA3130 (1.5×10^{12} ohms), this COSMOS operational amplifier is well suited for use as U2.

Pin 2 of U2 is fed by Q3, another constant-current source, and is connected to pin 6 by way of R22 and R21 in order to control the range. An explanation of the procedure for testing resistors is covered under calibration.

Construction

The compact arrangement of components without the sacrifice of easy access to the parts is evident in the photograph showing the construction features. In the prototype, I mounted the circuit board against the front panel which is also a piece of circuit board material. This feature permits mounting everything on one chassis, a convenience for easy servicing. The front panel, shown in the first photograph, was polished with fine steel wool and coated with polyurethane varnish. The circuit board is soldered on both sides and at right angles to the front panel. Its purpose is to provide a rugged chassis for mounting all components.

General procedure for constructing the adapter is to assemble all parts, except the ICs, on the circuit board and mount the switches and jacks on the front panel. Connect the switches as shown on the schematic diagram. All soldering should be done with high-quality solder to assure good solder joints. Proper wiring can be simplified with the use of color-coded wire. C1 is mounted on S1B and is the only component mounted off the board. Connect a jumper from point X to point X on the board.

Upon completion of construction work, recheck for possible errors and poorly soldered connections. Then plug the ac line into a 117-V source and turn the dude on. Test for proper supply voltages at U1 and U2.

Next, turn the unit off and plug in U1. *Caution: Be very careful in handling U2.* This unit comes from the factory secured to a piece of black foam which, in effect, shorts all pins together. Before removing U2 from the foam, wrap several turns of very small wire around the pins close to the case. After plugging U2 in the socket, remove the wire. This measure is to protect the device from damage by static electricity. Once installed, the danger is over.

Calibration

After the adapter has come off the production line and the initial tests, described above, are completed, calibration is the only remaining task. If you suddenly have a feeling of dismay because of all the variable resistors, may I assure you that calibration is not at all difficult. Simply relax and proceed one step at a time.

Capacitance

A good approach would be to start with the capacitance section first. One should understand at the very start of this exercise that capacitor values have a very high tolerance. A 4.7-μF capacitor, for instance, may well have a tolerance of −10 percent to +50 percent such that the capacitance might actually be anywhere from 4.23 to 7 μF. However, we will read it out as 4.70 on the DVM. This situation might be compared to sending a *race horse* out to plow the north 40; extreme accuracy is rather foolish.

The advice, therefore, is to locate the following values of capacitors in the best tolerance rating you can get your hot little hands on: 0.47 μF, 4.7 μF, 47 μF, and 470 μF. Connect the 0.47-μF capacitor to J1 and J2. Set S1 to position B (the ÷10 position). Plug the unit output lead into the DVM with the latter set for DCV and DC10, the one-second time base. Press S3 and observe a reading. Release the switch and adjust R10 a little. Repeat this procedure until 4.700 is read on the DVM. Recall, now, that the adapter is in the DIVIDE-BY-10 position. Therefore, 4.7 should be divided by 10 with the result indicating a capacity of 0.47 μF. What may disturb you is the slow decrease of the reading on the DVM as you hold S3. The reason for this decline is that the DVM is slowly drawing the voltage out of C2, a normal condition.

Continuing the calibration process, a 4.7-μF capacitor should next be connected to J1 and J2 (observe polarity) and set S1 to C, the MF position. Press S3 and note the reading. Release S3 and adjust R3. Repeat until the DVM indicates 4.70. Proceed to S1D (×10) and S1E (×100) following the same process for calibration.

Resistance

Adjustment of the resistance section is just as easy. Locate the most accurate resistors you can in the following values: 470 ohms, 4700 ohms, 47 kΩ and 470 kΩ.

Set S2 to L (×100). Turn R21 to midrange. Short J1 to J2. Adjust the fine zero on the DVM. Connect a 470-kΩ resistor to J1 and J2 after removing the temporary short between the terminals. The exact value of the resistor is not important but do get a resistor with the best tolerance available. Adjust R34 for the exact reading of the resistor. Next, try several resistors between 100 kΩ and 1 MΩ. What this test should disclose is whether or not the adapter is providing a linear reading. If not, move R21 and try again. Continue until the linearity seems satisfactory.

For the remaining adjustments move S2 to the H position (Ω). Connect a 470-ohm resistor across J1 and J2. Adjust R13 for exact reading. Use a 4700-ohm resistor for adjusting R15 and a 47-kΩ resistor for setting R17.

With the construction and calibration completed, your little shoe box now has the capability of testing two more component parameters. Should you not have a DVM/counter (by all means you ought to), the output of the adapter can be matched to any high-impedance meter, digital or analog, by changing the values of R28 and R29. For instance if a meter should have an input impedance of 2 MΩ, then the values for R28 and R29 would be changed to 2 MΩ respectively.

The auxiliary positions have been provided to enable the builder to meet future needs. For example, one might desire to have a particular testing range apart from those in the basic design. Some possible uses for the auxiliary positions might be for temperature sensing, antenna elevation indication, or rain-gauge measurements. These could be handled through the auxiliary no. 3 channel. A use for the capacitance auxiliary might be the testing of a variable capacitor.

The adapter is capable of rendering dependable capacitance measurements between 0.01 μF and 1000 μF. While it is possible to take measurements in the vicinity of 5000 μF there could be a higher margin of error.

Although not directly related to the adapter, I'd like to conclude with a suggestion for those amateurs who may experience difficulty in construction and operation of the DVM. You *must* get the frequency counter section working first, followed by the dc-volt portion, and finally the ac-volt section. QST

Locating Geosynchronous Satellites

Tracking a satellite requires new azimuth and elevation figures every few minutes . . . unless its position is "fixed." Then a pocket calculator will tell you where it's at.

By Bill Johnston,* N5KR, ex-WB5CBC

Radio amateurs have developed much interest over the past few years in the use of satellites. Most of this interest centers on the OSCAR communications satellites — those amateur "repeaters" which are circling the earth several times daily. There are others, as well, known as NOAA, ITOS and TIROS. These series are weather satellites, and all are in very nearly identical polar orbits.

But more recently several pioneering amateurs have sparked an interest in the use of other satellite series, such as those called ATS, SMS and GOES. For some years these satellites have been transmitting high-resolution earth photos on vhf and microwave frequencies. Transmissions are made in both real-time and in play-back modes. A number of hams have prepared home-built equipment to receive the pictures.[1,2] What's so different about these latter satellites? Each is placed in a geosynchronous orbit, one whereby the satellite seems to remain in the same place all the time. A geosynchronous OSCAR is entirely within the realm of possibility within the next few years. The task of directing antennas to it would become an important element of its use.

Computing azimuth and elevation angles with a pocket calculator for non-synchronous satellites is not particularly practical since this type of satellite is constantly changing position and requires recomputation of a new set of figures every minute or so. Consequently, most hams tracking these satellites use some form of computer-generated perpetual printout[3] or plotting board.

The synchronous satellite is a different story, however, since it always remains in the same position in the sky, relative to the observer. This occurs because the satellite is placed in a perfectly circular equatorial orbit. Its altitude is such that its orbital period exactly matches the rotation of the earth (i.e., 24 hours), corresponding to an altitude of about 35,800 km (22,245 miles) above the earth's surface. Consequently, it is necessary to compute only one set of azimuth and elevation angles to position an antenna for a given synchronous satellite. This task can be easily accomplished in a few seconds on any pocket calculator with trig functions.

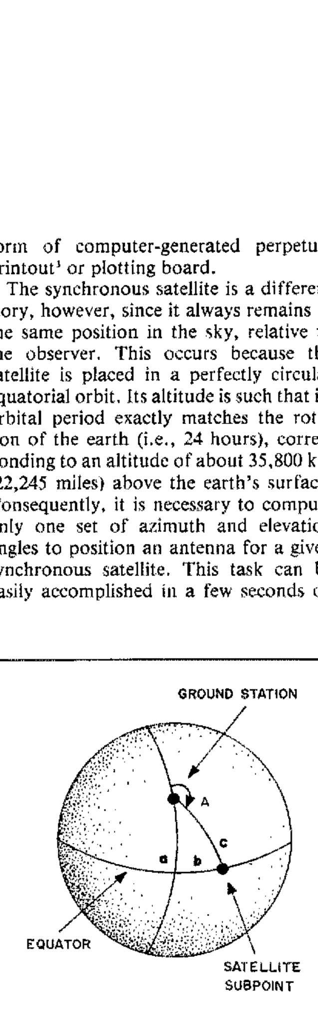


Fig. 1 — The angle of great-circle arc, c, between the ground station and the satellite subpoint may be solved as a right spherical triangle (see Eq. 1). The satellite subpoint is that point on the earth directly beneath the satellite.

The procedure for computing satellite azimuth and elevation angles is well documented,[4] and the method to be used for a synchronous satellite is actually no different from any other. Its special characteristics, however, permit a number of simplifications, and the problem reduces to little more than the solution of a right spherical triangle. Additionally, for our purposes we can make the following assumptions: (1) that the earth is perfectly round, and that its radius is 6367 km (3957 miles), and (2) that every synchronous satellite has a perfectly circular orbit, lying directly over the equator, at an altitude of 35,800 km (22,245 miles) above the earth's surface.

The Actual Computation

The first step we want to carry out in the actual computation is to compute the great-circle angle, c, between the ground station and the satellite subpoint. (This is the point on the earth directly below the satellite.) See Fig. 1. The formula, then, is that for a right spherical triangle

$$c = \cos^{-1}(\cos b \times \cos a) \qquad \text{(Eq. 1)}$$

where

c is the great-circle angle between the ground station and the satellite subpoint.

a is the latitude of the ground station (north is +, south is −).

$b = g - f$.

g is the longitude of the ground station (east is +, west is −).

f is the longitude of the satellite subpoint (east is +, west is −).

When computing b, be sure to retain the proper algebraic sign. Also, b must re-

*1808 Pomona Dr., Las Cruces, NM 88001
[1]References appear on page 25.

main within the range from −180° to +180°, and if it does not, we must add or subtract 360° as necessary to put it back within that range. Note that c is an angular measure, just as a and b are angular measures in terms of latitude and longitude.

Not only is c used in a subsequent calculation, but it gives us a quick check at the beginning as to whether the satellite is actually within view of the ground station (i.e., above the horizon). The absolute value of c must be less than 81.3° to be useful. (This is the value of c when the elevation angle is zero). If it turns out to be greater than this value, then the satellite is below the horizon and there is no need to carry out any further calculations. For that matter, in the step prior to computing c, if b turns out to be greater than 81.3° we know even then that the satellite is not visible. That difference of longitude would put it below the horizon even if the ground station were located on the equator.

Incidentally, if you care to know the great-circle distance along the *surface* of the earth between the ground station and the satellite subpoint, multiply c (in degrees) by 111.136 to get the distance in kilometers, or by 69.057 to get the distance in miles. We can now compute the azimuth angle, A, directly.

For a northern-hemisphere ground station, use

$$A = 180° + \tan^{-1}\left(\frac{\tan b}{\sin a}\right) \quad \text{(Eq. 2n)}$$

For a southern-hemisphere ground station, use

$$A = \tan^{-1}\left(\frac{\tan b}{\sin a}\right) \quad \text{(Eq. 2s)}$$

The purpose of having separate formulas (2n) and (2s) for northern- and southern-hemisphere ground stations is simply as an aid in handling the algebraic signs of the computed angles and identifying the appropriate angular quadrant in the final result. This simplifies matters when solving the problem on certain types of calculators, but I do not mean to imply that this is the only way to get the solution. In either case, if you come up with a negative azimuth angle, add 360° to it so that it will lie in the range from 0° to 360°.

Now, looking at the earth in cross section, Fig. 2, the great-circle angle, c, is shown on the surface of the earth. The central angle, C, is the same angular measure and is equal to c.

The slant range, S, between the ground station and the satellite is found by the law of cosines

$$S = \sqrt{R^2 + (R + h)^2 - 2R(R + h) \cos C} \quad \text{(Eq. 3)}$$

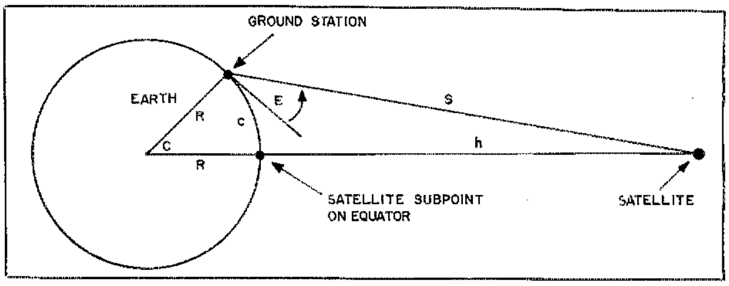


Fig. 2 — Cross-section representation of the earth showing the ground-station/satellite relationship. The angle of great-circle arc, c, is the same as that shown in Fig. 1, and is equal in degrees to included angle C.

where

R is the radius of the earth (6367 km or 3957 miles).

h is the height of the satellite above the surface (35,800 km or 22,245 miles).

C is the central angle, equal to c. The elevation angle, E, then, is given by

$$E = \cos^{-1}\left\{\frac{S^2 + R^2 - (R + h)^2}{2 RS}\right\} - 90° \quad \text{(Eq. 4)}$$

We now have all the formulas we need to compute azimuth, elevation and slant range, plus a couple of other useful items. So that we can put them to practice, Table 1 gives the present longitudes of a few synchronous satellites that we might be interested in.

Table 1
Geosynchronous Satellites

Satellite	*Longitude*	*Frequency (MHz)*
GOES-1	75° W	1691.0/1687.1
GOES-2	en route	1691.0/1687.1
SMS-1	105° W	1691.0/1687.1
SMS-2	135° W	1691.0/1687.1
ATS-1	149° W	135.6
ATS-3	69° W	135.6

(See text for address to obtain latest status.)

Because of a variety of orbital pertubations, most geosynchronous satellites wobble a few degrees from a perfect orbit, and for operational reasons their station longitudes are adjusted from time to time. For these reasons, the longitudes shown in the table are rounded values, but they will be quite suitable for our purposes.

Also keep in mind that not all of the satellites transmit continuously. ATS-1 and -3, for example, have both been in orbit for over 10 years, and for the past few years have at various times been placed in reduced activity or inactive status, as their functions were replaced by the SMS series satellites. The same is now true of SMS-1 and -2, as their primary functions are in the process of being replaced by GOES-1 and -2.

For the latest information on geosynchronous satellite status and station longitude, write to United States Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Services, Washington, DC 20233. Be sure to be specific in your request as to what information you need.

Example Calculations

Now let's take a look at a few examples which will help in using the formulas.

Example 1:

Ground station at Atlanta, GA, 33°45′ N, 84°24′ W (latitude 33.75, longitude 84.40). Satellite: GOES-1 at 75° W (−75.0°).

Then, a = 33.75°, g = −84.40°, f = −75.0°, and b = (−84.40°) − (−75.0°) = −9.4°. Since the absolute value of b is less than 81.3°, we may proceed.

From Eq. 1, c = $\cos^{-1}$(cos −9.4° cos 33.75°) = 34.9°. Since the absolute value of c is less than 81.3°, we know that the satellite is visible.

The ground station is in the Northern Hemisphere, so we use Eq. 2n to get the azimuth angle:

$$A = 180° + \tan^{-1}\left(\frac{\tan -9.4°}{\sin 33.75°}\right) = 163.4°$$

The slant range is determined from Eq. 3, and the elevation angle from Eq. 4. The solutions for this example are given in Table 2. From that information, then, an antenna in Atlanta, set at an azimuth of 163.4° and an elevation of 49.5° would point directly at GOES-1.

Example 2:

Ground station at Honolulu, HI, 21°18′ N, 157°52′ W (latitude 21.30°, longitude

Table 2
Determination of Slant Range and Elevation for Example 1.

$$S = \sqrt{(6367)^2 + (42,167)^2 - (2)(6367)(42,167)\cos 34.9°}$$
$$= 37,124 \text{ km}$$

$$E = \cos^{-1}\left\{\frac{(37,124)^2 + (6367)^2 - (42,167)^2}{(2)(6367)(37,124)}\right\} - 90° = 49.5°$$

Table 3
Slant Range and Elevation Determination for Example 4.

$$S = \sqrt{(6367)^2 + (42,167)^2 - (2)(6367)(42,167)\cos 74.1°} = 40,879 \text{ km}$$

$$E = \cos^{-1}\left\{\frac{(40,879)^2 + (6367)^2 - (42,167)^2}{(2)(6367)(40,879)}\right\} - 90° = 7.3°$$

−157.87°). Satellite: GOES-1 at 75° W (−75.0°).

Then a = 21.30°, g = −157.87°, f = −75.0°, and b = (−157.87°) − (−75.0°) = −82.87°. Since the absolute value of b is greater than 81.3°, we know that the satellite is below the horizon and there is no need to make further calculations.

Example 3:

Ground station at Quebec, PQ, 46°49′ N, 71°13′ W (latitude 46.82°, longitude −71.22°). Satellite: ATS-1 at 149° W (−149.0°).

For this example: a = 46.82°, g = −71.22°, f = −149.0°, and b = (−71.22°) − (−149.0°) = 77.8°. Since the absolute value of b is less than 81.3°, we may proceed.

From Eq. 1, $c = \cos^{-1}(\cos 77.8° \cos 46.82°) = 81.7°$. Since the absolute value of c is greater than 81.3°, the satellite is below the horizon, and there is no need to proceed further.

Example 4:

Ground station at Brisbane, Australia, 27°28′ S 153°02′ E (latitude −27.47°, longitude 153.03°). Satellite: SMS-2 at 135° W (−135.0).

Then: a = −27.47°, g = 153.03°, f = −135.0°, and b = (153.03°) − (−135.0°) = 288.03°. Since 288.3° is greater than 180°, we subtract 360° to put the value in the range from −180° to +180°: b = 288.03° − 360.0° = −71.97°. The absolute value of b is less than 81.3°, and we may proceed. Again from Eq. 1, $c = \cos^{-1}(\cos -71.97° \cos -27.47°) = 74.1°$.

Because the absolute value of c is less than 81.3°, the satellite is visible. The azimuth angle, from Eq. 2s, is

$$A = \tan^{-1}\left\{\frac{\tan(-71.97°)}{\sin(-27.47°)}\right\} = 81.5°$$

The solution for slant range (from Eq. 3) and for elevation (from Eq. 4) is shown in Table 3. Therefore, an antenna at Brisbane, set at an azimuth of 81.5° and an elevation of 7.3°, would point at SMS-2. Note, however, that this is not very far above the horizon and reception would probably be marginal.

The examples above demonstrate the straightforward method that one can use on a pocket calculator to determine, first of all, if a particular geosynchronous satellite is within view of his ground station, and then to compute the azimuth and elevation angles for pointing the antenna. Accurate results are obtained in a few seconds just by plugging the appropriate figures into the formulas.

Although most geosynchronous satellites are located in the western hemisphere, the formulas work for all satellites and all ground-station locations. The only word of caution is to make sure that you always retain the proper algebraic sign for latitudes and longitudes, as explained earlier.

As a final note on the use of synchronous satellites, you will remember that the great-circle angle between the ground station and the satellite subpoint must be less than 81.3° if the satellite is to be visible. Obviously, then, no ground station beyond 81.3° north or south latitude can possibly see any synchronous satellite regardless of longitude. These areas include parts of Greenland, Svalbard, Franz Josef Land, the northernmost Canadian arctic islands, and of course a good-sized chunk of Antarctica. As a practical matter, however, few stations beyond 70° north or south latitude would be within view of an operational geosynchronous satellite, but even these areas include no significant population centers.

So if you've been thinking about building a station to receive weather photos and other information from synchronous satellites, but were worried about how to aim your antenna, worry no more. And if you're too lazy to even pull out the ol' pocket calculator, you may just send along a large s.a.s.e. and $1 (to cover the cost of computer time), and I'll have a giant IBM 360 print you out a nice chart showing azimuth and elevation angles, plus range, from your station location to every possible synchronous satellite location, in one-degree increments. (Readers outside the U.S. may omit the s.a.s.e.)

A number of amateurs are presently receiving high-resolution earth photos from these satellites, and aiming the antenna is even easier than tracking OSCAR. It's another facet of our hobby that you're sure to enjoy. QST

References

[1]Taggart, "Amateur Weather Satellite Reception," 73, May, 1976, p. 52.
[2]Taggart, *Weather Satellite Handbook*, 73, Inc., Peterborough, NH, 1976.
[3]Johnston, "Perpetual Orbital Printout for OSCAR 6 and 7," *AMSAT Newsletter*, September, 1975.
[4]Gould, "An OSCAR Angle Nomogram," *AMSAT Newsletter*, December, 1973.

Strays

SHORT ON WALLPAPER?

☐ The Union de Radioaficionados Espanoles offers three different awards, available to all amateurs. The "Diplomas 100 EAs-CW" is issued for submitting proof of 100 QSO points, with the QSO point value dependent on the applicant's *CQ Magazine* zone. For contacting 125 different EA stations, with at least three QSOs in each of the eight Spanish districts, URE awards the "Espana Diploma." In addition, the most outstanding amateur with an Espana Diploma is awarded a gold medal. Finally, the "C.I.A. Diploma" is given for proof of contact with either 20 different Latin American countries for the gold certificate, or 15 for the silver certificate. Both must include contact with Puerto Rico, Portugal and Spain. Obtain full details on all these from URE, Hortalezy St., 2-6° Derecha, P. O. Box 220, Madrid 4, Spain.

☐ The Highveld Branch of the South African Radio League offers the "Highveld Branch Award" for proof of contact with six to 12 ZS stations. The exact requirements are dependent on where the applicant's station is located and bands used. Write to SARL, Awards Manager, P. O. 117, Edenvale, Transvaal, South Africa.

☐ Island-hoppers can receive the "Islands of the World DX Award" by working either 50, 100, 150 or all 162 islands, including Whidbey Island, WA, which appear on a list prepared by Bill Gosney, WB7BFK. More information can be obtained from him at 4471 40th N. E. St., Oak Harbor, WA 98277.

A Permeability-Tuned Variable-Frequency Oscillator

Want a top-notch VFO with precision tuning? Here 'tis!

By Warren A. Gregoire, Jr.,* W6TME (ex-WA6BIP, ex-W5CUV)

Digital frequency readout — that contemporary bit of electronic showmanship — can provide a touch of glamour to your station. Watch a visitor's eyes. The moment the LEDs respond to the tuning knob's movement, eyes are drawn to the display. But for you, the operator, the DFR is a practical device; the attraction offered is of lesser importance. You have learned to rely on this accessory for correct frequency indication.

But are the results as reliable as you'd like? Is it possible that your receiver VFO is the weak link in the chain? If it doesn't toe the mark, then a permeability-tuned oscillator may be the remedy.

Providing a precision tuning mechanism is perhaps one of the most challenging hurdles facing the home constructor of amateur radio communications equipment. The builder may elect to splurge on this crucial item, spending $50 or more for a variable capacitor and suitable reduction-drive dial. Surplus units as adapted by Brunmeir[1] are means for a convenient solution, but in my case, the diminutive size of the station receiver eliminated this possibility. I decided, therefore, to build my own miniature permeability-tuned oscillator, precluding the need for a variable capacitor and including a built-in vernier mechanism.

The PTO described here is intended for use as the tunable oscillator in homemade receivers with 160-meter tunable i-f stages, as featured in recent issues of *QST*.[2,3] Frequency coverage is 2255-2505 kHz and the direct-reading dial is accurate within ± 1.5 kHz over the entire 250-kHz tuning range, even without moving the mechanically adjustable pointer. Error from any 25-kHz dial mark to either adjacent 25-kHz mark is less than 1 kHz. Thus, when the pointer is reset at the nearest 25-kHz mark, very accurate readings are possible, as the main dial is calibrated in divisions of 1 kHz each. Tuning is smooth, with excellent freedom from backlash, slipping and mechanical instability. The dial is also resettable with a high degree of accuracy.

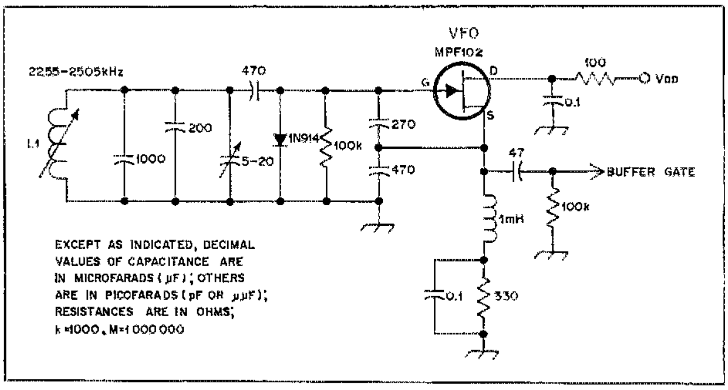


Fig. 1 — The circuit for a permeability-tuned oscillator that provides stability and linearity at low cost. It is well suited as a VFO replacement for communications receivers such as described in *The Radio Amateur's Handbook*, 54th edition, ARRL, 1977, page 277. L1 consists of 28 turns of no. 36 enameled copper wire occupying 1/8 inch on a J. W. Miller form (part no. 64A022-2).

Mechanical parts list:
- 1/4-inch shaft with integral panel bushing, H. H. Smith no. 148.
- Phono idler wheel, approximately 1-1/8-inch diameter, available at GC and Walsco parts dealers. See text.
- Main drive wheel, approximately 1-13/16-inches diameter, center hole threaded to accept a no. 6-32 screw and provision for setscrew. See text.
- 1-1/4-inch angle-aluminum stock, 2-1/2-inches long.
- 2-inch angle-aluminum stock, 1-1/2-inches long.
- Vinyl tubing, 1/4-inch inside diameter for tight fit on shaft.
- 8 metal washers, 1/4-inch diameter. A 1/4-inch sleeve with setscrews may be substituted as shown in photographs.

A Different Approach

After conducting preliminary experiments based on prior publications on the subject of permeability-tuned oscillators,[4,5,6,7] this writer decided to try an entirely fresh approach using a standard J. W. Miller slug-tuned coil form with an adjustable lead screw. A simple arrangement results. The wheel which supports the main dial scale couples directly to the tuning inductor lead screw and is secured by a knob-type setscrew. A 1/4-inch shaft, covered with vinyl tubing, rotates against this wheel, causing it to turn and effecting a 6:1 turn reduction for the tuning knob. The dial-scale drive wheel moves back and forth along the 1/4-inch shaft as it follows the in-and-out motion of the tuning core. Since the total in-and-out travel of the dial scale is only 3/32 inch, this movement is not easily perceptible during normal operation.

My associates have expressed skepticism over the simplicity of the friction-drive system and seemed surprised that it doesn't slip. Actually, similar friction-drive mechanisms are used in very prestigious, commercially marketed products, such as the Collins S/Line and Heath SB series.

*940 Diamond St., San Francisco, CA 94114
[1]References appear on page 28.

The oscillator tank circuit was developed so that for each revolution of the tuning core (and also the dial scale), approximately 100 kHz is spanned. Since 2-1/2 revolutions of the dial are required to cover the 250-kHz range, a means of identifying the particular 100-kHz segment being tuned is provided. This function is performed by a small rubber wheel (phonograph idler wheel replacement) which rides atop the tuning-inductor lead screw, immediately behind the main dial. This small wheel turns only a few degrees for each complete revolution of the main dial because it is driven by the much smaller diameter lead screw. The black rubber wheel is calibrated and marked with white dry-transfer numerals such as those used for panel lettering. The position of the turns-counter dial is indicated by the edge of the main dial scale.

Winding the Coil

The tuning inductor consists of 28 turns of no. 36 enameled copper wire, close wound, occupying about 1/8 inch along the ceramic coil form. This size wire is rather delicate and must be handled carefully to avoid kinks which can cause aberrations in dial linearity. First, the brass mounting threads of the coil form are gently chucked into a hand drill which has been secured laterally in a vise. Then one end of the wire is soldered to the terminal nearest the mounting end. Now the coil form is slowly rotated in the drill as the wire is fed under light finger tension to achieve an even, close-spaced winding. Care should be exercised so the lead of the winding is perpendicular to the form. Any wobbling motion should not appear as the coil is rotated. Counting turns as the winding progresses is advisable. The finished coil is secured *temporarily* with cellophane tape as the remaining end is soldered. During final adjustment of the PTO, the cellophane tape is replaced with coil dope.

Modifying the Tuning Core

In order to obtain good dial linearity without using a variable-pitch inductor, this design includes a simple modification of the tuning core itself. After removing

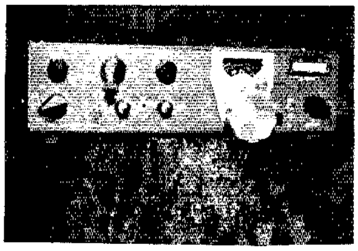


Fig. 2 — A precision-tuned VFO is located behind the faceplate of this neatly constructed device. Tuning is accomplished by a simple friction-drive mechanism.

the core from the form, the lead screw is wrapped thickly with vinyl electrical tape to protect the threads, then placed in the chuck of a high-speed drill. *During this operation, one should provide some form of protection for the eyes and hands.* In general, proceed with caution. As the core is rotated at high speed, use a file to grind the core to a shape which conforms approximately to the illustration of Fig. 6. Although the cores are sturdy and indeed seem almost to fight back during grinding, spare cores are recommended in case of breakage. The notched contour of the core spreads out the naturally more compressed area in the center of the tuning range. As a result, the central dial segments of tuning conform more closely to those at the extremes of the range.

Mechanical Construction and Alignment

Form a sturdy, adjustable, two-piece frame from 1/8-inch angle-aluminum stock. Elongated holes allow a wide range of adjustment to the friction-drive system. Bolt the 1/4-inch shaft, locked into the integral panel bushing, in place on the front section of the frame. Vinyl tubing is slipped over the shaft, followed by several 1/4-inch washers — the exact number of which is selected to allow the two parts of the frame to be joined and adjusted. The shaft should fit snugly but rotate freely.

Next, install the circuit board into the frame. The tuning coil is mounted loosely in the elongated hole, after which the dial-scale wheel is attached to the lead screw. Now tighten the inductor mounting nut to lock the coil into position at the exact spot which allows the dial-scale wheel to engage the 1/4-inch shaft under tension. The tension should be just enough to take up the slack in the threads and to press the lead screw firmly against the stationary threads. This adjustment, executed properly, prevents backlash and assures good resettability of the dial. If the slug fits very tightly in the stationary threads, removal of the compression spring on the coil may be necessary before installing the dial-scale wheel.

Finally, the turns-counter wheel is aligned so that the rubber edge becomes compressed slightly by the lead-screw threads. Since small changes in these adjustments result in large variations in tension, experimenting is necessary to produce the desired "feel" and smooth operation. Light grease should be used to lubricate the bearing points but *the friction-drive surfaces must not be lubricated!*

Dial Bezel and Pointer System

The faceplate, constructed from 1/8-inch scrap aluminum, serves not only to enhance the appearance of the dial presentation, but also functions as the support for the resettable pointer. To fashion the faceplate, a hacksaw, a coping

Fig. 3 — A closeup of the dial faceplate. The shaft for the tuning knob is at the bottom. A vernier knob is at the right, just beneath the dial.

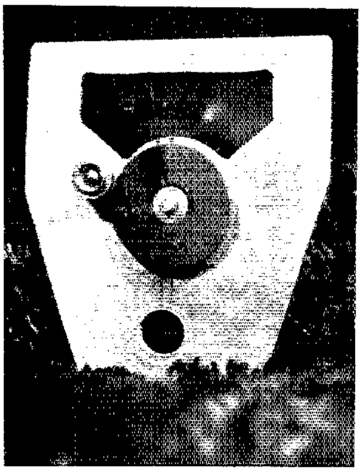


Fig. 4 — The dial pointer is mounted as shown.

saw and a drill were used. Another impromptu friction drive is used in the faceplate. It is inserted between the reset knob and the pointer, as may be seen in Fig. 4. A flat plumbing washer with a no. 6-32 nut pressed into the center hole of the washer is used to mount the thin, red-painted brass pointer.

As used by the author, the friction-drive shaft consists of a "captive bolt" with two circular nuts locked together on the bolt threads. Since these are not available readily, an ordinary bolt which fits the reset knob is suggested for the drive shaft. The hole for this bolt should be located so that the washer will be engaged by the bolt in a positive nonslip manner.

In order to reduce parallax errors in dial

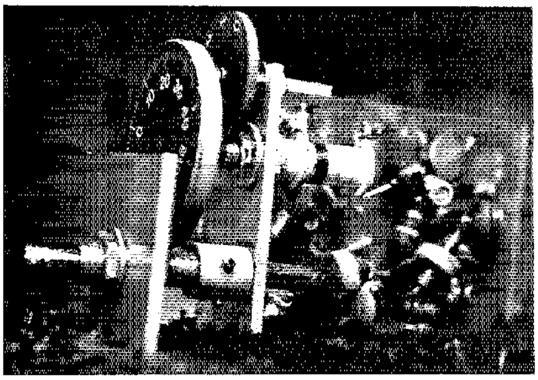


Fig. 5 — The inner construction of the precision-tuned VFO. Behind the large main tuning dial is the smaller counter dial. Beneath the dials is the sleeve with setscrews mentioned in the mechanical parts list. The manner in which L1 is mounted is clearly visible in the component area.

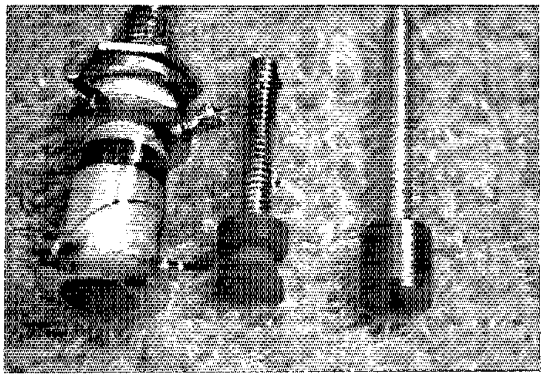


Fig. 6 — Coil assembly and slugs for the permeability-tuned VFO. Positioning of the coil on the Miller form is illustrated. Steps to be followed for winding the inductor and for modifying the tuning core, as shown above, are explained in the text.

reading, the pointer depth should measure 1/8 inch from front to back. The completed bezel/pointer assembly is mounted on the main 1/4-inch shaft bushing with an additional 3/8-inch nut.

The Circuit

A variation of a recent design by DeMaw[8] is used for the VFO circuit. This adaptation uses a parallel-resonant tank in a Colpitts configuration. Because of availability, a 5- to 20-pF trimmer capacitor was included, but a unit with a greater capacitance range would be preferable from the standpoint of easy initial adjustment.

Parts Procurement and Substitution

The 1/4-inch shaft, complete with panel bushing is obtainable from large electronic parts distributors. A length of brass brazing rod, or even a common 1/4-inch bolt may be substituted, but for smooth tuning the panel bushing is highly recommended.

Visible in Fig. 3 is the turns-counter wheel. This is a replacement phonograph idler drive wheel. Such wheels are often found displayed as "hanging stock" at parts outlets serving the radio and TV repair trade. A flat, black plumbing washer with a no. 6-32 nut pressed into the center hole can be substituted, with some sacrifice in reliability of the counter dial. The plumbing washer is very well suited for use with the pointer drive mechanism.

Vinyl tubing for the main 1/4-inch shaft may be purchased from large hardware and home-handyman stores, but vinyl electrical tape is a very satisfactory substitute. Almost any truly round wheel with an accurately located center hole and some means of securing it tightly to the inductor lead screw can serve as the main dial-scale wheel. The dial scale itself may be hand drawn[9] or, for a more professional appearance, should be drafted at large scale, photographed, and printed at the desired smaller size.*

Development of Tuning Inductors for Other Frequencies

For other tuning ranges, the VFO is assembled and a coil is wound with even, close spacing. The number of turns applied should be that which could reasonably be expected to resonate at the desired frequency. Parallel capacitance and turns of wire are added or subtracted as necessary to produce resonance at the center of the tuning range with the tuning core located at the middle of the winding.

Then, with the inductor functioning in the VFO circuit, dial readings are recorded at 25-kHz intervals throughout the tuning range of the inductor. This is accomplished by using the PTO to tune the receiver while listening for the 25-kHz crystal-calibrator markers. The PTO output may also be monitored on a frequency counter. You'll observe that greater bandspread exists at the extremes of the tuning range than in the center. A relatively large number of 25-kHz segments may occupy approximately the same number of dial divisions (more than likely not the desired 25 divisions!). If, for example, a centrally located 25-kHz segment occupies about 47 dial divisions, the coil may need rewinding with smaller diameter wire. Alternatively, a smaller diameter coil form may be used. The goal is to wind a coil which provides too little bandspread with perhaps 15 or 20 dial divisions occupied by a 25-kHz segment. Then the tuning core may be notched or otherwise reduced inside, in small steps, until the central segments occupy the desired 25 dial divisions.

The entire tuning range of an inductor must be investigated because the same frequency spectrum may appear more than once within the range of the slug adjustment. The degrees of bandspread in each case will be different.

Current design goals were accomplished as the result of very early experiments with "contouring" the tuning core. Additional attention has not yet been devoted to exploration of this area. Perhaps with the proper slug configuration at a higher frequency, 500-kHz linear coverage would be possible using these methods.

I hope information supplied here will inspire further experiments by other amateurs into the realm of precision permeability tuning and simple, friction-drive vernier mechanisms. The cost is low and the results can be very satisfying!

*The author has available a limited quantity of duplicate drive wheels and photographically reduced dial scales, both of which will be supplied by mail to interested amateurs, for $6 postpaid in the continental U.S.

References

[1]Brunmeir, "Precision Tuning — WWII Vintage," *QST*, February, 1975.
[2]DeMaw, "More Receiver Design Notes," *QST*, June and July, 1974.
[3]DeMaw, "His Eminence — the Receiver," *QST*, June and July, 1976.
[4]Arnold, "Transistor VFO with Linear Tuning," *QST*, March, 1960.
[5]Horn, "A High-Precision Permeability-Tuned VFO," *QST*, July, 1964.
[6]Perolo, "A Solid-State Permeability-Tuned VFO with Digital Frequency-Readout," *CQ*, October, 1970.
[7]W2BMU and W2ZHI, "Transistorized VFOs," *G.E. Ham News*, May-June, 1956 (Vol II, No. 3).
[8]"A Communications Receiver with Digital Frequency Readout," *The Radio Amateur's Handbook*, 1976 edition.
[9]Hulick, "The Companion," *CQ*, April, 1967.

The Flagpole Deluxe

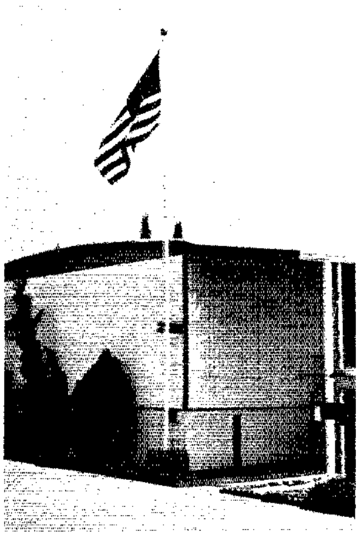
If you've got to hide your antenna, make this flagpole do double duty as an efficient four-band vertical.

By Fred J. Schnell,* W6OZF

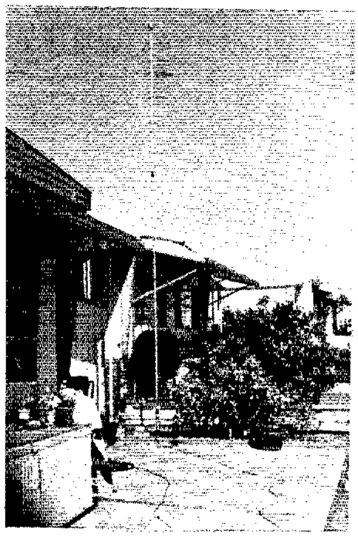
When I moved into a mobile home park some eight years ago I was faced with an antenna problem. The manager of the park told me I could put up an antenna at night, but would have to take it down during the day and also "stay out" of the TV system. The TV problem did not bother me, but putting up an antenna at night and taking it down every day had no appeal. I first mounted a Swantenna mobile antenna on a 42-inch, chain-link fence and got along very well for several years. But I was always dreaming of something different, something with automatic band switching.

I decided to concentrate my efforts toward building a flagpole antenna, with no bulges like the trap verticals. It had to cover 40 through 10 meters and be able to fly a 4 × 6-foot flag. I had room for neither radials nor a large copper screen, so only a ground rod could be used — a compromise. Faced with these constraints, I proceeded with the design of my flagpole.

When finished the antenna is an aluminum tubing vertical with slim, home-built traps, covered by standard PVC pipe, and topped with a toilet-tank ball. The PVC pipe has nothing to do with the antenna itself; it is the flagpole. The base is small and simple, thus easily concealed by brickwork, rocks or flowers.



Would you believe this flagpole is really a four-band antenna, covering 40 through 10 meters? Sturdy enough to fly the flag in a stiff breeze, this trap vertical presents a good match to 50-ohm coaxial line.



The test site for the development of the antenna was the "backyard." Upon completion the antenna was moved to its permanent location and "camouflage" was added to conceal the base, shown at left.

Problem Solving

A suitable ground system and skinny traps were two areas requiring some head scratching. I settled on a 10-foot (3.05 m) length of copper water pipe for the ground rod. Installation of this pipe was accomplished by soldering a hose fitting on one end of the pipe, connecting a garden hose to it, and turning the water on full force. You'll have to stand on a step ladder to do this but the method works beautifully. I have another ground rod under the mobile home, and the ground system consists of the two ground rods and also the "skin" of the home.

*97 Blue Sky Lane, Oceanside, CA 92054

After much experimenting I finally settled on putting the capacitors inside the trap forms; I selected capacitors which would keep the total height of the vertical under 19 feet. It topped out at 17 feet, 9-3/4 inches (5.43 m). The capacitors used are the Centralab 850S series doorknob transmitting type. I had used them before when I built a five-band dipole which has been described in *The ARRL Antenna Book*. The first traps were made of formica tubing reinforced with Lexan rod, but I recommend fiberglass rod for the added strength and lighter weight.

Learn to Be a Pack Rat

If you start from scratch, you will have to visit several stores in order to obtain all the materials. Try stores like Sears, Ward's and Penney's for miscellaneous items, then hardware, metal, building and lumber companies. The aluminum tubing is 6061-T6 or equivalent, 0.058-inch wall thickness. The T- and U-bar stock is construction aluminum pieces and is available from most metal supply companies.

Auto supply and discount stores are excellent sources for U bolts and clamps. The 1-1/4-inch conduit may be purchased from an electrician, but since you will only need 2 feet of this he will probably give you that much from his scrap heap. Assemble all the materials before you start since nothing is more exasperating than beginning a project and then not being able to readily get all the parts. Table 1 is a complete list of the necessary parts.

Getting Started — Preliminary Construction

Fig. 1 shows details of the base mounting assembly. Drill and countersink a hole to accommodate a no. 8-32 × 9/16 flat-head screw. Drill and tap the insulator block and mount it inside the U channel. Drill eight 3/8-in. (10 mm) holes in the T bar as shown; the 2-in. U bolts will straddle the U channel. Assemble the U and T

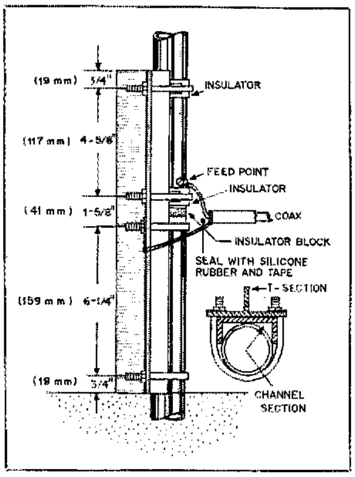


Fig. 1 — U- and T-bar stock details for the base assembly.

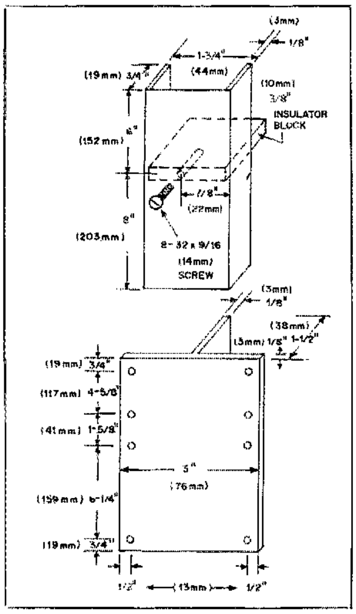


Fig. 2 — Construction details of the T bar and U channel for the base mounting assembly.

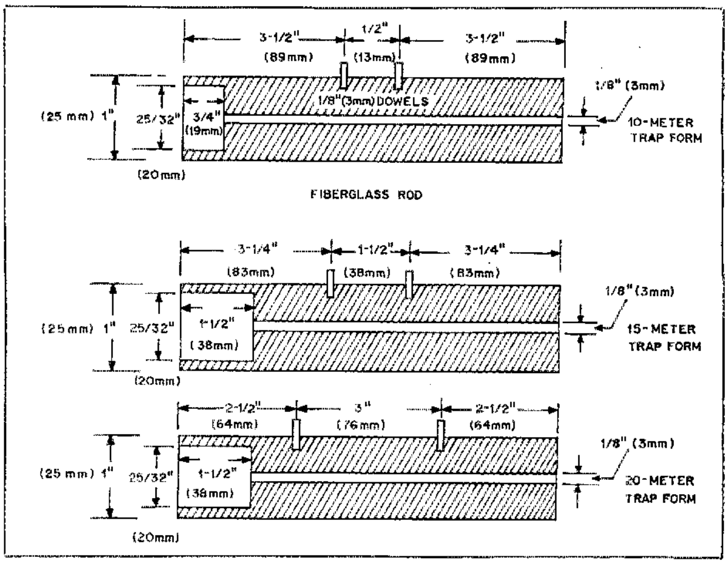


Fig. 3 — Cross-sectional views of the three traps.

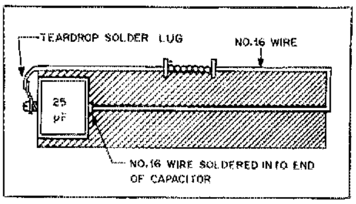


Fig. 4 — 10-meter trap winding detail.

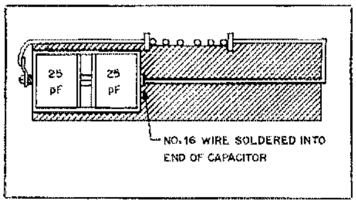


Fig. 5 — 15- and 20-meter trap winding details.

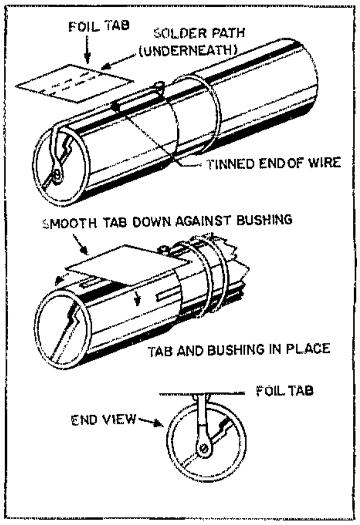


Fig. 6 — Further details of trap construction, showing the foil tab and bushings.

bars per Fig. 2, leaving the U bolts loose.

Fit the insulator sleeves on the 36-in. length of 1-1/8-in., 0.125-in. wall tubing (Fig. 2). These insulators should fit snugly and the U bolts which clamp them to the base assembly will hold them tight. Drill and tap the tubing for a no. 10 screw, 1/4 in. (6 mm) above the top insulator; this will be the feed point.

Preliminary Construction — Traps

Refer to Fig. 3. Cut one 7-1/2-in. (191-mm) and two 8-in. (203-mm) lengths of 1-in. fiberglass rod, and through all three pieces drill a 1/8-in. (3-mm) hole lengthwise. In one end of the 7-1/2 in. rod, drill a 3/4-in. (19-mm) hole 3/4 in. deep. In the other two pieces, drill a hole in one end 1-1/2 in. (38 mm) deep. I used masonry drill bits for these holes.

In the 7-1/2-in. rod, drill two 1/8-in. holes (3/16 in. deep) for pegs, as indicated in Fig. 3. Insert 1/8-in. pegs in these holes. These pegs will be used to hold the windings in place.

Referring to Fig. 4, wind the 10-meter trap. Begin by soldering one end of a suitable length of no. 16 wire (Formvar or Thermaleze) to one end of a 25-pF capacitor. Push the wire through the rod from the large hole end and push the capacitor all the way in, then pull the wire snugly over the end of the rod to the nearest peg and wind five turns, close spaced. Coming off the next peg, dress the wire to the capacitor and solder to it by means of a no. 6 solder lug. This completes assembly of the 10-meter trap.

Following the same procedure, wind the

15- and 20-meter traps. Note that these traps are space wound and that the last turn is spaced a little more than the others; Figs. 4 and 5 illustrate. The 15-meter trap has 13 turns spaced to a length of 1-3/8 in. (35 mm) and the 20-meter trap has 23 turns spaced to a length of 2-3/8 in. (60 mm), with the last turn of each spaced slightly more than the rest. This aids in later tuning of the traps.

Referring to Fig. 5, scrape the enamel off both ends of each winding from the pegs to the ends of the fiberglass rods, and carefully tin each one with a hot soldering iron. Cut six foil tabs, each 3/4 × 1-1/2 in. (19 × 38 mm) and run a solder-path lengthwise along each tab, on one side only. Now solder these tabs onto the previously tinned wires (Fig. 5).

Cut six lengths of the 1-1/8-in. tubing, each six in. (152 mm) long. In one end only of two of the tubes cut a slot 3-1/2 in. (89 mm) long, using two hacksaw blades together in the hacksaw (Fig. 7). This will make a slot about 1/8 in. wide. On the other four tubes, make this slot 3 in. (76 mm) long. Remove one hacksaw blade and cut three more slots in the same end as the wide slot, spacing them 90 degrees apart. Clean and deburr all cuts. These slots permit tight compression when the hose clamps are applied.

Carefully push these bushings (the slotted tubes) into place on the trap forms, up against the pegs; the longest slotted bushings go onto the 10-meter trap. Then gently press the foil tabs down against the tubing. The bushings must be in place for the following operation (Fig. 8).

The traps should be grid dipped and adjusted for resonance at the following frequencies: 28.0 MHz, 20.5 MHz and 14.0 MHz. Do not couple too tightly to the traps as the grid dipper can be "pulled," resulting in erroneous readings. Adjust the traps by carefully spreading or compressing the last turn on each trap.

Construction of Adjustable Sections

Refer to Fig. 9 and cut the 12-foot (3.66-m) length of 1-1/4-in. tubing into four lengths, as follows: 5 ft, 6 in. (1.68 m); 1 ft, 9 in. (0.53 m);* 2 ft, 10-1/2 in. (0.88 m);* 1 ft, 10-1/2 in. (0.57 m). The starred (*) items may be cut in half and a bushing inserted to permit adjustment of the 15- and 20-meter bands (Fig. 8). If you choose this method, four more hose clamps will be required.

The tubes just cut are all slotted and deburred on both ends, inside and out. If this deburring is not done the aluminum may sieze or gall and it then becomes difficult (if not impossible) to separate or adjust. A stainless-steel hose clamp is placed over each slotted end of each tube.

Cut and deburr a 6-foot (1.8 m) length of the 1-1/8-inch tubing and insert the 1-inch piece of round aluminum rod, which should be drilled and tapped for 1/4-20 thread all the way through. Secure this in the end of the tubing by drilling two no. 36 holes and tapping for 6-32 screws.

Putting It Together

Fig. 9 provides an overall picture of assembly of the vertical. Nothing is critical except that care must be exercised when attaching the traps to the 1-1/4-inch tubing sections. Start by spreading *one* of the slots in the tubing ends to expand the diameter slightly. The foil on each trap must be started smoothly between the trap bushing and the tubing sections. This is made easier by carefully pushing the foil tightly against the bushing before sliding the bushing onto the trap itself.

Start by sliding the 21-inch, 15-meter tubing section onto the capacitor end of the 10-meter trap, up against the peg, and tighten the hose clamp securely. In the same manner, clamp the 34-1/2-inch, 20-meter section onto the capacitor end of the 20-meter trap. Tighten all clamps securely, then slide the 15- and 20-meter sections onto the bottoms of their respective traps. See Fig. 9. Next, clamp the 6-foot length of 1-1/4-inch tubing to the bottom of the 10-meter trap, the 36-inch

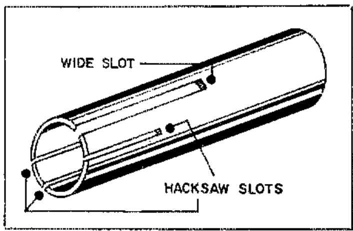
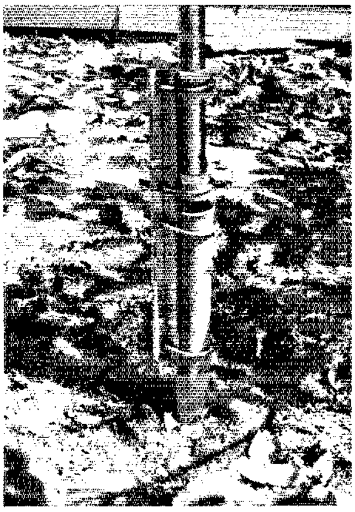


Fig. 7 — Method of slotting the tubing for use as bushings.



Complete base-mounting assembly in place.

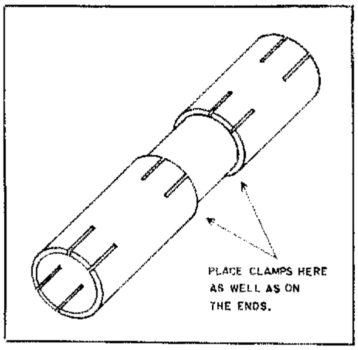


Fig. 8 — Bushings mounted in place on the 20-meter trap.

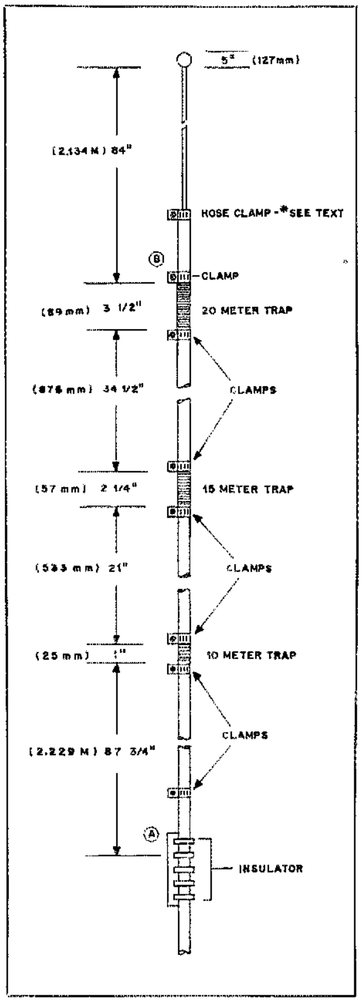


Fig. 9 — The complete Flagpole Deluxe vertical.

Table 1

1 — Insulator block, 1 × 1-1/2 × 3/8" (25 × 38 × 10 mm) (formica, Plexiglas, plastic, etc.).
1 — Length aluminum tubing, 1-1/4 × 0.058 × 144" (3.66 m) 6061-T5.
1 — Length alumimum tubing 1-1/8 × 0.058 × 144" (3.66 m) 6061-T5.
1 — Length aluminum tubing 1-1/8 × 0.125 × 36" (914 mm) 6061-T5.
1 — Piece of aluminum rod 1 × 1" (round).
1 — Fiberglass round rod 1 × 24" (25 × 305 mm).
4 — 2" U bolts.
5 — 25-pF Centralab transmitting capacitors, 850S series.
1 — Piece of construction aluminum channel stock, 3/4 × 1-3/4 × 14" (19 × 44 × 356 mm), 1/8" wall thickness.
1 — Piece of construction aluminum T-bar stock, 3 × 1-1/2 × 14" (76 × 38 × 356 mm), 1/8" wall thickness.
8 — 1-1/4" hose clamps.
1 — 2-foot length (0.61 m) 1-1/4" EMT conduit.
1 — 3-foot length (0.91 m) 1-1/4" EMT conduit.
1 — 12-foot length (3.66 m) of 2" PVC schedule 40 water pipe.
1 — 2"- to- 2"PVC coupling.
1 — 1-1/2" PVC cap.
1 — 12-foot length (3.66 m) of 1-1/2" PVC schedule 40 water pipe.
1 — PVC reducer, 2" to 1-1/2".
1 — Tank ball or Eagle 5".
1 — 10-foot length (3 m) copper water pipe (for ground, if required).
1 — Piece of copper or brass foil, 0.005 × 1 × 12" (0.13 × 25 × 305 mm); this may be salvaged from an old transformer or shim stock, or may be purchased from auto supply or metal suppliers.
2 — Insulating sleeves made from plastic tubing 1-1/8" inside diameter, 1/2" wall thickness. These can be made from two PVC 1-1/4-to-3/4"bushings. These are obtainable wherever PVC pipe is sold. The bushings will have to be reamed very slightly to have a press fit over the 1-1/8 × 0.125" aluminum tubing. Either file or turn the flange off on a lathe.

length of 1-1/8-inch tubing into the last tubing just installed and adjust the total length to 87-3/4 inches (2.23 m) from the 10-meter trap to the end of the tubing.

Install the ball on the end of the 6-foot length of 1-1/8-inch tubing, which has the aluminum plug in it, using a 2-inch length of 1/4-20 threaded stock. This can be cut from a 1/4-20 bolt. Install this section of tubing into the end of the tubing on the 20-meter trap and adjust to the dimension shown in Fig. 9. Recheck all clamps for tightness at this time.

Testing and Adjustment

If your situation is like the author's, you will be forced to test and tune the antenna somewhere other than its eventual "camouflaged" location. Do your tuning in the final position if it is at all possible, since the effects of surrounding objects can undo an entire afternoon's work. Set the 3-foot length of 1-1/4-inch EMT conduit in concrete next to your ground rod, leaving 7-3/4 inch (197 mm) above the concrete. Mount the antenna assembly on this conduit (Fig. 1), and connect a ground strap from the ground rod to the base assembly.

Once everything is in place and tightened, grid dip to determine the resonant frequencies of the vertical on each band. When making adjustments, remember that any change made on one band affects all *lower* frequency bands. Adjust the 10-meter section first, and measure the SWR by attaching the coax and applying very low power to the antenna through an appropriate SWR indicator. Continue with the other bands; very little trimming or adding should be required. If adding length is necessary, the alternate method described earlier of cutting a section of tubing in half and adding a sleeve is recommended.

After the 40-meter section is adjusted, remove the hose clamp and secure the tubing with four no. 6 sheet-metal screws. This is necessary because the 1-1/2-inch PVC pipe will not clear the hose clamp. After all adjustments have been made, SWR should not exceed 2:1 at any band edge.

Camouflaging

The time has come to turn the vertical into a flagpole, or vice versa. Lay the entire antenna (including the base mounting assembly) flat on the ground, with the 2-inch PVC alongside it. Carefully measure the distance from the top of the base assembly (Point A, Fig. 9) to the top of the 20-meter trap (Point B) and cut the PVC to length. Install the 2-inch to 1-1/2-inch reducer assembly with PVC cement. Next measure the distance from the ridge inside the reducer to the top of the tubing of the 40-meter section; make sure you have the end of the 2-inch PVC even with the top of the base assembly. Cut the 1-1/2-inch PVC to length and cement it into the reducer.

Drill a hole in the PVC cap to clear the 1/4-20 stud in the end of the 40-meter section. Remove the base assembly and slide the antenna through the PVC pipe until the stud comes out the top; slip the cap onto the stud and screw the top ball on tight. Then slide the antenna back until the cap slides all the way on in place on the end of the 1-1/2-inch PVC. Do *not* cement the cap in place. One word of caution — make certain all clamps are tight before sliding the antenna back and forth in the PVC, to prevent any change in dimensions. The end of the 2-inch PVC should now be even with the base mounting assembly when the antenna is reattached.

This completes construction of the Flagpole Deluxe. The author uses a small pulley and rope for flying a flag from his vertical, and comments from neighbors indicate full approval of the obviously handsome flagpole. Results radio-wise have been rewarding, and it is not even necessary to stop operating when it rains! Finally, the author gratefully acknowledges the assistance of George Rice, W6OGR, in the preparation of this article.

Strays

QST congratulates . . .

☐ the South Eastern Massachusetts Amateur Radio Association, W1AEC/WR1ADR, for being awarded the "Outstanding Service Award" by the National Foundation for the March of Dimes. The amateurs provided communications support during walk-a-thons in New Bedford and Westport.

☐ Benjamin Frank Borsody, K4EC, whose biography appears in the latest editions of *Who's Who in America* and *Who's Who in the World*. He has also been admitted as a senior member in the Florida Engineering Society, a component of the National Society of Professional Engineers.

A PROSPECTIVE HAM NAMED JASON

☐ One prospective amateur in Arkansas is a bit more determined than most others. But then again he has to be. Jason White, a seven-year-old from Texarkana, AR, was born with a rare disease that prevents him from digesting food. He has been critically ill many times but has always managed to struggle back. Still, he requires treatment at the Texas Children's Hospital in Houston.

Among those helping to offset the staggering medical debts is the southern section of the Country Cousins Net. Also, they gave him a receiver so he can listen to hams, a pastime he enjoys a great deal. Besides continuing to give of themselves as a group project, they are asking other amateurs to make contributions to the Jason White Trust Fund, P. O. Box 1998, c/o The Commercial National Bank, Texarkana, AR 75502, Attention: Mr. Mike Sanders. — *W4YWP*

Microwave Mobile Propagation

Get ready now for the super highs from your wheels.

By Bob Thornburg,* WB6JPI

Is 2 meters filled up in your area? Are 220 and 420 looking like they aren't far behind? Amateurs in many parts of the country can answer these questions in the affirmative and can envision amateur mobile work in the microwave region of the spectrum as more than just idle dreaming in the next decade or so.

Routine amateur work above 420 MHz becomes more of a possibility every day; Microwave Associates (and others) now offer commercial gear for the microwaves at reasonable cost and in configurations usable by amateurs. Experimentation in Europe has shown astonishing DX possibilities even at 10,000 MHz (10 GHz). Repeaters and remotes are using microwaves for point-to-point auxiliary links. This article will examine some of the propagation quirks in the 1200-MHz region in particular and the possible effects of those quirks on amateur mobile work.

Mobile Flutter

This parameter has a number of names, including short-term fading, multipath loss, and mobile flutter. At vhf and uhf this characteristic produces a slight modulation at a few cycles per second on weak signals. Throughout this article we will assume an fm mode of communication with good limiters in the receiver. This mobile flutter modulation is, for the most part, an amplitude modulation of the received signal caused by the vector addition of signals arriving at the antenna from a number of different paths. The process is stationary in the short term (not changing with time), but is very spatially sensitive, changing with movement. In general, it will change significantly for distances on the order of one-half wavelength.

The resulting "frequency" of the flutter is therefore directly proportional to the carrier frequency. In fact, there is a relationship between this multipath phenomenon and Doppler shift, at least in that they are in the same frequency range. Because of the angle of arrival and the multitude of paths involved, the flutter frequency will be higher than the equivalent Doppler, but usually by less than a factor of two. For example, measurements indicate that for 1200 MHz and a speed of 55 mi./h the flutter rate will be about 100 Hz average. Instead of a flip-flip-flip type of flutter common on 2 meters or a ch-ch-ch common on 420, the 1200-MHz flutter will be a buzz, and at 10,000 MHz a whine. At 1200 MHz this frequency is in the domain of CTSS (Continuous Tone Squelch System) and PL (Private Line) circuits and will undoubtedly wreak havoc on them.

The amplitude of mobile flutter is not greater at higher frequencies (uhf), but is about the same as at 420. As mentioned, flutter arises from alternating enforcement and cancellation caused by signals from a number of different paths. These paths result from energy reflecting off objects in the propagation path. Since most objects in the real world are large compared to a 420-MHz wavelength, they are also large compared to a 1200-MHz wavelength. The probability that all those reflections are exactly the correct amplitude and phase to cancel, say, 20 or 30 dB is very small, so the flutter is mostly a 10- to 15-dB problem and signal strengths sufficient to cause limiting of this level will remove the amplitude flutter from fm receiving systems.

Another related problem is called phase distortion. This phenomenon is caused by the reflections having sufficiently different path lengths to actually have different modulations at any given time. This requires the reflection points to have path lengths that are different by a number of miles. This phenomenon seems to dissipate as the frequency becomes higher, being most noticeable on 2 meters and relatively rare on 420 MHz. It is not a problem on the microwave frequencies.

Note that mobile flutter is most annoying at 2 meters because it occurs at about the syllabic rate of speech. The fades remove syllables of words. At 420 MHz the flutter frequency is higher and is just another noise and does not bother intelligibility as much as it does at 2 meters.

*Thorntech, Inc., 13135 Ventura Blvd., Suite 206, Studio City, CA 91604

The rate is higher than syllables but lower than voice-pitch components. At 1200 MHz the flutter is near the voice pitch and will give distortions like poorly tuned ssb but will not affect intelligibility as much as at 2 meters. At 10,000 MHz the flutter will once again appear as being noise.

In summary, mobile flutter is not a unique or serious problem with microwave mobile operation but it *is* different. For those interested in playing with quasi-stationary random-variable mathematics, there are some good realistic models developed for evaluating microwave mobile path phenomena.[1,2,3,4]

Signal Strength

The previous section discussed the short-term fading problem but did not address the average signal strength or coverage one could expect from a transmitter. Several factors play a part here.

First, the general rumor that microwaves only propagate over a line-of-sight path is bunk. The stuff goes everywhere, or at least places that are not anywhere near line-of-sight. As the frequency increases, the number of obstacles that are large compared to the wavelength increases and more things in the real world become reflectors. For 10 meters, mountains are significant; for 2 meters, buildings get in the way; at 420, objects the size of cars are reflectors, and at 10,000 MHz (wavelength about one inch) almost everything is a reflector. If an object is reflecting energy, it will make an equivalent shadow behind the object. This makes radar work and also gives rise to the rumor that microwaves only go where light would go (line of sight).

But what of these reflections? They act as little transmitters, scattering the microwave energy back in all directions (diffuse reflection) to be once again reflected off some other object. Most every real object has "roughness" on the order of a quarter wavelength, so the reflection is not specular (like a mirror), but is diffuse (like a wall painted white) and radiates over the exposed hemisphere where it can encounter another object and repeat the process. So the microwave energy "bounces" around and conceivably can go anywhere.

However, each time microwave energy is reflected it loses energy. Some is absorbed by the reflector, and since it is reradiated over a hemisphere, some is lost by going in unwanted directions. Finally, there is also a propagation phenomenon known as the "knife edge" effect.[5] This effect, operating by diffraction, causes the rf power to "bend" over an obstacle, and may enhance signals in an area where you'd expect a shadow.

The propagation characteristics described are very difficult to analyze and model, but numerous measurements have been made indicating that hope is with us.[1,4,6] The measurements show that, for antennas that have very low elevation, the loss in the city is very high (70 dB below line of sight) and not much better in suburban areas (50 dB). This will preclude mobile-to-mobile direct communication using microwaves over more than a mile or so. For repeater operation things pick up considerably. If the repeater (or base station) is located at 600-1200 feet above the mobile, the excess loss (above line-of-sight loss) is only 30-40 dB at 1200 MHz. At 10,000 MHz, for urban ranges out to 20-30 miles, the excess loss is 40-50 dB, and is 10-20 dB better for suburban areas. This is usable.

Another interesting phenomenon has been observed in New York City: Signals at 11.2 GHz arriving parallel to the direction of the street are 10 to 20 dB higher than waves arriving at other angles. Luckily, NYC is nearly *all* streets!

The effect of rain on microwave signals must also be considered. At 1200 MHz the effect is negligible but at 10,000 MHz you can forget communicating if it's really pouring. The rain loss at 10 GHz in a good downpour can reach 5 dB per mile. A slight sprinkle, however, is only about 0.01 dB per mile.

Getting Down to Some Real Numbers

Let's now consider an example. A repeater, located at 600-feet elevation on a mountain with an antenna gain of 10 dB, is receiving a mobile transmitter with 10 watts effective radiated power. We will calculate at both 1200 MHz and 10,000 MHz. The power density, P_{DR}, at the receiver is given as (free-space line of sight)

$$P_{DR} = \frac{P_T}{4\pi R^2} \qquad \text{(Eq. 1)}$$

where P_T is the erp of the transmitter and R is the separation of the transmitter and receiver.

The received power P_R is given as

$$P_R = P_{DR} \cdot A_R \qquad \text{(Eq. 2)}$$

where A_R is the effective area of the receiving antenna given by

$$A_R = \frac{G\lambda^2}{4} \qquad \text{(Eq. 3)}$$

where G is the gain and λ is the wavelength. Combining these equations along with a loss factor, K, accounting for the urban loss and solving for the range, R

$$R = \frac{\lambda}{4\pi} \sqrt{\frac{P_T G K}{P_R}} \qquad \text{(Eq. 4)}$$

For the preceding example,

$\lambda_{1200} = 0.82$ ft
$\lambda_{10Q} = 0.098$ ft
$P_T = 10$ watts
$G = 10$
$K_{1200} = 0.001$
$K_{10Q} = 0.0001$
$P_R = 10^{-15}$ watt (-120-dBm or 50-kHz noise bandwidth, 10-dB noise figure).

The range for 1200 MHz is 124 miles and for 10,000 MHz is 4.7 miles in an urban environment. In suburban terrain the range for 1200 MHz would be limited by curvature to about 200 miles and at 10,000 MHz one could expect 50 miles.

Antenna Considerations

Note that the effective area of the receive antenna (in Eq. 3) is directly related to the square of the wavelength. Well, the 10-GHz wavelength is very small. A quarter-wave stub is about a quarter inch long. A 10-dB-gain antenna with 360-degree coverage is quite small physically and its effective area is also quite small. If the size (gain) is made larger, the angular coverage will become smaller and the number of multipath directions that will be accepted will reduce. This will cause more flutter problems. The best approach is to keep the antenna gains at 10 dB or less and increase the height.

For the base or repeater antenna a change from 300 feet to 3000 feet will improve the signal by over 20 dB. Even more drastic improvements are possible by raising the mobile antenna. Moving the antenna from rooftop (five feet) to 13 feet improves the signal by 6 dB. As the antenna is quite small, it is practical to mount it on the end of a pole.

In conclusion, it may be stated that short-range mobile two-way communication using microwave frequencies is practical. This is true for the entire 1- to 10-GHz range, for base- or repeater-to-mobile fm voice communications in urban and suburban areas. As the lower amateur bands become more and more congested in urban areas the appeal of microwaves is bound to increase.

Footnotes

[1] Reudink, "Properties of Mobile Radio Propagation above 400 MHz," *IEEE Transactions on Vehicular Technology*, Vol. VT-23, No. 4, Nov., 1974, pp. 143-159.

[2] Jakes and Reudink, "Comparison and Mobile Radio Transmission at UHF and X-Band," *IEEE Transactions on Vehicular Technology,*" VT-16, Oct., 1967, pp. 10-14.

[3] Nyland, "Characteristics of Small-Area Signal Fading on Mobile Circuits in the 150 MHz Band," *IEEE Transactions on Vehicular Technology,* Vol. VT-17, Oct., 1968, pp. 24-30.

[4] Longley and Reasoner, "Comparison of Propagation Measurements with Predicted Values in the 20 to 10,000 MHz Range," *ESSA Tech. Report ERL148 ITS-97*, Jan., 1970.

[5] Dougherty and Maloney, "Application of Diffraction by Convex Surfaces to Irregular Terrain Situations," *Radio Phone*, Vol. 68B, No. 2, Feb., 1964.

[6] McQuate, et. al., Numerous tabulations of propagation data in *ESSA Tech. Reports. ERL65-ITS52*, Mar., 1968, *ERL65-ITS58-2*, Dec., 1968, *ERL65-ITS58-3*, July, 1970 (available from the U.S. Government printing office).

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

VARIABLE-BANDWIDTH FILTERS — IRISH STYLE

□ I read with interest W9QQ's September 1977 *QST* article on a variable-bandwidth filter. Incorporation of this facility in an existing piece of equipment is undoubtedly a fine piece of work, but I was disappointed to find little information regarding the minimum bandwidth he achieved. He does state, "When receiving cw, the bandwidth can be made so narrow that ringing will be severe enough to obliterate intelligibility." I would like to suggest that such ringing may not be caused by exceptionally narrow bandwidth, but perhaps by some other fault (which I cannot discern).

My remarks here are based on personal experience with a variable-bandwidth system similar in operation to Hulick's in which a minimum bandwidth of 240 Hz is obtained. The absence of ringing, particularly on impulse noise, is remarkable. Several people on listening to signals in this bandwidth were skeptical that it was so narrow due to the lack of ringing and hollow sound one associates with conventional 250-Hz crystal filters.

For the following calculations I do not have the exact figures for the 2.1-kHz filter response of the SB-303, but I believe that the figures of 2.1 kHz at −6 dB and 6 kHz at −60 dB are not wide of the mark. The Collins filter used by W9QQ, although not positively identified, probably has a −60-dB bandwidth of 4.2 kHz (as used in the Collins 75S-1). The skirt attenuation factor of each filter is obtained by subtracting the 6-dB bandwidth from the 60-dB bandwidth, dividing that answer by two and then by 54. The resulting factor is Hz per dB for each skirt. The assumption is made that skirt attenuation is constant. It's then a simple matter to predict the response resulting from the overlapping of two similar passbands. Around the nose of the passband, predicted results tend to be optimistic. In practice the transition from skirt to passband of each filter is rounded, and the two passbands may have to be offset from each other considerably to achieve the narrowest 6-dB bandwidth theoretically attainable. Using the two filters above and by tolerating high "insertion loss," a 6-dB bandwidth of about 325 Hz should be obtained. The 60-dB bandwidth will be approximately 2.9 kHz. That's not exactly a sharp filter. By using better filters and additional crystals, I obtained the results set out in Table 1.

Table 1
Results of Combining Passband Filters

Nominal Bandwidth (Hz)	*−6 dB (Hz)*	*−60 dB (Hz)*	*Insertion Loss (dB)*
250	240	960	−6
250	270	1004	−3
500	500	1260	+2
1500	1500	2220	0
2100	2140	2776	0

Insertion loss is that measured relative to response midband in the 2.1-kHz bandwidth.

Those who judge filters by shape factor will observe that the 2.1-kHz position has a 100-dB bandwidth of 3.5 kHz. A more meaningful view of filter effectiveness is obtained by observing the skirt attenuation factor or by simply quoting the frequency difference, in Hz, between the 6- and 60-dB-down points on the skirt. For the 2140-Hz filter in the table, this figure is 300 Hz, while for all other bandwidths selected it is 360 Hz.

The filters used were a KVG XF9-B and a YTK 107-2.4, the latter being Japanese made with a center frequency of 10.7 MHz. To obtain the very steep skirts two crystals per filter were shunted across the filter input and output and tuned to series resonance on the hf skirt of each filter. Additionally, part of the source resistance at each filter input was bypassed by another crystal tuned to series resonance around the hf shoulder of the filter passband to sharpen up the shoulder. This procedure accounts for the 500-Hz position, having an insertion "loss" of +2 dB, and it also materially assists in reducing relative insertion loss at the very narrow bandwidths. Fig. 1 shows how the variable bandwidth filter is incorporated into the front end of the complete receiver here. The receiver is part of a comprehensive hf-bands transceiver presently under development. Extensive listening tests confirm that the expense and trouble involved are worthwhile; it's a remarkably inexpensive way of having four or more (or indeed *any* number of) filters available to cope with today's crowded band conditions. — *C. P. Clarke, EI3CP, 16 the Grove, Woodpark, Ballinteer, Dublin 16, Ireland*

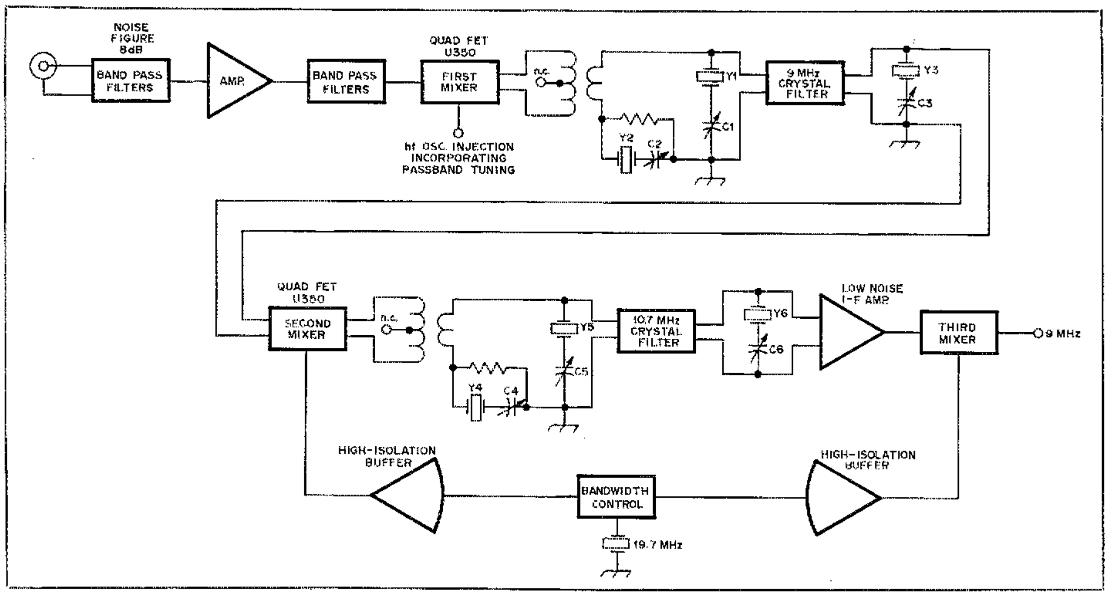


Fig. 1 — EI3CP's experimental receiver setup.

Table 1

Standard Frequency and Time Stations, LF and VLF

Station	*Frequency kHz*	*Output Power (kW)*	*Radiated Power (kW)*	*Antenna Efficiency (%)*
GBR, Rugby, U.K.	16.0	300	40	13
NAA, Cutler, ME	17.8	2000	1000	50
NBA, Canal Zone	24.0	300	30	10
NPG/NLK, Jim Creek, WA	18.6	1200	250	21
NPM, Lualualei, HI	26.1	1000	100	10
NSS, Annapolis, MD	21.4	1000	100	10
WWVB, Ft. Collins, CO	60.0	30	9	30

(Source: *ITT Radio Handbook*, Fifth Edition)

LOWFERS — LOW-FREQUENCY EXPERIMENTERS

☐ Here are some excerpts from *LOWFERS*, a bulletin I recently sent to lf buffs around New England. Through the month of September, 1977, I ran a beacon on weekends on 186 kHz. I called it beacon "B" as a propagation experiment, to increase lf interest in New England, and notified all LWCA (Long Wave Club of America) members within a 130-mile radius. Best DX reported was 38 miles, and I uncovered four lf-equipped stations! My conclusion was that a 50-foot antenna (such as I am using) is not a serious handicap, and routinely working several hundred miles is a reasonable expectation. This fall and winter I am planning equipment and antenna improvements, and perhaps some experiments below 10 kHz. The accompanying table gives us some idea of what the "professionals" do with short antennas (and quite a bit of power).

Beacons

We all use lf aircraft-beacon stations to check band conditions and equipment, but know little about them. So perhaps a description is in order. Their standard antenna system is a 30- to 60-foot vertical wire, and a 250-foot flat top for loading. The ground systems consist of 12 radials in an elliptical pattern, about 100 by 250 feet. Where coupling to power lines is a problem, and for new installations, instrument-landing systems (ILS) use a 30-foot vertical with a distributed winding and top loading. The ground system is 12 50-foot radials.

Beacons used as ILS outer markers are usually 15-watts output, to give a 15-mile-radius aircraft range. Some are 25-watts output for 25 miles. In mountains, where attenuation is higher, 50 watts is the norm, while a few beacons are 2 kW for 75 miles (such as TUK at 194 kHz on Nantucket Island, MA). Canadian beacons are 400-watts to 2-kW output.

Carrier-Current Signals

Those pesky unmodulated carriers now stand revealed: They are radiated by power company "carrier current" equipment. The power companies feed rf into their high-voltage lines to actuate receivers connected at the other end. Frequencies used are from 30 kHz to 300 kHz, and most seem to have migrated to 160-190 kHz to escape high-power, lf RTTY stations. Power levels are mostly from 1 to 20 watts, occasionally as high as 100. Modes used are fm, ssb, fsk and keyed carrier for relaying and telemetering.

Equipment for these power companies' circuits is coupled to the high-voltage lines via capacitors. Traps are used at transformers, as they present a low impedance to ground for rf. Receivers are typically very narrow band (about 200 Hz) and, due to the noise environment, receiver sensitivity is usually measured in volts. Maximum sensitivity is 5000 microvolts!

The commonly heard carriers are a "guard" channel, which shows the circuit is live and presumably working. When something is supposed to happen the signal will shift frequency about 100 Hz and may increase power from 1 to 10 watts. Considering their receiver characteristics there is little chance of interfering with these carrier-current systems. Anyway, the power companies have been using them for the last 50 years without benefit of FCC authority or regulation and theoretically they have no legal standing.

Light Dimmers

Finally, consider light-dimmer interference. Such dimmers fill the 1800-meter band with synchronous hash during the evening hours, rendering it useless. This would be a joke if FCC made the band a new broadcast band. Dimmers come under Part 15 of the FCC rules and regulations as incidental radiation devices. It allows 100 mV of rf on the power line from 450 kHz to 9 MHz, and more at higher frequencies. There are *no* restrictions at lower frequencies. The only quiet dimmer is the "Lutron." — *Richard G. Brunner, W1ATO, 10 Brookside Dr., Foxboro, MA 02035*

SOLDERING ALUMINUM?

☐ By a strange coincidence my reading this evening encompassed two articles on the soldering of aluminum. One was in a 1902 issue of *Model Engineer* and the other was W1FB's item on Alu-Sol 45D (*QST* for October, 1977). Only the 1902 item emphasized the real problem in soldering aluminum. There are dozens of ways of getting a good, initial bond; some simple, some complex, but no inventor has solved the corrosion problem that causes failure of the bond. W1FB hints at this in the last sentence of his first paragraph, but neglects it in the remainder of the article.

As was explained in the 1902 article, aluminum is an extremely active metal, and were it not for a self-repairing, protective oxide coating, the metal and its alloys could not be used for any commercial purpose. When aluminum is bonded to a metal or alloy (a solder) of considerably lesser activity, the protective oxide film either cannot form or is imperfect. The aluminum, therefore, becomes strongly anodic to the solder and is converted at the interface to corrosion products having little or no strength, and the bond fails. This may take a few hours, weeks or months, depending on the system and environment, but you can be sure that failure will occur sooner or later. There may be little or no visual evidence of the corrosion because it is confined to the very narrow zone that comprises the interface.

Obviously, someone should invent a solder whose activity is the same or nearly the same as that of aluminum and its commercial alloys. So far no one has done this. (The composition of Alu-Sol 45D makes it evident that it is strongly cathodic to aluminum and that it will fare no better than its myriad of predecessors.)

As is evident from the preceding remarks, there is no point in working on fluxes (there are plenty of good ones available); the culprit is the solder. I don't envy anyone the task of finding an alloy that will meet the chemical and electrochemical requirements as well as those for a solder.

Perhaps *QST* readers should be alerted to the probability of bond failure for Alu-Sol 45D, or the manufacturers should be asked to provide evidence that their solder bond is permanent in the environments likely to be encountered in electronics service. — *Harold J. Read, Professor Emeritus of Metallurgy, Pennsylvania State University; P. O. Box 5085, Grove City, FL 33533*

HW-8 ITEMS

☐ Interest in my July 1977 *QST* article, "Full Break-In and RIT for the HW-8," inspired me to relay a few more notes on this popular little Heathkit rig. A common complaint with both the HW-7 and HW-8 is ac hum when using a commercial main's power supply instead of a battery. This hum was easily eliminated from both the Heath HWA-7-1 supply and a Calrad supply. The method is to open up whatever supply you have and try connecting a 0.005-µF disk capacitor from chassis to various transformer and rectifier terminals. Usually a cure results with the capacitor from either primary connection to chassis. Connecting the capacitor to a secondary terminal and chassis is preferable, but two capacitors connected to different rectifier or secondary terminals may be needed for a permanent cure.

Keep in mind that ac is very hard on a capacitor and so is heat. A 150-V dc rating is sufficient for capacitors connected to the secondary side of a 13-V supply, but at least a 1000-V dc rated capacitor must be used where connection is made to 120-V ac. Double that rating is needed if the supply is ever to be fed by 240 V ac, although high-quality capacitors rated at 1.4 kV are commonly used in commercial gear to bypass 120- and 240-V ac lines to the chassis. A capacitor should not be mounted above a power transformer nor too close to any component that generates heat. If the capacitor itself heats up in use, it is not suitable and should be immediately replaced by a better one. The primary circuit is only to be connected to an outlet properly protected by a fuse or circuit breaker.

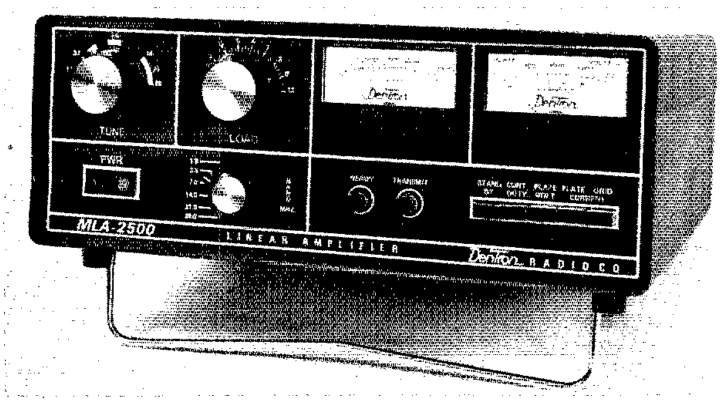
Finally, the QRT-262 varactor diode specified in the article is, with other "Q" numbered parts, an item from the Sprague Q-Line. Many stores stock these items, along with the following suitable replacements: D201, GE90, HEPR2503, RT-262, SK3126 and ZEN453. — *Ben Saylor, K6TG, Box 2314, Modesto, CA 95351*

Product Review

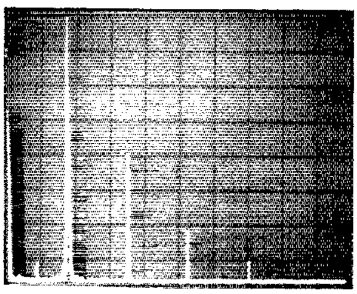
The Dentron MLA-2500 Amplifier

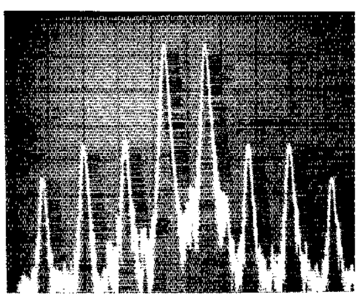
It was a crisp day in the fall of 1976 when Dennis Had and his top engineer, both of Dentron Radio Co., stopped in at Headquarters for a combination business/pleasure visit. Three well-wrapped shipping cartons accompanied them. One contained a Dentron 160-10L SuperAmp which was in for testing. The second box, quite a bit lighter than the first, contained an alphanumeric code reader that displayed the characters Broadway style — right to left across the front of the unit. Onlookers stood marveling at the device, which, at the time, was copying W1AW code practice, flawlessly.

It had become obvious that the gentlemen from Dentron were anxious to show us the contents of the third box. By now you've probably guessed what emerged from the carton — the MLA-2500 prototype. Although not nearly as pretty as those units presently being sold, the unit gave us a good idea of what was to come. As the prototype was wired into the test setup, several skeptics drew near. There were a few "oohs" and "aahs." Most seasoned amplifier buffs chuckled to themselves, "This'll never work — it's just too darned small to be any good!" With the head of Dentron at the controls, the amplifier promptly placed the needle of the Bird model 43 wattmeter, with a 2500-watt element, in the "peg" position. Any doubts concerning the capability of the amplifier were quickly dismissed.



Would you believe a 2.5-kW amplifier in a 5 by 14 by 14-inch box, weighing only 47 pounds? Well, here's one! It's the Dentron MLA-2500.





The photograph at the left is the worst case for spectral purity. This spectrum analyzer photograph shows the output of the amplifier on 160 meters running one kilowatt dc input. The second harmonic is down approximately 40 dB. The horizontal scale represents 1 MHz per division and the vertical is 10 dB per division. The analyzer photograph at the right is a two-tone IMD display of the MLA-2500 at the 2000-watt PEP level. The horizontal display represents frequency with each division corresponding to 1 kHz. Each vertical division represents 10 dB. The display is adjusted so the amplitude of each component may be read from the scale at the right, directly in dB below the peak-envelope power (PEP) output. Responses other than the two individual tones near the center are distortion products. Third-order products are down approximately 35 dB, fifth down 37 dB, seventh down 45 dB.

Physical Attributes

The review MLA-2500 arrived several months later in two boxes. One contained the 8875 tubes (two), time-delay relay, and control relay. The other box housed the remainder of the amplifier. To insert the vital components, the top cover of the '2500 must be removed. This is accomplished by removing six flat-head, hex-type screws (hex wrench included with amplifier).

Upon removal of the cover the first area of interest is the rf compartment. Two high-quality variable capacitors are used for the plate tuning and loading controls with additional fixed capacitances switched in for 160-, 80-, and 40-meter operation. A hefty rotary switch handles all of the band-switching functions, including adding in the extra capacitances mentioned above.

The 10-, 15- and 20-meter section of the plate tank coil is wound with silver-plated, heavy-gauge wire to help assure good tank efficiency on those bands. The rest of the tank coil (160, 80 and 40 meters) is a bit unconventional in the sense that the coil turns are close-spaced. To prevent the turns from shorting, type-E Teflon-covered stranded wire is used.

Two Eimac 8875 external-anode, ceramic/metal triodes are mounted at the rear of the rf compartment. These tubes are designed to be transverse cooled through their large fins. To accomplish this the amplifier makes use of a two-speed, muffin-fan system attached to the rear apron. A thermal sensor mounted near one of the tubes determines whether the tubes are operating within the specified temperature range. If the tubes are running hot, as would be the case when operating continuous duty or contest style, the fan is automatically switched to high speed for additional cooling. Once the tubes are sufficiently cooled the fan automatically switches to the lower speed. A front-panel switch labeled CONTINUOUS DUTY overrides the thermal control to place the fan in the high-speed position at all times. Other items of interest in the rf compartment include the rf-switching relay with plated contacts, the rf-wattmeter circuitry, which is mounted on a small circuit board, and the alc components, also on their own board.

The most striking object in the power supply compartment is the power transformer. This specially designed and built transformer occupies nearly 1/4 of the space available inside the amplifier. A glass-epoxy circuit board (all boards used in the amplifier are of the same material) supports the 12 power supply diodes and associated spike protection capacitors along with the time-delay relay and control relay. The wiring harness and mounting screws are arranged so that the board can be swung up

Table 1

MLA-2500 Manufacturer's Specifications

Frequency coverage: 1.8 to 2.5 MHz
3.5 to 4.5 MHz
7.0 to 7.3 MHz
14.0 to 14.35 MHz
21.0 to 21.45 MHz
28.0 to 29.7 MHz.
Power requirements: 235/117 V ac, 50/60 Hz.
Plate power input: 2000 watts PEP for ssb operation; 1000 watts dc for cw, RTTY and SSTV.
Drive requirements: For 2 kW PEP, approximately 65 watts; for 1 kW dc, 36 watts.
Duty cycle: 100 percent at full legal power.
Output impedance: 25-100 ohms.
Wattmeter accuracy: ±10 percent full scale into a 50-ohm resistive load.
Harmonic radiation (third-order): Equal to or better than 30 dB down from output signal at full legal power, on all bands.
Tube and semiconductor: 2 tubes, 18 diodes, 1 Zener diode.
Accessories: Rack-mounting kit (standard 19-inch rack).

Table 2

Results of MLA-2500 Tests Performed in ARRL Laboratory

Band	*Power Input (Watts)*	*Power Output (Watts)*	*Internal Wattmeter Reading (Watts)*	*Drive Power (Watts)*	*Eff. (%)*
160	1000	460	330	30	46
160	1900	1250	950	100 +	66
80	1000	340	300	23	34
80	2000	1260	1100	100 +	63
40	1000	360	360	20	36
40	2000	1200	1200	70	60
20	1000	580	700	27	58
20	2000	1250	1300	85	62.5
15	1000	560	750	32	56
15	2000	1350	1600	100 +	67.5
10	1000	580	700	30	58
10	2000	1250	1600	100 +	62.5

for easy access should parts ever need to be replaced. The power supply filter consists of six electrolytic capacitors, each with its own bleeder/equalizing resistor.

Five push-button switches control the metering functions (plate current, high voltage and grid current), fan speed and the amplifier "through" mode for exciter tuneup. The switch contacts are soldered directly to a circuit board into which plugs a multiconductor cable.

Electrical Details

The heart of the amplifier is a pair of Eimac 8875 triodes operating in grounded grid. Anyone who is familiar with an amplifier using the 8873, 8874 or 8875 series of tubes knows that only a relatively small amount of drive from the exciter will push the tubes well past the legal amateur input level. In order to dissipate some of the extra drive from a 100-watt exciter and provide a better match to the transmitter, Dentron uses a 100-ohm, noninductive, swamping resistor from the cathodes (input) to ground.

An 8.1-volt Zener diode in the cathode circuit causes the tubes to run Class AB2. During receive, the cathodes are connected to ground through a high-value resistor, effectively cutting off the tubes. Alc voltage from the exciter is also fed to the cathodes with the amount controlled by the alc-adjust potentiometer located in the rf compartment.

The plate tank circuit is of the standard pi-network variety. Relatively small values of variable capacitors are used for the plate tuning and loading controls. Additional fixed-value, transmitting-type capacitors are paralleled with the tuning control on 80 and 160 meters while additional capacitors are paralleled with the loading variable on 40 through 160 meters.

A built-in rf wattmeter monitors the forward power at all times. The second meter is push-button switched for the parameters outlined earlier.

The cathodes of the 8875 tubes require a one-minute warm-up period before drive is applied. A 60-second delay relay is provided to keep drive from being applied to the tubes during the initial warm-up. Should the user inadvertently apply drive during this time there's no need to worry. The amplifier will be in the "through" mode and the drive power will be transferred to the load.

The power supply makes use of a full-wave, voltage-doubler circuit. There are four power-transformer secondary windings: 800 volts for the high-voltage supply, 120 volts for the alc circuitry, 12.6 volts for the pilot lights and control relay, and 6.3 volts for the tube filaments and delay relay filament. A dual-winding primary allows the amplifier to be run from either 117 or 235 volts, 50/60 Hz. The manufacturer recommends that the amplifier be run from 235 volts if at all possible for best voltage regulation.

Six 1N4007 diodes are used for each leg of the voltage doubler. Across each diode is a transient-suppressor capacitor (0.01 μF). Six 150-μF, 450-volt, electrolytic capacitors make up the filter. Each is strapped with a 100-kΩ, 2-watt, composition resistor.

Operation

When the amplifier is first switched on only the meter illumination lights will come on. The amplifier will automatically go into its 60-second delay routine. After the delay period, a green panel light will come on signifying that the amplifier is ready for use. Whenever the amplifier is in the transmit mode, a red panel light will shine.

Amplifier tune-up is smooth and simple. All the operator need do is watch the plate-current meter and power-output meter, adjusting for maximum power output consistent with the legal amateur input level. One should keep in mind that the built-in wattmeter reads both forward and reflected power on the line. A high SWR will cause erroneous readings as far as actual power output is concerned.

Problems and Corrections

Several problem areas were noted while gathering data for this review. First, it was found that the plate-current meter was indicating values approximately 25 percent lower than those actually being run. This meant the amplifier was running nearly 1250 watts when tuned up for an apparent kilowatt! Also, it was noted that the grid-current meter was sampling a portion of cathode current — not grid current. Additionally, the amplifier suffered from rather poor efficiency on the lower bands at the cw, 1-kW input level.

When the manufacturer was contacted concerning these findings, a fresh unit which incorporated changes to correct the problem was promptly sent.[1] The error in the plate-metering circuitry was traced to non-uniformity of hand-wound meter shunts. For better accuracy Dentron now uses commercially made shunts in all MLA-2500s. Circuit changes were made to allow the meter to monitor actual grid current when switched into that position.

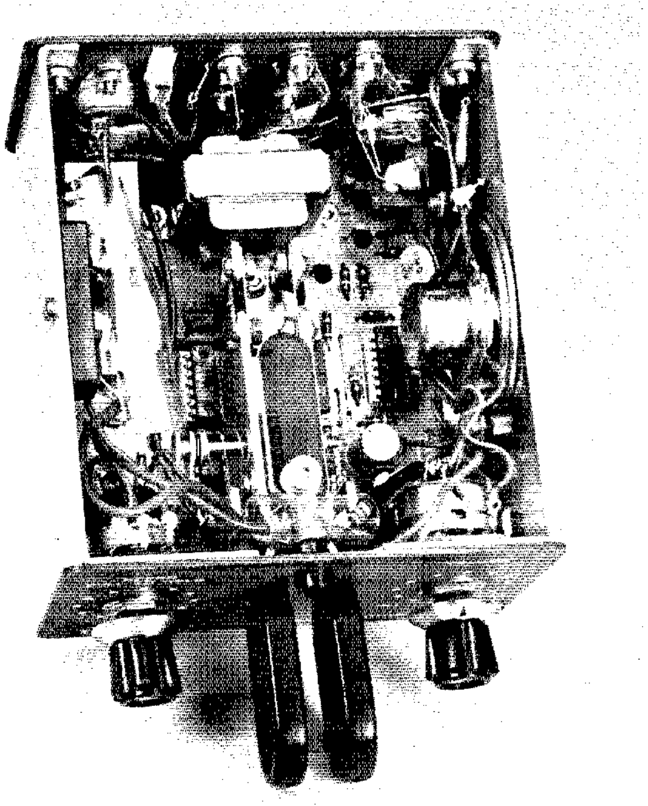
Poor efficiency at the 1-kilowatt level on 80 and 40 meters still remains a problem (34 and 36 percent respectively at the low ends of the bands). Although Dentron has added a fixed-value capacitor (100 pF) directly across the loading variable, it is insufficient for operation into a 50-ohm load — the loading capacitor remains fully meshed on these bands at the 1-kilowatt level. One could expect the efficiency to be somewhat better when operating the amplifier into a higher impedance. On the other hand, it will be somewhat worse when operated into impedances lower than 50 ohms.

All pertinent specifications, spectral displays and test data are presented elsewhere in this review. More information can be obtained from Dentron Radio Co., Inc., 2100 Enterprise Parkway, Twinsburg, OH 44087. The price class of the amplifier is $800. — *W1VD*

[1] The manufacturer informs us that a modification kit will be sent to every MLA-2500 owner from whom they have received a warranty card.

HEATH HD-1410 ELECTRONIC KEYER

The Heath HD-1410 electronic keyer represents a substantial departure from the earlier model HD-10 keyer that came on the market in 1966. Not only is the new keyer attractively packaged in a manner characteristic of the SB-equipment series, but also the design incorporates squeeze-paddle iambic operation. With its low profile and small size, the keyer requires a minimum of operating space. Attractive contours of the HD-1410 are compatible with most modern equipment and will blend well with the appearance of many older transmitters and receivers.



The versatile Heath HD-1410 electronic keyer. Squeeze-paddle design permits iambic operation. A built-in sidetone oscillator and monitor speaker with adjustable tone and volume are provided.

Operators will find several conveniences provided in this electronic keyer. There is a built-in sidetone oscillator and speaker, with adjustable tone and volume. A headphone jack on the rear panel permits speaker silencing. Audio from the receiver is routed to the headset through a separate rear-panel jack. The built-in paddles are adjustable for tension and travel. No springs are exposed that could pop loose during operation. The solid-state output eliminates bounce and sticking commonly associated with relay-equipped devices. Sufficient weight is provided in the construction to prevent the keyer from walking while in use. A front-panel "hold" switch is convenient for transmitter tune-up. An external key may be connected by means of a rear-panel jack.

For portable or emergency operation the HD-1410 may be powered by an external battery. A diode protects the power supply against reversed battery polarity. The ac power cord, which plugs into the rear panel, may be easily disconnected. A conventional, series-regulated bridge circuit supplies 5 V dc for the memory, clock, generator, oscillator and output circuits.

Keying speed may be varied from less than 10 wpm to over 60 wpm. An alternative connection may be made on the circuit board to cover speeds of 10 wpm to 35 wpm. A Darlington transistor pair is used to key positive lines to ground, and the keying current is limited to 10 mA.

Heath designed the HD-1410 to be compatible not only with most transmitters that use solid-state keying circuits, but also those sets employing grid-block keying or cathode keying. For those solid-state keying circuits which require the keyed line to be brought to within a few tenths of a volt from ground to operate properly, a minor modification may be made as explained in the instruction manual.

Assembly of the HD-1410 can be comfortably accomplished as a nice weekend project.

Heath HD-1410 Keyer Specifications

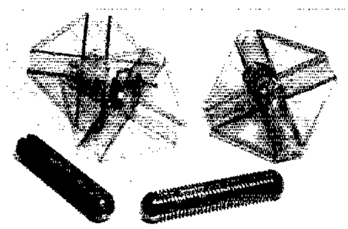
Power requirements: 120/240 V, 50/60 Hz ac, 3.5 W, or 10 to 14.6 V dc, negative ground, 150 mA.
Keying function: Iambic (less than 10 to over 60 wpm).
Sidetone: Frequency internally adjustable from 500 to 1000 Hz.
Audio: Built-in speaker or external headset.
Dimensions (HWD): 3 × 5 × 7.4 inches (76 × 127 × 188 mm).
Weight: 2.75 lbs (1.25 kg)

Directions are explicit. The builder may find a magnifying glass to be helpful while installing the IC sockets and for positive identification of small components.

When tested, the keyer built for this review displayed no glitches. There appeared to be no difficulty with RFI when operating on the 10- through 160-meter bands, but careful removal of paint from panel bolt holes to secure good continuity is a must. Price class is $49. It is manufactured by Heath Company, Benton Harbor, MI 49022. — *W1JEC*

PROPAGATION PRODUCTS INSULATORS AND QUAD KIT

Propagation Products has made available two products that should be of interest to amateurs who like to make their own antennas — and many of us do! The first item is called a Trend insulator. The Trend insulator is molded from a material having good dielectric qualities and, according to the manufacturer, excellent weatherability. The insulator is 6-3/8 inches long. It is grooved to take a coil winding (trap); the available coil-winding length is 5-1/4 inches at 6 turns per inch. The total turns available are



At the top are the Propagation Products quad spiders and immediately below are two of the Trend insulators.

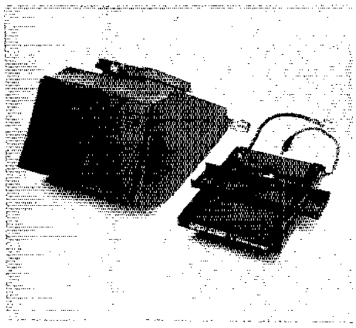
32 at one-inch diameter. The spiral grooves will handle any wire size up to and including no. 12. Price class is $5 per pair.

The other item from the company is a quad spider kit (shown in the photograph). The spiders are made from injected molded GE Lexan providing a lightweight support for quad elements. The spiders will accept one-inch diameter elements and will fit on a boom of 1-1/8-inch diameter. The kit contains two half-spiders (makes one quad element) and two clamps for attaching the spider to the boom and the necessary screws and nuts. Price class for a single kit is $8. Additional information is available from Propagation Products, 1855 Cassat Ave., Jacksonville, FL 32210. — *W1ICP*

GAMBER-JOHNSON SOUND MOUNT

An interesting item that could appeal to many amateurs is an item called the Sound Mount. This unit can be installed in an automobile or van, either on the transmission hump or the inside roof of the vehicle. Your transceiver can be mounted on a bracket which in turn slides into the Sound Mount. When you park or leave the vehicle it is a simple matter to slip your rig off the mount and take it along with you, avoiding theft.

In addition, the Sound Mount has a built-in speaker, snap-in mic holder, and all the necessary connections for antennas and power. The case is made from a combination of black



At the left is the Sound Mount. Note the fittings on the top of the mount. At the right is the unit that is to be attached to the transceiver.

plastic and metal, presenting a very pleasing appearance. Gamber-Johnson informs us that they also make an under-dash mount. Literature is available from the manufacturer on request. Price class of the Sound Mount is $32. Manufacturer: Gamber-Johnson, Inc., 801 Francis St., Stevens Point, WI 54481 — *W1ICP*

TELCO 125 2-METER CLASS C AMPLIFIER

If a piece of equipment has a lot of knobs and switches, a reviewer can go on *ad nauseum* listing every detail, but what can you say about a piece of equipment that has no switches or knobs to fiddle with? Well, it is certainly simple to operate. The Telco 125 is a 2-meter, Class C (fm and cw) amplifier designed to operate from 12 volts. One watt of rf drive gets you 25 watts of output. Its size of 4 × 6-1/2 × 1-1/2 inches (102 × 165 × 38 mm) permits it to be mounted out of sight (under the dash), although I was reluctant to do so because it is a strikingly attractive piece of equipment.

The 125 is the second generation of Telco vhf power amplifiers: The company has been building them for marine and land-mobile services for marketing under private label. Thus, it is not surprising that the unit we tested easily met the new FCC standards (see accompanying spectrum analysis), nor is it surprising that the 125 is built like the proverbial battleship. High-quality components along with rugged construction should provide reliable continuous service.

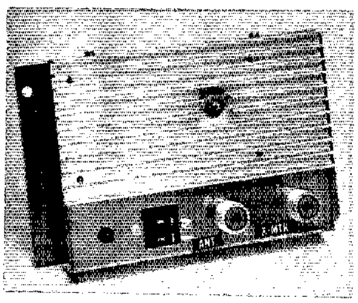
An antenna changeover relay is used to switch the amplifier in and out of the circuit. The 1-watt signal goes through a 9-dB attenuator and the input network, which is essentially a low-pass filter designed to transform the line impedance down to that of the transistor. The attenuated signal (1/8 watt) is applied to the first amplifier, an MRF237 transistor in a common-emitter configuration, which produces a 3-watt signal. After passing through the tuning and filtering network, the 3-watt signal is applied to an MRF238 amplifier stage which brings the level up to 25 watts. From there the signal passes through the tuning/filtering output network.

The 25-watt output is a continuous-duty rating. The 125 will withstand high-SWR mismatch and is protected for incorrect dc polarity. Insertion loss on receive is less than 1 dB. The owner's manual gives complete instructions for retuning if that should become necessary.

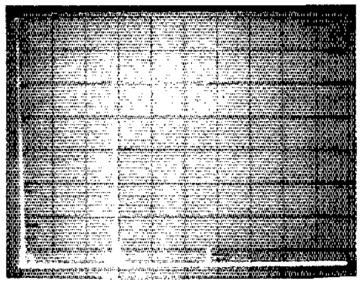
So much for the technical details, the main concern of most amateurs is "Does it work?" The initial test was to try to key a distant repeater that can just barely be heard, and cannot be keyed at all with a Drake TR-22 by itself. There was no problem keying it and we were told that we were making it about 80 percent full quieting, which was better than the repeater was doing. The net results of several weeks of testing is that if I can hear a repeater, I can work it with the amplifier in. If I can key it with the TR-22 barefoot, I make it full quieting with the 125 added. In short, it works quite well for the operator who wants to use a handheld rig for mobile operation. With the proper antennas, it would be useful for getting on Mode-A OSCAR.

Additional information can be obtained from Telco Products Corp., 44 Sea Cliff Ave., Glen Cove, NY 11542. Price class is $85. — *WB8NAS*

The Telco 125 amplifier makes a neat, compact package for mobile mounting.



Spectral analysis of the Telco 125 output (drive for the amplifier was provided by a Drake TR-22 at 147 MHz when this photo was made). The amplifier introduced no detectable spurious energy. The horizontal scale is 50 MHz per division, and the vertical scale 10 dB per division. As may be seen, the second harmonic is down 70 dB from "full scale." (After calibration of the analyzer for full-scale representation of the fundamental signal, a notch filter tuned to 147 MHz was added to the system to enhance its dynamic range.)



NEW BOOKS

80-Meter DXing

80-Meter DXing, by John DeVoldere, ON4UN. Copyrighted 1977 by Communications Technology, Inc., Greenville, NH 03048. Price is $4.50. Softbound, 8 1/2 × 11 inches.

Just the call sign ON4UN on the cover lends credibility to the contents of this 75-page manual for long-haul work on the 80-meter amateur band. Many, perhaps most amateurs, still subscribe to the myth that 3.5 MHz is a "local band," not supportive of more than an occasional 3000-mile contact. This does not deter author DeVoldere from convincing us not only that plenty of good DX is available on the band, but also that it can be predicted and sought methodically. So much for the local ragchew band.

The book is divided into four chapters: The first, on 80-meter propagation, combines elementary ionospheric wave propagation theory with specific techniques to deal with factors peculiar to the 80-meter band. Namely, factors such as auroral disturbances, seasonal variations, and "gray-line" propagation constitute the meat of the chapter for the 80-meter beginner.

Similarly, ON4UN's discussion of antennas begins with well-known principles of directivity, gain and impedance matching before discussing specific, effective antennas for 80-meter work. Of special interest are charts showing expected radiation angles for delta loops and quad loops with different feed points, and a good discussion of the Beverage receiving antenna. For the optimist, Wilkinson power dividers and splitters are examined. Those anticipating vertical antennas will perhaps be needlessly discouraged by DeVoldere's admonitions. "They should be kept at least a quarter wavelength away from any object that is greater than one-third of the antenna height and, generally, two wavelengths away from structures that are as tall as the antenna itself." Forty-meter Yagis aren't supposed to work at 50 feet, either, but they do!

Chapter 3 deals with equipment, and contains a tabulation of receivers used by 40 "well known, 80-meter DXers." Happily, the chapter consists of one page on transmitting and four on receiving. The table of receivers in use may be somewhat skewed by the probability that the stations surveyed are not located in midtown Manhattan! DeVoldere's comments on desirable receiver characteristics (cross modulation rejection and selectivity) are right on the mark.

Perhaps most useful is the final chapter on operating practices, beginning with a chart showing allocations of frequencies within the 80-meter band for various countries. One wonders how many DXers have worked a hundred countries on 80 and still don't know that VK DXers hang out between 3690 and 3700 kHz; ON4UN knows and tells all. Consideration is also given to "master-of-ceremonies" operations, "list operation" and even how to zero beat properly on cw. A few pictures of well-known stations around the world round out the operating chapter.

Like anything else 80-meter DXing is best learned by experience, but a start with DeVoldere's book can help the newcomer avoid the pitfalls of such learning. Nothing is more embarrassing than to jump into a pileup, do the wrong thing, and get called a lid by a dozen stations on frequency. — *K1TN*

Hints and Kinks

CW AND THE HW-101

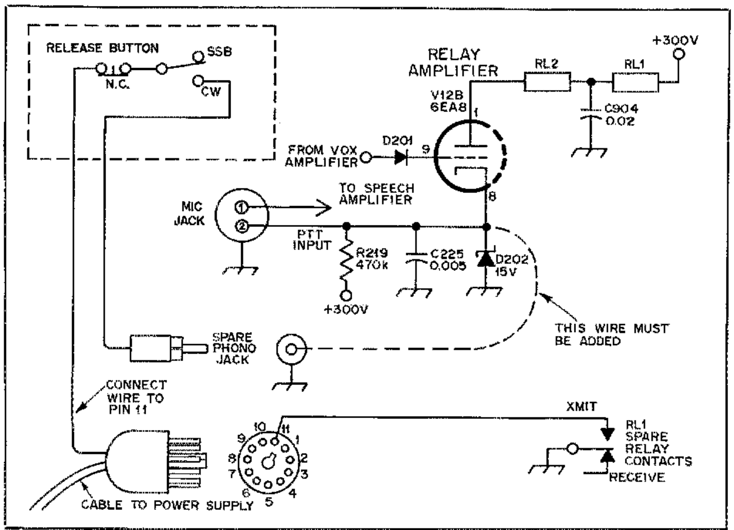
The Heath HW-101 operates on cw in the semi-break-in mode. When the key is depressed, an audio tone is applied to the input of the VOX amplifier. This is amplified and sent to the relay amplifier, which pulls in the transmit-receive relays. If a pause exists between characters beyond the time limit set by the VOX delay, the transceiver will drop back to the receive mode. This can be annoying.

What is needed is an easy way to make the transceiver latch in the transmit mode so that it won't drop back to the receive mode until a release button is pressed. The HW-101 contains a spare phono jack and a spare set of relay contacts on one of the transmit-receive relays, making it easy to implement such a function. The only change required internally is the addition of a wire connected from pin 8 of V12B to the center conductor of the spare phono jack.

A miniature spst toggle switch and a normally closed, push-button switch are mounted in a small metal box measuring 1-3/4 × 2 × 2-1/4 inches (44 × 51 × 57 mm) and connected in series to a pair of wires extending from the box. One of the wires is connected to the center of the phono plug and the other to pin 11 of the power plug. The phono plug is then pushed into the spare phono jack.

The small box may be placed adjacent to the cw key. To operate cw, the toggle switch is put in the cw position. Pressing the cw key down switches the transceiver to the transmit mode in the normal fashion. However, once in the transmit mode, the spare contacts on RL1 are closed which, via the switch box, ground pin 8 of V12B. This latches the HW-101 in the transmit mode.

To receive, press the release button, which will break the latch and allow the transceiver to drop back to the receive mode. For ssb operation, the toggle switch is placed in the ssb position which prevents the transceiver from latching in the transmit mode. — *James O. Fishbeck, WA1STQ*



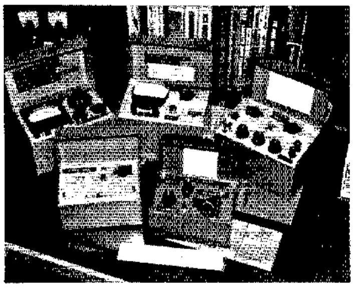
Useful latching circuit for cw operation with the HW-101.

DRESSING SMALL CABLE HARNESSES

Dental floss works quite well as lacing cord for small cables found in miniaturized equipment. The rubber tip mounted on the handle of some toothbrushes works well to clear inadvertent solder bridges on printed-circuit boards. After melting the solder with a soldering iron, quickly draw the rubber tip through the solder bridge. — *Duane Latourell, W6IG*

METAL CARD-FILE BOXES MAKE NIFTY CABINETS

The photograph shown on this page illustrates an idea that may interest those amateurs who have recently priced small cabinets. All the enclosures shown are metal card or index files. Each device shown is the result of a project described in *QST*. Reading left to right in the top row — Wheatstone bridge, *QST*, November, 1976; capacitance meter, *QST*, December, 1975; and sweep generator for fm, *QST*, January, 1972. These cabinets are 6 × 4 × 4-1/2 inches (152 × 102 × 114 mm) and cost $1.19 each.



Compact testing devices in this photograph are installed in inexpensive card-file cabinets.

In the front row — frequency calibrator, *QST*, July, 1976; and audio oscillator, *QST*, November, 1974. These cabinets are 5 × 3 × 3-3/4 inches (127 × 76 × 95 mm) and cost just 89 cents each. — *Roy E. Lyon, WA4WZJ*

ON-OFF INDICATOR FOR BATTERY DEVICE

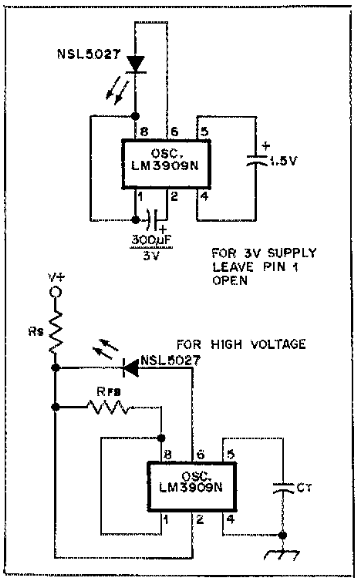
Have you ever wanted an on-off indicator on a battery-operated device but excessive current drain of the incandescent lamp prohibited it? The little-publicized LM3909N flasher/oscillator is a practical solution.

Table 1

Component values for flasher/oscillator. Resistance is in ohms. Capacitance is in μF. One-watt resistors are used for R_s.

V_t	6	15	100
Nom. Flash Hz	2	2	1.7
C_t	400	180	180
R_s	1000	3900	43k
R_{fb}	1500	1000	1000
V+ Range	5-25	13-50	85-200

The LM3909 (available from Digi-Key, Box 677, Thief River Falls, MN 58701, for 69 cents) is an 8-pin DIP requiring only an external electrolytic timing capacitor to set the flashing rate of an LED. It will operate on potentials as low as 1.5 V from an AA battery, and battery life is almost as long as the shelf life.



A useful flasher/oscillator. Top circuit is for use with low operating voltage. The bottom circuit is for higher voltages as shown in the table.

This little device has other applications, such as a square-wave oscillator or a buzz-box continuity and coil checker. The data sheets shown in the Digi-Key catalog give full details. — *Chuck Shaw, K8ET, ex-WB8CND*

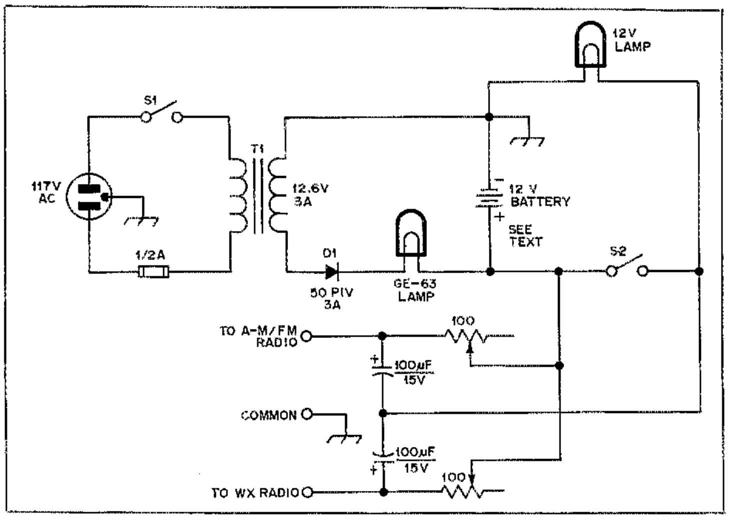
SIMPLE EMERGENCY POWER

In emergencies that interrupt commercial power service, an independent energy source that will operate a light as well as a weather radio and a portable a-m/fm receiver can be most useful. The family flashlight or the portable radio cannot always be depended upon for having batteries that are up to full charge.

The arrangement I use employs a 12-volt motorcycle battery and a trickle-charge circuit. Sufficient energy is provided for the single light, activating the two radios and even operating a handheld transceiver for many hours.

About 100 mA are drawn by each receiver. Variable dropping resistors, such as a Mallory M100PK, may be used to drop the potential to 9 V for each receiver. The lamp assembly may be constructed from an automobile dome light, or a 12-V lamp may be jury-rigged inside an empty coffee jar.

The GE-63 lamp in the charging circuit acts as a current limiter and the glow indicates the charge condition. Charging current is about 150 mA. Power from the battery will operate both radios for several weeks without recharging. The single light may be used for up to four days. — *Joe Rice, W4RHZ*



A radio and a single light may be powered in emergencies with this simple system. T1 is Radio Shack no. 273-1511. D1 is Radio Shack no. 276-1141.

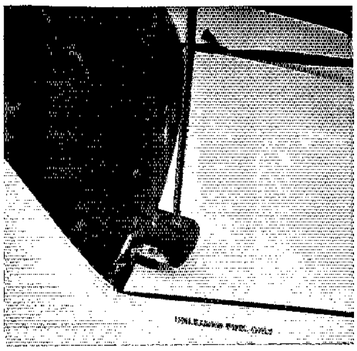
DEMAGNETIZING YOUR SCREWDRIVER

To prevent your screwdriver or pliers from picking up unwanted steel, nuts and screws, simply insert the particular tool all the way between the rods of your soldering gun. Next, turn on the gun and slowly withdraw the tool until it is completely out. The problem of magnetized tools has plagued me many times while working in places that are difficult to reach. — *Roger Mace, W6RW*

INEXPENSIVE 2-METER ANTENNA MOUNT

Like many amateurs who must tighten the purse strings, I have always searched for alternatives to buying expensive parts and accessories. Recently I needed a trunk mount for my 2-meter mobile antenna, but the nine-dollars-plus figure quoted for this item seemed ridiculously high for such a simple device.

While eyeballing other clamps, angles, brackets and hardware, I saw an object called a universal driving lamp bracket. This item contained two no. 12-24 hex bolts and a flat, thick, neoprene gasket to avoid marring the auto paint. The lip fits snugly under the trunk lid and when secured makes a tight, nonmoveable neat installation. This unit is sold by S.S. Kresge Co. stores (K-Mart) and bears the code number 82-20-65. The price? Just $1.88. — *Rene M. White, W6WDF*

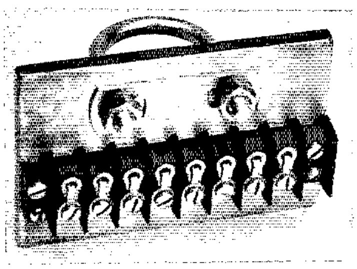


This inexpensive lamp bracket is used for an antenna mount.

LIGHTNING ARRESTOR FOR ROTOR CABLE

To improve the lightning protection for my beam antenna, I not only installed a Cinch-Jones plug on my rotor cable for quick disconnection, but also constructed the arrestor shown in the photograph as a means of providing a path for shunting any strike current. This arrestor is installed on a tower leg at the point where the rotor cable is fed away from the tower at a 90-degree angle.

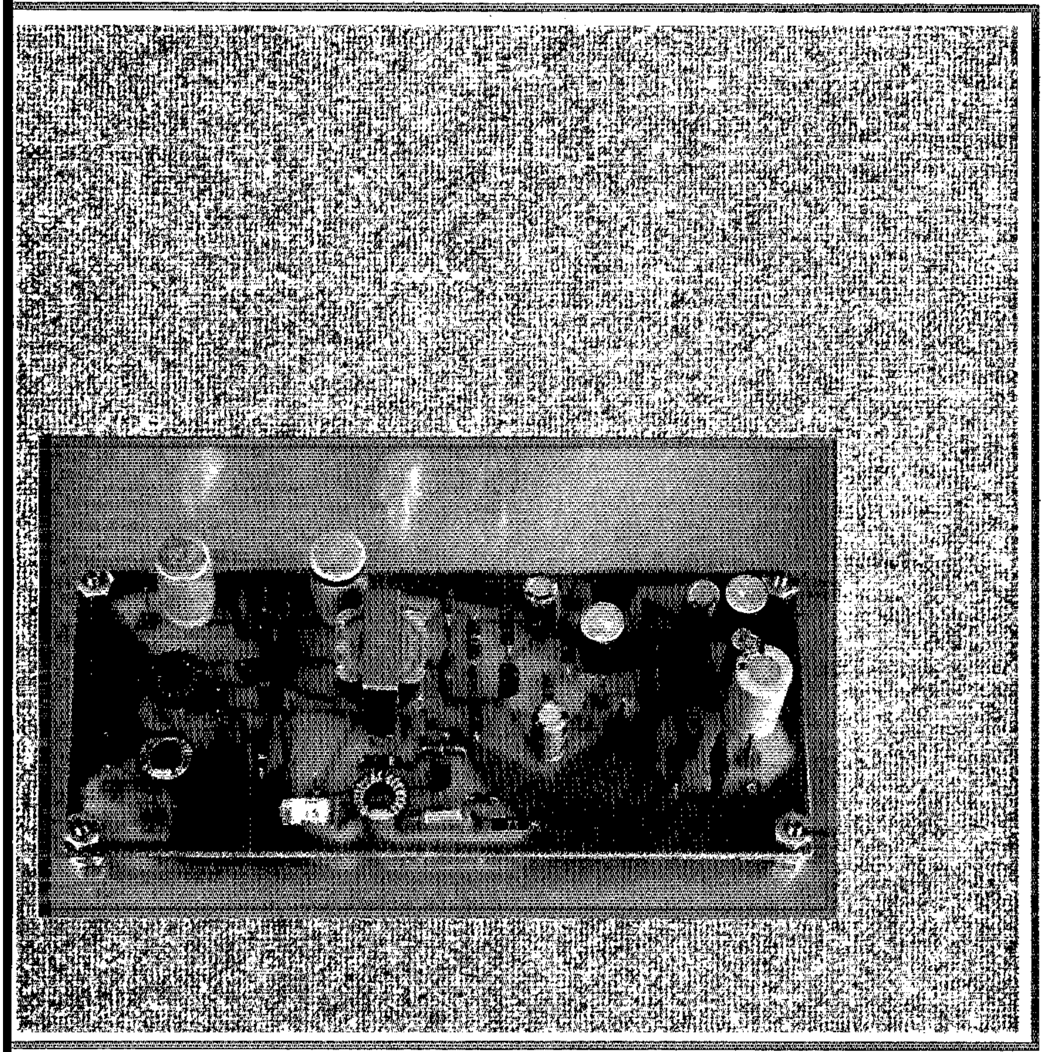
The arrestor is made from a terminal strip mounted on a durable copper plate. Tabs on the strip are cut flush with the back of the strip. The terminal assembly is supported a small distance away from the plate by means of washers in order to provide an electrical gap. A U bolt holds the arrestor to the tower leg. After the cables are connected, a means of weatherproofing may be employed. — *Lance Q. Johnson, K1MET*



A homemade lightning arrestor for a rotor cable. The "gaps" for the arrestor are between the backs of the terminals and the mounting plate.

QST

levoted entirely to Amateur Radio April 1978 $2.00



A 20-meter receiver on a circuit board! You can build it.

Page 11

QST

April 1978
Volume LXII Number 4

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

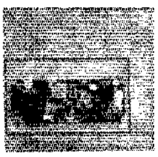
Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index. Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER



This direct-conversion 20-meter receiver is simplicity itself. See page 11.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A 20-Meter High-Performance Direct-Conversion Receiver

Looking for a homemade receiver design that's nearly guaranteed to work the first time? Assemble this radio and enjoy hours of listening from your home QTH or "in the field."

By Jay Rusgrove,* W1VD

"Ho hum. This looks like another direct-conversion receiver. Well, let's flip the page and see what the next article is."

Chances are, if you're not a dc-receiver enthusiast this is what you are thinking. "After all, who would want a dc receiver? They all suffer from excessive hum, BFO pulling, drift, are microphonic and susceptible to a-m broadcast pickup." To that, we not-so-politely say BUNK!

A well-designed, direct-conversion receiver suffers from none of those maladies and in fact will provide a certain, pleasing clarity and depth of sound that is not possible with highly filtered and agc'ed superhets. Signals seem to stand out against a nearly noiseless background. Since the circuitry is simple, the cost is low and the chances of the receiver working "first time" are excellent.

Circuit Description

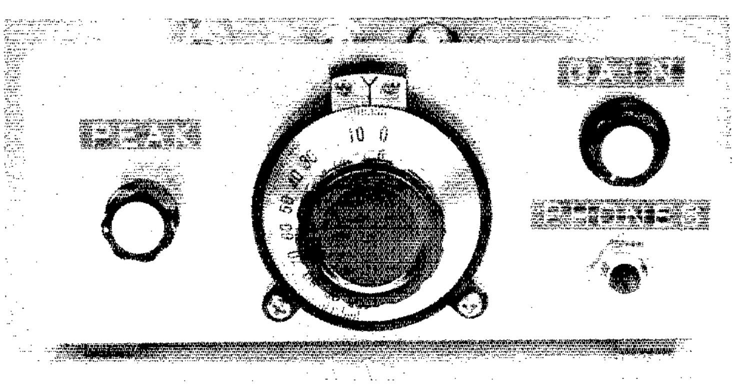
There are two main areas where the performance of most dc receivers is compromised — the product detector and the BFO. The product detector is responsible for mixing the input signal to the receiver with the BFO (the frequency difference being audio) and provide as its output an audio signal.

Many designs make use of a single device for the detector, quite often a dual-gate MOSFET. While the MOSFET is reasonable as far as IMD, blocking and cross modulation are concerned, it is poor in the way it handles a-m signals. This is of particular concern in the amateur 40-meter band where many commerical broadcast stations share the same spectrum. Also, it is not uncommon to have standard a-m broadcast stations in the 525- to 1625-kHz range completely overrunning a dc receiver. Both of these problems can be considerably reduced by using a balanced product detector, as is done in this design. If careful attention is paid to circuit balance, the detector should function very well. For this reason the two FETs should have matched characteristics (I_{DSS} and $V_{gs(off)}$). Matched, for this application, is within 10 to 15 percent.

The product detector is preceded by a sharp-tuning (high Q) preselector. C1 tunes the circuit to resonance, with links L1 and L3 used to couple signals in and out of the resonator. L3 feeds L4/L5, a broadband toroidal transformer, which in turn drives the gates of the FETs. BFO energy is injected through the center tap of the transformer. The FET drains are connected directly to an audio transformer, T1. C4 and C5 function as bypass capacitors shunting rf drain currents to ground, allowing only the audio information to be fed to T1.

Q3 and associated components comprise an audio preamplifier which boosts the output of the detector to a level suitable for driving the audio-output stage. U1 is a low-voltage audio power amplifier featuring high gain, low distortion, and a reasonable price tag. There is even sufficient output from U1 to drive a small speaker! The gain of the IC is adjustable by varying the elements connected between pins 1 and 8. As the amplifier is presently configured, the gain is approximately 50.

It is interesting to note that the only selectivity in the receiver (aside from the preselector) is that obtained through shaping of the audio channel. As shown, the receiver was primarily designed for ssb reception rather than cw. A bandwidth



The front panel of the high-performance receiver is simplicity itself.

*Senior Assistant Technical Editor, ARRL

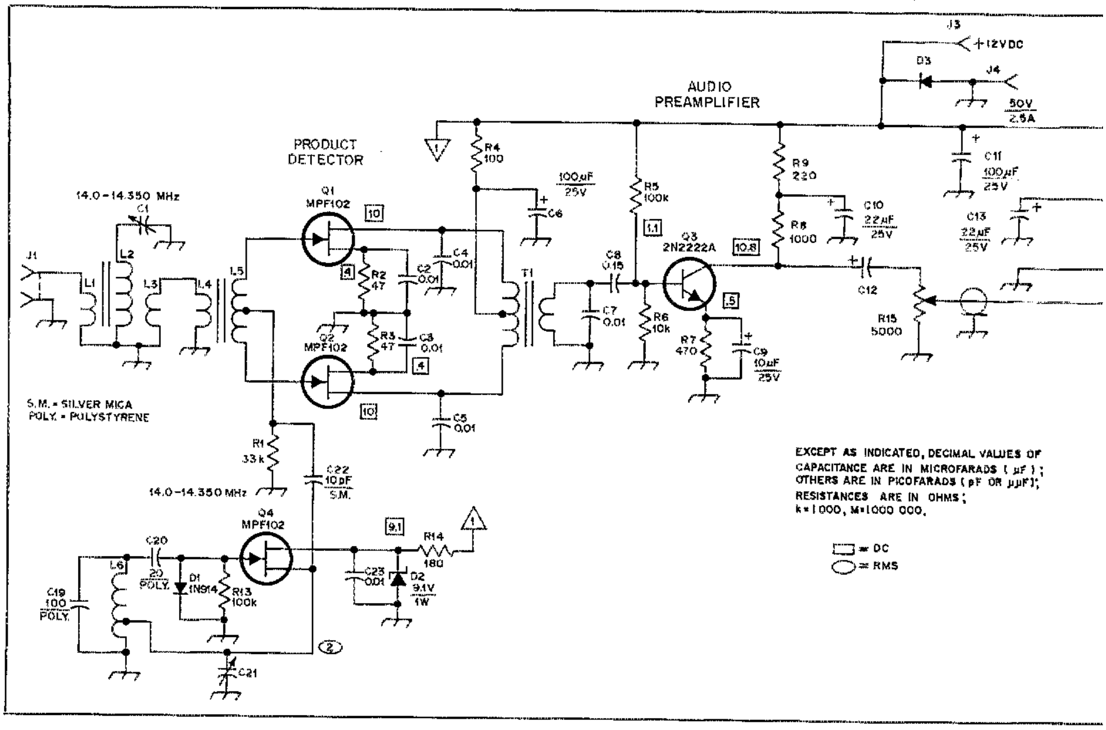


Fig. 1 — Schematic diagram for the high-performance, direct-conversion receiver. Numbered components not appearing in the parts list are for text reference only.

C1, C21 — Variable capacitor, 35 pF maximum.
J1 — Coaxial connector.
J2 — Headphone jack.
J3, J4 — Binding post.
L1 — 2 turns no. 28 enam. wire on L2.
L2 — 40 turns no. 30 enam. wire on a T-37-6 core.
L3 — 4 turns no. 28 enam. wire on L2.
L4 — 4 turns no. 28 enam. wire on L5.
L5 — 16 turns no 28 enam. wire on an FT-37-63 core. Make center-tap connection.
L6 — 19 turns no 28 enam. wire on a T-37-6 core. Tap at 7 turns above ground end.
Q1, Q2, Q4 — JFET, MPF 102, HEP F0015.
Q3 — Silicon npn high-speed switching or rf-

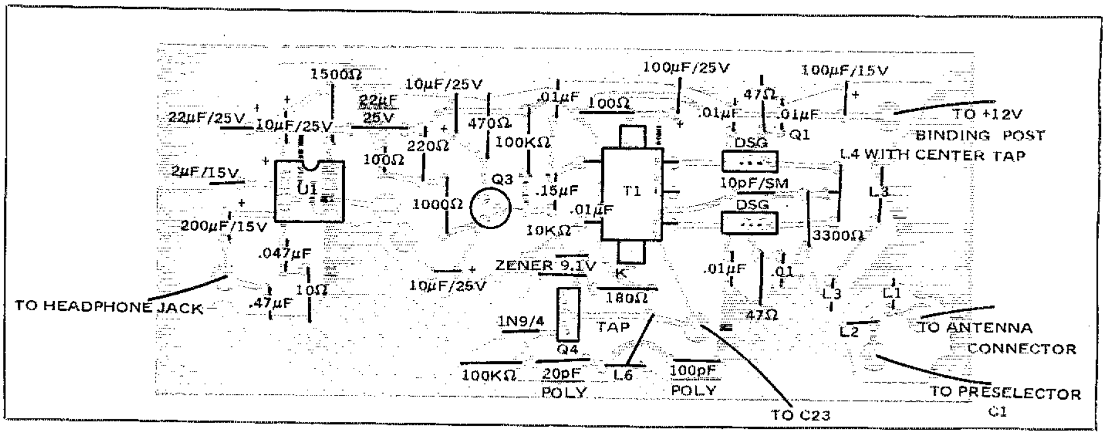
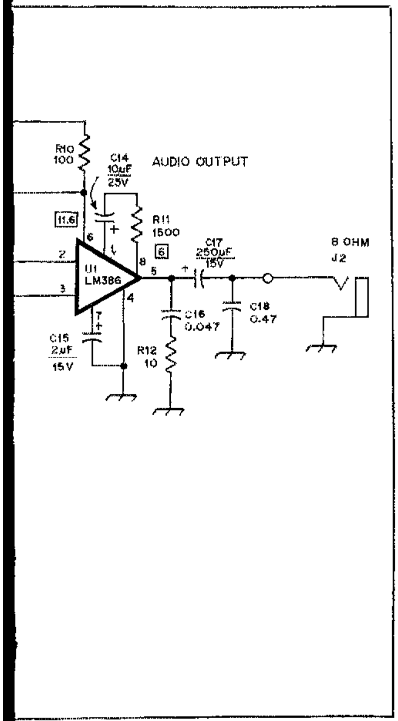


Fig. 2 — Shown here is the foil side of the circuit board with parts layout. Grey areas represent unetched copper. Drawing is to scale.

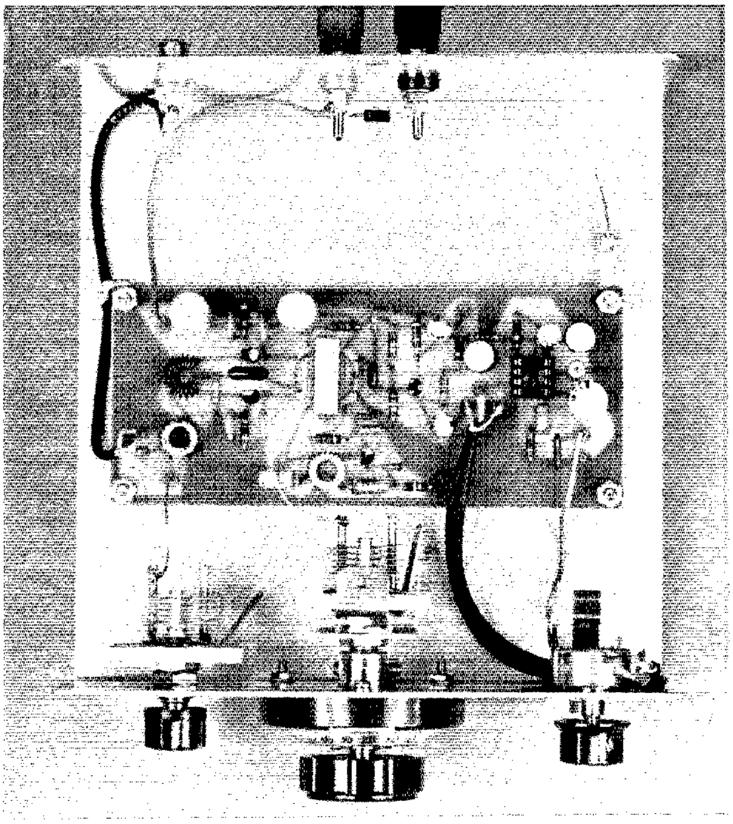
more appropriate for cw work can be had by increasing C7 to 0.02 or 0.047 µF.

As we mentioned earlier, one other area of compromise in many dc receivers is the BFO. Since most design criteria call for simplicity of design, a BFO buffer is seldom used. In many receivers this omission results in excessive frequency drift. For optimum stability the designer must carefully choose the frequency-determining components and pay particular attention to the manner in which power is extracted from the circuit.

The BFO circuit shown in Fig. 1 is very stable, drifting only a few tens of hertz from a cold start. Also, the oscillator does not pull when the preselector is peaked or when strong signals are being received — an inherent problem with some circuits. Many designs have the output taken through a small-value capacitor connected



amplifier transistor, 500 mW, 2N2222A or equiv.
T1 — 10-kΩ to 2-kΩ ct. Stancor TAPC-35, UTC/TRW SO-8.
U1 — Audio-amplifier IC, LM-386 (National Semiconductor).



Inside the dc receiver. Note that D3 is mounted directly across the power supply binding posts. Also, an IC socket is used for U1 to simplify replacement should that be necessary.

to the gate of the FET, a point of very high impedance. Oscillator stability can be improved by removing the necessary energy from the source — a somewhat lower impedance point in the circuit. Polystyrene capacitors and a Zener-diode regulator both go a long way in helping the oscillator "stay put."

Construction

The majority of the circuit components are mounted on a circuit board that measures 2-1/4 × 5-1/4 inches (57 × 133 mm). The foil pattern and parts layout information for the board are shown in Fig. 2. Components not on the circuit board are mounted directly on the front or rear apron, with the exception of the main tuning capacitor. Since a vernier dial is used for this control, the capacitor must be mounted back one-half inch or so from the front panel. A small, L-shaped bracket was fashioned from a piece of scrap aluminum for this purpose.

All rf wire runs, except those to the variable capacitors, are made with RG174/U miniature coaxial cable. The short lengths of wire to the variable capacitors are ordinary, solid hookup wire. Connections to the headphone jack and power supply binding posts are made with covered hookup wire. A piece of aluminum bent into the form of a "U" is used to house the receiver. Its dimensions are 5-3/4 × 2-1/2 × 6 inches (146 × 63.5 × 152 mm).

Alignment

The receiver is designed to tune the entire 20-meter band. Only one adjustment is required, and this involves setting the BFO to the proper frequency range. Several different methods of alignment can be used. If a calibrated signal generator or transmitter is available, simply couple a very small amount of energy (through a one- or two-turn coupling loop) to the antenna terminal. Set the main tuning capacitor for full mesh, and adjust the vernier dial so it reads "0." With the frequency of the transmitter or signal source set to 14.000 MHz, spread or compress a few turns of L6 (near the ground end) with an insulated tool. As this is done the signal should be heard in the headphones. Careful adjustment of the turns will allow the received signal to be placed exactly on frequency.

If a calibrated receiver is available the adjustment can be made in a different manner. Couple a small amount of energy from the direct-conversion receiver BFO to the calibrated receiver by means of a piece of wire placed in the vicinity of the BFO. While listening on the calibrated receiver at 14.000 MHz, adjust the turns of L6 as outlined above until the BFO signal is heard. This completes the alignment of the receiver.

For the builder who wishes to use this receiver on bands other than 20 meters a few simple modifications will be required. Appropriate changes of the preselector and in the frequency-determining components of the BFO will allow the receiver to work on any of the hf bands. Oscillator stability on the higher bands will likely be degraded compared to 20 meters, although it may be suitable for portable operation.

It is interesting to note that when K1ZZ took the receiver home for a shakedown, the first signal he copied in the phone portion of the band was SMØAGD/S2 in Bangladesh, which he promptly worked for a new country. Everyone should have such luck! QST

The State-Variable Filter

With a single filter network, your receiver can have low-pass, high-pass, band-pass and notch-filter responses simultaneously. Prescribe one for your station now! The facts and figures are here!

By Howard M. Berlin,* W3HB

In a previous article[1] I presented the design of multiple-feedback active filters. Using a single operational amplifier, I illustrated how the basic multiple-feedback circuit could be used to establish low-pass, high-pass or band-pass audio filters suitable for cw and ssb reception.

There are several disadvantages or limitations in designing multiple-feedback active filters, however. Two of the major drawbacks are to be mentioned. The Q of a multiple-feedback, band-pass filter is generally limited to the range of 10 to 15. In addition, because of the interrelationships between the five frequency-dependent resistors and capacitors, it is difficult to smoothly change the filter center or cutoff frequency easily without changing other parameters, such as the damping factor and passband gain.

The State-Variable Filter

To overcome the two points just mentioned, we can use a state-variable filter, which is also called a universal filter. As shown in Fig. 1, such a filter is made up of several different functions. These consist of one summing block, two identical integrators, and one damping network.

Because of the manner in which these functional blocks are connected, we are able to have simultaneously the following filter outputs — a second-order low-pass filter, a second-order high-pass filter, and a single-pole band-pass filter. For this type of filter, the cutoff frequencies of the low-pass and high-pass responses are the same, and, in turn, are equal to the center frequency of the band-pass response. In addition, the damping factor is the same for all three responses. However, to do all of this, three operational amplifiers are required as compared with a single op-amp for the multiple-feedback design.

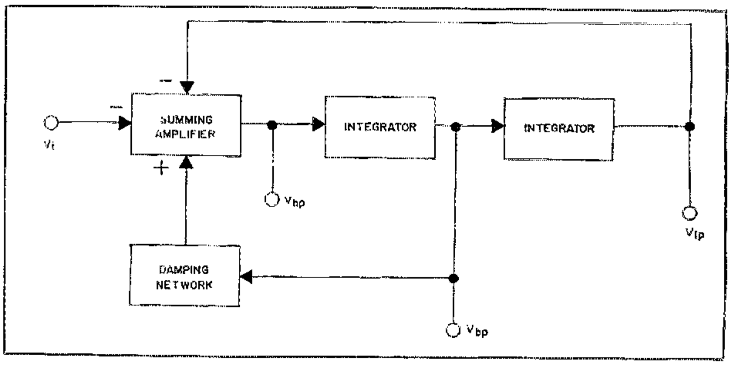
The Three Op-Amp S-V Filter

As shown in Fig. 2, a circuit using three operational amplifiers replaces the block diagram of Fig. 1. U1 is the summing block (really a difference amplifier) for the input, low-pass and band-pass signals. In series with this summing block are two identical op-amp integrators, U2 and U3, which determine the filter cutoff frequency f_c, and the center frequency f_o by the formula:

$$f_c \text{ or } f_o = \frac{1}{2\pi RC} \qquad \text{(Eq. 1)}$$

The damping network is composed of

Fig. 1 — State-variable filter block diagram.



*519 Dougfield Rd., Newark, DE 19713
[1]References appear on page 16.

resistors R_A and R_B. Depending on the value of the filter damping factor α, the following relationship holds

$$R_A = \left[\frac{3}{\alpha} - 1\right]R_B \quad \text{(Eq. 2)}$$

This relationship *in no way affects the cutoff or center frequency of the filter.* For both the low-pass and high-pass outputs to exhibit a second-order Butterworth, or "maximally flat" passband response, the damping factor must equal 1.414, which is the same as a Q of 0.707, inasmuch as $\alpha = 1/Q$.*[2]

When we make the damping factor equal to 1.414, however, the response of the band-pass output suffers terribly since the Q is 0.707! On the other hand, if we have a Q of 10, the damping factor for the low-pass and high-pass responses is 0.1, which is definitely not a Butterworth response. *Consequently, there is no possibility of obtaining optimum performance with all three outputs simultaneously, and we have to compromise. We then design either for a second-order Butterworth low/high-pass response* (Q = 0.707), or for a high-Q, band-pass response (Q < 500).

Using the circuit of Fig. 2, the low-pass and high-pass responses will both have a passband voltage of 1.0 (unity), so that

$$\frac{V_{LP}}{V_i} = -1 \text{ for } f < f_c \quad \text{(Eq. 3)}$$

$$\frac{V_{HP}}{V_i} = -1 \text{ for } f > f_c \quad \text{(Eq. 4)}$$

The minus sign in Eq. 3 and Eq. 4 tells us that the output signal for both the low-pass and high-pass responses, in the passband, is inverted with respect to the input signal, or has been subjected to a 180° phase shift.

For the band-pass section, the voltage gain at the center frequency will be numerically equal to the filter Q, or

$$\frac{V_{BP}}{V_i} = Q \text{ at } f = f_o \quad \text{(Eq. 5)}$$

and the band-pass output signal will be in phase with the input.

Because there are only two components required to determine the cutoff or center frequency (Eq. 1) of the filter, we can use the simple graph of Fig. 3, which utilizes standard resistor and capacitor values.

The above equations are applied in the design of a unity-gain, second-order, low-pass or high-pass Butterworth filter with a cutoff frequency of 700 Hz. From Fig. 3,

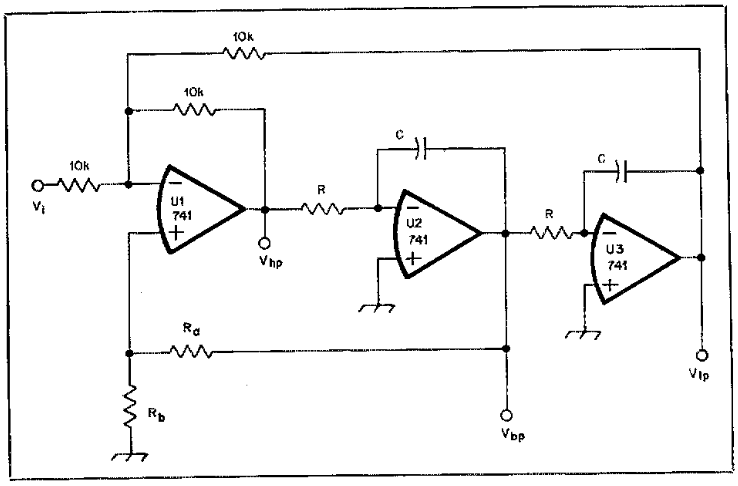


Fig. 2 — Basic unity-gain, state-variable filter employing three operational amplifiers. Linear integrated circuits U1-U3 are general-purpose operational amplifiers such as Texas Instrument type μA741. Resistors are 1/4 watt.

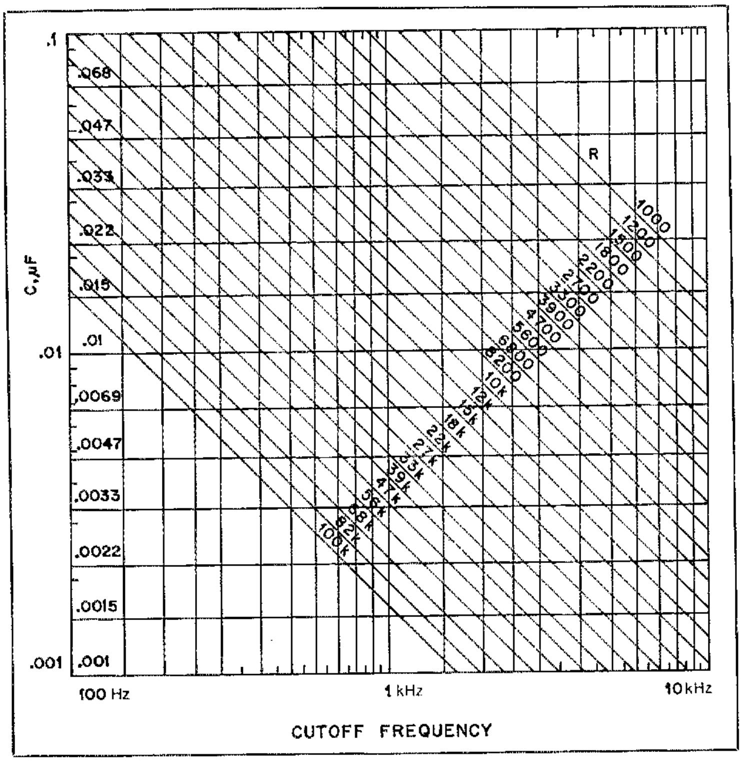


Fig. 3 — Graph for determining values of R and C.

we see that the best combination for R and C is R = 6800 ohms and C = 0.033 μF. For a second-order Butterworth response, the Q must be fixed at 0.707 and from Eq. 2, R_A must be 1.12 times R_B. By selecting R_B equal to 2700 ohms, then R_A may be considered to be 3000 ohms with the use of 5 percent resistors. As another

*The parameter α is referred to as the "damping factor," and is numerically equal to 1/Q.

example, suppose we are interested in designing a 700-Hz band-pass filter with a Q of 50. Well, everything remains the same except R_A and R_B. Again applying Eq. 2, R_A must now be [(3) (50) − 1] or 149 times that of R_B. By using a 1000-ohm resistor for R_B, we can then use a 150-kΩ resistor for R_A, which is close enough for practical purposes.

An S-V Notch Filter

One very nice feature of the S-V filter is that we can simultaneously add the low- and high-pass outputs equally to obtain a notch or band-reject filter. For the notch filter, what is needed is a dual-input, summing amplifier with equal gains, similar to the one shown in Fig. 4.

As an example, we wish to design a 600-Hz notch filter with an approximate Q of 100. From the graph of Fig. 3, we can determine the appropriate values of R and C, so that R = 27 kΩ and C = 0.01 µF. Then, from Eq. 2, R_A is 299 times R_B. If R_B is chosen to be 1000 ohms, then R_A is 300 kΩ resulting in the final circuit of Fig. 5.

Simple, economical and effective well describe the S-V, a single network that simultaneously has the capability of providing low-pass, high-pass, band-pass and notch filtering. Indeed, it is truly a universal filter!

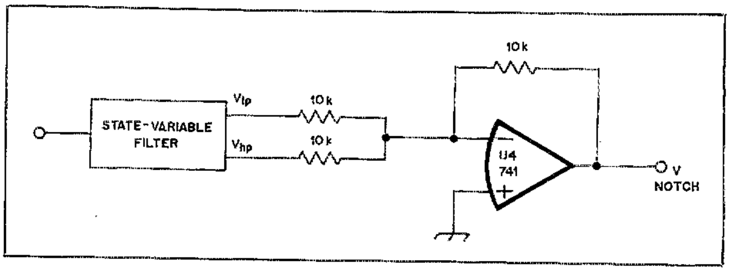


Fig. 4 — Formation of a notch filter by addition of a summing amplifier. U4 is the same as U1-U3.

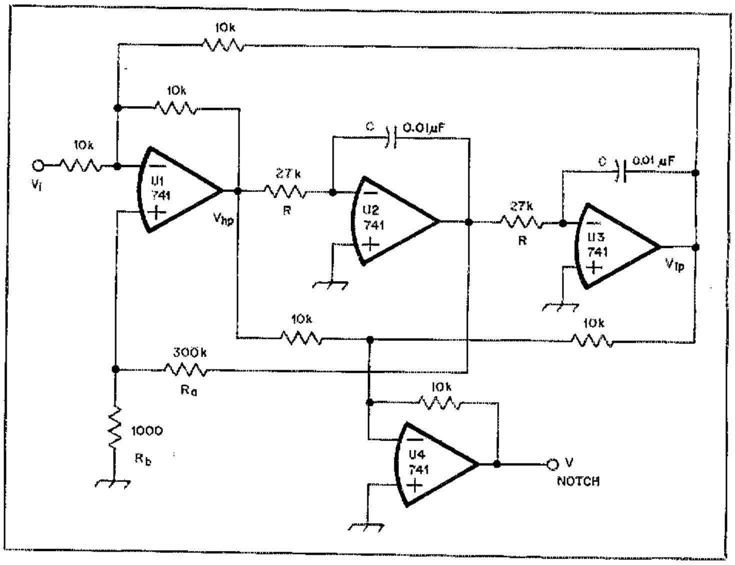


Fig. 5 — Completed design of a 600-Hz notch filter with a Q of 100.

References

[1]Berlin, "Design Your Own Active Audio Filters," *QST*, June, 1977.

[2]Berlin, *The Design of Active Filters, with Experiments*, E & L Instruments, Inc., Derby, CT, 1977.

Strays

R. H. G. Matthews (right), ex-9ZN and Bruce Kelley (left), W2ICE, were well qualified to discuss the merits of an early C.R.L. receiver at the recent National Historical Radio Conference in Dearborn, MI. "Matty," an ARRL director in the early '20s and again in the mid '30s, manufactured the receiver. Bruce is the curator of the Antique Wireless Association Museum in Holcomb, NY. — *W1DX*

Gathering in front of the York (PA) Chapter, American Red Cross, these three amateurs represent 154 years of amateur radio experience: (l-r) Paul L. Stumpf, W3AQN, 50 years; Albert E. Gibson, Jr., W3ABN, 51 years; and Edward J. Dillmeir, Jr., W3LMA, 53 years. All are still active on the air and in the York ARC.

Collecting a Ham's Tools of the Trade

Use your knowledge, test gear and calculator as ham "tools," but don't forget that a good set of hand tools is also necessary. If the contents of your toolbox look like leftovers from a scavenger hunt, consider purchasing these essentials!

By Jim Bartlett,* WB9VAV

As I poked my head through the door of my friend's ham shack recently, John greeted me with the familiar "howzit-goin?" I had begun to expect.

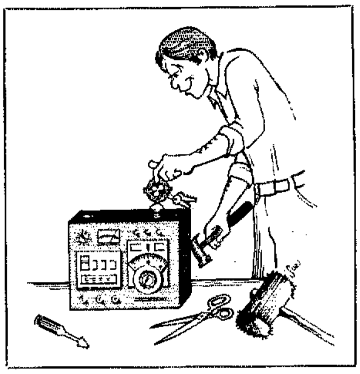
Sidestepping the rat's nest of wire on the floor, I entered the room as John fished his key ring from his pocket. He proceeded to tighten the last screws on his latest project with his "lucky charm" pocket screwdriver. "Whew, all done!" he beamed as I approached the work-bench. Strewn across the bench top were John's "tools" for electronics: the kitchen scissors, an ice pick, and numerous other items, all looking only remotely like the tools I was accustomed to using. Not that John couldn't afford the *right* tools for the job, he probably never discovered the idea of using *real* tools instead of "make-dos." So this is for John, and those of you who, like John, are still "making do!"

When a new ham first joins the ranks after having spent time previously as an audio buff, SWL or certified tinkerer, he soon finds that, as a ham, he must do a considerable amount of "tinkering and fidgeting" with his equipment to become fully accepted and respected by his fellow radio operators. Along with this required activity comes the need for certain tools to make the task easier. Let's look at the more common tools first.

A soldering iron, a pair of needle-nosed pliers, diagonal cutters, and a screwdriver make up the most basic tool kit for the ham. Of course, you can purchase many other "more advanced" tools, but for now let's consider those to be accessory and luxury items; the ones listed above are *essential!*

If any of you have had the misfortune of having to replace broken tools, you will agree that the old proverb, "You only get what you pay for," is good advice! So remember, buy the best tools you can afford, and buy them *as you need them* instead of trying to cover every square inch of pegboard with goodies on your first trip to the store! Do some shopping. A number of excellent brands are available; some manufacturers offer lifetime guarantees on tools and replace them when they break.

*Basic Radio Editor, *QST*



John pulled out his "lucky charm," four-way pocket screwdriver and began tightening the last screws.

Numero Uno

Probably the most used (and abused) tool in the ham's workshop is the soldering iron. This hot little number comes in configurations ranging from miniature pencil and cordless battery-operated types, to the larger "guns" and monster irons notorious for their secret use as cigarette lighters and for the large scorch marks they leave as signatures on workbenches. For all-around radio work, however, a 40-watt pencil type is probably the best choice. Though large enough to handle joints of heavy gauge wire, it won't cause copper pads to separate from pc boards if you're careful. The soldering technique won't be discussed in this article, as that subject is well-treated in other ARRL publications. However, you should remember that a heat sink attached between a sensitive component and your 40-watt iron will protect the device from heat damage while soldering. Fig. 1 shows several types of soldering units and accessory items.

If you've ever fried your fingertips while juggling five wires, solder and iron, all at the same time, you know what it's like not to have needle-nosed pliers. Although probably dozens of different types of pliers are in use today, the most useful to the ham is the needle-nosed variety. Despite their nasty-looking appearance, they can really be quite friendly as long as you keep your flesh out of their jaws! (This is not always as easy as it sounds!)

When you shop for this tool, keep in mind the size of the parts you work with. Many times the impulse is to buy a large pair of pliers that fit your hand rather than a small pair that would be more suited to electronics. Going back to tool quality for a minute, when shopping for pliers, you should check the "bite" and alignment of the jaws for proper fit. A good pair of pliers will grip evenly from front to back and side to side. One way to examine a prospective purchase is to hold it up to the light and look for places where the light sneaks through. Let's face it, some tools are going to be better than others, and you might as well have the best you can find! (If light sneaks through, so could thin component leads.)

Needle-nosed pliers also come in two versions — with or without a wire cutter on the side. The prices are about the same, and since the wire cutters can come in handy and save you time, the pliers *with*

Fig. 1 — In this photo (l-r) are a pencil-type iron with stand, a soldering gun, and a large iron with cradle. Near the bottom of the photo are a solder sucker, vacuum bulb, soldering tool and 60-40 solder.

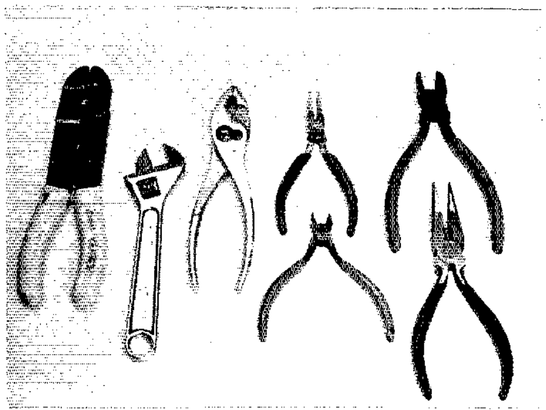


Fig. 2 — Shown here are (l-r) wire strippers, adjustable wrench, adjustable pliers, small set of diagonal cutters (dikes) and needle-nosed pliers, larger set of diagonal cutters and needle-nosed pliers.

the side cutters are probably the better buy. See Fig. 2.

Cutters and Strippers

Another tool you can "quality check" with the light-bulb technique is a pair of diagonal cutters, sometimes known as "die cuts" or just "dikes." These jewels are indispensable when you are nipping off protruding wires and leads from a soldered pc board. They can also function as miniature bolt cutters if you don't mind their getting dull. Again, try to resist the urge to buy the largest pair. Settle instead for the more dainty variety if you plan to do a lot of circuit-board work. With one exception, your diagonal cutters can also double as wire strippers. In fact, with practice, you may find that they can be used as skillfully as bona fide strippers. The exception is Teflon-covered wire. When stripping wire coated with Teflon, you must use regular strippers or a knife because of the toughness of this insulation.

Screwdrivers

If you're like most hams I know, you've probably dreamed of owning all the necessary sizes of screwdrivers in both regular-blade and Phillips-style tips. With these, you could rule supreme — and no screw, large or small, would escape your grasp! Fortunately, several types of interchangeable-shaft screwdriver kits offer a reasonable economic alternative. You just pick the right blade for the job, and pop it into a common handle, thus giving the effect of having separate tools. This system of sharing a common part not only makes the kit less expensive than individual tools, but also makes it more compact and easier to fit in the tool box. For those screwdrivers you use most frequently, you may want to purchase separate tools of good quality to eliminate having to change screwdriver shafts in the middle of a delicate operation. (You wouldn't want to lose your patient!) Fig. 3 shows several options you can take in purchasing your screwdrivers.

Expanding Your Capabilities

These tools are essential for the beginning ham's toolbox. However, many other tools can make the difference between simply repairing or converting ham gear, and actually *building!* Ironically, these are the more destructive tools: those which cut, punch, rip, bore holes in, or otherwise make mincemeat of those shiny new chassis boxes.

For many years the electric hand drill was considered an expensive luxury by a number of hams. Today the prices are quite attractive. This is especially true when the prospective builder visualizes the hundreds of pin-sized holes that must be drilled in an individual pc board. It wasn't like that in the days of point-to-point wiring. Today, without an electric drill the builder is destined to a world of broken bits and frustration. This is not to say that a hand-crank drill isn't a wise investment; in fact, many times it can be a lifesaver! But in the long run, a 1/4- or 3/8-inch electric drill is hard to beat.

Good drill bits are just as important as the drill itself. In fact, it is usually helpful to know what type of bits are going to be used *before* buying the drill. Why? Because drills vary, and one thing that doesn't stay constant is the drill-bit holder, or *chuck.* For the average guy who's only using 1/8-inch bits and larger, this shouldn't present a problem. But for the ham who builds lots of circuit-board projects, a chuck that doesn't squeeze down narrow enough to clamp a no. 60 drill bit firmly just won't do the job. (I didn't find out that my drill wouldn't hold a no. 60 bit until a year after I had purchased it!) If you want to be sure that your new drill will accommodate small-size drill bits, take along your smallest bit when you go shopping. You may find that very few 3/8-inch drills will handle a no. 60 bit. But if you can find one that *will* take a no. 60, get the 3/8- rather than a 1/4-inch drill. That way you can also get some good-sized (half-inch or larger) bits with reduced shanks into the chuck.

Once you start drilling holes you'll find that drills leave burrs and sharp edges behind, and sometimes the hole you drill isn't quite large enough to clear the part to be inserted. Here's where a reamer and a couple of rat-tail files come in handy! A reamer is a conical tool with cutting edges down the side. It can be twisted into a hole by hand or inserted into the drill chuck and used as a large drill bit to remove burrs, enlarge holes, and smooth rough edges easily. Rat-tail files can help with very small and very large holes by rounding off sharp edges and filing notches or clearance grooves in chassis boxes when necessary. Fig. 4 shows a drill, drill bits, reamer and other metal-working tools.

With some oversized drill bits, an electric drill, and a reamer, you can cut holes up to about an inch with ease. And if your poor aluminum chassis box doesn't die from these gaping wounds, you can finish it off by chopping out a two- or three-inch hole and inserting a panel meter. This can be easily accomplished using chassis punches, or a "nibbling tool." See Fig. 5.

Chassis punches are really big artillery, and thus cost big dollars! But if you find yourself hacking out the same-size holes week after week, the investment might be worth it. Chassis punches can punch square or round holes anywhere from about 1/2 inch to over three inches in diameter. They consist of two pieces that fit one inside the other, and a bolt used to pull the two together. A small hole is

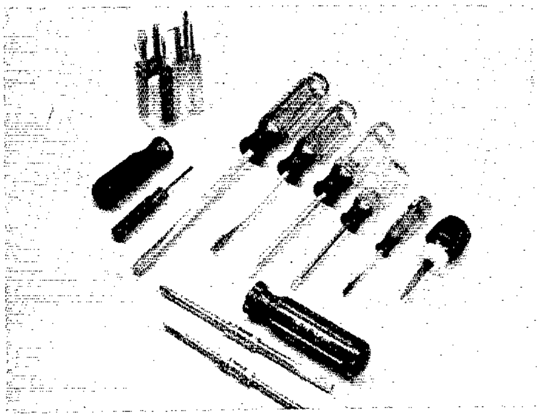


Fig. 3 — Several options are available to the ham who is purchasing screwdrivers. Shown here are two types of "kit-type" screwdrivers, and a standard set of individual tools.

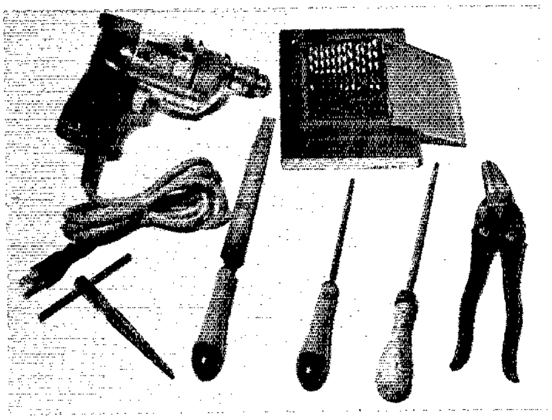


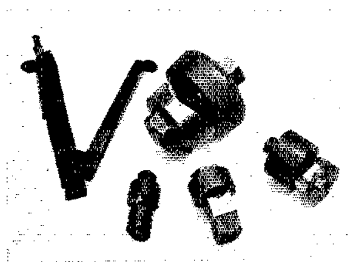
Fig. 4 — A 3/8-inch drill capable of clamping very small bits is a desirable tool if you plan to work on pc boards. Also shown below the drill and bits are (l-r) reamer, files and sheet-metal shears.

drilled in the chassis first. Then the bolt is pushed through one side of the punch, inserted in the hole, and the other punch half is attached. The two halves are then pulled together by turning the bolt until they cut through the metal between them.

If buying a separate punch for each size of hole sounds like an expensive proposition, you're absolutely right! But there's still another way to knock out those mammoth holes in a professional manner: the nibbling tool. This gadget is probably one of the handiest items to have around, if building is your bag. It can be used to chop holes of any size or shape in aluminum, copper or thin-steel sheet metal — even pc-board material. To use a nibbler, you must first drill a small starter hole. Then the tool is inserted through the hole and small bits of metal or material can be cut out piece by piece by squeezing the nibbler's handle.

In addition to the tools already mentioned, there are others which can save you time and money if properly used. Some are items that you most likely have around the house, and others are simply

Fig. 5 — With a nibbler and an assortment of chassis punches, you could cut holes of any size or shape in aluminum stock. Shown here are a hand nibbler and several sizes of chassis punches. Note the different shapes of holes these punches can cut out.



accessories and "niceties." The household items include a hacksaw, hammer, ruler, scribe or pencil, and pocket knife. The accessory items fall into several groups, the first being those used with the soldering iron.

Many good joints can be made using just a soldering iron and a roll of 60/40 solder, but there will be times when you'll want to reverse the process. Several items can make desoldering a more pleasant operation. See Fig. 1. A cheap method of removing molten solder is to apply Solder Wick or a similar substance to the joint while heating with your iron. The wick is made of braided wire, similar to the braided shield around coax, except that it is flat. It "attracts" or actually absorbs solder when placed on top of a heated solder joint. When all of the wick becomes completely saturated with solder, it is discarded, and a new supply purchased. (Sometimes the old wick can be used for common bus strips in breadboard projects.)

When larger quantities of solder must be removed from a joint or from a pc-board foil, a solder vacuum bulb, or solder sucker is probably more expedient. These devices quickly apply a strong vacuum to a hot solder joint, and pull the molten metal from the connection.

Tuning tools are indispensable if you plan to do any tuning of i-f cans, slug-tuned coils, and the like. Fortunately, they are also quite inexpensive and can be purchased in kits or individually. Most tuning rods have stepped ends which will fit several sizes of slugs, and some wands will even count the number of turns as the rod is twisted.

One last invaluable accessory tool is the Vise-Grip pliers. These pliers allow you to clamp any part, small or large, tightly and quickly for drilling, painting, grinding, soldering, or what have you.

To review the tools discussed so far in this article, see the list in Table 1. Of course, many other tools can be useful to the ham, but those described here should prove to be more than adequate for most jobs the newcomer encounters in his "fidgeting."

Recommended reading for the beginner are the "Construction Practices" chapter in *The Radio Amateur's Handbook*, and the chapter on "Workshop and Test Bench" in *Understanding Amateur Radio*. These describe in detail such things as care of tools, chassis working, circuit-board etching, and soldering. QST

Table 1
Recommended Tools

Soldering iron — 40-watt pencil type.
Solder — use 60/40 rosin-core solder only.
Needle-nosed pliers.
Diagonal-cutting pliers.
Screwdriver set (interchangeable blades).
Screwdriver — regular blade tip, 3/16 inch.
Screwdriver — Phillips tip.
Electric drill — 3/8- or 1/4-inch chuck.
Drill bits — from no. 60 to 3/8 inch, various sizes.
Hand reamer with T handle.
Rat-tail files, small and medium (triangular and flat files useful also).
Chassis punches — buy only as needed!
Nibbling tool.
Hacksaw — with metal working blade.
Hammer — Ball-peen, one-pound head.
Ruler — metal edge is best.
Scribe or pencil.
Pocket knife (Boy Scout or similar).
Solder Wick or similar material.
Vacuum bulb or solder sucker.
Tuning tools — buy as needed, or in kit.
Vise-Grip pliers.
*Nut drivers.
*Adjustable wrench.
*Center punch.
*Combination pliers.
*Stripper-crimper pliers.
*Channel Loks pliers.
**Emery cloth, electrical tape, cement.
Items with * are not mentioned in article text, but are additional tools that may be of use to the ham. Items with ** are shop materials.

Frequency Memory for Receivers with Digital Readout

If you're tired of trying to remember the operating frequency you've departed from while you temporarily scan the band, read this suggestion! Let your digital display be your memory, and give that old "noggin" a rest.

By Wes Hayward,* W7ZOI

Does your communications receiver use digital frequency readout in place of a mechanical dial? Among the numerous advantages of digital display is excellent resettability. This is of great advantage to the DXer or contester. He can return exactly to the frequency of a station with relative ease. There are, however, some operational problems. With a simple digital readout it is necessary for the operator to note the frequency of a station, either mentally or on paper, before tuning away from the frequency where the receiver is set.

*7700 S. W. Danielle Ave., Beaverton, OR 97005

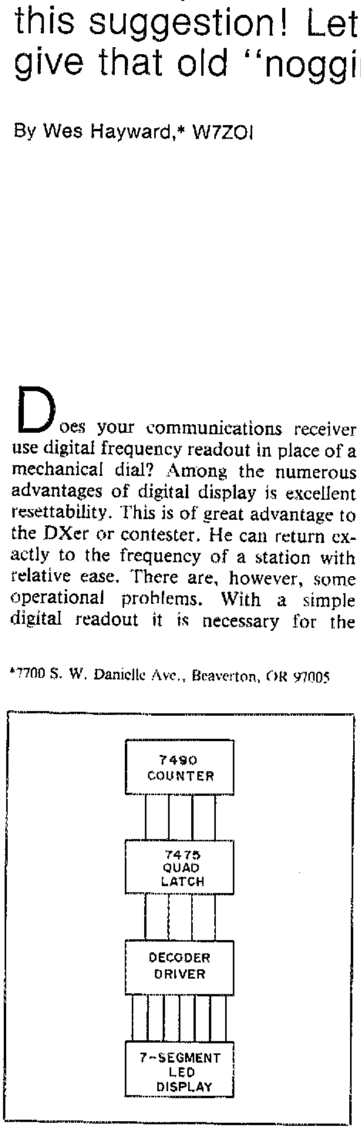


Fig. 1 — One decade of a typical digital frequency counter.

A convenient feature for a receiver would be a "memory" switch on the front panel. If a frequency is to be "remembered," the switch is activated and a departure from that frequency is electronically displayed. This would be analogous to a memory in a pocket calculator. Ultimately, one can envision receivers that use frequency synthesizers under microprocessor control. With such a system a large number of frequencies could be "remembered." Pushing a recall button would automatically retune the receiver to the desired frequency. A system with this versatility must be designed with such features in mind from the beginning. The memory described here can be added to many existing receiver readouts.

Some Details

Shown in Fig. 1 is one decade of the typical digital counter used in a receiver. There will be one such block for each digit of front-panel display. The frequency counting is performed with a decade divider such as the SN7490. The BCD output of the counter is applied to a quad latch, typically an SN7475. This is a memory element. When the control lines to the latch are high, whatever information present at the input is transferred to the output. A low input to the control line causes the last information presented to the input (when the control line was high) to be remembered and be presented at the output. Four of these elements are contained in the 7475 package. The BCD output of the latch is applied to a decoder driver that, in turn, drives the seven-segment LED display.

Shown in Fig. 2 is a simple memory system that has been added to the writer's receiver.[1] The key to this system is the exclusive-OR gate. This component is remarkably versatile for the digital designer. The output of the exclusive-OR gate will be high if one of the two inputs is also high. However, the output will be low if both inputs are low or if both are high. The truth table of the exclusive-OR gate can be paraphrased by stating that the output will be high only when the two inputs are *different*.

With reference to Fig. 2, the output of an existing latch is routed to a second quad latch, U1. When switch S1 is closed, all information present in the latches prior to switch closure is remembered. The binary outputs and inputs to the latch are compared in an SN7486 quad exclusive-OR gate, U2. Any difference, which would result from tuning the receiver to a different frequency, produces a high out-

[1]Hayward, "A Competition-Grade CW Receiver," in two parts, *QST*, March and April, 1974.

put at one or more of the output pins of U2. The four outputs of the 7486 are applied to U5A, half of a dual 4-input NOR gate (SN7425). This yields a low output whenever any frequency difference occurs. The low output turns on a small light-emitting diode. The diode is mounted just above the corresponding seven-segment readout digit.

In the writer's receiver, memory was applied only to the two right-hand digits. The complete circuit is shown in Fig. 2. While it would be handy to have an error indicator for the third digit, this would have added to the complexity and cost. It was necessary to add only five ICs to the existing system.

Fig. 2 shows just one method of implementing a memory. There are many other techniques that could be used. A second set of display elements could be activated to record the "remembered" frequency. Alternatively, binary word comparators (SN7485s) could be used instead of the exclusive-OR gates. This would allow LEDs to be activated that would inform the operator if the receiver was tuned above or below the remembered frequency. While separate LEDs have been used to indicate a frequency change in the writer's receiver, other indication methods could be used. For example, the intensity could be reduced on digits where an error exists.

The author has used this memory for routine hf communications. However, a number of other applications are suggested. The system would be especially useful for measuring Doppler shift in a satellite, active or passive. Of greatest significance, it offers a glimpse at some of the operating features that will be available in equipment of the future.

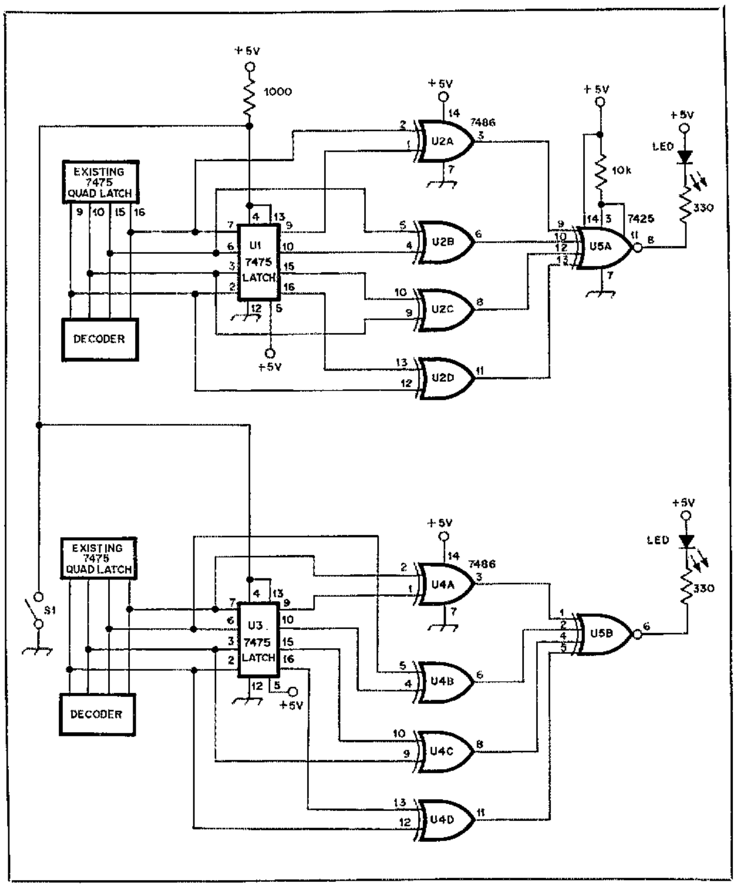


Fig. 2 — Diagram of the simple memory system which the author added to his homemade receiver.

Strays

UNCONFIRMED QSLS

☐ Yacht *Exodus* was lost on a reef off the coast of Santo Domingo on March 16, 1977, and all logs were destroyed. There is, therefore, no way of confirming QSOs from W4AMG/MM, K4DL/MM, OZ1BAA, ZB2CU, 9H3K, K4DL/KV4 and K4DL/KP4 for that period. — *K4DL*

HAMS-SPELUNKERS UNITE

☐ From responses received as a result of my July, 1976, "Stray," I have found these hams who are also spelunkers: WA3DGE, K3OWN, WB4DWP, WB4WBH, K8DOC, WA8QZZ and WB9SIN. I thought I was the only one! — *WB4AZY*

CALL FOR PAPERS

☐ Amateur Computing 78 microcomputer festival will be held July 22-23 at the Sheraton National Motor Hotel, Arlington, VA. Especially welcome will be topics concerning amateur radio applications of microcomputers. Those interested in presenting a paper, participating in a panel discussion, displaying an amateur computer system or sponsoring a tutorial should submit a letter of intent along with a one-page abstract or outline *by April 15* to John Wall Miller, Program Chairman, 6921 Pacific Lane, Annandale, VA 22003, 703-256-5702. Authors will be provided with instructions for preparation of camera-ready papers, which are due by June 1.

Information on Amateur Computing may be obtained by writing AMRAD, P. O. Box 682, McLean, VA 22101.

IT'S THE FIRST

☐ The first ARRL-affiliated club located outside the U.S. and Canada received its certificate of affiliation recently from Brigadier General John Maurer, military community commander at Wiesbaden, West Germany. Aside from sponsoring a Novice class, the club operates DA4FB, a 70-cm repeater. A DXpedition to Liechtenstein (HBØ) and an American-style hamfest are planned for May.

WE'RE ALL OVER!

☐ Teaching English to foreign students at Georgia Tech, Dr. Ed Richmond, W4MGN, was surprised to learn that his students included YV5YA, HI8XIM and HI8GMN. He remembered a 20-meter QSO with the latter because of the similarity of their calls.

ILLUSIONS OF CW

☐ *The Cleveland Press* reports that an amateur in Dallas, TX, started to hear messages at odd times. The sender — a mockingbird perfectly imitating the Morse code rhythm. — *W8FLD*

Go ATV with This Transceiver

Get into the amateur television picture! Operate portable, mobile or airborne with fast-scan TV. Assembly from commercially available parts takes less than an evening and doesn't require paying the king's ransom!

By Henry B. Ruh,* WB9WWM

Many ham operators rationalize their failure to participate in television by indicating a lack of equipment. In prior years such reasoning could be considered acceptable. Recent developments in solid-state products, however, make such rationalization today as weak as jail-house coffee. Now, in this semiconductor age, there is little difficulty in obtaining essential components,[1] nor does one have to worry about putting the arm on a rich uncle to pick up the tab. Why an amateur television station can even be assembled in an evening.

How Sweet Can It Be?

If you have had a latent desire to branch into communicating by television, now is the time to get involved. Based on my experiences, I sincerely believe the best approach is by way of ATV. "What is ATV?" you might ask, provided you are relatively new to ham radio. Let me explain that by recapping the trend in amateur communications.

When widespread interest in television sprouted after World War II, bandwidth technicalities required a split of TV operations in the amateur bands. Slow-scan television (SSTV) is used in the hf bands where interference must be minimized. Fast-scan TV (ATV) is permitted on the bands above 420 MHz where wider bandwidths needed for this mode can be accommodated. This article is concerned with the latter method.

A Converter for Reception

Understandably a station that transmits well but is deficient in receiving for want of a good receiver leaves much to be desired. Efforts by some amateurs to modify the home-TV uhf tuner have proved rather disappointing. Others have geared up homemade devices that failed to live up to expectations. What is the alternative?

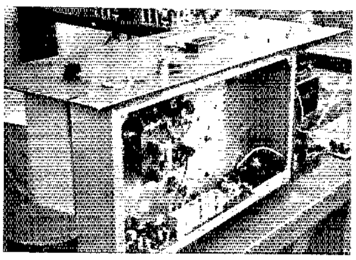
P. C. Electronics, which produces the units one needs for an ATV station, has resolved the matter of providing a means for obtaining excellent reception. The TVC-1 converter, available in ready-made form, is tailor-made for the 439-MHz enthusiast. You simply wouldn't want this device to be more compact than it is. It fits nicely inside a TV set and presents no problem if one wishes to mount it on the antenna.

The TVC-1, sensitive and selective, performs exceptionally well, yet it is an example of simplicity. Performance is enhanced by a commercially manufactured, double-balanced mixer and a voltage-

*Publisher, *Amateur Television Magazine*, Rte. 1, Box 12, Ellettsville, IN 47429

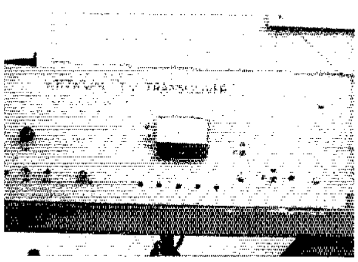
[1]Footnotes appear on page 26.

The front panel and bottom assembly of the ATV transceiver. Nestled in the channel of the back edge of the chassis is the TX-432 transmitter. To the right of the TX-432 is the MHW-710 power amplifier. Above the transmitter are the 4.5-MHz subcarrier audio generator and the agc amplifier as well as the video modulator. The area at the upper right is for the video i-d unit. Note that the TX-432 i-f cans have been soldered on the sides and tops to improve shielding.

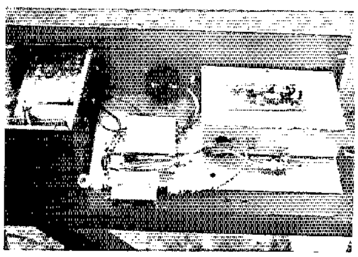


Front panel of the nearly finished WB9WWM transceiver. Holes are for the video i-d board controls for positioning the i-d horizontally or vertically, changing the luminescence level from black to white, keying on the i-d, and for setting the sync-triggering level as well as the flash rate.

The Calectro 0-100 mA meter has been recalibrated to work with a Bird power sensor. Range of the scale is 0-16 watts cw.



Top view of the ATV transceiver. The power supply is at the left. A coaxial relay and bird power sensor are near the center of the back apron. The TVC-1 tunable converter has been placed atop a Janel converter box for size comparison. A 12-V regulator chip has been provided for the converter because the main supply furnishes 15 volts to enable the power amplifier to reach full output.



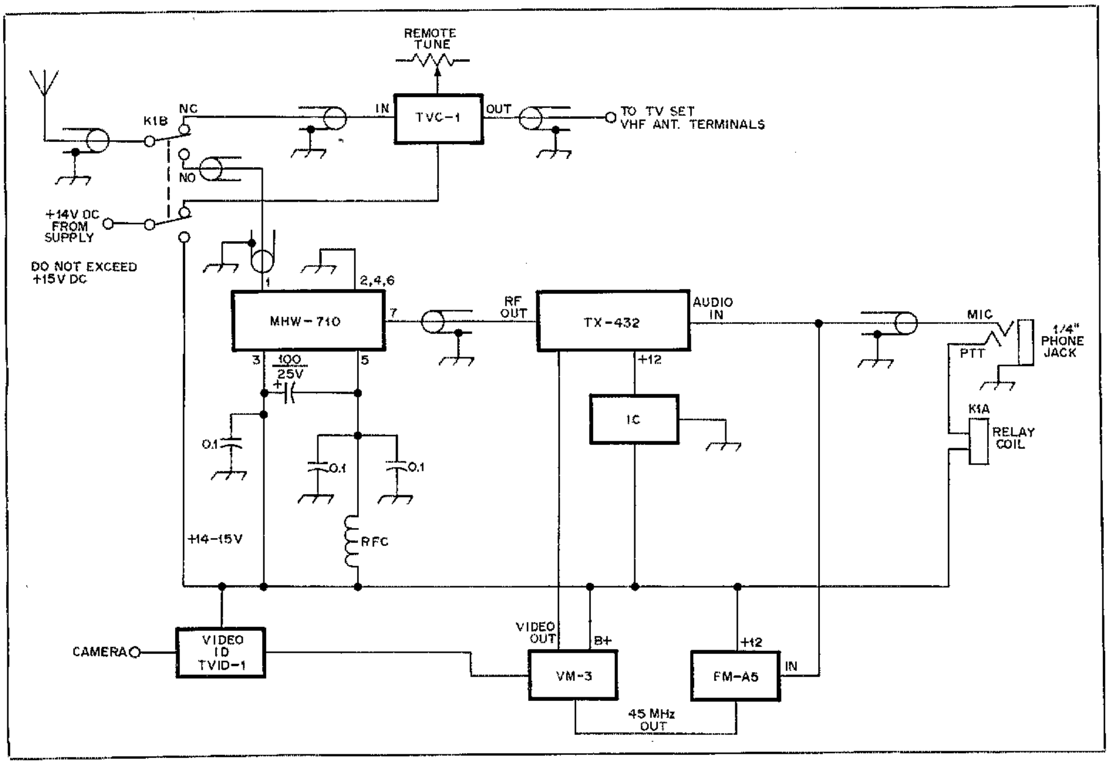


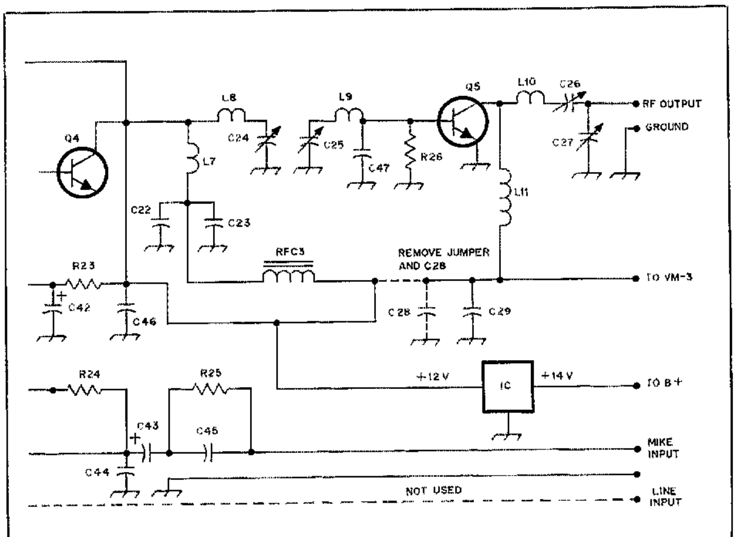
Fig. 1 — Block diagram of the ATV transceiver. Principal units of the circuit are the VHF Engineering TX-432 transmitter. Motorola MHW-710 amplifier, P.C. Electronics TVC-1 converter, VM-3 video modulator, FM-A5 audio subcarrier unit, and video i-d generator. Output of the converter is connected to a standard TV set. The IC is a type 7812 12-V dc regulator.

controlled oscillator that is tuned by a 10-kΩ potentiometer. The latter feature enables the converter to be tuned remotely by a similar potentiometer. Such remote-control operation would be useful if the converter is to be mounted on the antenna or some location apart from the operating position.

One of the goals in designing the TVC-1 was to obtain a high degree of stability. That goal was achieved. The converter would have been unsatisfactory without it. Physically, the TVC-1 components are mounted on a very small pc board. There is a choice of a 50- or 75-ohm input. A coaxial-cable connector is provided for the output on channel 3. The output signal may be fed to an ordinary television set for viewing the picture and hearing the sound. No modification of the TV set is required. Therefore the TV receiver may be used in the normal manner for home entertainment without any inconveniences.

As manufactured, the converter module is supplied pretuned and ready to connect to the ATV system. The TVC-1 should be installed in a shielded chassis or enclosure. Power for the module is to be supplied by

Fig. 2 — Two minor changes are all that need be made to modify the TX-432 transmitter for ATV. C28 and the jumper connecting it with RFC3 are removed. The line input at the lower right of the diagram is not used.



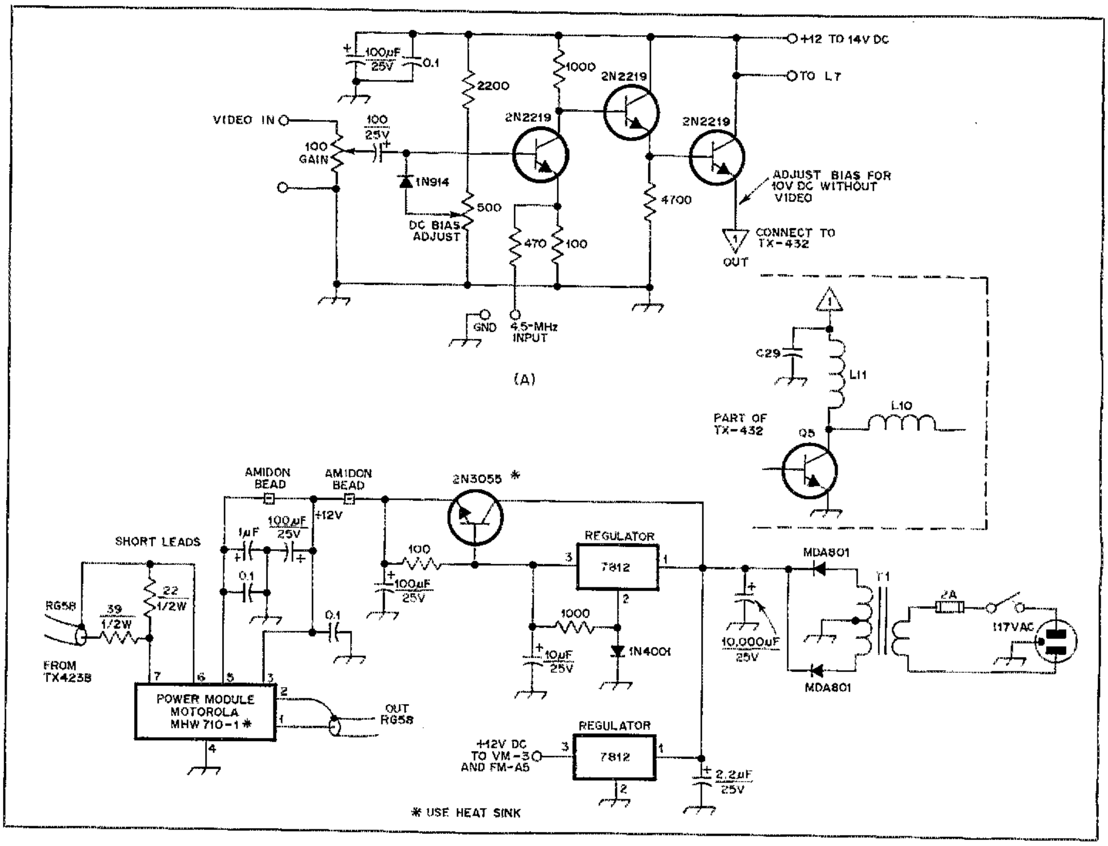


Fig. 3 — The VM-3 solid-state video modulator. The wide bandwidth capability of the modulator enables it to resolve 64 character-per-line signals from TV typewriters and microcomputers. The 3-dB-down point is typically 8 MHz, more than enough for color and sound plus greater resolution than broadcast. The upper portion of the drawing illustrates the modulator circuit. The lower portion covers the power source and the MHW-7-10-1 amplifier. T1 consists of two 25-V ct filament transformers with primaries paralleled and secondaries paralleled. Triad no. F-41X or Radio Shack no. 273-1512 may be used.

a regulated 12-V source. The power supply must be turned off when transmitting.

Special precautions are to be taken when connecting the TVC-1 converter to some TV sets. If the TV receiver does not have a power transformer the TV-set chassis may be "hot" being connected directly to the above-ground side of the 117-V ac line. Such a condition presents a serious shock hazard as well as the possibility that fuses will be blown when the ATV antenna is connected, provided that there is a ground on the antenna system.

Where the television receiver lacks a power transformer, an isolation transformer is *urgently* recommended for installation between the television receiver and the 117-V ac line. A thorough check of the television receiver must be made to determine if a 117-V potential does exist between the chassis and ground before proceeding with the installation.

A length of 50- or 75-ohm cable should be used for connecting the converter to the TV tuner. Remove or unclip the twin-lead at the tuner. The coaxial-cable shield is then connected to one of the antenna terminals. The other terminal is left open.

To adjust the converter, tune the television set to either channel 2 or 3 (whichever is not used locally). Fine-tune the selected channel to minimize any signals from a commercial TV station. Then connect the ATV antenna and swing the converter across the band to locate a nearby ATV station. After the station has been found by tuning with the 10-kΩ potentiometer, fine adjustments are made with C1. When the latter is properly set, tuning will be good for ±10-MHz. For installations where the converter is mounted on the antenna, the 10-kΩ frequency control on the VCO may be replaced by the remote tuning circuit shown in Fig. 4. Use of this arrangement allows the tuning adjustments to be made from the operating position. Shielded cable is recommended for the connection between the VCO and the remote 10-kΩ potentiometer.

Transmitting Equipment

Basic units for transmission of ATV include a video modulator, a sound-subcarrier device, a transmitter and a power amplifier. The VHF Engineering TX-432 and Motorola MHW-710 rf-module power amplifier serve as the rf strip. Both have been adequately described in other articles which appeared in *73* for August, 1976 and in *A-5 Magazine* for March, 1977. The circuits, in articles by Bruce Brown, WB4YTU, are presented here for the convenience of *QST* readers.[2,3]

Video modification of the VHF Engineering TX-432 strip is simple. One capacitor, C28, and the 12-V dc bus jumper to the pad connecting C28, C29 and L11, are disconnected. The strip is supplied with +12 V for all stages except

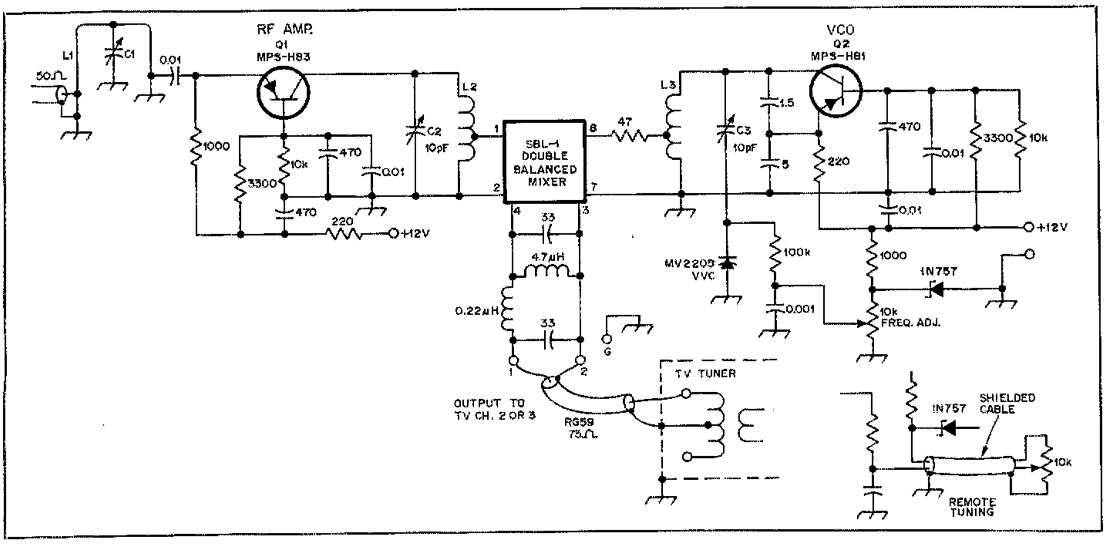


Fig. 4 — The circuit of the TVC-1 converter consists of a low-noise, high-gain, rf amplifier, a doubly balanced mixer and a Varicap-tuned VCO. Remote tuning of the converter permits it to be mounted on the antenna if desired. For remote operation, the remote tuning circuit replaces the 10-kΩ potentiometer shown below the oscillator transistor, Q2. C2 and C3 are Arco 400, 1-10 pF, capacitors. L2 consists of 1-1/2 turns no. 22 wire, 1/4-inch diameter, tapped 3/8 inch from the lower end. L3 is a hairpin loop, 1/2 inch across the bottom and 5/8-inch high. It is made with no. 22 bus wire.

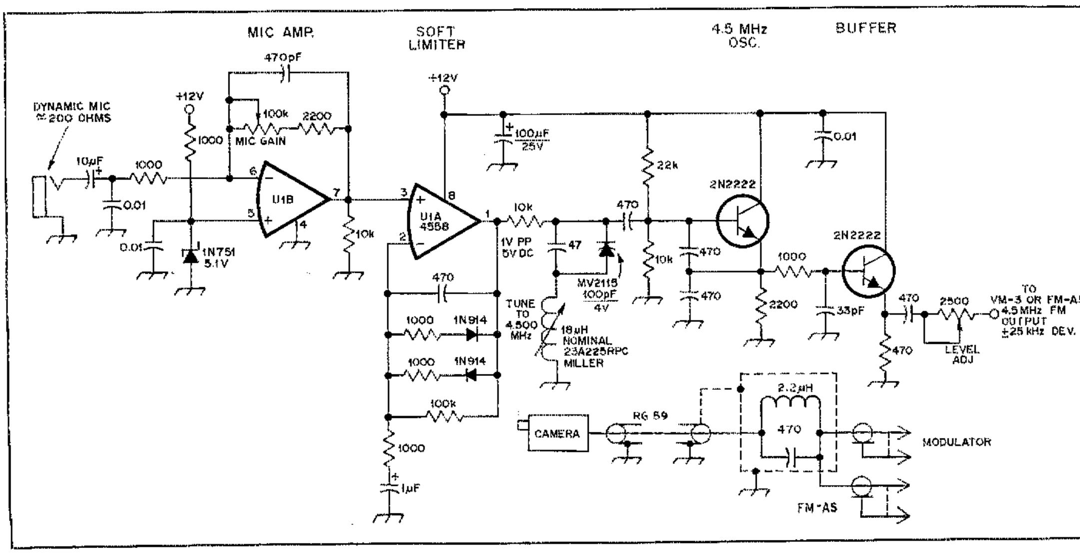
the final. L11 is the final-stage rf choke which is connected to the B+ line and is the feed point for the video/audio signals. C28, an electrolytic capacitor on the TX-432 pc board, is not used. C29 is a small disk capacitor that is retained for rf decoupling.

When tuning the TX-432 for operation below 444 MHz, one may find substitution of Arco no. 402 compression capacitors for the Arco no. 400s desirable. Improved heat dissipation may be achieved by replacing the thin metal heat sinks furnished with the TX-432. The solid-aluminum TO-5 heat sinks sold in the Motorola HEP line are better suited for the purpose.

Fast-Scan Modulator

The VM-3 fast-scan modulator, another P.C. Electronics unit, was developed to be used mainly for supplying video to the TX-432B exciter. Because of the wide bandwidth of the VM-3, it has the capability of resolving 64-character TV typewriters and microcomputers. The 3-dB point is typically 8 MHz which is more than enough for color and sound plus greater resolution than found in broadcast TV. Another feature is a

Fig. 5 — This ATV sound-subcarrier generator module permits both voice and video to be transmitted. The trap shown in the diagram is necessary to isolate the capacitance of the long coaxial cable from the FM-A5 output. The capacitance would act as a bypass to the 4.5-MHz signals without the trap. U1 is either a Motorola MC1458CP1 or Raytheon RC4558DN operational amplifier.



separate input for 4.5-MHz subcarrier for sound transmission. An ATV operator will appreciate this advantage. Figs. 2 and 3 illustrate the connections to be made for adding the modulator to the installation. Price-wise, the VM-3 is sold for about $20.

Subcarrier System for Sound

One of the better subcarrier systems available is also produced by P. C. Electronics under the guiding hand of Tom O'Hara, W6ORG. The FM-A5 utilizes a stable 4.5-MHz oscillator that is fm modulated by a Varicap diode driven from an IC audio amplifier. The unit has sufficient gain to fully modulate the transmitter to 25-kHz deviation even with an inexpensive microphone placed at a distance of 25 feet or more. Provision is made for microphone sensitivity and subcarrier rf level control to customize the operation according to the operator's liking. Moreover, the FM-A5 incorporates a soft limiter to prevent overdeviation. Distortion is extremely low, providing broadcast-quality sound to accompany video pictures.

This subcarrier module is designed for feeding the VM-3 video modulator directly or it may be connected to any 75-ohm video coax line with the addition of a 4.5-MHz trap. The trap, as shown in Fig. 5, is necessary for isolating the capacity of the long coaxial line from the FM-A5 output. That capacity would act as a bypass to the 4.5-MHz signal without the trap.

Output from the FM-A5 is adjustable to match the camera video level. Nominal subcarrier level is 0.5 to 1.0 V peak-to-peak. In some cases there may be other band-pass attenuation in the transmitter and modulator that could require more adjustment.

Under operating conditions, the oscillator should be adjusted to within 10 kHz. The receiving station should be tuned to the high-frequency side of a signal for best sound with picture. The transmitter should also be peaked to the high side.

Frequency response of the FM-A5 is rolled off just short of 300 Hz and just above 3000 Hz for best voice communication. Deviation is fixed at the 25-kHz broadcast standard. P. C. Electronics has priced this subcarrier generator in the $25 class.

Table 1
Where to Buy Components

Component	*Source*
Audio subcarrier unit FM-A5 Tuneable converter TVC-1 Video ID generator TVID-1 Video Modulator VM-3	P.C. Electronics, 2522 S. Paxson, Arcadia, CA 91006
MHW-710 power amplifier	Motorola parts dealers or Regency Electronics, 7701 Records, Indianapolis, IN 46226
Power supply	Godbout Electronics, P. O. Box 2355, Oakland Airport, CA 94614
Regulators	Poly Paks, Box 942R, Lynnfield, MA 01940
TX-432 transmitter	VHF Engineering, 320 Water St., Binghamton, NY 13902

The MHW-710 Module

To give the transceiver an energy boost, the rf amplifier uses a Motorola MHW-710 rf module. As mentioned earlier, only a few parts (as indicated in the drawing) are needed to complete the amplifier stage. The module may not be a stock item at some Motorola parts dealers, but it can be ordered from the source indicated in Table 1. It is sold for about $54.

Video Call Identifier

For the amateur who wishes to go a step beyond the basic installation, there is the PCE TVID-1 video call identifier which superimposes call letters or any six alphanumerics over the camera video. Controls are provided to place the letters anywhere vertically or horizontally on the screen. Black and white intensity may be varied, but white usually shows up best. Sync is taken from the input video. Therefore, no external sync generator or connection is needed. Color call signs may be used by means of phase shifting.This module requires a regulated 5-V source rated at 350 mA.* Video from the camera is applied directly to the module input. The level should be the standard, 1-V peak-to-peak. The video signal goes to a sync separator and to a video mixer inside the TVID-1. The input provides a 75-ohm termination for the line. There is a bias adjustment at the input which may have to be adjusted, depending on the camera being used.

A programmable read-only memory, programmed to contain the call letters of the station, supplies the binary data to superimpose the i-d on the picture picked up by the camera. The composite video comes out of a video mixer through a 75-ohm line driver. RG59/U coax should be extended from the TVID to the transmitter or monitor. The termination for the cable should be resistive 75 ohms. Capacitive coupling should not be used.

In my opinion, the video call identifier adds a nice touch to the ATV station. It is available from P. C. Electronics for about $79.

*[Editor's Note: Space limitations prevent us from publishing a schematic diagram of the TVID-1 identifier in *QST*. This diagram and a brief circuit description are available separately upon receipt of a stamped return envelope. (IRCs are acceptable from outside the U.S.) Address your request to ARRL, Dept. TD-ATV, 225 Main St., Newington, CT 06111.]

Some Final Thoughts

If the fast-scan TV enthusiast chooses this essentially ready-made path to get on 439-MHz ATV, consideration of the power supply and a few possible refinements are all that need to be mentioned in conclusion. Refinements might include a good transmit-receive relay for transferring the B+ and switching the antenna from transmit to receive and vice versa. A good coaxial relay, such as one from a cast-off Motorola 80-D (part no. 80D83252G02) can be salvaged from a retired 80-D or other commercial two-way unit. Alternatives would be to buy a Dow Key coaxial relay, or simply use diode switching. Transfer of the B+ may be accomplished through the auxiliary contacts of the 80-D.

In the photographs of my unit you will notice some additional knobs, a meter and an additional pc board. These are for the purpose of enhancement. If the ATV station is to include the video call identifier, there could be a set of controls provided to turn the i-d on or off, and move the position of the call sign left or right, or up and down.

The TV transceiver pictured in the photographs uses a surplus 12-V dc supply originally intended for powering a portable video recorder. The manufacturer rated this supply for 2 amperes but the supply easily furnishes twice that. A single internal conversion provided more than 6 amperes. Godbout Electronics, on the other hand, has a good regulated supply that also would serve well to power the ATV station.

Note that in my unit some additional "on-card" regulators have been added. These are inexpensive three-lead, 12-V regulator chips from Poly Paks. The purpose of the regulators is to provide protection should the main supply "go bananas." Another reason for these devices is for protection during mobile operation where the 12-V supply varies from +11 to +16 V. Because the ATV equipment I have described is designed for 12-V dc operation, it will operate conveniently as a portable, mobile or airborne station. In fact it will even operate from a balloon, thanks to the NiCad battery!

Footnotes

[1]See Table 1.
[2]For more information about amateur TV, read *Amateur Television Magazine* (Amateur Television Magazine, Box 1347, Bloomington, IN 47401).
[3]P. C. Electronics is now producing the TXA5-2 ATV exciter, designed to drive the MHW-710-1 power module directly with no instability or attenuator. Included with the exciter is a high-resolution video modulator with dc restoration to insure transmission of black blacks as well as maximum power on sync tips regardless of picture contrast. The TXA5-2 is sold, wired and tested, but less the crystal, for $69, postpaid.

Mycoder

Update that Micoder! Try this modification for stable tone generation and positive results. It's a change the autopatch can't refuse!

By George K. Fallenbeck,* K1HQW/4

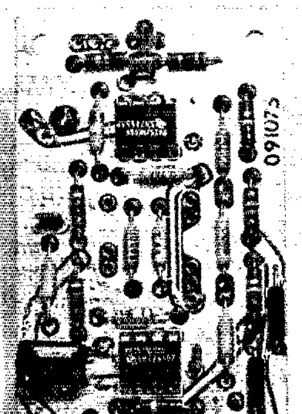
A blinding rain sweeps the highway. You're 10 miles from the nearest town and more than 30 from home where dinner awaits your usually punctual arrival. Then it happens. You feel the engine miss.

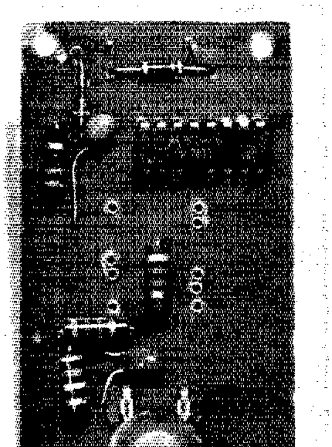
*1008 Pine Lake Dr., Niceville, Fl. 32578

It chugs and then stops dead. That gas tank you neglected to fill is drained of the last drop. "Tonight just had to be the night," you grumble to yourself. "Better let the spouse know and have some gas brought out."

On goes the mobile rig. You punch the pad to bring up the autopatch at the Washington Mountain repeater, some 18 miles to the northeast. Dutifully, the equipment on the mountain responds to your signal, but the autopatch remains inactive. You try again and again in vain. And so. . .

A hypothetical situation? Yes, but discovering that a tone encoder fails to put an autopatch system into operation is not uncommon. I was curious about the difficulties some amateurs have experienced while attempting to trigger an autopatch with a Micoder, so I investigated the device.



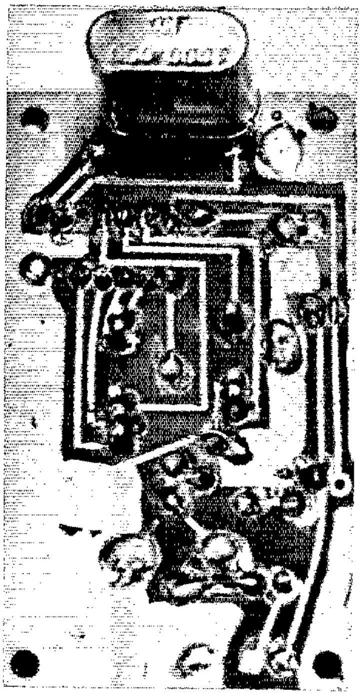


Heath Micoder board (left) versus Mycoder board (right). Notice simplicity of the Mycoder board. The Heath version has nine components hidden on the opposite side of the board.

As the investigation began, I harbored the feeling that the design of the Micoder could be improved. The feeling was just that. I had not been dissatisfied with mine. As a matter of fact it had worked quite well.

My analysis disclosed, for one thing, that while operating in a mobile environment, the Heath tone pad appeared vulnerable to drifting. Tones did not always fall within the 1.5-percent tolerance needed for correct autopatch operation. To perform frequency and level adjustments seemed tedious, requiring disassembly of the unit. In addition, the tone adjustment controls face each other from the board underside. The level adjustment is also on the lower side of the board and facing downward. A frequency counter is required in order to obtain correct settings.

A main reason for the drift, I contend, is the use of two NE555s and seven RC circuits which are employed to generate the Touch-Tone frequency pairs. Such RC circuits are known to be temperature sensitive. With the desires of a perfectionist, I



Reverse (foil) side of Mycoder. The etching pattern is a crude prototype.

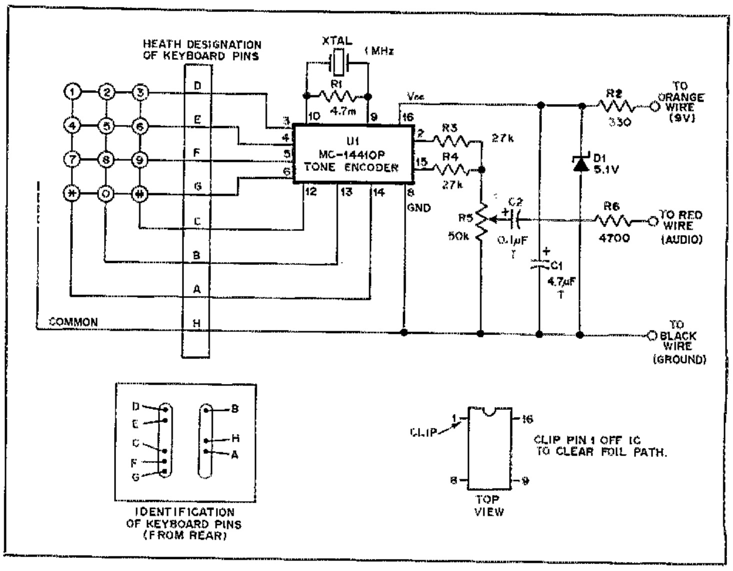


Fig. 1 — The Mycoder schematic diagram. Resistors are 1/4 watt. R3 through R6, as shown in parts list, are for low-impedance operation. The main ingredients are the Motorola IC tone encoder, and the 1-MHz reference crystal. For clearance remove pin 1 of U1.

C1 — Tantalum, 4.7 µF. A higher value may be used.
C2 — Tantalum, 0.1 µF.
R1 — 4.7 MΩ.
R2 — 330 ohm.
R3, R4 — 27 kΩ.
R5 — Potentiometer, 50 kΩ, linear taper Radio Shack no. 271-219.
U1 — Tone encoder IC, Motorola MC-14410P. Available from Poly Paks ($10.50).
Y1 — 1-MHz ±0.005 percent freq. standard HC-33/U crystal. Available from JAN Crystals or Poly Paks for about $5.
Optional: 8-pin sockets, Heath no. 432-932.

began my search for better tone generation.

From the drawing board came plans for the prototype. Design requisites were to include a unit with no frequency adjustment. All tones would be frequency synthesized and held within a tolerance of 0.2 percent. Drift would be inexcusable. The level adjustment must be externally accessible. And for the appearance? Well, that would be just like the original Micoder. Not too bad an arrangement, if I may say so. The end results fulfilled those requirements elegantly. For that reason I am indeed happy to share my ideas.

Let's consider the features of my new unit, which I have elected to call the Mycoder. At the heart of this device is a Motorola MC14410P CMOS tone-encoder chip.[1] The circuit is that of a digital synthesizer requiring only a 1-MHz reference crystal, four resistors, a couple of capacitors, a Zener diode, and a potentiometer. An example of simplicity it is, but nonetheless effective. Furthermore, this redesign represents a considerable reduction in parts count from the Heath version. The latter uses 21 resistors, three ICs, three potentiometers, one capacitor, a transistor, and an LED. Except for the IC and the crystal, other components are commonly available.[2] See the parts list.

From Micoder to Mycoder

Modifying the Micoder requires normal workmanship care. Caution should be exercised in detaching the Heath keyboard which is supported only at the corners. The board is a plug-in type. Also one must avoid static damage to the CMOS. Careful handling procedures of this IC are essential.

The microphone may still be used as usual during the modification because the circuit board and the microphone are electrically independent. The microphone element and amplifier are not disturbed in the reconstruction process. All that is required is to unsolder the red, orange and black wires from the board, tape the ends, and tuck them away. The battery should be taped on to prevent it from rattling around inasmuch as the circuit board will not be restraining it. The latter, once removed, may be consigned to the infamous junk box.

The suggested pc layout for the Mycoder is critical only to the extent of the location of the four corner holes, keyboard pins, and overall dimensions. The dimensions must be observed closely to avoid physical interference between the keyboard and the microphone case. I purposely left extra copper on the circuit board for shielding, even though the MC14410P is supposedly immune to RFI. Besides that, it saves etchant. My board was laid out with the use of narrow graphics tape and a bit of the XYL's nail polish. Technical showmanship is not essential.

Obtaining a small potentiometer for the level control did pose a problem. I was able to use a Radio Shack no. 271-219 potentiometer, which I modified by bending all pins at right angles to the body and toward the metallic side of the pot. In order to make the profile thinner, it was necessary to file the plastic top of the knob. This effort provided a flush-mount control that could be nestled under the keyboard.

To retain the plug-in keyboard features, I purchased and installed eight extra pin sockets from Heath (part no. 432-932). These cost only 20 cents each, but are not strictly necessary for the modification.

Words of Advice

Soldering to the Chromerics keyboard is not recommended. Also, because the keyboard overlays most components, any

[1]References appear on page 29.

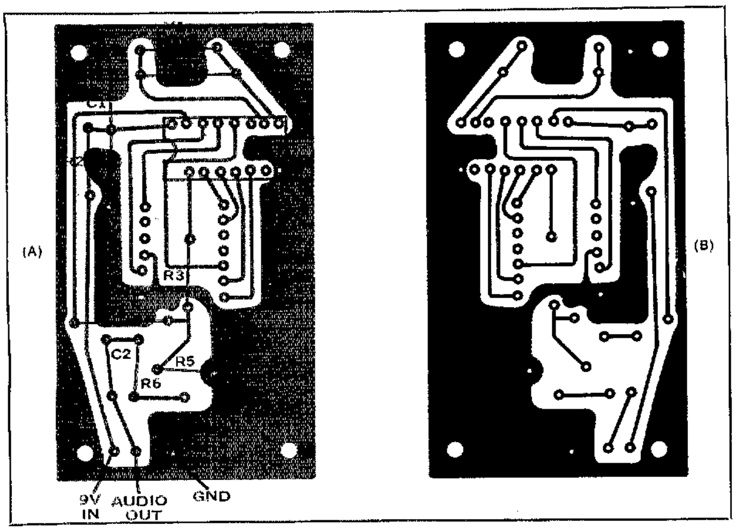


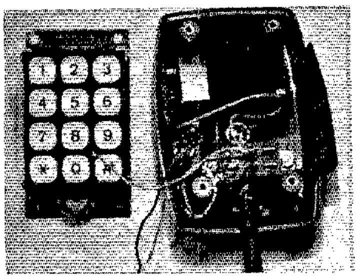
Fig. 2 — The component side of the Mycoder pc board is illustrated at A. Keyboard mounting holes are drilled to 1/16-inch diameter and Heath sockets are installed. A foil-side view of the pc board at actual size is shown at B, with black representing copper.

necessary removal of the keyboard would require a nasty desoldering job. There could be a need to replace parts or to make an adjustment at a future time. For instance one might desire to accommodate equipment having a different impedance from that currently in use.

Because of the narrow clearance between the pc board and the keyboard, the installation of an IC socket is not recommended. Only space-saving, 1/4-watt resistors should be employed. To prevent static damage to the IC, that device should be mounted only after all other components are aboard. The CMOS IC is supposedly diode protected, but I have had bad experiences with other protected devices. Therefore, use normal CMOS handling procedures until the keyboard installation is complete.

Other than being careful with the IC, assembly is straightforward. Temporarily line up the board and mic case. Note where the level-potentiometer adjustment control falls, and carefully drill a hole in the microphone case (the keyboard half) at the appropriate location. Solder the existing Micoder red, black and orange wires to the indicated locations. Assemble the unit, including the 9-V battery. The Mycoder should be ready for action.

Finished Mycoder board ready for installation. Three existing wires are evident; see text.



The encoder is designed to match the Micoder microphone low-impedance output. Should the output not be sufficient for a particular rig, R3 and R4 may be changed to 4700 ohms. I doubt that the Micoder microphone has enough output to drive high-impedance sets using high-output ceramic microphones such as the Regency HR-2B. If one so desires, R3 and R4 may be changed to 47,000 ohms and R6 to 470,000 ohms. In any case, the only adjustment is the externally accessible level control. To set the level, I suggest the enlistment of an aide via the repeater. Without the help of such a person, the alternative is to feed the tone signal at a low level (full ccw) and increase the level until the repeater autopatch is brought up.

I feel positive that those who try this modification will be pleased with the results. The tones appear to be more accurate than the repeater decoder. I've been told, furthermore, that the Heath autopatch encoder for the HW-2021 handheld radio uses the same components as the Micoder. The Mycoder conversion, therefore, should be applicable to this set, also.

References

[1]See Motorola specification sheet ADI-311 (1975).
[2]Touch-Tone encoder kit information is available from Poly Paks, Box 942M, Lynnfield, MA 01940.

[Editor's Note: For additional information about the application of the MC-14410P IC, see the following articles: DeLaune, "Digital Touch-Tone Encoder," *ham radio* for April, 1975. Lowenstein, "Hand-Held Touch-Tone," *ham radio* for September, 1975.]

Feedback

☐ There were two typographical errors in the article, "Calculating Capacitor Values," by Doug DeMaw (February *QST*, pages 28-29). In Fig. 2, the lower formula should have been shown as

$$C1 = \frac{1}{2\pi f X_{C1}} = 0.095\ \mu F$$

In addition, radical signs were omitted over the ratios in Eq. 2. The corrected formula is

$$I_{rf} = \sqrt{\frac{W}{Z_p}} = \sqrt{\frac{600}{4000}} = 0.39\ A.$$

☐ Group tours of the Jet Propulsion Laboratory can be arranged through the Public Education Office, 4800 Oak Grove Drive, Pasadena, CA 91103, Tel. 213-354-4321. The JPL Amateur Radio Club does *not* arrange the tours (February *QST*, page 24).

Tours are booked several months in advance. On the last Sunday of every month from 1 to 4 P.M., there is an open house for the general public. The amateur radio shack is not normally open to the public for either tours or during the open house. — *K6PGX*

☐ The secretary/treasurer of the QRP Amateur Radio Club International (February *QST*, page 82) is Joe Szempias, W8JKB.

☐ N5EE, the shortest U.S. call sign, is actually held by William Wageman of Los Alamos, NM (February *QST*, page 27). Fredrick Walworth, N5ET, of Dallas, applied for the shortest call, but was beaten to it. He and N5EE have met on the air and exchanged their notable QSL cards.

☐ The call sign of Albert C. Quinn (Silent Keys, February *QST*) should have read W1OGF.

☐ The call sign of the person who discovered an armed robbery in New Orleans (February *QST*, page 70) should have read W5ZPA.

Strays

STARTING EARLY

☐ Recently, Jerry Lloyd, WA1TCA, of West Haven, CT, entered an ARRL family membership for his son, Peter Lee, commenting, "He does not have a license yet, but I am sure some year he will get one. . . ." Peter is seven months old.

Short Ground-Radial Systems for Short Verticals

When is a ground not a ground? Should my radials be buried? How deep? How many? Will my vertical work without a ground? Let W2FMI give you the answers.

By Jerry Sevick,* W2FMI

How do you engineer the performance of ground-radial systems under vertical antennas? There isn't much engineering design information available, particularly for conditions where space is limited and cost is an important consideration.

The often-asked questions which need answering are (a) Do four quarter-wavelength radials constitute an adequate ground system? (b) Must radials be buried deeply in the earth? (c) Must the thickest copper conductor available be used? And while we are at it, how about the mistaken notion that short verticals can never compete in performance with a full-sized quarter-wavelength antenna?

This paper presents experimental evidence which answers these questions in a clear and concise way. Investigation shows that short verticals over very small radial systems of almost any kind of thin wire on the ground's surface can perform surprisingly well. On-the-air comparisons with much larger verticals over extensive ground systems show performance reduced by only a few decibels.

Introduction

Vertical antennas have enjoyed considerable popularity on the 80- and 160-meter amateur bands because of the difficulty of erecting horizontal antennas at heights sufficient for low-angle radiation. Optimum heights, which are in excess of a half wavelength (λ) on these bands, are impractical for most amateurs. In many cases short verticals are used since they have been shown to compete favorably with 1/4-λ vertical antennas.[1] This is true if losses in the ground system, matching networks and loading elements are small compared to the reduced radiation resistances of the short antennas.[2] Considerable information is available describing the effects of buried radials on the efficiency of 1/4-λ verticals in the mf and lf bands as a function of length and number of radials, and conductivity of the soil.[3-19] But little is available on radials lying on the ground's surface, particularly in connection with short verticals.

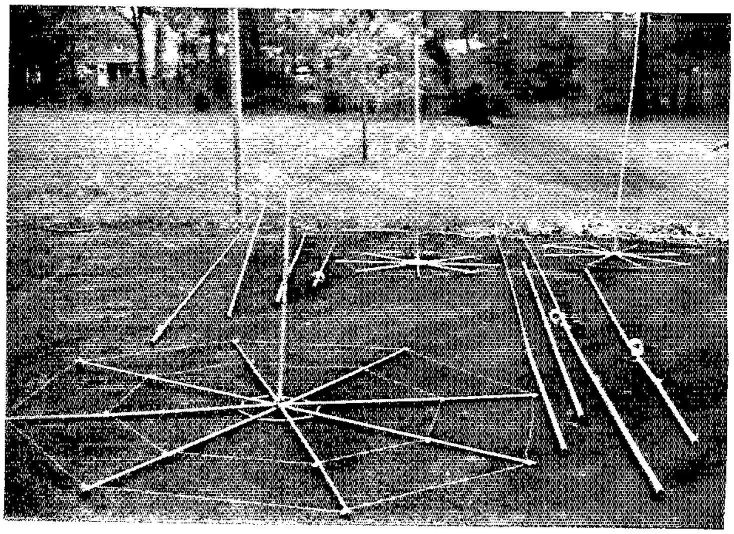
During the author's experiments, various antenna heights from 1/4 λ to 1/8 λ were included. Also developed and described here is a simple method for measuring an important parameter for vertical antennas — soil conductivity. The conductivity of the soil under and in the near vicinity of the antenna is most important in determining the extent of the radial system required and the overall performance. As will be seen, short verticals with very small radial systems can be surprisingly effective.

Soil Conductivity

Most soils are nonconductors of electricity when completely dry. Conduction through the soil results from conduction through the water held in the soil. Thus, conduction is electrolytic. Dc techniques for measuring conductivity are impractical because they tend to deplete the carriers of electricity in the vicinity of the electrodes. The main factors contributing to the conductivity of soil are

1) Type of soil.
2) Type of salts contained in the water.
3) Concentration of salts dissolved in the contained water.
4) Moisture content.

Elements of the 10 vertical antennas used on 20 and 40 meters to experimentally determine the efficiency of shortened verticals with abbreviated radial systems.



*Bell Laboratories, Murray Hill, NJ 07974
[1]References appear on page 33.

5) Grain size and distribution of material.

6) Temperature.

7) Packing density and pressure.

Although the type of soil is an important factor in determining its conductivity, rather large variations can take place between locations because of the other factors involved. Generally, loams and garden soils have the highest conductivities. These are followed in order by clays, sand and gravel. Soils have been classified according to conductivity, as shown in Table 1. Although some differences are noted in the reporting [20,21] of this mode of classification because of the many variables involved, the classification generally follows the values shown in the table.

Table 1
General Classification in Conductivity

Material	*Conductivity (millimhos/meter)*
Poor Soil	1-5
Average Soil	10-15
Very Good Soil	100
Salt Water	5000
Fresh Water	10-15

Since conduction through the soil is almost entirely electrolytic, ac measurement techniques are preferred. Many commercial instruments employing ac techniques are available and described in the literature.[22] But rather simple ac measurement techniques can be used which provide accuracies on the order of 25 percent and are quite adequate for the radio amateur. Such a setup was developed by a colleague and neighbor, M. C. Waltz,[23] W2FNQ and is shown schematically in Fig. 1. Fig. 2 shows the conductivity readings taken over the last three months in 1976. It is interesting to note the general drop in conductivity over the three months as well as the short-term changes due to periods of rain. The results presented in the following sections on antenna efficiencies were obtained in the period October 10 to November 10, 1976, when the conductivity varied between 22 and 25 millimhos/meter.

Antenna Efficiency Considerations

The antenna efficiencies to be discussed are based upon the losses which appear in series with the radiation resistance of resonant verticals. Although this approach does not give a comparison between the very low angles of radiation (i.e., less than 15 degrees) of various radial systems, it does allow for comparisons in the 15- to 30-degree range which is important for sky-wave transmission on the 40-, 80- and 160-meter bands. Mathematically this definition for antenna efficiency can be written as

$$\text{Antenna efficiency} = \frac{R_{rad}}{R_{rad} + R_g + R_A}$$

where R_{rad} = radiation resistance
R_g = ground loss
R_A = ohmic losses due to loading and the antenna itself.

With high-Q loading coils and practically any size of aluminum tubing for the antenna, R_A can be minimized and therefore eliminated from the relationship above.

An example of this technique for determining antenna efficiency uses the results shown in Fig. 3. The input impedance of a resonant quarter-wavelength vertical is plotted as a function of the number of radials. Two lengths of radials (0.2 λ and 0.4 λ) were considered. Since the radiation resistance is 35 ohms for the thickness of the verticals used in this experiment, it can be seen that with 50 radials, losses were about 2 ohms and with 100 radials, 1 ohm. This amounts to efficiencies of 94 and 97 percent, respectively. Also, it can be seen that the efficiency with only four radials is less than 60 percent. This poor efficiency exists even for a location with a soil conductivity that can be considered average.

Further, the efficiency of a radial system employing small numbers of radials is quite dependent on the moisture content of the soil. Fig. 4 shows this result with a resonant quarter-wavelength vertical on 20 meters while the number of radials varies from one to eight. As can be seen, the difference in efficiency between wet and dry conditions becomes less pronounced as the number of radials is increased. The antenna system also becomes more independent of soil conductivity as the number of radials is increased.

In order to determine the efficiencies of shortened verticals over abbreviated radial systems, input impedances were compared with similar antennas over a near-ideal radial system. Fig. 5 shows the experimental results[24] obtained by the author on a near-ideal image plane (100 radials on the ground, about 50 feet long, and terminated in 10- to 12-inch nails). The top-hat loading consisted of an eight-spoked wheel with several rings of aluminum wire to improve its effect. This family of curves has been very useful to the author in designing verticals since it predicts the value of the input impedance of shortened verticals using various loading methods. In particular, it was noted that a simple rule of thumb existed for top-hat loading. That is, a top hat with a diameter D is equivalent to an electrical height of 2D. Further, top-hat loading yielded the highest impedance and bandwidth for a particular height.

Since the investigations reported here involved short radials on the surface of the ground, a study of the effect of the length of a spike terminating the radials was necessary. The efficiency for resonant 1/4-λ verticals with small numbers of

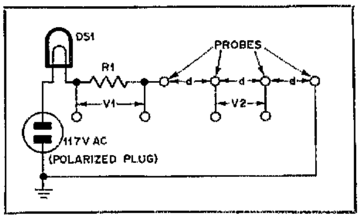


Fig. 1 — Schematic diagram of four-point probe method for measuring earth conductivity.
DS1 — 100-watt light bulb.
R1 — 14.6 ohms (5 watt).
Probes — 5/8-inch dia (iron or copper); spacing, d = 18 inches; penetration depth, D = 12 inches.
Earth conductivity = (21) × $\frac{V1}{V2}$ (millimhos/meter).

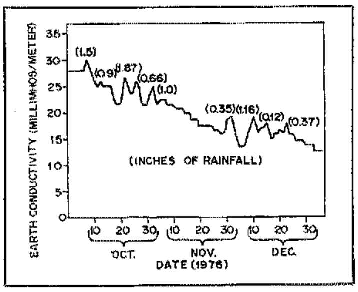


Fig. 2 — Earth conductivity at author's location during last three months in 1976.

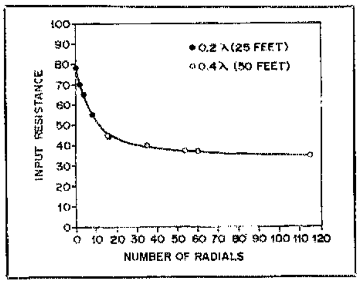


Fig. 3 — Input impedance of resonant quarter-wavelength vertical as a function of the number of radials.

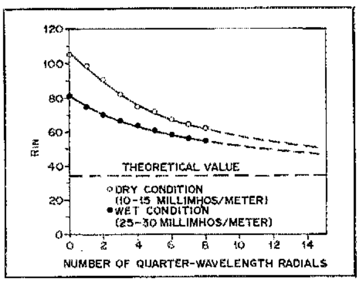


Fig. 4 — Input impedance of resonant quarter-wavelength vertical as a function of the number of radials and the condition of the soil.

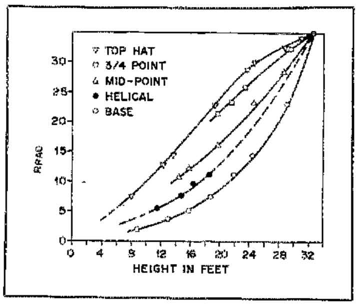


Fig. 5 — Experimental results of radiation resistance as a function of height of antenna for various methods of loading.

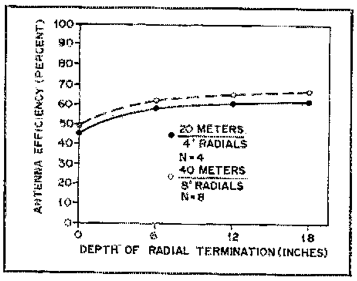


Fig. 6 — Efficiency of resonant quarter-wavelength verticals on 20 and 40 meters as a function of the length of spike terminating the radials.

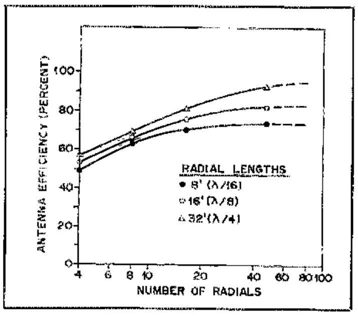


Fig. 7 — Efficiency of resonant quarter-wavelength vertical as a function of the number of terminated radials with three different lengths.

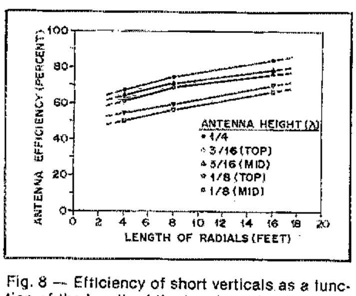


Fig. 8 — Efficiency of short verticals as a function of the length of the terminated radials, with the number kept constant at 48.

shortened radials was measured on the 20-and 40-meter bands. The radials were four and eight feet long (1/16 λ) respectively. Fig. 6 shows the results for four different depths of termination. As can be seen, depths of 10 to 12 inches should be sufficient for the soil conductivity at the author's location for 20 and 40 meters, and most likely for 80 and 160 meters as well. Incidentally, the effectiveness of radials of a 1/4 λ or longer did not change appreciably as a function of the depth of the termination. Therefore, terminations for long radials are primarily used for mechanical reasons.

Abbreviated Radial Systems

In order to determine experimentally the efficiency of shortened verticals with abbreviated radials on the surface of the ground, five verticals of different heights and loading schemes were used on the 20-and 40-meter bands. The results were then compared with similar antennas on a near-ideal image plane as shown in Fig. 5. The five resonant verticals selected were

1) 1/4 wavelength.
2) 3/16 wavelength, top-hat loaded.
3) 3/16 wavelength, midpoint loaded.
4) 1/8 wavelength, top-hat loaded.
5) 1/8 wavelength, midpoint loaded.

One of the photographs shows the elements for these 10 antennas.

A radial system with various lengths of 17-gauge steel electric fence wire, terminated with 10- to 12-inch nails, was employed. A picture shows the 12-inch aluminum base and the input connection arrangement. The antenna system was erected in the front yard about 50 feet from the house, and it offered an opportunity for on-the-air comparisons with verticals mounted on the near-ideal system in the backyard.

The results are shown in Figs. 7 and 8. Only the 40-meter data is presented since little difference was noted on 20 meters. Fig. 7 shows the effect on the efficiency of a resonant 1/4-λ vertical on 40 meters as a function of the number of radials using three different lengths of terminated radials. Although these curves were taken on a 40-meter system, the relationships are generally valid for all other frequencies in the hf range if the same fractional wavelengths are used for the radials. As can be seen the longer radials (1/4 λ) yielded the highest efficiency. But it is interesting to note that this improvement in efficiency with length decreases as the number of radials becomes smaller. At four radials, the efficiency with eight-foot radials is not much poorer than that with 32-foot radials, i.e., 50 percent compared to 56. Further, other interesting trade-offs exist with various lengths and numbers of radials. Fig. 8 shows that 16 1/4-λ radials are equivalent to about 35 1/8-λ radials, and 8 1/4-λ radials are equivalent to only 12 1/16-λ radials. Obviously other equivalences can be obtained from the figure.

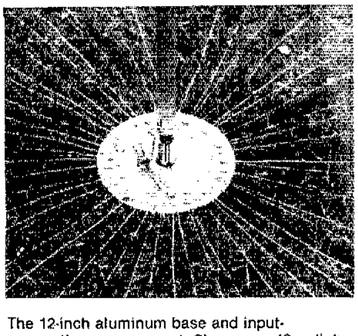
Fig. 8 shows the results of antenna efficiency for short verticals as a function of the length of radials, with the number of radials kept constant at 48. As expected, 1/4-λ verticals, with their higher radiation resistance, have the highest efficiencies. Surprisingly, the efficiency of the 1/8-λ verticals does not suffer proportionally. That is, the 1/8-λ vertical with midpoint loading still has a 67-percent efficiency compared to the 84-percent efficiency of the 1/4-λ vertical, even though its radiation resistance is only about one-third as large (12.5 ohms compared to 35 ohms). A further comparison with a 1/4-λ vertical over an ideal image plane predicts that this 1/8-λ vertical with 48 1/8-λ radials (terminated) should show a reduced performance of only 1.7 dB.

On-the-Air Comparisons

As was shown in the previous section, short verticals with a sufficient number of abbreviated radials that are terminated should yield performances only a decibel or two poorer than 1/4-λ verticals over extensive ground systems. Several on-the-air comparisons were made to confirm this prediction, which was based upon efficiency considerations.

The first comparison involved a 40-meter, 1/8-λ, top-hat-loaded vertical with 48 1/8-λ radials (17-gauge steel wire on the ground and terminated with 10- to 12-inch nails). The input impedance of this vertical was about 25 ohms and it was matched to the 50-ohm transmission line with a highly efficient 2:1 step-down transmission-line transformer. This antenna system was compared with a 29-foot vertical using a 13-1/2-foot-diameter top hat in the backyard. The ground system for this larger antenna consisted of 100 radials of no. 15 aluminum wire, each about 50 feet long. Each radial was on the surface of the ground and terminated with 10- to 12-inch nails. This larger antenna was resonated by a small variable capacitor in series at the base. Over 100 contacts on 40 meters plus about 200 observations on reception showed that the differences between the two systems were generally negligible. A few reports showed a 1- to 2-dB difference in favor of the larger system but these were in the minority.

An even more interesting comparison was made on 80 meters. A 20-foot vertical with an 8-foot top hat was erected over the same image plane of 48 16-foot radials in the front yard. It required a base-loading coil of about 20 turns of 12-gauge wire, 2-1/2-inch diameter, 6 tpi to resonate it. The input impedance was about 12 ohms and a 4:1 transmission line transformer was used for matching. This antenna configuration represents a radiation resistance of about 5 ohms and a loss in the ground system and loading coil of about 7 ohms. The 29-foot vertical with the 13-1/2-foot diameter top hat needed



The 12-inch aluminum base and input-connection arrangement. Shown are 48 radials of 17-gauge steel electric-fence wire.

about eight turns on a powder-iron core (T200) at the base to resonate it on 80 meters. Its input impedance was 15 ohms (showing negligible loss in the ground system and base loading coil), and matching was accomplished with an efficient transmission-line transformer having a 3.33:1 step-down impedance ratio. Again about 100 contacts were made on the air and another 200 observations were made on reception. The average difference between these two systems amounted to only about 5 dB in favor of the much larger system in the backyard. This is quite noteworthy since many previous contacts with the larger antenna established it as a very competitive antenna system.

Concluding Remarks

Quarter-wavelength vertical antennas over an extensive radial ground system have been known to be efficient, low-angle radiators. Even short verticals over the same large ground system have been shown to lose little in the way of performance. With low-loss matching and loading techniques, short verticals over a large ground system suffer only in bandwidth. But full-sized verticals and radial ground systems are beyond the reach of most radio amateurs on the 80- and 160-meter bands. This investigation was undertaken because little information was available on limited radial systems, particularly for short verticals.

As was shown, short radials over soil of average conductivity can perform quite acceptably for verticals of all heights. The results of this investigation now allow one to predict quite accurately the operation of verticals with heights less than a quarter-wavelength and with radials as short as 1/16 λ in length. The simple soil-conductivity measurement scheme described also gives one a tool for comparing a given location with others, as well as predicting the performance of a vertical antenna system. QST

References

[1]Sevick, "The W2FMI Ground-Mounted Short Vertical," *QST*, March, 1973.

[2]Sevick, "Broadband Matching Transformers Can Handle Many Kilowatts," *Electronics*, November 25, 1976.

[3]Brown, Lewis and Epstein, "Ground Systems as a Factor in Antenna Efficiency," *Proc. IRE 25*, pp. 753-787, June, 1937.

[4]Abbott, "Design of Optimum Buried R.F. Ground Systems," *Proc. IRE 40*, pp. 846-852, July, 1952.

[5]Wait and Pope, "Input Resistance of LF Unipole Aerials," *Wireless Engineer 32*, pp. 131-138, May, 1955.

[6]Wait and Pope, "The Characteristics of a Vertical Antenna With a Radial Conductor Ground System," *Appl. Sci. Research (B) 4*, pp. 177-195, 1954.

[7]Monteath, "The Effect of the Ground Constants and of an Earth System on the Performance of a Vertical Medium-Wave Aerial," *Proc. IEE*, Vol. 105C, Pt. 2, pp. 292-306, January, 1958.

[8]Smith and Devaney, "Fields in Electrically Short Ground Systems: An Experimental Study," *J. Res. NBS* 63D Radio Prop. No. 2, pp. 175-180, September-October, 1959.

[9]Larsen, "The E-Field and H-Field Losses Around Antennas With a Radial Ground Wire System," *J. Res. NBS* 66D Radio Prop. No. 2, pp. 189-204, March-April, 1962.

[10]Maley and King, "Impedance of a Monopole Antenna With a Circular Conducting-Disk Ground System on the Surface of a Lossy Half Space," *J. Res. NBS* 65D Radio Prop. No. 2, March-April, 1961.

[11]Maley and King, "Impedance of a Monopole Antenna With a Radial-Wire Ground System on an Imperfectly Conducting Half-Space, Part I," *J. Res. NBS* 66D Radio Prop. No. 2, March-April, 1962.

[12]Wait and Walters, "Influence of a Sector Ground Screen on the Field of a Vertical Antenna," NBS, Monograph 60, April 15, 1963.

[13]Maley and King, "Impedance of a Monopole Antenna With a Radial-Wire Ground System on an Imperfectly Conducting Half-Space, Part II," *J. Res. NBS* USNC-URSI, 68D, No. 2, February, 1964.

[14]Maley and King, "Impedance of a Monopole Antenna With a Radial-Wire Ground System on an Imperfectly Conducting Half-Space, Part III", *J. Res. NBS* USNC-URSI, 68D, No. 3, March, 1964.

[15]Gustafson, Chase and Balli, "Ground System Effect on High Frequency Antenna Propagation," *Research Report*, U.S. Navy Electronics Laboratory, January 4, 1966.

[16]Jager, "Effect of the Earth's Surface of Antenna Patterns in the Short Wave Range," *Int. Elek. Rundsch*, 24(4), pp. 101-104, (1970).

[17]Hill and Wait, "Calculated Pattern of a Vertical Antenna with a Finite Radial-Wire Ground System," *Radio Science*, Vol. 8, No. 1, pp. 81-86, January, 1973.

[18]Rafuse and Ruze, "Low Angle Radiation from Vertically Polarized Antenna Over Radially Heterogeneous Flat Ground," *Radio Science*, Vol. 10, No. 12, pp. 1011-1018, December, 1975.

[19]Stanley, "Optimum Ground Systems for Vertical Antennas," *QST*, December, 1976.

[20]Card, "Earth Resistivity and Geological Structure," *Electrical Engineering*, pp. 1153-1161, November, 1935.

[21]*Reference Data for Radio Engineers*, Fifth Edition, Howard W. Sams and Co., Inc., ITT, 26-3 to 26-5.

[22]Lagg, *Earth Resistances*, Pitman Publishing Corp. 1964, pp. 206-229.

[23]Private communication.

[24]See Ref. 1.

Strays

YLs on the air are younger than ever. In Ravenswood, WV, Katrina Stewart (l), WD8NXU, got her Novice ticket at the age of eight so she "could talk to people like daddy (AMSAT area coordinator W8TN) does." Although she learned the code in record time, she had to wait for her writing speed to catch up. She may just be the youngest YL in the U.S. and Canada! At the age of 13, Joni Orange (r), of Jeanette, PA, may be the youngest licensed broadcast personality with a regular show. Holding a Third-Class Radiotelephone license with broadcast endorsement, she is the daughter of W3ZDF.

HAVING TROUBLE FINDING PARTS?

☐ As an aid to the parts-procurement problem discussed in our December 1977 *QST* editorial, it is worth mentioning that the J. W. Miller Company is discussing ways to add specific small-parts items to their inventory as an aid to amateurs. Their consultations with the League in this regard are appreciated.

Those who have experienced difficulty in obtaining pc boards, pc-board negatives and component parts for *QST* projects over the past two years should check with WAØUZO of Circuit Board Specialists, Box 969, Pueblo, CO 81002. Complete parts kits for many *QST* projects are available from that source. — *W1FB*

POSTAL WARNING

☐ Effective April 1978, new postal regulations require post cards (QSLs) to be 3 1/2" × 5 1/2" or a surcharge will be made. Undersized cards have got to go. — *WB2FHN*

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

ADDITIONAL BANDS FOR THE QUAGI

☐ A number of amateurs have written the author inquiring about the use of the vhf quagi (*QST* for April, 1977) on frequencies other than the three amateur bands for which dimensions were given (144, 220 and 432 MHz). Within the vhf spectrum, mathematically scaling the quagi to other frequencies is a relatively simple matter. To do so, take each dimension given for the amateur band nearest the desired frequency and apply this formula:

$$\text{New dimension} = \frac{\text{original dimension} \times \text{original frequency}}{\text{new frequency}}$$

Thus, the driven element for the ATS-1 and ATS-3 weather satellites at 135.6 MHz would be computed as follows:

$$DE_{135.6} = \frac{82 \times 144.5}{135.6} = 87.38 \text{ in. } (2.22 \text{ m})$$

Each element length and interelement spacing dimension should be scaled to the new frequency, using the same formula. Between about 100 and 500 MHz, this mathematical scaling procedure will produce an antenna delivering substantially the same performance as the original design. However, the builder should bear in mind that a given element diameter "looks" three times as large at 432 MHz as at 144 MHz, for instance. Unless the diameter is reduced as the frequency increases, the element lengths must be adjusted accordingly. Example: When 1/8-inch rod is used for the directors, the 432-MHz quagi requires directors fully 1/4-inch shorter than the mathematical scaling from 2 meters would suggest, and the dimensions given in *QST* included this correction.

In scaling a quagi to a frequency reasonably close to an amateur band, the calculation may be made from the nearby ham band and this variation in element diameter-to-length ratio may be ignored. But for a frequency far removed from 144, 220 or 432 MHz, it would be best to calculate from amateur bands above and below the desired frequency and then interpolate between the two sets of dimensions.

For frequencies significantly higher than 500 MHz or lower than 100 MHz, construction techniques would typically vary so much from the original design that the correct element lengths may be expected to deviate substantially from those mathematically derived. The best approach in such a case would be to experimentally determine the correct element lengths. — *Wayne Overbeck, N6NB, Pepperdine University, Malibu, CA 90265*

NARROW-BAND MODULATION

☐ The purpose of this letter is to raise some questions regarding narrow-band modulation schemes and related matters. Bandwidth as a measure of quality in a communication scheme is straightforward in the clear-channel case. Cutting the bandwidth in half doubles the number of clear channels, obviously a gain. However, the following will show that this simple test is not sufficient in situations where there are *no* channels, but instead random positions of signals. The test is also not sufficient if channels are shared, i.e., where there is mutual interference between stations. Since amateur operations involve the last two items, it seems that we need a way of evaluating the gain or loss involved in narrow-bandwidth plans.

Since random location and shared channels both involve interference, it seems reasonable to use interference produced as a measure. The most common measure is the spectral power density, the output power divided by the bandwidth. As usually used by the CCIR (International Consultative Radio Committee), this is a transmitter quantity, the bandwidth being of the emitted signal. It can also be used as a system quantity, with the bandwidth being that of the receiver. Where systems of radically different types are sharing, the CCIR has also used the audio bandwidth and the resulting spectral power density multiplied by transmitted bandwidth, which is just the total power radiated.

Change in system design can yield a gain or loss in communication capability. At present there is no standard for this. One I have used is based on the fact that the measure should increase as transmitted information power increases, and also increase as the receiver input needed to give a fixed output signal-to-noise ratio decreases. This leads to the ratio of transmitted information power divided by required receiver input (for standard output S/N) as the measure for communication potential.

Suppose we apply these concepts to a simple "narrow-band phone" system, in which the modulation is folded to give a signal of just half the usual bandwidth. With no power change, the spectral power density will double, so the interference potential has increased by 3 dB. At the receiver, the information power is the same, but the receiver noise will be less by a factor of two because of the decreased bandwidth, so the communication potential also increases by 3 dB. Using the ratio of the two measures as the net effect, there is no overall gain or loss.

With respect to standard receivers, the total power radiated is the same, so there is no change in relative interference. Assuming the signal can be read, there is no change in communication potential. However, if two stations should be introduced to take advantage of the apparent gain due to decreased bandwidth, the interference would increase by 3 dB. The increase, however, is because of the increase in number of stations, and not because of the modulation scheme.

This analysis is obviously simplified, both in assumptions as to the system employed and in neglect of such factors as changes in subjective interference with pitch changes, etc. However, I believe the analysis does show the dangers of using emitted bandwidth as the only measure of improvement.

It is instructive to apply these principles to other situations. For the old argument of ssb versus a-m, we find a reduction of interference potential of about 16 dB for ssb, but a loss in communication potential of 3 dB (due to the fact that there is no second sideband to add coherently). Overall, there is a net gain of about 20:1, but this is caused by the elimination of the carrier, and not by the reduction in bandwidth.

Many stations are using speech processors. These increase the average radiated power, typically by 6 to 10 dB. Under weak-signal conditions this increases the communication effectiveness; subjectively, the gain may be very great. However, the processor also increases the interference potential by the same 6 to 10 dB, and, under strong signal conditions, the processor may actually reduce the subjective communications potential. Overall, the processor is worthwhile only if kept switched out unless needed.

Because it occupies the same bandwidth, slow-scan TV has been placed in the phone segments of the amateur bands. However, since its carrier is on 100 percent of the time, SSTV has about 16-dB greater interference potential than ssb. If slow scan were sharing with cw, assuming 200 Hz as a practical receiver bandwidth, slow scan would have about 10-dB less interference potential than a cw signal of equal strength.

These examples seem to say that we need to reexamine the principles of sharing in the Amateur Service. In particular, they do seem to indicate clearly that bandwidth alone is not the proper criteria for making decisions. — *R. P. Haviland, W4MB, 2100 S. Nova Rd., Box 45, Daytona Beach, FL 32019*

FURTHER NOTES ON THE MORSE KEYBOARD

☐ For the benefit of the many amateurs who are building the "Inexpensive Morse Keyboard" described in *QST* for January, 1978, these corrections have been furnished by the author. In transposing the article for publication, the data inputs to U9 and U10 were reversed. These exchanges should be made.

IC	*Pin*				*IC*	*Pin*
U9	12	Change	lead	to	U10	11
U9	11	"	"	"	U10	10
U9	10	"	"	"	U10	9
U10	11	"	"	"	U9	12
U10	10	"	"	"	U9	11
U10	9	"	"	"	U9	10
U1B	15	Connect to pin 13 of U2B (not pin 3).				
U6	6 & 7	Connect to ground.				

Other changes:

A8 is connected to pin 14 of U12 (not pin 13).
E goes from A7 to B5.
F goes from A5 to B3.
Comma goes from A8 to B4.
Period goes from A9 to B5.
Connect a 100-kΩ resistor from pins 5 and 6 of U11 to ground.
U14 is a type 4001 (not 4011 as shown).
The pinout for the type 4051 IC should indicate pin 1 as I/O-4.

Several builders who have constructed their keyboards from the *QST* article with the aid of these corrections now have working models which verify the basic design. The keyboard runs best from an 8- to 13-volt supply. If a relay is used, it must be suited to the supply voltage. A series resistor may be added to the coil circuit for those cases where the supply voltage is higher than the rated voltage of the relay coil.

My advice for those amateurs who may be unsure of the keying method provided in a particular transmitter is that a reed relay should be used in the keying circuit rather than some solid-state method. If the transmitter is a vacuum-tube type, relay sticking may be avoided by placing a 100-ohm resistor in series with the relay contacts.

This keyboard will not send a seven-dot error character. I use the question mark to correct errors, which, incidentally, seldom occur with a Morse keyboard. One could program a six-dot character for errors by connecting the switch from pin 4 of U12 to B7. The board is capable of sending Morse code faster than human fingers can move. If it does not perform fast enough to suit the operator, then the 0.1-μF capacitor between U3D and U3C should be lowered.

There is no easy way to add a weight control or vary the ratio of dots to dashes. The ratio is set to a perfect three-to-one relationship. I don't know why anyone would want to change it.

No pc boards have been made to date. Radio Shack has a universal DIP board similar to the one I used. The part no. is 276-152. As for keyboard sources, here are the names of some suppliers who have sold them: John Meshna, Box 62, E. Lynn, MA 01904; Formula International, 12603 Crenshaw Blvd., Hawthorne, CA 90250; James Electronics, 1021-A Howard Ave., San Carlos, CA 94070; Band F Enterprises, Box 619, Lynnfield, MA 01940 (their stock no. 6M1A 60202 appears to be exactly like mine); Radio Shack recently has had a closeout on a beautiful keyboard.

I'm confident that those who follow the corrected information will find the keyboard they build to be a source of real operating pleasure, as mine has been. If you continue to have difficulty with your board, do write to me, giving as much information as you can. An s.a.s.e. will be appreciated. — *Al Helfrick, K2BLA*

BUYING SURPLUS GEAR

☐ I think that two articles recently published in *QST*[1,2] have made some statements which need to be elaborated upon about military surplus receivers. The general impression that military surplus receivers are "boat anchors" with wide bandwidths and little bandspread is not necessarily true. I do think that beginners with little technical knowledge or without a person with that knowledge to help should be steered away from surplus. Even the so-called, "checked-out" receivers arrive misaligned and frequently without the crystal filters working. Restoration is always required. However, the military surplus receiver is an excellent buy if the ham with a little technical knowledge is willing to allow a few months to bring it to top performance.

The receiver that K2CBY refers to as "what went over big in a B-17" is a winner on cw today. This receiver, the BC-348, is "hot" and boasts a crystal filter. But one of the most widely distributed models, the BC-348-Q, has the crystal in the filter mounted in a plastic holder, and over the years I have always found that the nuts on the bolts giving pressure to the crystal have sunk into the soft plastic, releasing the pressure on the crystal.

The best way to cure this is to clip the four leads to the crystal (actually they are two leads to each of two terminals), then soak the unit in paint thinner to remove the encapsulating wax on it. Then open the unit by removing the two nuts and bolts. Soak the holder and crystal in more paint thinner and reassemble. Put the unit back in place in the radio by soldering the leads in place, but be sure to arrange it with the heads of the bolts up so that in the future they may be tightened again, if necessary. It is not necessary to reencapsulate the crystal.

My BC-348-Q has been running for five years without the crystal being encapsulated and without retightening of the nuts. With the crystal filter I have no trouble separating stations on cw and have found the tuning ratio very satisfactory as compared with many commercial receivers costing much more.

It is necessary to build a power supply for the BC-348, which I did by using the dynamotor chassis within the receiver itself. The dial markings are a little coarse but I have not found this to be a handicap for cw use. I do not recommend the radio for ssb on the air, but it is satisfactory for just listening to ssb. The main problem is just that the BFO is not as stable as one would like, requiring occasional retuning.

K2CBY also states that the R-392 has a bandwidth of 10 kHz; not true. The R-392 has selectable bandwidths of 2, 4 and 8 kHz with extremely sharp skirt selectivity drop-off. It is a world better and functions on ssb with a dial that has markings to 200 Hz and dead-stable calibration. It does have a problem on ssb because of some instability in the BFO. Audio filters are desirable for cw use (although not entirely necessary) since the 2-kHz position is a little wide. This receiver operates on 28 V dc for both the filaments and plates. An external power supply is necessary.

One receiver overlooked by both articles was the Collins R-390, an excellent radio. This receiver operates directly on 120 V ac and needs no conversion. It supplies most everything a ham could want in a receiver. Unfortunately, it is still fairly high priced.

It is true that there is junk on the surplus market, but the above receivers are, I believe, excellent buys. This is particularly so if one realizes that once the radio is restored to initial operation, one is using a radio which cost the government thousands of dollars, let alone the historical interest of being able to say you are using a receiver from a Jeep, a flying fortress, or a PT boat.

Here are some general notes for people who are new at the game of restoring military surplus equipment: Most troubles result from old age. Common maladies are bad tubes, bad switch contacts and dirty controls. [These problems may be found in any equipment, not just surplus. — Ed.] The best procedure is to clean everything with paint thinner (which works wonders). Spray all switch contacts and wiping contacts on variable capacitors with TV-tuner cleaner. On controls which are sealed and are still noisy when rotated, drill a small hole in the control, spray the tuner cleaner into the hole, and then seal the hole with a piece of tape.

All rotating components, particularly dials, should be lubricated sparingly with household oil (3-In-1). One drop is more than enough in most cases. Keep the oil away from switch contacts and wiper contacts on variable capacitors. A great improvement in appearance can be had by spraying the front panel with clear spray paint. Either mask off the control knobs or remove the entire front panel (which is quite easy on some radios).

With the recent letters in *QST* on the high prices of equipment, I am distressed that more articles on surplus have not appeared, especially since military ssb equipment is starting to show up on the market. I think it is important that members who have had experience in converting and restoring equipment write in so that others may profit from that experience. How about it? — *Joe Stephany, K2KSJ, 950 W. Lake Rd., Williamson, NY 14589*

References

[1]DeMaw, "Your First Receiver — How to Choose It," *QST*, May, 1977.
[2]Anderson, "Technical Correspondence," *QST*, September, 1977.

FURTHER NOTES ON THE ULTRAMODERN LINEAR AMPLIFIER

☐ In the "Technical Correspondence" column of September 1977 *QST*, I read a letter from W6SAI regarding my "Ultramodern Linear Amplifier" article (*QST* for May, 1977). I am indebted to Mr. Orr for pointing out my drafting error, i.e., the 0.25-A fuse should be placed just ahead of the 4500-ohm, 50-watt, bleeder resistor. Those building a similar screen supply should do so.

Regarding the screen supply, any similarity to the Collins KWS-1 supply was coincidental; I designed mine from an old Aerovox "Research Worker" bulletin, Vol. 20, No. 9, September, 1950. I specifically tailored both the screen and bias supplies to accommodate both the 4CX1000A and 4CX1500B tubes, since these are often available to amateurs.

As for not mentioning parasitic problems and means of suppressing them, I assumed that anyone who would consider building a high-power amplifier such as I described would certainly want to read the data sheets and bulletins provided by the manufacturer regarding the behavior of tetrodes, particularly when using a high-priced tube like the 4CX1500B. — *Carmen F. Moretti, W2AIH, 1619 Boulevard, Peekskill, NY 10566*

Strays

I would like to get in touch with . . .

☐ hams using solid tubes in the Heathkit SB series of transceivers. Lloyd Gosa, WB8TNC, 1423 Upland Drive, Kalamazoo, MI 49001.

☐ other Hewlett-Packard employees for the purpose of creating an active club. Pete Olin, WA2IZP, HP, W120 Century Rd., Paramus, NJ 07652.

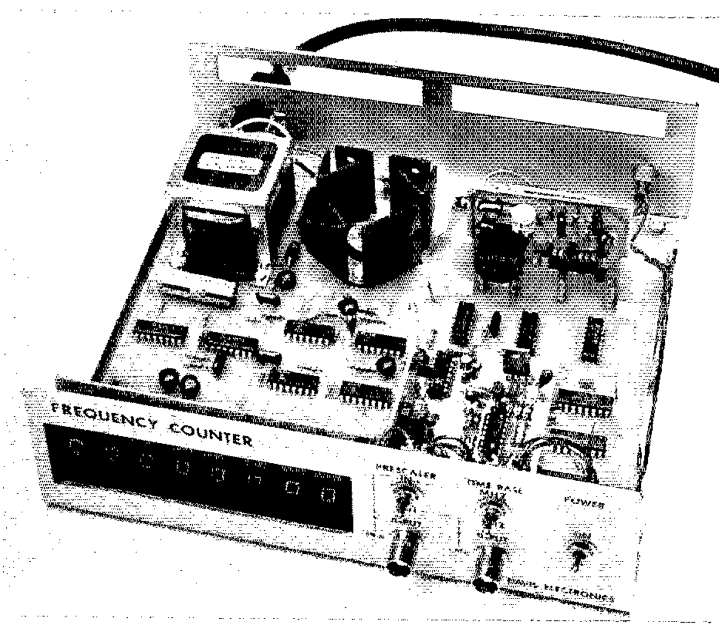
☐ members of a technical net that assists people with troubleshooting and other technical problems. Sandy Walch, WB4DTS, Box 615, Williston, FL 32696.

☐ cw operators in the state of South Dakota, to complete my WAS. Antonio Villano, CX7BBB, Box 37, Montevideo, URUGUAY.

Product Review

The Davis CTR-2-500 Frequency Counter

Ask the man who owns one and invariably he will admit that his frequency counter is one of his most useful troubleshooting instruments. Amateurs who realize the advantage of having a counter and who are in the market for one will do well to consider the Davis Electronics CTR-2-500 kit. This is a wide-range frequency counter developed especially for communications, engineering laboratories, and general electronics work. A built-in prescaler extends the frequency coverage to 512 MHz.



This view shows the neat appearance of the Davis counter. The time-base oscillator is visible at the right rear on the vertically mounted board.

The Package

The CTR-2-500 is available as a kit or may be purchased completely wired by the manufacturer. Optional equipment includes a precision, oven-controlled, time-base oscillator board for greater stability. Other options include 0.43-inch, seven-segment-readout LEDs instead of the 0.3-inch size, and a 10-second readout delay for extending the display time.

A contemporary style enclosure of heavy-gauge metal not only makes this counter attractive, but also rugged. Measurements for this 3-pound, 10-ounce (1.64 kg) device are (HWD): 8 × 8.8 × 8.0 inches (71 × 223 × 203 mm).

Two signal-input BNC connectors are mounted on the front panel for access to a 1-megohm, low-frequency feed point and a 50-ohm, high-frequency input for the prescaler. Power is applied at the rear of the chassis. For units having the 12-V option, a four-contact Jones receptacle accommodates both the 12- and 117-V supply lines which are separate, detachable cables made to connect to each respective voltage source. Selection of either of two time bases and the engaging of the preselector are controlled by front panel switches. For units with the 10-second option, a delay switch is rear mounted.

Other Considerations

When selecting a counter, the prospective purchaser should not only consider the frequency range and sensitivity of the device, but thought should be given also to such specifications as resolution, accuracy and stability. In these areas the CTR-2 performs very well.

For frequencies of 50 MHz and below a resolution of 1 Hz may be achieved with the time-base switch in the kHz position and utilizing the 1-megohm direct input but not the prescaler. A resolution of 0.1 Hz is possible with the 10-second option. By placing the time-base switch in the MHz position and again utilizing the 1-megohm input, signals can be measured with a resolution of 1 kHz. The latter position is useful for reading the output of a signal generator while searching for a specific frequency. With the built-in prescaler, the CTR-2 will measure over 500 MHz with a resolution of 10 Hz or 10 kHz depending upon the position of the time-base switch.

Sensitivity is rated at 10 mV at 25 MHz, and 150 mV at 500 MHz. Accuracy has been established at ± 1 count ± the time base accuracy. Temperature stability for units with the standard TCXO oscillator is ±2 ppm for 15° to 55°C. For those units having the oven-controlled crystal option, the temperature stability is ±0.5 ppm, 0° to 60°C.

Although a special probe is not required for use with the CTR-2, some users may find using a 10:1 oscilloscope probe or the Davis Electronics counter probe advantageous where a higher input impedance may be required. Another aspect of the CTR-2 that users will appreciate is the provision for expansion and options; the prescaler and time-base oscillator are designed as plug-in modules. Diode protection provides a maximum safe input rated at 120-V rms up to 10 MHz, and 2.5-V rms at 500 MHz.

A Builder's Comment

Kit builders with proficiency in doing close work on printed circuits requiring numerous ICs should be able to assemble the CTR-2-500 over a weekend. Working at a less experienced pace, I spent two weekends being extra cautious with my efforts. Work, nevertheless, must be performed carefully while following the step-by-step procedures detailed in the manual. Calibration by using WWV as a standard was easily performed. Laboratory tests confirmed specifications provided by the manufacturer with the exception of not being able to quite reach 10 Hz on the lower-frequency limit.

With regard to the manual, I would have appreciated an enlarged overview at the beginning. This could include a brief summary of the options available and their relation to the instrument being constructed. A separate category for information pertaining to units powered only by 117 V and another for information applying to those with the 12-V option could avoid a measure of uncertainty. Mention might also be made of the need to remove a jumper in the dividing chain when the 10-second switch is to be installed. The latter point, however, is obvious at the time of installation.

Information about the CTR-2-500 may be obtained by contacting Davis Electronics, 636 Sheridan Dr., Tonawanda, NY 14150. Tel. 716-874-5848. The kit price class is $250; assembled, $350. Davis also makes both high-impedance and low-impedance probes, available at a price class of $15. In addition they manufacture a prewired, preamplified probe. — *W1JEC*

THE L-TRONICS LITTLE L-PER VHF DIRECTION FINDER

If your interests lie in fm and repeaters, civil defense, or just hidden-transmitter hunting, you've probably wished some company would market a direction finder for vhf or uhf. Aside from "bunny hunts" and the tracking of repeater jammers, such a device would be useful in emergency work where it might be necessary to find a disabled vehicle carrying a vhf transmitter. The L-Tronics Company of

Santa Barbara, CA, has recently introduced a radio direction finder suitable for use from between 100 and 470 MHz.

Direction finders basically consist of a receiver with some type of analog indication of signal strength or phase, and a directional antenna. The Little L-Per is no exception. The dual-conversion fm receiver is equipped with a dual-function meter which indicates either signal strength or the phase difference between two dipole antennas. Separate rf decks may be installed, allowing operation on any two of the ranges shown in the table. Operation on up to four crystal-controlled frequencies is possible.

We requested the review model be supplied with a crystal for 146.52 MHz, the most popular 2-meter-fm simplex frequency in the Northeast. Also supplied was a dual-dipole array mounted on a collapsible wooden frame. A switching circuit mounted between the antennas is used in the direction-finding mode, to alternately select the antennas. In use, the function switch is first placed in the REC position and the antenna rotated until the signal is strongest. The SENSITIVITY control is adjusted so that the meter indicates about half-scale deflection. When the function switch is placed in the DF position, rotating the antenna will cause the meter to indicate from minimum to maximum as the target is scanned. At two positions the meter will be at center scale. Target position is then perpendicular to the antenna plane. This might seem to provide ambiguous results as target location could be in either of two directions. If the operator is properly oriented, turning the antenna counterclockwise as viewed from above (operator turns to his left) will cause the meter to deflect to the right. If turning to the left causes the meter to deflect to the left, the operator is oriented 180 degrees from the target. This simple memory requirement is the most difficult part of operating the Little L-Per.

A built-in speaker and volume control are provided but a separate headphone may be used if desired. Because the Little L-Per was designed for use by nontechnical persons, the manufacturer elected to delete the squelch control commonly found on fm receivers, fearing that an inexperienced operator would advance the control too far and effectively degrade the sensitivity. The circuit diagram of a suitable squelch circuit is provided in the instruction manual for those desiring this feature. Power for the receiver is provided from two 9-volt batteries installed in the case. The batteries are connected in parallel, indicating that limited operation from one battery would be possible in an emergency. Internal voltage regulators allow operation from an external source of 10- to 30-V dc. Power consumption with fresh batteries varies from 20 to 130 mA, depending on the position of the volume control.* Receiver sensitivity was measured at 0.17 microvolt for 10 dB of quieting.* Despite the tiny speaker, audio quality is quite good. The meter is illuminated with a switched red lamp for night use.

As supplied for the review, the Little L-Per is intended for handheld, portable operation. A dual-dipole antenna with a shorter mast is available for use in densely wooded areas. L-Tronics originally designed the unit for use in detecting aircraft emergency-locator transmitters (ELTs), and a variety of antennas are available for mounting on fixed-wing airplanes and helicopters. Aircraft-type antennas may also be mounted on the metal roof of a car or truck. Also available is a combination line-operated power supply and tone-operated squelch circuit. The tone-operated squelch responds to the modulation of an ELT and allows continuous monitoring without hearing the receiver hiss.

*Measured in the ARRL lab.

Table 1
Available Frequency Ranges and Services

MHz	*Band*
100-136	Vhf aircraft
136-160	Amateur, business, marine
160-190	Business, TV
190-235	TV, amateur
270-320	Uhf aircraft
320-400	Uhf aircraft
400-470	Amateur, business

The 44-page instruction manual supplied with the Little L-Per may be described in one word: complete. A thorough description of the receiver is provided in simple terms. Once the unit is unpacked, a few minutes spent reading the first chapter of the manual will allow the operator to begin direction finding. A large, fold-out schematic is provided, as well as a complete parts list. Should service ever be required, a full-page pictorial of the circuit board is given, showing test points. Another page is devoted to listing the correct voltages at the test locations. Installation and operation instructions for the various antennas are given a thorough treatment. A separate 12-page chapter on direction-finding techniques rounds out the manual. This has to be one of the best instruction manuals the reviewer has ever seen. Anyone who has struggled with a tiny, poorly printed schematic diagram or wrestled with the confusing jargon of some technical manuals will surely appreciate this book. Indeed, it amounts to a short course in direction-finding techniques, with experiments.

The receiver portion is enclosed in a 3-5/8 × 4-5/8 × 2-1/4-inch (9.2 × 11.8 × 5.7-cm) die-cast aluminum box. Combined weight of the receiver and antenna is about 2.3 pounds (1 kg).

After reading the manual and getting used to the operating techniques, the reviewer decided to do some hunting. Assuming the station remained on the air long enough to allow a few trial "fixes," it was possible to determine the direction to any station heard. The reviewer lives on top of a mountain and driving around in the valley below sometimes caused loss of signal or confusing results due to the shielding and scattering caused by the New England rocks. This condition probably simulated that which would be experienced in an emergency. In any case, moving to a new location always allowed a fix to be taken which resolved the ambiguity. Potential owners of Little L-Pers are hereby warned that nonamateurs usually react in a negative fashion when they see the direction finder in use! Except when an emergency exists, it would be wise to avoid trying the unit out in residential neighborhoods after dark.

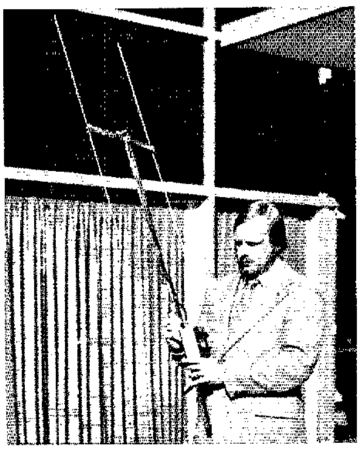
The Little L-Per is the only direction finder currently manufactured with the nonprofessional market in mind. As such, it fills a need which has existed for some time. The unit is available from L-Tronics, 5546 Cathedral Oaks Rd., Santa Barbara, CA 93111. Price class is $180. — *W1XZ*

INFO-TECH M-150 AND M-75 RTTY UNITS

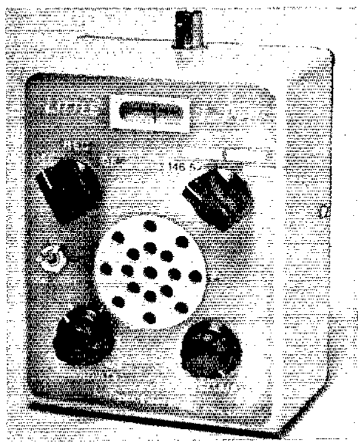
Tired of the clatter produced by your press-room sound-effects generator? (That's a Model 15, 19, 28 or the likes for those of you not afflicted with the RTTY "green-key" craze.) Info-Tech models 150 and 75 offer a silent alternative at a reasonable price!

There are many times when printed copy of a radioteletype transmission is not needed, or wanted — especially with the cost of teleprinter paper continually increasing. Current state of the art in this mode connotes the use of solid-state keyboards and terminal units, video character generators, and TV-style video display which seem to spit out little white letters without expending any energy. Desirable as these systems are to some of us, the retail prices of most video setups are still not within the means of the average RTTY buff.

The Little L-Per with antenna attached is tested by W1XZ. In use, close proximity to reflecting surfaces, such as the League headquarters building in the background, should be avoided.



The fm receiver and indicator circuits of the Little L-Per are enclosed in a die-cast aluminum box. Approximate size may be determined by reference to the BNC connector mounted on the top of the case.



One of the lower-priced video RTTY arrays currently on the market is the M-150/M-75 combination from Info-Tech. With these two units, a video monitor, and a transceiver, you can RTTY till your fingertips turn blue, and not make a sound (or use up any paper)! That's why video is so neat. Your family will think so too!

The Info-Tech model 75 is an RTTY-to-video, receive-only converter that can transform the audible "beedle-eedle-deedle" emanating from your receiver's speaker into a composite video signal to drive a video monitor. The receiver is tuned to the incoming signal so that the tones at the speaker are between 1200 and 3000 hertz. This 1800-hertz-wide window is the passband of the RTTY converter. Teleprinter speeds can be selected by a knob on the front of the unit. The M-75 is capable of copying 60, 66, 75 or 100 words per minute in the baudot (five-level) code, at 170-, 425- and 850-Hz shifts. The receiver section, which takes the place of the decoder in a regular terminal unit, also contains *mark* and *space* indicators to aid in tuning. Audio-limiter and normal/reverse switches also are present on the M-75 front panel, giving the RTTY man (or woman) maximum control over the decoding of the received signal.

In addition to the on/off switch, power indicator, and controls mentioned above, the M-75 also is supplied with a CLEAR button which wipes the video screen clean, instantly.

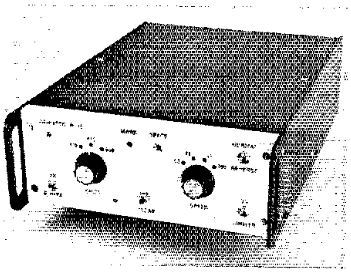
Info-Tech's Model 150 is a solid-state RTTY keyboard and generator with audio (afsk), fsk, and loop-keying outputs. The M-150 is capable of operating at all speeds and shifts mentioned above for the M-75. It also has a provision for cw identification while in the RTTY mode. Typewriter format is used in the M-150, making data entry much easier than on a standard teleprinter. If in the middle of a sentence, for example, you wish to type a number 9, on a teleprinter you must first type *figures*, and then the numeral 9. On a typewriter-style keyboard, you can simply type the 9 and the *figures* character is generated first, automatically! The same is true when returning to the *letters* mode.

When a complete line is typed (either 64 or 72 characters), a *carriage return* (CR) and *line feed* (LF) are sent automatically. The M-150 will not break up words less than six characters long, going through the CR-LF sequence whenever a space is sent within six characters of the end of a line. The keyboard also contains a 64-character, running-buffer memory that allows you to type ahead of the machine's output.

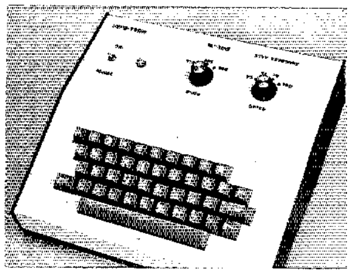
Double-sided, plated-through, glass-epoxy boards are used in both Info-Tech units, and the ICs are socket-mounted. The Model 75 video-generating unit also has automatic-carriage-return, line-feed and unshift-on-space capabilities. These help keep the copy on the screen even when the received copy lacks the proper end-of-line signals, or is being affected by fading. Unshift on space is very helpful when fading is encountered on an RTTY signal, because it keeps your display from spitting out lines of gobbledegook just because a *letters* command was missed during the QSB. Video output from the Info-Tech M-75 also features automatic scrolling, with each new line appearing at the bottom of the screen and old lines moving up and eventually off the top of the screen. For specific data on both units, refer to the table.

A video monitor is also necessary with the M-75/M-150. However, many inexpensive black-and-white television sets can be easily converted to serve as monitors.

For more information on these items, write Info-Tech, Inc., 20 Worthington Dr., St. Louis, MO 63043, or call 314-576-5489. — *WB9VAV*



The Info-Tech M-75 pictured here is an RTTY-to-video receive converter. This single piece of equipment decodes the audio tones received from the station receiver and generates video characters to be viewed on a monitor or TV screen.



With the Info-Tech M-150, the typewriter-style keyboard not only generates the baudot code, but also the audio tones to be fed into the transmitter. Word speeds and frequency shifts are shown on the two knob switches.

Info-Tech Model 75

Description: Audio RTTY-to-video converter.
Input: Audio, 8- to 600-ohms impedance, 1200 to 3000 Hz (from receiver).
Output: Composite video signal, 1.5 V peak to peak, negative sync., horizontal frequency — 15,750 Hz, 75-ohm impedance, 16 lines, 5 × 7-dot matrix, 32 or 72 characters per line (price difference).
Shift select: 170, 425 or 850 Hz.
Speeds: 60, 66, 75, 100 wpm (45, 50, 57 and 74 baud).
Tuning indicator: Two LEDs for mark and space tuning.
Audio limiter switch: Selectable — in or out.
Clear feature: Push button for instant screen clearing.
Norm/reverse switch: For inverting signal when desired.
Size: 3 × 9 × 13 inches (76 × 229 × 330 mm) (HWD).
Weight: 6.25 lbs (2.83 kg).
Power requirements: 115-V ac, 50/60 Hz, 15 watts (230-V ac available).
Price class: $325 (32-character video) or $350 (72-character video).

Info-Tech Model 150

Description: Solid-state RTTY keyboard/generator.
Speeds: 60, 66, 75 and 100 wpm.
Shifts: 170, 425 and 850 Hz.
Identification: Built-in cw i-d provision.
Keyboard: Automatic CR and LF, 64- or 72-character line (specify when ordering), 64-character running buffer.
Rear panel connections: Loop/fsk keying, afsk audio (3.5 V peak to peak), TTL/MOS compatible serial output.
Size: 3 × 12 × 11 inches (76 × 305 × 279 mm) (HWD).
Weight: 4 lbs (1.81 kg).
Power Requirements: 115-V ac, 50/60 Hz, 10 watts.
Price class: $290.

ANTENNA SPECIALISTS HM-187

One of the more common complaints concerning magnetically mounted mobile vhf antennas ("maggie mounts") is that they will not remain on the car at expressway speeds — or in windy weather. Antenna Specialists Co. appears t have mastered this problem in their nev 5/8-wave, 2-meter mobile whip antenna. Th model HM-187 boasts a very strong magne secured within a high-quality chrome base. Th tapered heavy-duty chrome spring attached t the base mates with a ball-tipped whip which i also quite easy to store in a suitcase, for thos traveling by air.

Although the base carries a label readin "138-154 MHz," the data sheet offers a con venient chart for cutting the whip to resonanc within the 144-MHz amateur band. The anten na is supplied with 17 feet of RG58/U coax at tached to a PL-259 connector. Price class i $32. The HM-187 is manufactured by Antenn Specialists Co., 12435 Euclid Ave., Cleveland OH 44106. — *WA6IDN*

NEW BOOKS

Saga of the Vacuum Tube

Saga of the Vacuum Tube, by Gerald F. J. Tyne, 1st edition. Published by Howard W. Sams & Co., Inc., 4300 West 62nd St., Indianapolis, IN 46268. Soft cover, 5-3/8 × 8-1/2 inches, 494 pages, $9.95.

It isn't often that a reviewer can become ecstatic over a book but it is certainly easy to do so over Tyne's *Saga of the Vacuum Tube*. Gerry Tyne, who is a research associate of Smithsonian Institution worked under a grant from them and the Antique Wireless Association in writing this epic history of the vacuum tube. Tyne has a great deal of expertise in the field of vacuum tubes, beginning his research in the early twenties. The book consists of 22 chapters, starting with electrical developments prior to 1880. Considerable space is devoted to the era of 1910 to 1920 when the military demands served to create many of the advances of the time.

The early days of broadcasting and the roles played by the manufacturers are covered in detail. Not only are manufacturers of the United States treated, but those of most of the major nations of the world as well.

The book is profusely illustrated with photographs of tubes and early equipment. Hundreds of photographs are included — and we do mean hundreds!

If you are "into" antique radio as a hobby, then you certainly need this book for references. If you just happen to be an electronic enthusiast, then we can promise you many hours of enjoyable reading. — *W1ICP*

Hints and Kinks

IDEAS FOR BEAM ANTENNAS

Many radio amateurs seem to have coaxial feed lines that eventually break away from the beam assembly of their antennas. My illustrations show how I relieved this problem as well as that of water getting into the cable.

The drawing at lower right is a "plumber's delight" plastic adaptor that can serve as a top bearing for beam antennas. These plastic plumbing components are readily available at many hardware stores. The top cap or bolt and lower sleeve fit or screw together very nicely, making a fine adapter for holding and centering a mast to be installed in an X-type tower. The O ring may be omitted if desired. — *John Kassay, VE3FDK*

COLOR CODE BY ALPHABETIZING

Ever attach a handful of wires in a multiconductor cable to a terminal strip, seal the work off, and then neglect to write down the colors at each terminal? An easy way to eliminate this type of mishap is to always attach wires in alphabetical order. For example if you have four wires, black, red, green and white, you would put Black on terminal 1, Green on terminal 2, Red on terminal 3 and White on terminal 4. If you don't get around to wiring the other end of the cable for a week or two, this method will allow you to easily determine which wires were attached to which terminals.

With larger multiconductor cables containing several wires, use the same approach, but expand the alphabetical order. Consider this example:

BLAck	PInk
BLUe	PUrple
BRown	Red
GREEn	White
GREY	Yellow
Orange	

Where there may be two shades of the same color such as dark blue and light blue, they would be listed as D-BLUe and L-BLUe with D appearing before L. With striped wires, such as blue with red stripe, or white with orange, use this order: BLUe-R, White-O.

Non-striped wires of a particular color should come first, followed by striped. Alphabetize by color of the stripe. Hence:

Code	*Term No.*
D-BLUe	1
D-BLUe-R	2
L-BLUe	3
L-BLUe-O	4
BRown	5
D-GREEn	6
L-GREEn-Y	7

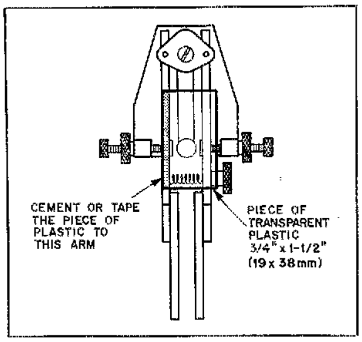
and so on.

Try this next time and avoid a real construction headache. — *WB9VAV*

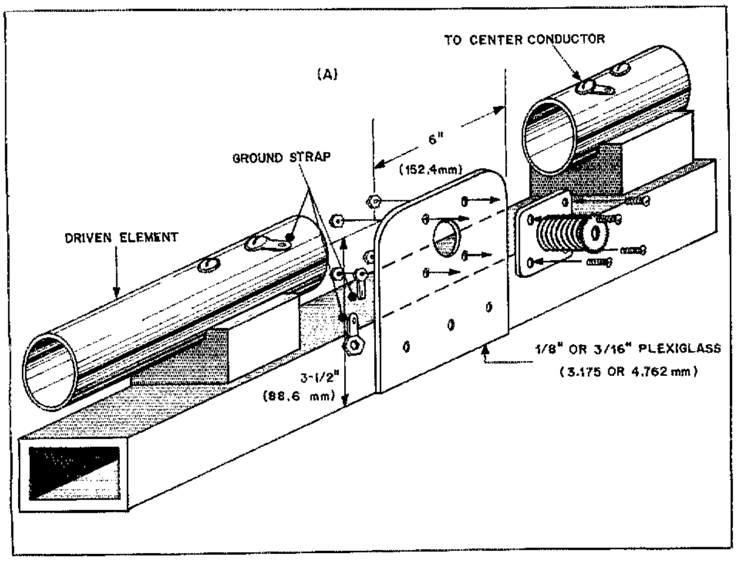
KEY PROTECTOR

The contacts of some keyer paddles are exposed, resulting, in time, in an accumulation of dust and dirt on the contact surfaces. Contact resistance increases when this occurs and greater force often must be applied to the paddles to overcome the condition. Poor contacts also present the risk of missed elements of code characters.

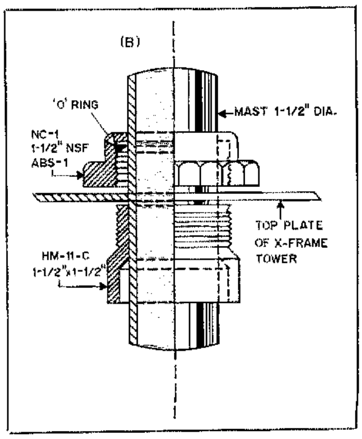
I use the following adaptation on my ham key which prevents such a buildup at these crucial points. A piece of transparent plastic measuring 3/4 × 1-1/2 inches (19 × 38 mm) is cemented to one, and only one, of the paddle arms. Use of double-sided Scotch tape makes removal and remounting of the cover easy when access to the contacts is needed. — *Jose M. Armengol, WA2BNM*



Keyer contacts can be protected from dust and dirt by cementing or taping a plastic cover to one of the keyer paddle arms. Double-sided tape makes removal and remounting easy.



A beam-antenna cable-protecting connector bracket is shown at A. It may be used with the TA-32, TA-33Jr., TA-33 and other beam antennas. A plumber's-delight plastic adaptor for 1-1/2-inch center top bearing for beam antennas is illustrated in B.



INACTIVE S METER

A Heath SB-101, brought to me recently for repair, had an inactive S meter that was most perplexing. The grids of V3 and V4 were found to have a constant positive 11 volts after I disconnected the various branches of the avc circuit in an attempt to isolate the problem. I found that removing the associated relay eliminated the undesired voltage. Ohmmeter pin-to-pin checks indicated that there was no leakage and visual inspection did not reveal any contamination. However, by scraping the ceramic around the pins I chipped away a grey coating which solved the problem. The relay apparently had previously been sprayed with one of the popular contact cleaners, leaving a conductive residue. — *Otho C. Lindsey, W5FR*

CHIPS FROM THE WORKBENCH

☐ If you are good at lettering, you can use typewriter correction paper for making panel labels. Place a small piece of correction paper over the section to be labeled. Use a ball-point pen for lettering the paper. The label is automatically transferred to the panel and should be treated with clear spray lacquer for protection. I use white correction paper to produce a very professional appearance for black panels. Other colors are also available at stationery stores. — *Duane Meyer, W9PVY*

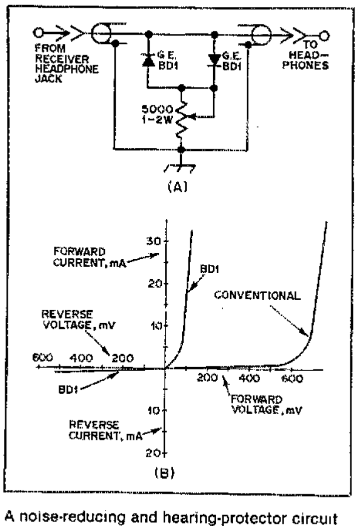
☐ Need a source for small enameled wire such as no. 30? TV yokes offer a lifetime supply of such wire for winding toroids and other small coils. To disassemble such salvaged coils, place them in a sealable container that has been located in open air. Pour in about a half-pint of acetone. Close the container and shake it vigorously. Then allow the coils to remain in the container for five to 10 hours. Remove the coils one at a time and unwind. One yoke will provide about 1000 feet of usable wire. — *H. O. Cantrell, WB5LOT.*

☐ Any screw can be temporarily attached to the blade of a screwdriver for application in hard-to-reach places by first filling the slot in the screw head with dial cord dressing or similar material. — *D. W. Kraeuter*

EFFECTIVE NOISE REDUCER AND HEARING PROTECTOR

With the recent advent of germanium "black diodes" that exhibit very low forward voltage drops compared to conventional germanium and silicon diodes, an exceedingly effective combined noise clipper and hearing protector can be built which plugs into the earphone jack of any receiver. The circuit makes use of two rather expensive General Electric type BD1 germanium back diodes costing about $11 each in small quantities (less in group purchases), and a 5000-ohm potentiometer. The extraordinarily low forward voltage of the BD1 diode as compared with that of a conventional silicon signal diode is illustrated.

Just 10 mA of forward current flows in the BD1 at a forward voltage of only 90 mV, whereas a voltage of over 600 mV is required to obtain the same current flow with a conventional diode. Note also that the BD1 has excellent reverse characteristics with the leakage current being only 1 mA at 440 mV. Taken



A noise-reducing and hearing-protector circuit for use with receivers is shown in A. Drawing B illustrates the forward characteristic of the BD1 diode versus a conventional diode. The reverse characteristic of a conventional diode is not shown.

together, the BD1 characteristics are well worth the $22 cost for this application.

When employed as shown in the diagram and set for maximum effectivity, the circuit will clip off excessive peaks of positive and negative noise bursts symmetrically without noticeably affecting the amplitude or readability of the desired signal. Also, strong, unwanted signals and "white noise" hiss will be reduced automatically in amplitude to a point where one no longer may be deafened by these assaults on the human ear. Amateurs constantly listening for hours on end to signals of varying amplitude, especially when using earphones, can cause themselves permanent hearing damage unless foolproof protection is provided against excessive signal bursts and noise. This new noise reducer and hearing protector is a dream in actual use. Signal-to-noise improvements of about 10 dB are easily obtained without any adverse difference whatsoever in the readability of very weak DX signals. Actually the weak ones are easier to copy. The absence of adjacent-channel splatter and ear-deafening bursts is almost eerie but indeed a joy to behold. — *Dr. Robert L. Rod, K6FZ*

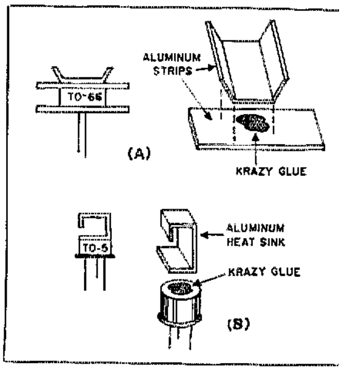
MORE ABOUT AC GROUNDS

While looking through some back issues of *QST*, I came across an item in a July, 1976, copy that drew my attention. The "Hints and Kinks" contribution from B. H. Hansen, W6HOZ, commented on an article by Howard M. Berlin, W3HB (ex-K3NEZ), entitled "Grounding AC Lines." W6HOZ wrote, "When a receptacle is properly mounted in a wall box, the pin-hole GROUND is at the bottom." While this configuration has merit (a power-cord ground pin will be last to break contact when the connector is being disengaged), it also may present a potentially dangerous situation. For example, if a bare wire or screwdriver should drop across the exposed terminals, the resulting short circuit could not only produce unwanted firewor but under hazardous conditions it might tou off a catastrophe.

For some time now, there has been a st dard practice on new installations, or wh replacing old receptacles, to mount the grou pin at the top as a means of protection agai accidental contact with live pins. Such an in dent recently took place in my medical el tronics department at the Nashville Memor Hospital. — *Dave Miller, WA4ZKZ*

SIMPLE HEAT SINKS

A strong adhesive available at many hardwa stores as Krazy Glue (originally developed f use by NASA) simplifies the mounting of he sinks. Small pieces of aluminum may be c and bent according to the user's needs. St faces should be as straight and clean as pos ble. Once the heat sink is formed, it may glued directly to the transistor. This can handy for use in places where a convention heat sink is either too difficult to mount, or i sufficient for radiating heat. *The glue shou be used very carefully.* It can be harmful to t skin and can glue one's fingers together. *Patrick K. Garrett, WA4SMU*



Where conventional heat sinks cannot be mounted easily or do not radiate enough heat simple homemade heat sinks like these can b effective.

FOR THE KENWOOD TS-520

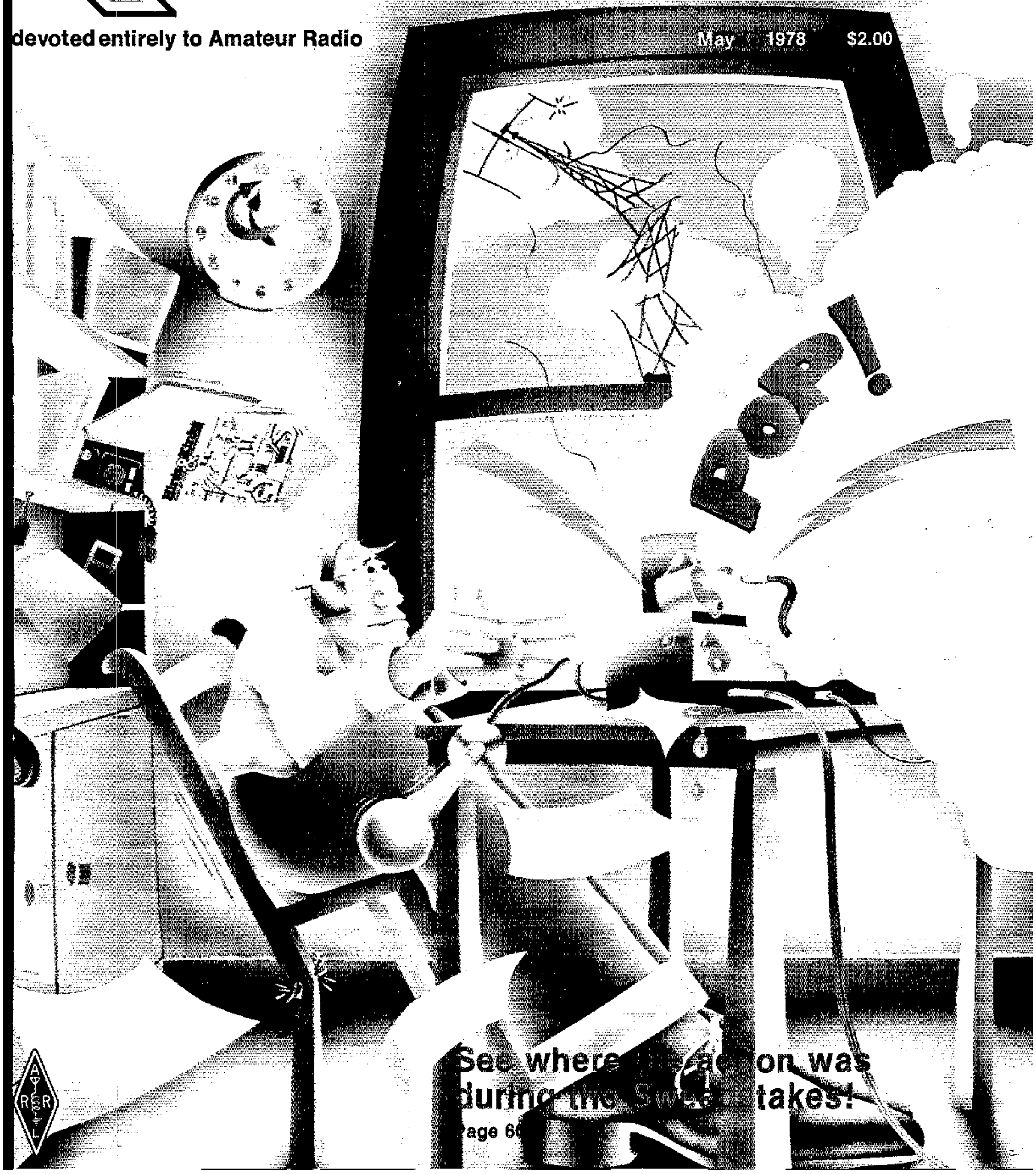
Recently my Kenwood TS-520, when in th receive cw mode, would occasionally jump fr quency. The problem was apparent after I ha tuned in a cw signal and keyed the transmitte Upon returning to the receive mode, the fr quency of the other station appeared to hav changed. This condition did not affe transmission from the Kenwood.

The manufacturer furnished me with th solution. Remove the cover from the TS-52 Locate the carrier board (X50-0009-01) on th underside of the transceiver. Solder the end c a piece of braid to the lower sideband cryst case (X3). Solder the other end of the braid t the case of T1 which is situated close to th three crystals on the carrier board. The cryst case and T1 should be scraped at the points o connection to assure proper soldering. — *Ro Johnson, WB4GWA*

QST

devoted entirely to Amateur Radio

May 1978 $2.00



See where the action was during the Sweepstakes!

Page 66

QST

May 1978
Volume LXII Number 5

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

The 44th SS was one of those! See how you fared, beginning on page 66.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A Modular Control Unit — Just for Repeaters

Tedious, on-site repeater maintenance a problem? Then go modular! This simple plug-in control unit makes a standardized repeater practical. Or use it to put an emergency repeater on the air in a jiffy!

By Robert D. Shriner,* WAØUZO

The vast number of fm repeaters in existence across the United States testifies to the success of this mode of communication. Behind the scenes, however, are the continuing efforts of responsible individuals who must oversee the operation and maintenance of those stations. Not all of these efforts are shining moments of pleasure, particularly if a station happens to be situated atop a distant mountain. Difficulty in reaching the site is just one of several hindrances that may be encountered by the service crew. Severe weather can make the trek impossible. Then there can be those unforeseen technical problems involved in equipment breakdown that cannot be immediately accommodated for want of a component.

Here in Colorado such problems confronted several repeater groups. Leaders of these associations have met on numerous occasions to confer about particular difficulties involved in operating and maintaining their respective repeaters. Although repeater advisory councils have been formed in some states, the associations in the Centennial state are tied together in little more than a loose confederation. We believe, however, that our conferences have been especially fruitful. In my opinion, what may well be viewed as a breakthrough in repeater maintenance has resulted directly from these discussions.

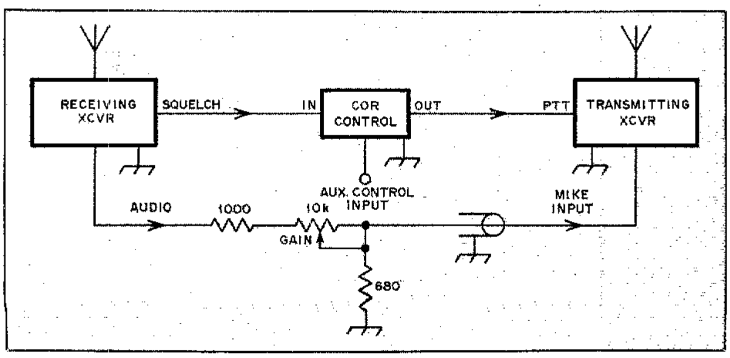
Could we simplify and perhaps even standardize, to some degree, our repeater installations? Surely there were reasons to do so. An unexpected windfall of some surplus Motrac railroad communications sets settled the question. The battle of standardizing was half won.

As we envisioned the standard plan, a repeater would have two transceivers in conjunction with a simple modular control system. Interchangeability of the transceivers would fill a need for backup support should the transmitting or receiving section of a unit fail. Plug-in design, where possible at the repeater, would offer another means of simplification.

But, in our opinion, a very significant advantage of the modular concept for a repeater station is that, in an emergency, a temporary repeater station can be established easily by pressing two mobile units into service. These two units, connected through a modular control unit, should be placed about 100 feet (30.5 m) apart for antenna separation. Imagine the convenience when urgent conditions require immediate repeater communications!

*Box 969, Pueblo, CO 81002

Fig. 1 — Block diagram of a repeater with two interchangeable transceivers. The COR control unit interfaces with any pair of transceivers. Audio from the output of one transceiver is fed to the microphone input of the other by way of the resistance network. Adequate level control is obtained by the 10-kΩ potentiometer. No loss of speech quality is encountered.



Planning the Control System

The task of planning and producing an effective control system fell largely into my hands. Perhaps that happened because

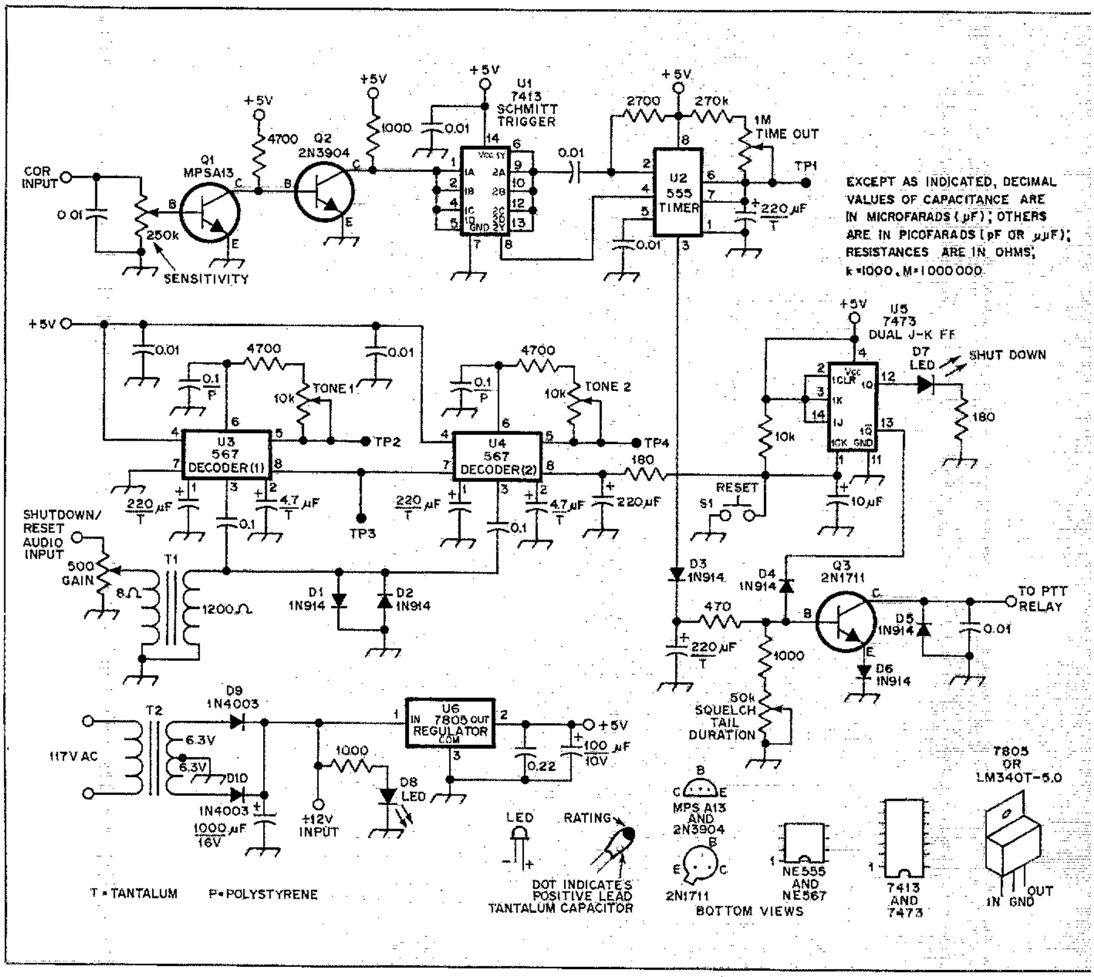


Fig. 2 — Schematic diagram of a simplified repeater control system. Power may be obtained from either a 12-V dc source or a 117-V ac line. All resistors are 1/4 watt, five-percent tolerance, except the variables which are Spectrol type 43 multi-turn potentiometers. All capacitors are expressed in μF. Tantalum capacitors are marked T. Polystyrene or Mylar capacitors are identified with a P. IC pin numbers not shown are not used. T1 is an 8-ohm primary/1200-ohm secondary audio transformer. T2, the power transformer, has a 117-V ac primary and a 12.6-V ct, 100-mA secondary. A normally open push-button switch is used for S1. All components, including the prefabricated circuit board, are available from Circuit Board Specialists, P. O. Box 969, Pueblo, CO 81002.

I had worked with repeaters rather extensively in recent years. The weaknesses of the beasts were no strangers to me.

From the drawing board came the basic configuration of the control system. First there were the original plans. Modifications followed. Final drafts of the prototype were inked not long after, imparting a feeling of reassurance that our efforts would not be in vain. The initial unit, carefully completed at the workbench, became a joy to behold, functioning with success through a round of tests.

What are some of the considerations applied to the COR design? There should be a high degree of sensitivity for tone decoding. The COR should be completely adjustable. Interfacing with *any* transceiver should be possible and not limited to one particular set or make of transceiver. Plug-in modular design would simplify servicing. All parts values should appear on the COR circuit board.

Examining the COR Circuit

Before I explain the circuit of the COR control system, take a moment to look at Fig. 1. This diagram illustrates, in block form, the arrangement of a repeater station that operates according to our plan. One transceiver is for transmitting, the other for receiving. These are interchangeable in the event of transmitting o receiving failure. Because of the adapt ability of the COR, the two transceiver do not have to be identical units. Yo want full backup capability? Well, here i is!

Next, a glance at the photograph wil give you an idea of the COR construction The components are mounted, withou being cluttered, on a 4-3/16 × 5-1/8-incl (106 × 130-mm) plug-in circuit board No need to stretch your imagination t realize how that can simplify repeate maintenance problems. Refer now to Fig 2.

A Schmitt trigger, fed by the dual tran

sistors, processes the COR signal, providing snappy action. The NE555 serves two purposes — driving the final transistor and handling the time-out function. I might point out that the COR section is a modified version of the one that KØPHF and I published in *ham radio* for July, 1976. The modification has been applied to the front end for use with solid-state receivers.

Two NE567 decoders are connected in tandem. These process the two-tone signals from any desired source for repeater access or shutdown. Control of the PTT relay in the repeater "transmit" transceiver is accomplished through Q3 and the associated components. At the lower left of the COR diagram is the regulated power supply which may be operated either from a 117- or 12-V source.

Let's probe the electronics a bit more carefully now that we have danced lightly through the circuit. The COR input is fed from the high side of the squelch circuit of the receiver. In most solid-state receivers the squelch voltage goes positive. When this voltage moves into the positive region, Q1, a Darlington transistor, becomes activated, providing high gain and minimum loading of the receiver squelch circuit. Q2 performs as an inverter to properly drive the 7413 Schmitt trigger.

Previously I mentioned the two purposes of the NE555 timer. (These are to drive the final transistor and establish the time-out function.) After each transmission, the timer is reset by a trigger input at pin 2. As a result the next transmission will have full time. The time-out function is controlled by a 1-MΩ variable resistor connected to pins 6 and 7 of the 555. Time range may be set from one to five minutes.

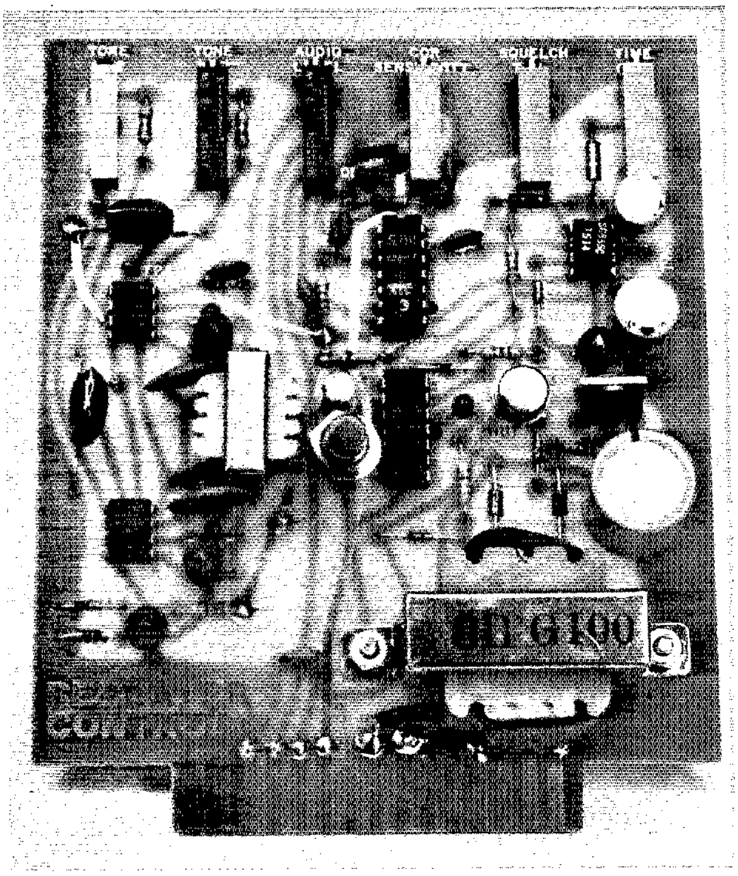
Q3, the final transistor, gets orders directly from the NE555. It, in turn, tells the transmitter to stop or go. To do this, the collector of Q3 is connected to the push-to-talk switch of the transceiver. The easiest way to make this connection is through the PTT switch on the microphone. Remove the back cover of the microphone and there it is.

Perhaps you may be curious about the 220-μF capacitor and resistor network at the base of Q3. This gimmick provides a squelch tail on the repeater. Adjustment of the 50-kΩ potentiometer will enable the repeater to have instant shut-off operation or up to several seconds of "tail."

We need only to mention a bit about the shut-down control before delving into the construction. The source of audio to be applied to the control section of the repeater can be left up to the builder. An auxiliary audio input is provided for control through an additional channel or through a telephone line.

Observe that the two NE567 decoders are connected in tandem. When a proper two-tone signal is fed to the audio input, decoder switching is accomplished through a link between pins 7 and 8 of the devices, as shown in the diagram. The second decoder keys the 7473 flip-flop. When pin 13 ($\overline{Q}$) of the 7473 goes low, it will remove any voltage from the base of Q3. This prevents Q3 from operating, shutting down the repeater.

What happens when the tones are received again? Well, the action is the same, except $\overline{Q}$ will go high and the repeater can now be accessed. A light-emitting diode is connected to pin 12. It glows when the repeater is shut down.



The repeater control board. Plug-in modular design provides quick replacement. Construction of the unit is made easy by means of the uncrowded arrangement of components.

Audio with Raised Eyebrows

Eyebrows will surely rise in view of the simple audio circuit (Fig. 1). But it is effective with no undesirable loss of quality. A load, consisting of a 10-watt, 4- to 10-ohm resistor, must be placed across the speaker terminals of the receiving transceiver.

You will note in Fig. 1 that a 680-ohm resistor has been placed across the audio line between the two transceivers. This is for the purpose of loading. Ample gain control is furnished by the 10-kΩ potentiometer.

Aiding the Repairman

Almost any repeater repairman can tell you about the time he went to the repeater site where he discovered a component burned to a crisp with no way to identify it. Boards with etched labels (not painted or inked) relieve the repairman of a similar difficulty. The photograph of the board depicts the uncluttered layout of components. Easy access to parts makes servicing much easier.

For the sake of sheer dependability, high-quality components should be acquired for the COR system. Tantalum capacitors are recommended for the timing and control circuits. Polystyrene capacitors are best for the frequency-control circuit of the shutdown function.

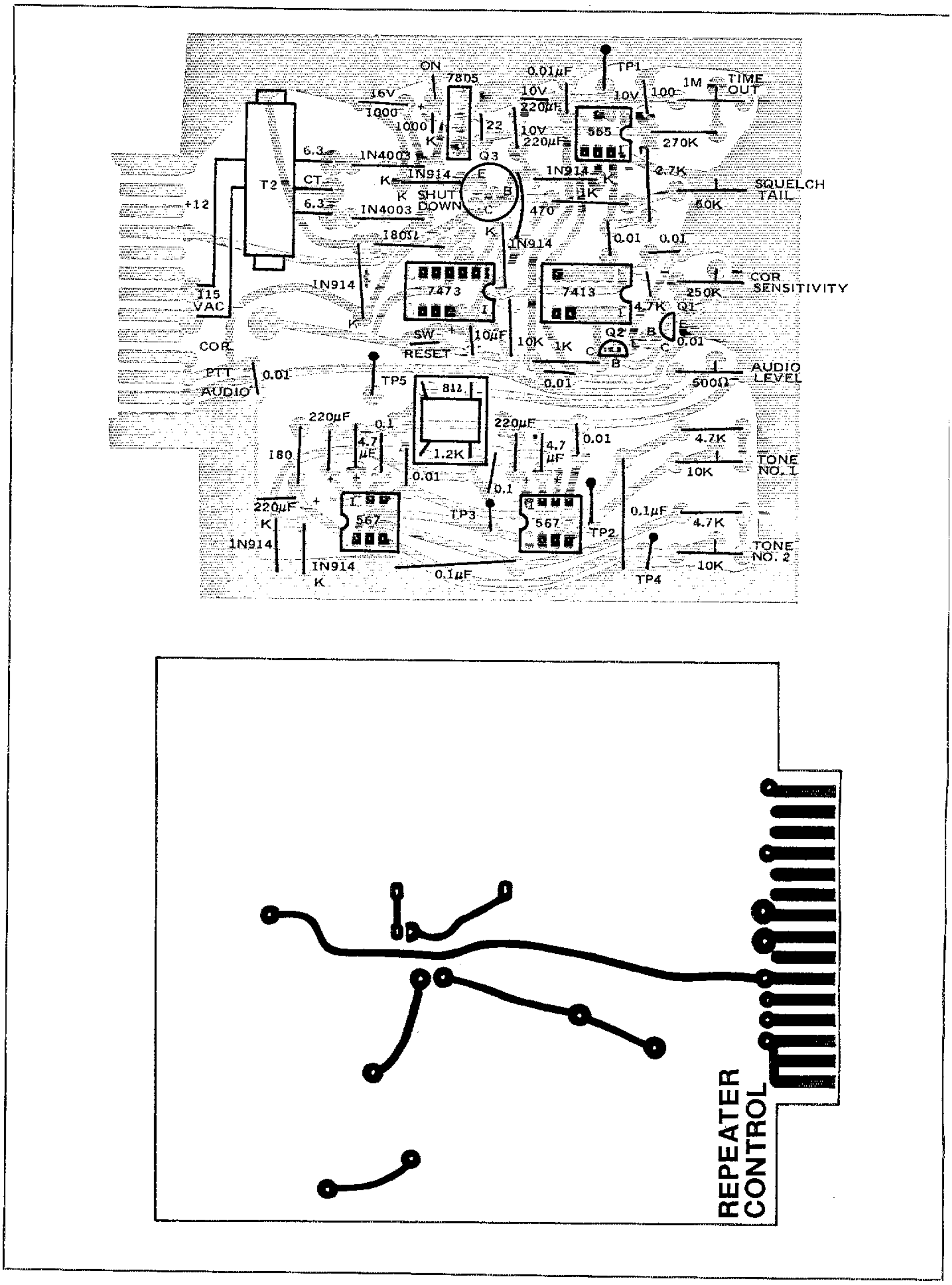


Fig. 3 — Actual-size template for the COR repeater control system with parts placement. The board is double-sided; in each pattern gray represents copper. Components are mounted on the lettered side of the board.

Preferably, IC sockets are to be avoided but if the builders choose to use sockets, only those of the highest grade should be employed.

Construction

The one who has to service a particular repeater at some future time will bless the builder if good soldering has been applied to the COR. And, while on the subject of soldering, I must mention that in the accompanying double-sided patterns the builder will find a pad on each side at a few points on the board. Feedthrough connections must be carefully soldered at both points. Also, at the connecting fingers, feedthrough wires (made from cutoff resistor leads, using the Z-wire technique) are to be installed connecting the fingers on one side of the board to the fingers on the other side. This gives double contact in the module socket for greater continuity and reliability.

I suggest building the power supply section first and then checking the output voltage. This should be within five percent of 5 volts. Note that a separate 12-volt dc input is available in addition to the 117-V ac input.

After one has determined that the power section is functioning correctly, all components for the COR circuit are then to be installed. To test this area of the unit, apply +5 V to the COR input and adjust the sensitivity control to the point where the circuit keys. Q1 will go from high (+5 V) to low (+0.75 V). Q2 will have a collector change from low to high. The 555 output will go from low to high.

The time-out function can be set to the desired time by the 1-MΩ variable control connected to pins 6 and 7 of the 555 timer. The operation can be seen on a high-impedance scope or VTVM by making the test at TP1. In order to observe the action of Q3, connect a small 12-volt relay to the PTT output and to a 12-V source. Set the drop-out time (squelch tail) to whatever is desired.

After the COR is functioning, install the 7473 flip-flop and associated components. The LED on pin 12 indicates when the system is shut down. A push-button switch is included for testing and local shutdown as well as reset. Operate this switch a few times as a test.

If all is well to this point, the next step is to install the two NE567 decoders and associated parts. Connect a frequency counter to TP2 and then set the frequency to whatever tone is desired by adjusting the 10-kΩ potentiometer (tone 1).

Move the counter to TP4 and ground TP3. Set the frequency of the second tone by using the 10-kΩ potentiometer (tone 2). Note that this can be set to the same frequency as the first tone if one desires to use a single tone for control.

To test the tone-operated portion of the system, apply the tones simultaneously for four seconds. The shutdown LED should become illuminated and Q3 should be inoperative. In the event difficulty is experienced, the tone level could be incorrect. The easiest way to determine if the level is improper is to turn the gain control completely down. Then slowly bring the level up until TP3 goes low.

Concluding Thoughts

With this circuit a repeater can be put in operation in a very few minutes. Our intention at the beginning was to enable repeater operators to install and service the station equipment with a minimum of time and effort. There are repeater groups in southern Colorado in both RA and RT classifications who are finding the dual-transceiver/simplified COR control system highly effective. I do wish to make it clear, however, that the circuit is not presented in order that anyone can indiscriminately pop a repeater on the air. Rather, my intent is to share with others an idea of how simplicity, reliability and dependable backup capability can be the keys to successful repeater operation.

Choosing the two transceivers should not be done haphazardly. Receiver selectivity, the ability to accommodate narrow-band reception, and minimum spurious output from the transmitter are factors to be considered.

Power output should not be a major factor in deciding which transceivers are to be obtained for a repeater. A power capability of 10 or 15 watts is quite satisfactory. The prospective buyers of equipment will do well to obtain commercial types of gear such as the mobile equipment made by General Electric and Motorola. The Motrac Motorola units,[1] mentioned earlier, are indeed excellent.

Although I am not about to deny the importance, generally, of good shielding at an installation, I do want to comment on our latest repeater, a 19/79 machine. This upstart has defiantly operated without covers or shielding of the transmitter or receiver. The two units are only two feet apart. We find no trace of desensing. I mention this because I'm convinced that the circuit simplicity is the reason for the trouble-free performance.

Needless to say, I trust that the concept of this repeater system may be beneficial to repeater clubs. I'm mindful especially of those whose service crews know well the vagaries of nature, the unpredictable breakdowns of remotely located equipment, and the undeniable workings of Murphy's laws.

[1]Gregory Electronics, 249 Rte. 46, Saddlebrook, NJ 07662, lists the Motrac units in its recent sales brochure.

Strays

No, this isn't a new version of that frustrating game of mischance, 52 Pickup. The U.S. Postal Service has a few tips for avoiding such occurrences.

A NEW WRINKLE IN 52 PICKUP

☐ The name of the game isn't "Help Stamp Out QSL Cards!" But the photograph does illustrate what happened to one amateur's packet of cards which was mailed to ARRL hq. for a WAS award. Perhaps the sender thought things were tied up pretty in a super-secure packet when he or she whistled off to the post office. Instead, what you see is what we got, and little can be done to unravel the mystery of whose cards were sent and how many are missing. The postal personnel bundled up what they could salvage from the floor sweepings, then sent us the grim remains.

What the U.S.P.S. does prefer is (1) packing the material so it won't shift in the container, and (2) using reinforcing tape instead of string and loose paper which may snag in the automatic sorting equipment. Whether you are applying for WAS, DXCC or another award, pack those cards securely! — *W1CKK*

CLUB NEEDS ASSISTANCE

☐ Having lost all their equipment to thieves, the University of California at Davis Amateur Radio Club is seeking donations of any usable hf or vhf surplus equipment. Please send inquiries to Thomas A. Behrens, W6YE, President, UCD/ARC, 200 Silo, University of California, Davis, CA 95616.

QST congratulates . . .

☐ Bernard Weinstock, K2MU, who passed his Extra Class exam at age 13. "I'm not a genius or anything like that," he writes. "I just like ham radio so much that I really try."

Transmitter Design — Emphasis on Anatomy

Part 1: Which is best — duplication of a published circuit or an understanding of how the circuit works? This builders course provides some "hows" and "whys" for a 10- to 15-watt, 40- and 20-meter cw transmitter.

By Doug DeMaw,* W1FB

A heap of burned-out transistors, some unsavory language and a hastily scrawled sign which read, "Help Stamp Out Transistors," greeted me as I walked into a friend's workshop recently. Fred stood there with a deeply furrowed brow and pointed to a wretched-looking, pc-board assembly which had been worked and reworked until it looked like no hope remained for it. Fred is one of those fellows who loves to build amateur gear, but never took the time to change his thinking from vacuum tubes to semiconductors. He could duplicate the circuits in amateur magazines, but couldn't make them "play" when something went amiss. After some casual conversation and a hot cup of coffee, Fred calmed down and we began troubleshooting his problem child. The major faults were instability in the PA stage and low output from the driver. An hour later we had his transmitter percolating nicely, and Fred poked his thumbs proudly into his chest and proclaimed, "Ain't it a beaut?"

It occurred to me as I sensed my friend's anguish that a better understanding of how a solid-state circuit functions would have saved him countless hours and a considerable amount of grace in the eyes of The Almighty. The foul language and extra money spent for transistor replacements could easily have been avoided. My adventures with Fred helped to inspire this course in transmitter anatomy. Knowing why a particular circuit was chosen by the designer, and how it is supposed to function in the composite assembly, should help you avoid the "Freddie syndrome."

Understanding Our Circuit

The circuit for our workshop project was based on numerous requests for a transmitter that would serve as a mate for "The Mini-Miser's Dream Receiver" which appeared in *QST* for September, 1976. A power output in the 10- to 15-watt bracket seemed suitable for most of the QRP applications one might encounter, and ample power would be available for driving an amplifier later on should the builder be motivated toward QRO.

Fig. 1 shows the block diagram of the transmitter. Let's run through it and see what each section does. Starting at the left we find a 7-MHz VFO. It operates straight through on 40 meters. The arrows show that S1A/S1B routes the rf energy directly to the broadband amplifier module during 7-MHz operation. For use on 20 meters, the VFO output is switched to a push-push doubler by means of S1. Output at 14 MHz is applied to the broadband amplifier when the switch is set for

Two versions of the 7- and 14-MHz cw transmitter are shown here. At the left is the W1FB prototype. On the right is a model built by WAØUZO. Both units are small and lightweight.

*Senior Technical Editor, ARRL

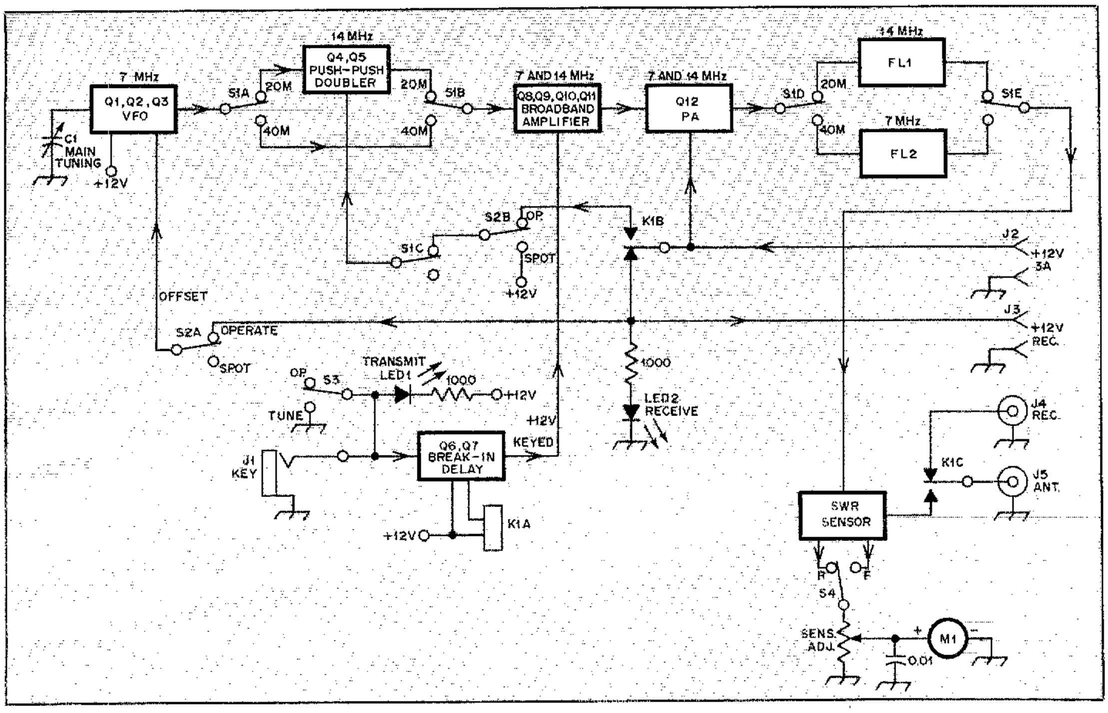


Fig. 1 — Block diagram of the two-band, solid-state transmitter. The arrow heads indicate the direction of signal or dc voltage flow. Coaxial cable (miniature) should be used between the various modules when completing signal paths. S1 is a five-pole, two-position, wafer switch with phenolic insulation. S2 is a dpdt miniature toggle switch. S3 and S4 are spst miniature toggle switches.

20-meter operation. You will notice that an offset line goes to the VFO. When S2A is in the OPERATE position and the key (J1) is open, relay contacts at K1B place +12 V on the VFO-offset line. This voltage turns on a switching diode in the VFO. The diode switches some additional capacitance into the VFO tuned circuit and moves the operating frequency outside the amateur band. This prevents an unwanted beat note in the receiver tuning range during the receive priod. When the transmitter is keyed the offset voltage is disconnected by means of K1B, and the VFO provides output on the desired operating frequency. It is necessary to disable the offset circuit for spotting (zero beating), so S2A is placed in the SPOT position for that function. Operating voltage must be applied to the push-push doubler during 20-meter spoting, and S2B is used for that purpose. Activating the doubler assures a loud beat note when zero beating another 20-meter signal.

As the signal moves to the right in Fig. 1 it reaches the broadband amplifier. This circuit was chosen because it requires no tuned circuits. Elimination of tuned, narrow-band circuits at the output of each of the three amplifiers in the module makes it possible to avoid complicated band-switching circuits. The broadband amplifier delivers approximately 1 watt of output and requires only 10 mW of rf energy from the VFO or doubler to develop its rated output power. Actually, the broadband amplifier is useful from 1.8 to 30 MHz, even though this transmitter covers only two bands. The amplifier is biased for Class A (linear) operation so that it can be driven easily by the VFO. The linearity is not a necessary feature for cw use, however, but would be ideal if this were an ssb exciter.

To the right of the broadband amplifier is a PA stage. It is driven to a power output of 10 to 15 watts by the 1-watt signal from the previous module. A Motorola MRF449A transistor is used in the PA. It is capable of 30 watts of output, and has a rated gain (typical) of 13 dB at 30 MHz. Our purpose in restricting the output to 15 watts is to minimize the overall current drain of the transmitter to 3 amperes or less. This will assure longer battery life during portable operation, and will simplify the requirements of an ac-operated dc supply (regulated). The actual amount of rf output power will depend upon the characteristics of the last stage in the broadband amplifier and the PA transistor. This results from the slight nonuniformity in transistor manufacture: Some have more gain than others. It is for this reason that an output figure of 10 to 15 watts is given.

At the far upper right of the block diagram are two filters — one for each band. They are selected by means of S1D/S1E. Since the PA is also a broadband amplifier there will be a substantial amount of harmonic current in the output. To keep the unwanted energy suppressed by 40 dB or greater it is necessary to use FL1 and FL2. The filters are low-pass types (T networks). They are pretuned, so no external peaking controls are needed.

Output from the filters is routed through an SWR-sensor circuit (lower right of drawing). A panel meter, M1, serves as a visual indicator for trimming an antenna or adjusting a Transmatch for a low SWR. The latter is essential if proper operation of the PA stage is to be realized. Relay contacts at K1C transfer the antenna from the transmitter to the receiver during standby periods.

At the lower left of Fig. 1 we have a break-in delay module. It has a variable time constant which controls the drop-out time of the changeover relay, K1A. The amount of delay time can be determined by adjustment of a potentiometer on the circuit board. Closure of the key charges the timing capacitor, which in turn actuates a bipolar-transistor dc switch. The switch closes K1A and applies operating voltage to the broadband amplifier. S3

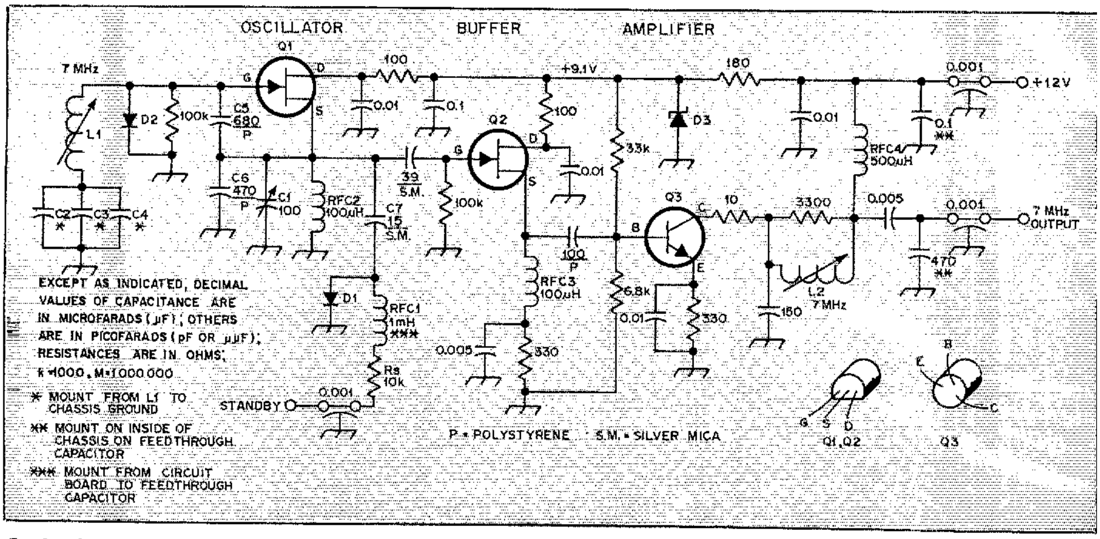


Fig. 2 — Schematic diagram of the VFO. Fixed-value capacitors are disk or chip ceramic unless otherwise indicated. Resistors can be 1/4- or 1/2-W composition. (See June, 1976, *ham radio* for the author's detailed explanation of this VFO circuit.)

C1 — 100 pF, miniature, air variable.
C2 — 50 pF, polystyrene.
C3 — 10 pF, silver mica.
C4 — 27 pF, polystyrene.
D1, D2 — High-speed silicon diode, 1N914 or equiv.
D3 — 9.1-V, 400-mW or greater Zener diode: 1N5293 or equiv.
L1 — Slug-tuned inductor with 6-μH nominal inductance (Miller 42A686CBI in W1FB unit, Miller 23A476RPC in WAØUZO model).
L2 — Slug-tuned, pc-board mount inductor, 3.2-μH nominal inductance (Miller 23A476RPC or 25 turns no. 32 enam. wire close wound on Miller 27A014-6 form).
Q1, Q2 — Vhf JFET, MPF102, 2N5486, 2N4416 or HEP802.
Q3 — 2N2222A or HEP-S3001.
RFC1-4 — Miniature rf choke (Millen J301 or equiv.).

locks the break-in delay circuit into the key-down mode for tune-up purposes. An LED indicator illuminates during transmit periods, and a second LED indicates when the circuit is in the standby (receive) mode. At that time the transfer relay routes 12 volts to the receiver via J3. This control voltage can be used for muting and unmuting the receiver.

Understanding the VFO

The VFO of Fig. 2 has a familiar face, as it has been used in a number of my circuits.[1] It has been such a faithful and predictable performer that it was chosen again. The circuit at Q1 is a Colpitts oscillator, but some of you may prefer to call it a series-tuned Clapp if you date back to the tube era when that type of circuit emerged as one of the more stable varieties of VFO.

Three capacitors (C2, C3 and C4) are used in series with L1 to ground. This method permits a larger amount of inductance to be used at L1 than would be possible in a more commmon, parallel-tuned, VFO tank. The higher inductance is less subject to changes in value from heating than would be the case if high C and low L were used. Three capacitors are used below the coil rather than one so that the circulating rf current will be divided among them. This lowers the heating in any one capacitor and improves stability.

C5 and C6 are feedback capacitors that take part of the oscillator output (source terminal) and route it back to the input (gate). This feedback is what causes the FET to oscillate. RFC2 is used to keep the feedback energy at the source of Q1 while providing a dc return to ground for the FET. Stated simply, it's an isolating choke for the rf.

Another purpose is served by C5 and C6: They add a considerable amount of shunt capacitance from the FET base to ground. This helps to disguise the small changes in FET junction capacitance during operation — a significant contribution to oscillator stability. D2 gets into this act, also. It conducts on the positive swing of the oscillator rf voltage, and that limits the change in FET junction capacitance. (Maximum capacitance change occurs near the peak of the positive half of the sine wave.) In addition to helping stabilize the oscillator, D2 reduces the harmonic output of Q1. This is because nonlinear changes in junction capacitance encourage the generation of harmonic currents. It is necessary to use a high-speed, rf type of diode for this purpose, such as a 1N914 switching kind.

C7, D1 and RFC1 are used in the VFO-offset circuit. When the +12 volts are applied to D1, as discussed earlier, C7 is placed in parallel with the main tuning capacitor, C1. This moves the VFO operating frequency lower so that the signal won't be heard in the receiver during standby. R_s is used to prevent damage to the diode; it limits the current through the diode junction when the offset voltage is applied through it and RFC1.

The 0.01-μF capacitor and 100-ohm resistor at the drain of Q1 are used to place the drain at ac ground (bypass) and to isolate Q1 from the other transistors in the VFO module. This is called a decoupling network, and it helps prevent unwanted self-oscillation in the remaining VFO-chain stages. Q2 has a similar decoupling network in the drain circuit.

A buffer stage (Q2) is shown in Fig. 2. It functions as an isolation circuit between the oscillator and Q3. It is used as a source follower — the output being taken from the source element of the FET. Because the gate of an FET has a very high impedance (megohms), the transistor does not load the output of Q1. The gate coupling capacitor is small in value (39 pF), and that also reduces the loading effects on Q1. The lighter the loading, the less chance there will be for oscillator "pulling" (chirps) when the transmitter is keyed. Because Q2 is a source follower it will not provide a voltage gain. Actually, a slight loss will occur at Q2. Typically, a voltage gain of 0.9 will be realized when using this type of buffer stage. This means that we lose 10 percent of the rf voltage that is applied to the gate of Q2.

RFC3 is used as a broadly resonant (low-Q) tuned circuit that peaks at 7 MHz with the approximate 5 pF of stray circuit

[1]Footnotes appear on page 19.

capacitance. Zener diode D3 is used to obtain a 9.1-volt regulated supply for Q1 and Q2. This prevents changes in oscillator frequency when the 12-volt power supply output changes. Regulated voltage is supplied to Q2 so that it maintains relatively constant operating characteristics: Voltage shifts at Q2 could cause slight changes in internal capacitance and resistance, and those variations could cause some pulling of the oscillator.

VFO Output Stage

It will be necessary to have ample drive to the broadband amplifier strip of Fig. 1. VFO buffer Q2 could not provide sufficient excitation to operate the remainder of the transmitter. Therefore, we have added Q3 to build up the VFO output power. This amplifier stage operates in Class A and uses a high-frequency, bipolar transistor — a 2N2222A. A 10-ohm resistor is placed near the collector terminal to discourage vhf parasitic oscillations. At 7 MHz the resistor offers minor resistance to the signal, but at vhf it looks like a high impedance; this prevents parasitics.

A pi network is used as the output tank for Q3. It is a low-pass type of network, which means it will attenuate harmonic energy. A 3300-ohm resistor is used in parallel with L2 to broaden the response. This will assure relatively constant VFO output to provide an even drive across all of the 40- and 20-meter cw bands.

The output capacitance for the pi network is obtained by utilizing the capacitance of the feedthrough terminal (C3) and the 470-pF shunt capacitor. The collector tank is designed to transform the 500-ohm output impedance at Q3 to 50 ohms at the pi-network output. Even though the input impedance of the first stage of the broadband amplifier is on the order of 500 ohms, this mismatch is desirable. The lower the VFO output impedance, the less chance there will be for pulling effects caused by the later stages in a transmitter. The base-bias voltage for Q3 is taken from the 9.1-volt regulated line to further reduce the chance for pulling at Q1.

Assembling the VFO

Double-sided pc board material is used as a shield box for the VFO. Fig. 3 shows the pc-board pattern and includes a parts-placement guide. Ready-made pc boards or parts kits for the entire transmitter are available from a supplier.[2]

The components should be assembled on the etched circuit board before the side walls are soldered together around the VFO board. A pencil type of soldering iron with a fine tip is recommended for this and all other modules of the transmitter. Excessive heat will damage some of the components, and can cause the pc-board pads to come loose from the base material. Therefore, a 25- or 30-watt iron is the largest size that should be employed.

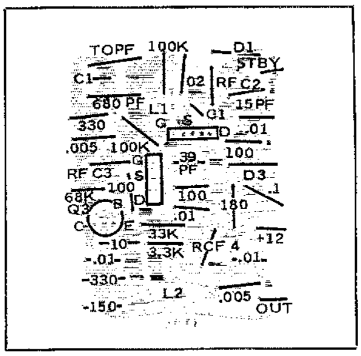
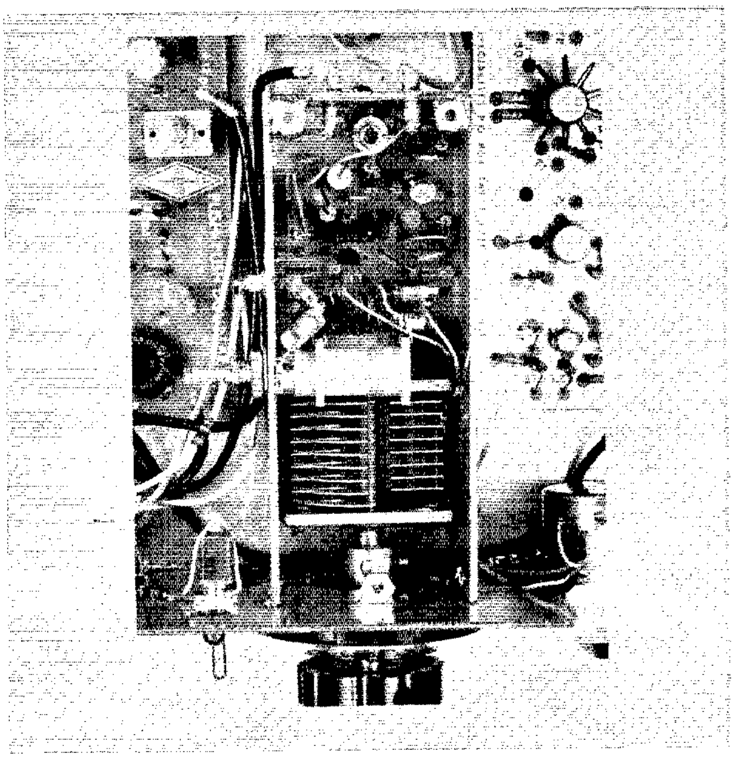


Fig. 3 — Scale layout of the VFO circuit board showing parts placement from the component side of the board.



A look into the VFO compartment of the WAØUZO model. Coil L1 is mounted on a side wall of the VFO box. Feedthrough capacitors are used as terminals for leads entering and leaving the VFO compartment.

Alignment

VFO testing can be accomplished by shunting the output to ground with a 560-ohm, 1/2-watt resistor and applying +12 volts where indicated on Fig. 2. Attach a two-foot piece of hookup wire to the output and place the loose end near the antenna terminal of a receiver. Next, set C1 so that the plates are fully meshed. With the receiver adjusted to receive 7.0 MHz, move the slug in L1 until the VFO signal is heard. At this point you can adjust L2 for maximum output at 7.1 MHz. The S meter on the receiver will be helpful when tweaking L2.

The offset circuit can be tested by connecting +12 volts to the offset line. The VFO signal can be expected to shift lower in frequency, as stated earlier. There should be no evidence of chirp when keying the 12-volt supply to the VFO.

Summary

Part 2 of this series will treat the push-push doubler and break-in delay circuits. They are on a common circuit board. At the conclusion of Part 2 you will be able to connect the VFO to the doubler and obtain output at 14 MHz. Also, the break-in delay circuit can be tested for correct performance at that time. I hope this explanation of the VFO circuit will prevent you from being afflicted by the "Freddie syndrome!"

Footnotes

[1] DeMaw, "QRP Shakedown, Caymanian Style!" *QST*, March, 1975.

[2] Negatives, pc boards or complete parts kits for this project can be obtained from Bob Shriner, WAØUZO, Box 969, Pueblo, CO 81002.

VHF Coverage for Collins S/Line Receivers

How to get Collins S/Line performance on vhf without using converters. F-layer DX on 6 meters plus OSCAR?

By Dick Bingham,* N6HZ

Getting started on the vhf bands is relatively painless if you have, as most of us do, an hf receiver already on hand. The Collins 75S-1 double conversion superhet, and later models 75S-3, 75S-3B and 75S-3C, are much more common than their high initial cost would suggest. The 75S-1 is an excellent, reasonably priced receiver readily available on the used market. N6HZ's ingenious scheme for putting an S/Line receiver on frequencies above 30 MHz with no modifications to the receiver is one of those "now why didn't I think of that?" ideas, ideas which seem to be painfully frequent!

Recently, the author purchased a used Collins 75S-1 receiver for use as a tunable i-f for vhf and microwave work. Upon examining the schematic, three very interesting things were noted.

First, the upper frequency limit of the receiver can be easily extended to 63 MHz (to 96 MHz with a passive frequency-doubler circuit for the LO). Second, no power supplies or external oscillators are required, and third, the receiver is not modified in any way.

To accomplish this, a doubly balanced mixer and a band-pass filter (BPF) are required and are connected as shown in Fig. 1. The 75S-1 fixed-oscillator output port, J1, is normally terminated by a 100-ohm load resistor. Local-oscillator power for the mixer is provided by unplugging the load resistor on the receiver chassis and connecting the mixer to J1 through an appropriate length of 50-ohm coaxial cable. The BPF is installed between the antenna and mixer input to eliminate image-frequency problems. The mixer output is connnected through another 50-ohm cable to the receiver antenna terminal, J5.

*4880 Burnside Rd., Sebastopol, CA 95472

The frequency of the crystal used in the receiver is calculated as

f_{REC} = lowest frequency to be received
f_{LO} = fixed LO out of receiver port
f_{IF} = frequency of signal applied to receiver antenna terminals

Consider the case where the desired tuning range is 50.0 to 50.2 MHz, where f_{REC} = 50.0 MHz:

$$f_{REC} - f_{LO} = f_{IF} = f_{LO} - 3.155 \text{ MHz}$$

$$50.0 - f_{LO_{XTAL}} = f_{LO_{XTAL}} - 3.155 \text{ MHz}$$

$$f_{LO} = \frac{50.0 + 3.155}{2} = 26.5775 \text{ MHz}$$

Note, however, that this local-oscillator frequency of 26.5775 MHz is controlled by a crystal selected via the front-panel frequency-range switch. The actual crystal frequency in this case is 13.28875 MHz because the tuned circuitry in the receiver doubles the crystal frequency. See the Collins instruction manual for a discussion of LO crystal frequencies.

Earlier, it was mentioned that the receive range can be extended to 96 MHz. This requires that f_{LO} be doubled and can be achieved passively (with no external power supply) by using a full-wave rectifier and a tuned circuit, as shown in Fig. 2. Transformer T1, used in the frequency doubler, requires a toroid core suitable for operation up to 66 MHz and has three 10-turn windings, two of which are connected in bifilar fashion to form the center-tapped secondary. L1 and C1 form a low-Q circuit resonant at twice the input frequency.

Construction of the doubly balanced mixer has been described previously[1] and uses two more toroids wound the same as transformer T1. Diodes are the hot-carrier type which are available from many sources (e.g., Hewlett-Packard 5082-2800). Also, suitable designs for the BPF are covered in recent editions of the ARRL *Handbook* and are not covered here.

[1] Bingham and Hayward, "Direct Conversion — A Neglected Technique," *QST*, Nov., 1968.

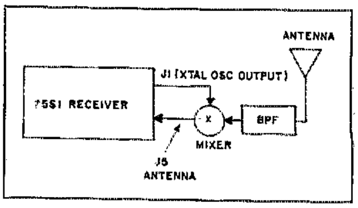


Fig. 1 — Block diagram for extending frequency coverage of the Collins 75S-1 receiver.

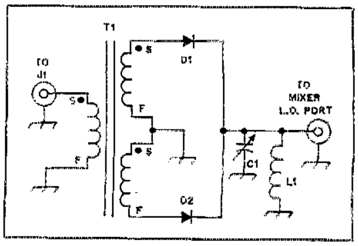


Fig. 2 — Full-wave rectifier and tuned circuit used to double local-oscillator frequency in the 75S-1. See text for component values.

The passive frequency doubler described was required when a surplus 8.860-MHz crystal was plugged into an unused 20-meter crystal position in the 75S-1 receiver. The resulting 35.440-MHz LO signal was used with the doubly balanced mixer and provides frequency coverage of 50.005 to 50.205 MHz as the receiver dial is varied from 0 to 200. Even though a preamplifier is not used, sensitivity is very good and 0.2-μV signals are copied easily.

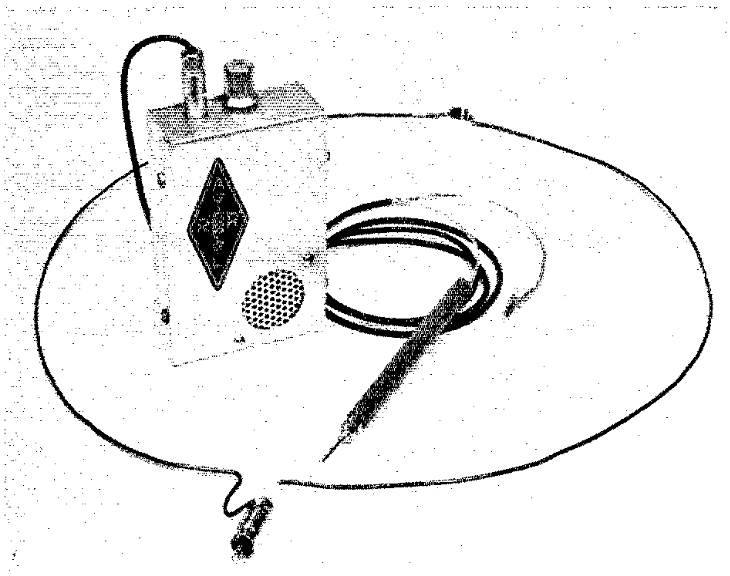
The author can supply the three toroid cores for a 13-cent stamp plus a self-addressed envelope, as long as the supply lasts. See you on 6 meters and up?

An Audio Continuity Tester

Basic Amateur Radio: Got your ACT together? If not, dig the parts out of your junk box and let's get going. This gadget is great for checking pc-board foils and low resistance values!

By Jim Bartlett,* K1TX

If you're thinking our ACT is part of a Broadway production, think again! It's actually a simple piece of test equipment. The acronym stands for Audio Continuity Tester. "What's so great about that?" you're probably saying. "I can use a buzzer and a D-cell battery!" Yes, you could use that type of checker for many continuity tests, but there are certain situations which require a more sophisticated circuit — one which will not apply much voltage or current to any components in the circuit under test, and one which will not read through transistor, diode or IC junctions. Of course, it would also be nice not to have to keep pivoting between the circuit under test and a meter or other visual indicator. If you've ever ruined a delicate transistor or IC because your probe slipped while you were glancing over at your VOM, you can appreciate the value of an *audio* indicator.



The ACT prototype is shown here with probes and direction-finding loop antenna. The cabinet was made from scrap aluminum sheet metal and decorated with an ARRL emblem cut from a larger decal.

Setting the Stage

Our ACT circuit fulfills all of the above requirements. It was originally designed by John Stenbakken, W6SZH, for checking circuit-board foils on computer pc boards. When the probes are placed across a low-value resistance, a low pitch is heard in the speaker — the higher the resistance, the higher the tone. When the probes are shorted together, the lowest obtainable audio frequency can be adjusted by turning the "sensitivity" knob attached to a 50-kΩ potentiometer. The ACT is capable of detecting or responding to resistances in the 0- to 60-ohm range. Of course the maximum value will vary slightly from unit to unit due to differences in component values, but the 60-ohm spread should be pretty close. So actually, the ACT is *most* useful for checking dead shorts — or shorts with little resistance, and this is where it really does a job!

When the pot is adjusted to give a very low tone (50 Hz) when the probes are shorted, substituting any small resistance between the probes will cause the tone to cease. The ACT can sense changes in resistance as small as 0.5 ohm: a change in pitch will be heard. This sensitivity to small changes in resistance makes the ACT an ideal piece of gear for checking circuit-board foil continuity, or for detecting cold solder joints.

*Basic Radio Editor, *QST*

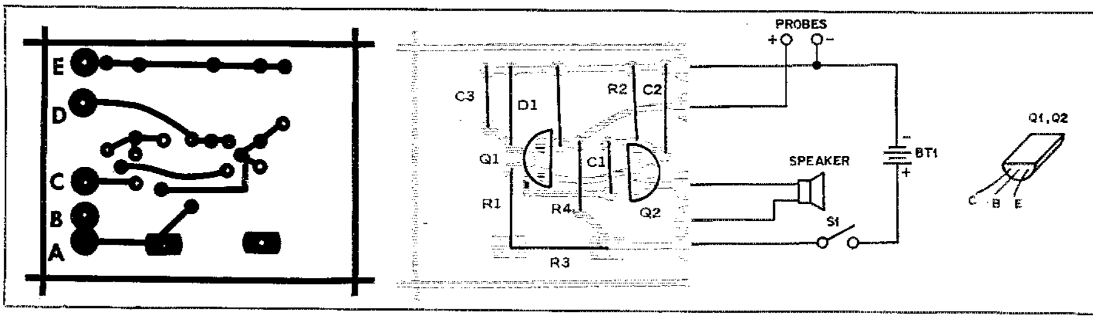


Fig. 1 — Shown here are the ACT pc board template (left) and parts placement diagram (right). Shown from the foil side, the template is reproduced full size with black representing copper. Parts located on the placement drawing are shown from the non-foil or component side of the board.

It will also detect shorted transistors, ICs, diodes and capacitors in or out of circuits. Large values of capacitance (about 1000 μF and larger) applied to the probe tips create a short tone "burst" from the oscillator as the capacitor charges. Once the capacitor has discharged, the burst can be repeated by touching the probe tips to the capacitor leads again. Usually the faster this can be repeated, the more leakage the capacitor has. Also, the longer the burst, the larger the value of capacitance. In order to get the best results when testing capacitors with the ACT, you should turn R3 to its minimum resistance position so that the highest pitch is heard when the probes are shorted.

Changing Scenery

Fig. 1 shows the circuit-board pattern and parts placement guide for the ACT. The prototype was enclosed in a homemade aluminum chassis box about 4 × 2-3/4 × 1-1/4 inches or 102 × 70 × 32 mm (HWD) as shown in the photos. The potentiometer, R3, was mounted directly to the pc board and serves as the sole mechanical support for the circuit board. A small battery clip was fashioned from a scrap piece of aluminum and attached to one of the speaker-mounting screws. Although any two-conductor wire would suffice, these test leads were made from a small length of RG174/U miniature coaxial cable.

An interesting sidelight to normal operation of the ACT is its unusual behavior in the presence of an rf field. When a resistance of between 1 and 120 ohms is placed across the probe tips of the ACT, R3 can be adjusted so that the oscillator will "turn on" when an appreciable amount of rf is present. The specific amount of radio-frequency energy necessary to trigger the oscillator will vary with the components used in construction, and with the length and type of probe leads attached. Of course, the longer and less shielded the test leads are, the more rf will be picked up; and the higher the beta (gain) of Q1, the more sensitive it will be to small signal changes in the base circuit of Q1. Anyway, the prototype has been tested with both a bench signal source and "off-the-air" signals and has been found to be fairly sensitive to rf.

The Plot Thickens

All of this means two things: First, you can't depend on tests you make with the ACT if you are close to an rf source at the time, and second, you can use this device for a number of other things besides continuity testing! For example, you can use it as a cw "off-the-air" monitor, an rf signal tracer, a handy-dandy handheld checker, or even a hidden-transmitter tracking device in a pinch! For use as a cw monitor, just stick any low-value resistor (50 ohms will do) across the probes and set the ACT down in your shack. A small adjustment of R3 may be necessary, but when you start transmitting, the ACT will be beeping right along with you. If a signal tracer sounds intriguing, just ground the common lead, stick a low value of resistance between the probes, and couple the hot lead to the circuit you are tracing. Use a small value of capacitance in series with the hot lead to couple the rf from the circuit to the ACT. Again, some adjustment of R3 may be necessary. The ACT is rf sensitive even at 2 meters, so to check your handheld or portable rig for output, just stick that 50-ohm resistor between the probes and key your microphone. With the right type of directional antenna (such as a small loop with a 5-ohm resistor at the top) substituted for the probes, the ACT could serve as a cw transmitter-hunt receiver at close range. Hot spots were found on W1AW's signal within the ARRL headquarters building using the ACT and a loop antenna 12 inches in diameter. (W1AW is only a few hundred feet from

With the case open, the ACT looks like this. At the left is the pc board supported by potentiometer R3. Also visible are the aluminum battery clamp at right, and a belt clip pop-riveted to the back cover. Having the ACT attached to my belt made using the device much easier, since there were no test leads dragging across the bench.

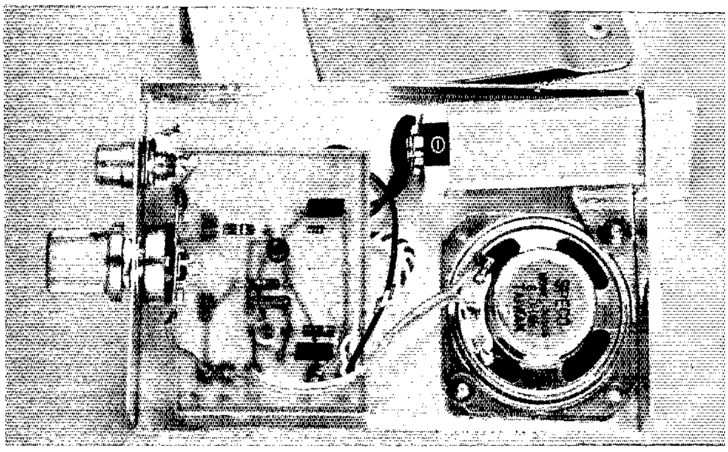


Table 1
Parts List for the ACT

BT1 — 9-volt transistor battery.
C1 — 1-μF Radio Shack no. 272-1406 or equiv.
C2, C3 — 0.1-μF capacitor RS 272-135.
D1 — Silicon signal diode, 1N914 or equiv. RS 276-612.
D2 — Germanium signal diode, 1N34 or equiv.
LS1 — 8-ohm speaker, 2-1/2 in. RS 40-247.
Q1 — Npn silicon transistor, general-purpose type (high beta).
Q2 — Pnp silicon transistor, general-purpose type.
R1, R4 — 10-kΩ resistor.
R2 — 10-ohm resistor.
R3, S1 — 50-kΩ linear miniature potentiometer with spst switch (Calectro B1-664), or
R3 — 50-kΩ potentiometer (RS 217-1716).
S1 — Spst toggle switch (RS 275-612).
Miscellaneous:
1 phono plug (RCA type) (RS 274-339).
1 phono jack (RS 274-346).
1 pair probes (Calectro F2-946).
1 9-volt battery snap connector (RS 270-325).
1 cabinet or enclosure.
Wire, hardware.

the Hq. building.) If DFing isn't your bag, you might even use the above technique to check for "bugs" in your house or shack.

Of course, let's not ignore the ACT's natural suitability as a spare code oscillator or miniature electronic organ. By adding either a hand key or a handful of push-button switches and Trimpots, you can transform your test instrument into a Christmas or birthday present for a young one. Variations of this circuit are limited only by your imagination.

Cast Description

The ACT is basically a two-stage amplifier with feedback to make it oscillate. Note in the schematic diagram (Fig. 2) that one npn and one pnp transistor are used. D1 and D2 are used at the base and emitter of Q1 to provide bias for the stage. This is accomplished by using the approximate 0.6- and 0.3-V drops across the diode junctions. With the diodes used to create a voltage drop instead of resistors, the bias is constant and is not affected significantly by changes in current.

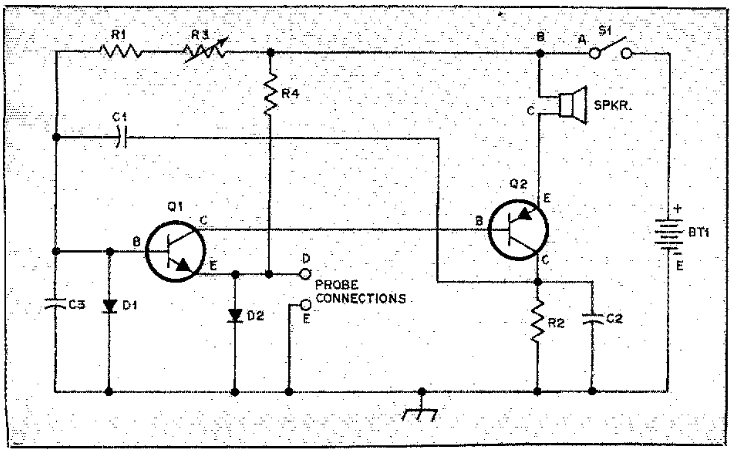
When D2 is removed from the circuit by shorting the probes, the bias on the base of Q1 increases to 0.6 V positive with respect to the emitter. C3 functions with C1 as a voltage divider network allowing only part of the audio produced by the amplifier-oscillator to be used as feedback voltage at Q1. R4 allows enough current flow through D2 to keep it forward biased, making the emitter of Q1 0.3 V above ground even when the transistor is cut off. (This 0.3 V is the maximum voltage applied to circuit components by the ACT.) The value of R4 is chosen to suit the power supply voltage. With a 9-volt battery supply, as is used here, R4 should be 10 kΩ. But for a 5- or 6-volt supply, R4 should be about 1000 ohms.

When a low value of resistance is placed across the probes at Q1, the bias level on the base of Q1 is raised. The lower the value of resistance that is shunted across D2, the greater the positive bias at the base of Q1. As Q1 is biased into conduction, it in turn biases Q2. R2 is used to limit collector current in Q2, which is set up as an emitter follower with the load (speaker) in the emitter lead. Oscillation occurs because feedback through C1 from the collector of Q2 is in phase with the signal at the base of Q1 (180 degrees phase shift in each transistor). This is called *positive* feedback. It causes regeneration.

Finale

If the circuit doesn't work properly when you first turn it on, check all connections for wiring errors or cold solder joints. Make sure the transistors are wired correctly, and that the battery is properly polarized. If the circuit still doesn't percolate after you've corrected any wiring errors, try substituting other high-gain npn transistors for Q1. You will probably find many uses for this device in your shack, but remember — you don't have to be a thespian to make an ACT, just halfway proficient with your soldering iron.

Fig. 2 — This schematic diagram shows the circuit used in the ACT. Specific part designations and values are displayed in Table 1. For those who prefer not to fabricate their own pc boards, pre-etched circuit boards are available from the Carson Chapter VICA Club, Carson High School, 22328 S. Main St., Carson, CA 90745 for an s.a.s.e. and 50 cents. (Pattern provided may differ slightly from that shown in this article.)



Strays

FAR SCHOLARSHIPS

☐ The Foundation for Amateur Radio, Inc., a nonprofit organization with headquarters in Washington, DC, will award five scholarships for the 1978-79 academic year. All amateurs holding at least a General class license or equivalent can compete for one or more of the awards if they plan to pursue a full-time course of studies beyond high school. The scholarship awards range from $250 to $750, with preference given in some of them to residents of various areas. Additional information and an application form can be obtained by sending a letter or postcard postmarked prior to June 1, 1978, to FAR Scholarships, 8101 Hampden Lane, Bethesda, MD 20014.

PVRC ON-THE-AIR REUNION

☐ The 1978 On-The-Air Reunion of the Potomac Valley Radio Club of the greater Washington, DC-MD-VA area will be held the first week in June, bringing together present members and inactive members spread throughout the world. Members no longer listed on the active PVRC rolls are encouraged to send their name, call sign, address and ZIP code to Red Gambrell, W3UO, Secretary, PVRC; 17937 Archwood Way, Olney, MD 20832. PVRC will mail to all active members a 1978 "PVRC Reunion Package" which will include a roster of names and call signs, reunion logs, and other PVRC information.

A DoppleScAnt

Lost any transmitters lately? Find them even when simple methods fail by using a Doppler Scanning Antenna. Ham ingenuity is far from dead, as this project demonstrates.

By Terrence Rogers,* WA4BVY

When our repeater society decided to sponsor a 2-meter transmitter hunt, a buddy and I joined in enthusiastically. Rochester, NY (where I lived at the time), is a high-technology area so we were correct in expecting a high level of competition. A minimum of a Yagi beam, a portable receiver with limiter meter, and good terrain maps seemed to be the order of the day. Although we expected to place well up in the standings, our best finish using the traditional Yagi method was fifth out of 13. This would not seem a humiliating defeat until you consider that we are comparatively poor losers!

A New Method of Direction Finding

A local university library provided the first directions toward a better solution, with a short paragraph about Doppler antennas. The theory of operation is reasonably simple. Radio signals received on a rapidly moving antenna experience a frequency shift due to the Doppler effect, an effect well known to anyone who has observed a moving car with its horn blowing. The radio-frequency shift may be detected by a frequency-modulation receiver which, of course, is the type most often used on 2 meters. The rapid antenna movement can be simulated with a special antenna array and a scanning adaptor, while the audio output of the receiver is analyzed to provide the direction of the received signals, based on the Doppler shift.

Fig. 1 shows a quarter-wave antenna being rotated in a circle about point P, with some constant angular velocity, omega (ω). The instantaneous tangential velocity of the antenna is $V = \omega \times R$. As the antenna approaches the transmitter, the received frequency will be shifted higher. The highest frequency is achieved when the antenna is exactly at point A with maximum tangential velocity toward the transmitter. Conversely, the lowest frequency occurs when the antenna is at point C, with maximum velocity away from the transmitter. The amount of frequency shift due to this Doppler effect is proportional to the channel frequency and the tangential velocity, which is itself a function of the radius R and the angular velocity.

Fig. 2 shows a plot of v_t, the component of the tangential velocity in the direction of the transmitter. Comparing Figs. 1 and 2, notice that at B in Fig. 2 v_t is crossing zero from the positive to the negative and the antenna is closest to the transmitter. The Doppler shift and consequent audio output from the receiver discriminator follow the same plot so that a negative-slope, zero-crossing detector will locate the direction of the transmitter.

The relationship between v_t and the Doppler shift is quantitatively:

$$f' = \frac{f\,(c \pm v_t)}{c} \qquad \text{(Eq. 1)}$$

where: f' = Doppler-shifted frequency
f = transmitter frequency
v_t = velocity of antenna toward or away from the transmitter
c = speed of light

Solving for the actual Doppler shift of $f \pm f'$ yields

$$\Delta f = \frac{f\,v_t}{c} \qquad \text{(Eq. 2)}$$

Since $v_t = v \cos\Theta$

$$f = \frac{f\,v \cos\Theta}{c} \qquad \text{(Eq. 3)}$$

where $\Theta = 0$ at A in Fig. 1

For example, we could find how fast an antenna would have to rotate to give a 147-MHz transmitter a 1-kHz Doppler shift. First, solve Eq. 2 for v_t:

$$v_t = \frac{\Delta f c}{f} = \frac{1\ \text{kHz} \times 3 \times 10^8}{147 \times 10^6} = 2000\ \text{m/s} \qquad \text{(Eq. 4)}$$

This is about six times the speed of sound, making the mechanical rotation of the antenna impractical. When this type of antenna is connected to an fm receiver a tone is heard. Knowing that $v = \omega R$, we can solve for ω when R is 0.5 meters. ω = 4000 radians/second, or 637 Hz.

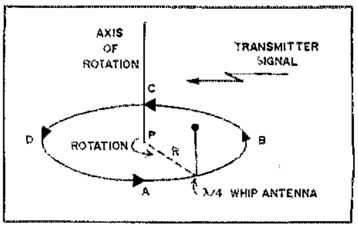
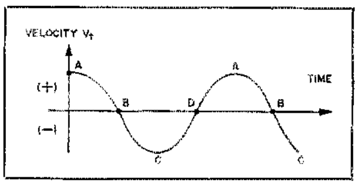
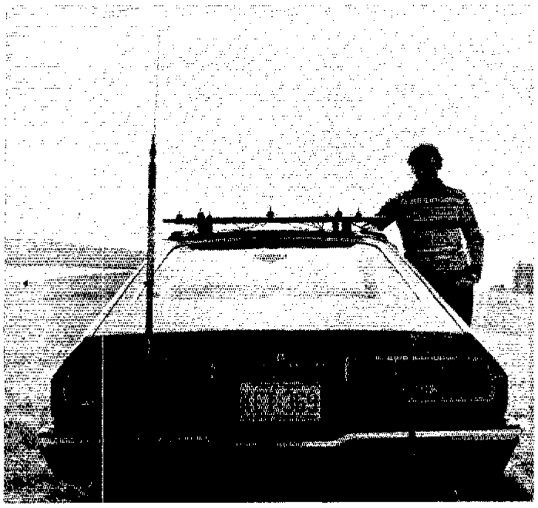


Fig. 1 — Pictorial diagram of the theoretical Doppler antenna, circling at six times the speed of sound.

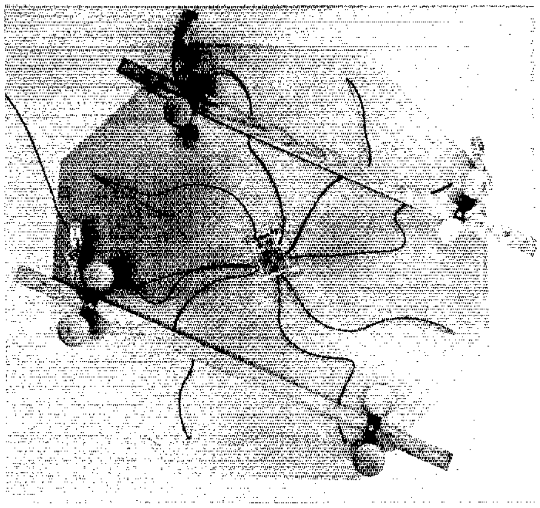
Fig. 2 — This graph illustrates the frequency shift related to antenna movement toward and away from the signal source. *Both* antenna rotation and signal are time-based.



*46 Oakwood, 6901 Buffaloe Rd., Raleigh, NC 27604



Shown here is the former Mustang II, along with the author and the Doppler antenna system. The pole-mounted whip for 2 meters had no effect on the Doppler system.



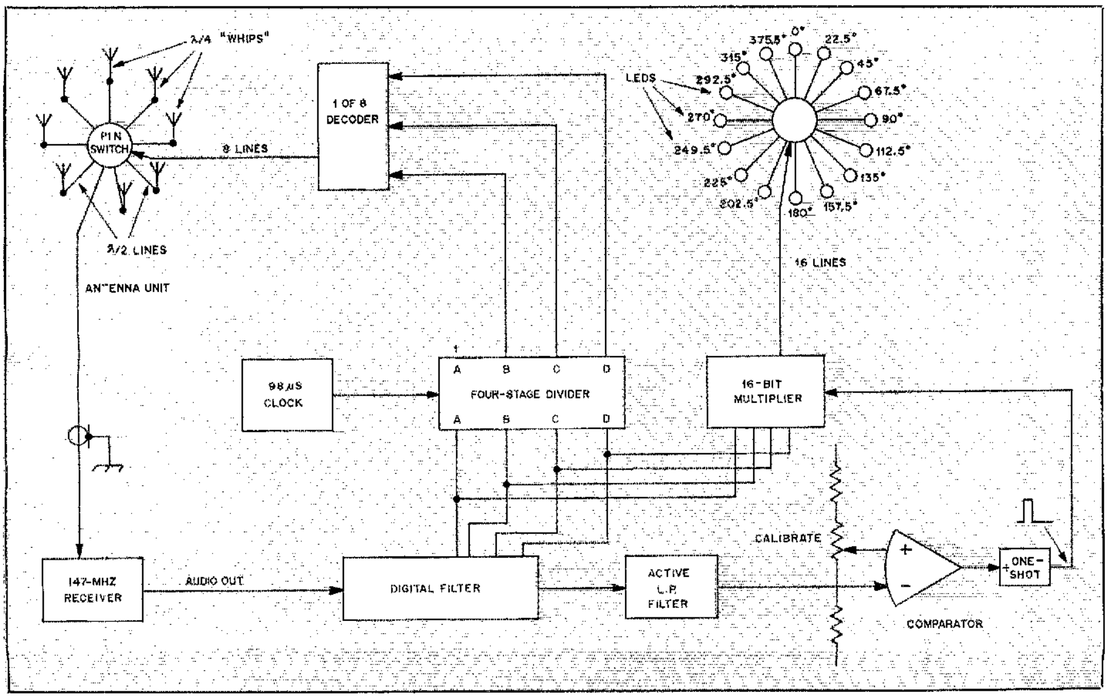
An underside view of the Doppler antenna mounting plate; note the eight equal lengths of small coaxial cable. The PIN diode circuitry is on the circuit board in the center.

Now refer to the system diagram in Fig. 3. The rotation is accomplished by constructing an array of eight antennas equally spaced in about a one-meter (half-wavelength) diameter circle. Any greater diameter leads to an ambiguity in direction. The antennas are then electronically scanned in sequence to approximate the rotation of a single antenna. We used PIN diodes to connect the individual antennas, since they allow us to stop the scan and transmit through the antenna system. The PIN diodes are capable of conducting more rf current than the dc bias current would indicate, whereas ordinary signal diodes will work but not conduct any appreciable rf current.

How the DoppleScAnt Works

Eight antennas are scanned in 1.57 milliseconds, so the clock must operate at

Fig. 3 — System diagram of the Doppler direction finder.



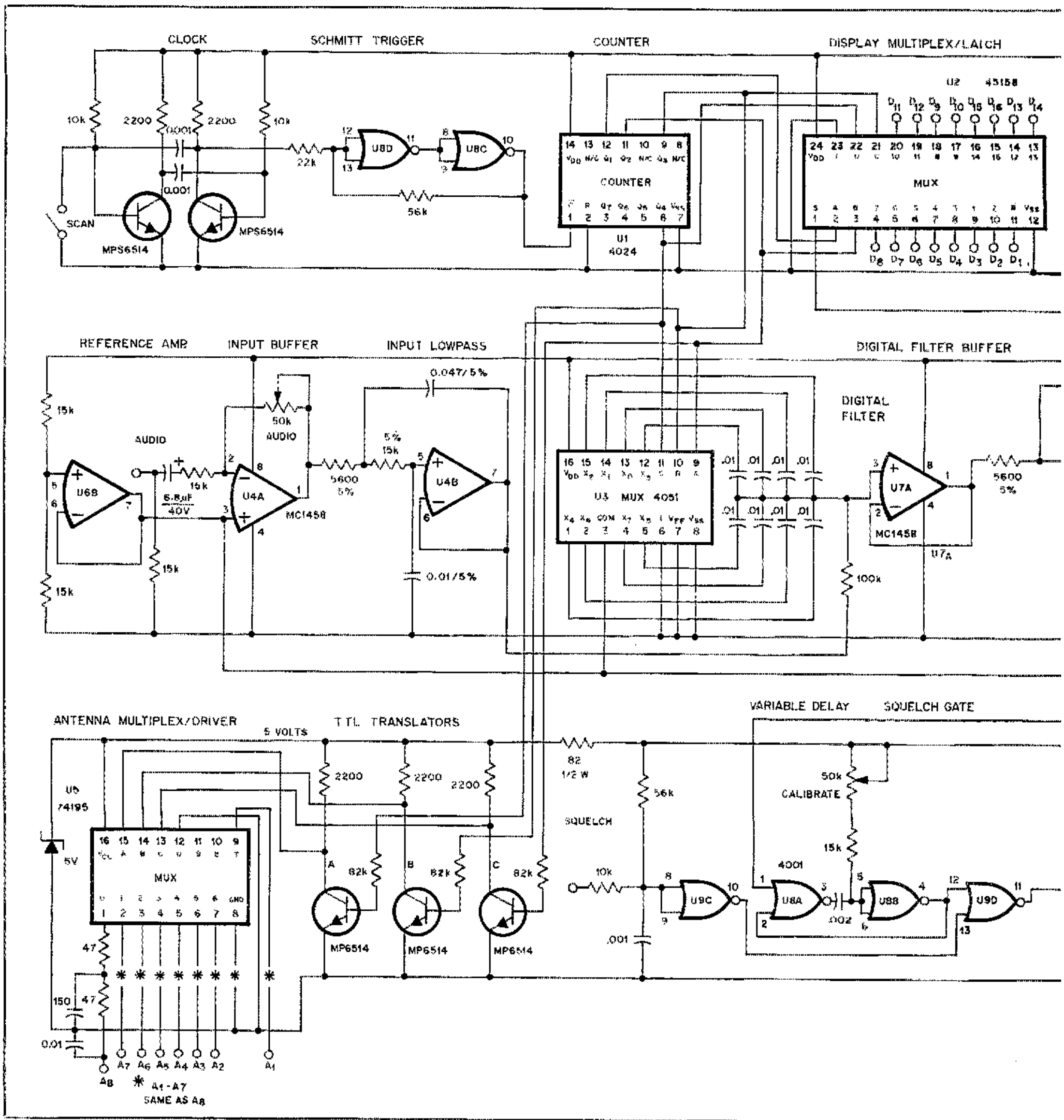


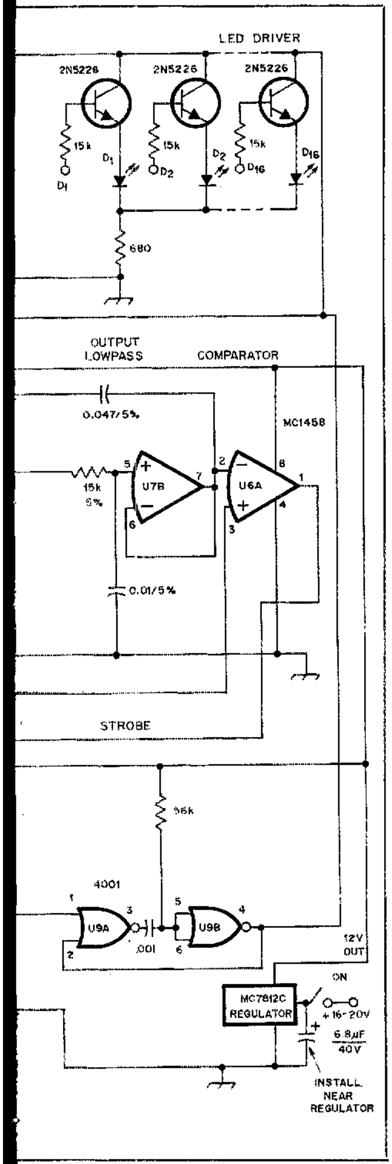
Fig. 4 — Schematic diagram of the control unit used in the vehicle. All resistors are 1/4 watt, 10 percent, unless otherwise noted; capacitor values less than one are in μF, more than one in pF unless electrolytic. All electrolytics are in μF. All capacitors are 20-percent tolerance unless noted. Connect pin 7 of each U8 and U9 to VSS and pin 14 to VDD.

1.57 ÷ 8 or 196 microseconds. We actually chose 196 ÷ 2 microseconds since our compass rose has 16 positions. The 637-Hz tone must be extracted from the composite audio output of the receiver by a narrow filter. However, such a narrow filter introduces considerable phase distortion with just a little mistuning. Therefore, we used a digital filter which is operated by the same clock that controls the scanning. The effect is to have a filter automatically centered on the scan tone even when there is some frequency drifting. A residual phase shift caused by the audio circuitry is calibrated out of the system.

How does the circuit work? Q1 and Q2 form a flip-flop operating at 16 times the scan rate of 600 Hz, or 9600 Hz. The RC waveform output is converted to square waves by the Schmitt trigger formed from U8C and U8D. The scan may be stopped for transmitting by closing the switch.

U1 is a seven-stage ripple counter, of which only the first four stages are used. The Q1, Q2, Q3 and Q4 outputs of U1 are all connected to U2, a four-bit latch and 4-to-16 line decoder. U2 is used to scan the LED display compass rose and to latch an output *only* when a pulse appears at pin 1, the strobe input from the calibrate single shot.

The LEDs are actually driven by 16 pnp switching transistors Q3-Q18, needed because of the low current output of the CMOS IC. All the LED directional



displays have a common current-limiting resistor, R61, since only one LED is on at a time. The diodes are mounted in a circle every 22.5 degrees on the front panel with D1 at the top (zero degrees) and proceeding counterclockwise (the same direction as the antenna is scanned). Number "one" antenna is usually at the right but its exact position is determined in the final test.

U6B is used to provide a stiff source for reference bias for the other op amps.

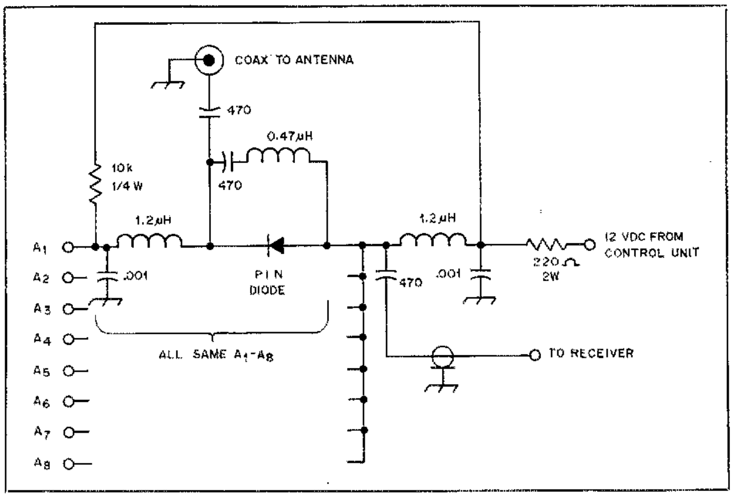


Fig. 5 — Schematic diagram of the PIN diode circuitry mounted beneath the antenna; eight identical circuits are used.

Audio input is to U4A, which is an adjustable buffer amplifier. It is set so that at typical levels of audio from the transceiver, clipping does not occur at pin 1 of U7A, which is the buffer for the digital filter. This is about 1.6 V rms when an 8-volt supply is used. U4B is a low-pass filter which reduces voice audio peaks and overloading to the digital filter.

U3 is fed by outputs Q2, Q3 and Q4 of U1, so a complete cycle for its eight outputs occurs in step with the 16-step cycle of U2. This eight-way-decoded, bidirectional multiplexer is connected as a digital filter with a bandwidth of 10 Hz or less. The stepped output of the digital filter is smoothed by U7B, another low pass.

U6A is a comparator connected to go positive on a negative half of the sine-wave input. This fires the variable single-shot of U8A and U8B. This is used to calibrate out variations between radios, component aging, and so on. A second short-pulse single-shot is formed from U9A and U9B; it fires on the fall of the calibrate single-shot and provides the latching pulse to U2, which then illuminates whatever LED position was decoded at the time of the pulse for the next cycle.

U5 is the only TTL circuit. Its drive comes from Q2, Q3 and Q4 of U1 for the same reasons that U3 is so connected. The CMOS level is translated to TTL levels by Q19, Q20 and Q21. The outputs are open collector and are rated to drive the PIN diodes in the antenna unit directly.

The single-shot which latches the LED display drive may be gated on and off by the receiver squelch. This connection to U9C is labeled SQUELCH and is arranged so that a low potential produces the gating which locks in the current display. This allows the unit to lock on very short transmissions of about 250 ms after the squelch opens. The digital filter is quite narrow and so the sine-wave output usually does not decay to unusable levels by the time the typical squelch has closed.

Fig. 4 is a schematic diagram of the control (adaptor) unit used in the auto. A control cable goes to the antenna unit, which is mounted on the roof with cartop carriers. The circuitry shown in Fig. 5 is mounted on the underside of an aluminum plate which forms the groundplane for all antennas. Aluminum plate of 0.0625 inch (1.6 mm) thickness is quite adequate. The antennas used are commonly available quarter-wave whips. These antennas must be identical, especially in length. The interconnecting half-wavelengths of coaxial cable must all be of the same brand and the same length to within about one-quarter inch.

The capacitor and coil combination around the PIN diodes forms a parallel-resonant circuit with the capacitance of the diodes to increase isolation from "off" units. Note that changing the diode will change the value of the coil. This circuit may be checked with a grid-dip meter. It is not too critical and might be left out with low capacitance diodes. The commonly available Motorola MPN3402 diodes survive a 25-watt, 2-meter transmitter signal if the scan is stopped when one transmits.

Following construction and preliminary trials, the unit should be taken to an open field for calibration. Adjust the audio gain control at a comfortable speaker level, taking care not to overload the digital or low-pass filters (8 volts pk-pk). Set the calibrate control in the middle of its range. A 2-meter (or other band used) transmitter is placed some distance off and the antenna array rotated until the compass rose reads true relative to the direction of the vehicle.

For aesthetics, the antenna may be rotated a slight amount before it is drilled and secured to the cartop carriers. Then the calibrate control may be adjusted to compensate for this movement. A walk around the auto with a handheld transceiver will reveal if the installation is functioning properly.

We first used a cable connector between the adaptor and the antenna unit which was not polarized. At one of the following practice sessions when the plug was reversed, the driver was instructed to follow the signal into Lake Ontario! Under such conditions the indicator reads correctly ahead and behind but reverses left and right, so it is best to check with a walk-around. Once calibrated in one direction, we did not find it necessary to compensate in other directions to the limit of readout accuracy. We left the pole-mounted, 2-meter antenna on the rear bumper during the tests and found no significant interaction.

Finding Bunnies

Use of this system does demand some skill. When driving down a street one may notice that the display will "dash around" the compass rose. This indicates the presence of multipath reflections that the Yagi competition will also have to weed out. You, however, will know that you are in a high-reflection area, whereas they often do not. If the car is stopped in a reflection the tone will sound distorted (tinny). Rock the car for the best note and then take the reading. You can also remain in motion, which is the best strategy, and have a companion watch the display. Every two or three seconds in a high-reflection area the display will momentarily come to rest. This reading is invariably accurate.

As time goes on and the competition becomes aware that you are using the DoppleScAnt, some countermeasures will have to be brought into play. Encourage the "rabbit" to reduce the time the hidden transmitter stays on the air. Since the system will lock on a bearing in about 250 ms you can find a hidden transmitter which is nearly "off the air" completely. You have just eliminated your Yagi competition!

Our targets tried power and polarization switching to throw us off. The first time that happened our team was not aware of it until we actually found the transmitter, because the system makes no use of amplitude or polarity information. Next, high power was used, as this causes the attenuators used by other contestants to be turned all the way up in the vicinity of the hidden transmitter, so that signals enter the receiver directly and the Yagi becomes useless. This trick is ineffective against the "octopus" system because it does not use an attenuator.

Finally, the sly devils tried transmitting a 600-Hz tone. This might have been effective but the digital filter is only 4 Hz wide and the rabbit does not know what exact frequency the clock is on, due to the tolerances of the components. We also realized that we could adjust the regulator voltage so the pitch changed slightly to avoid the interference.

Some remarks on strategy should be a fitting end to this article. It is sometimes of benefit not to drive immediately in the direction indicated, but rather at quite an angle to it, so that the approximate location of the bunny may be determined by "triangulation" as soon as possible. This will allow a course to be plotted to avoid the general flow of traffic and accompanying delays. The higher accuracy of the "octopus" should allow you to do this in situations where the small portable Yagis will not suffice.

We found that a three-person team is best: a driver, an equipment operator and a strategist. The driver pilots the auto while the operator sees to "calling" the bunny and interpreting the display. (The pictured Mustang II no longer exists, as a result of driver error while said driver was watching the electronics.) The operator also adds the relative bearing to the magnetic bearing of the car and thus obtains the magnetic bearing to the transmitter. The strategist then plots this information, discarding older, more distant (and thus less accurate) bearings, as the hunt progresses. The strategist is also responsible for the first coarse guess of the actual location, so that obstructions such as rivers with no bridges may be avoided in time. This task requires no technical expertise and is a good job to invite a nonham to do.

We found the DoppleScAnt to be our key to winning at an immensely entertaining club activity. If you have the competitive urge, get your club to start up a transmitter hunting program this spring; meanwhile, start building your "secret weapon!" QST

[Editor's Note: Photocopies of the circuit-board patterns provided by the author are available from ARRL hq. for one dollar (to cover handling) and a business-size stamped return envelope. The author has indicated that he can offer assistance in obtaining ready-made circuit boards and hard-to-find parts. A stamped return envelope sent to him will bring more information.]

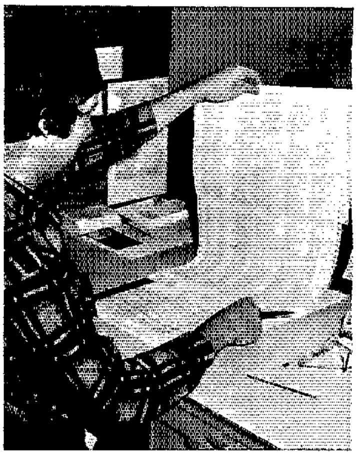
Strays

Predicted Orbits for OSCAR 8

Ref. Orbit	*Date*	*Time (UTC)*	*Long. W.*	*Ref. Orbit*	*Date*	*Time (UTC)*	*Long. W.*
786	1 May	0130	61	1037	19 May	0121	59
800	2 May	0135	62	1051	20 May	0126	60
814	3 May	0141	64	1065	21 May	0131	61
827	4 May	0003	39	1079	22 May	0136	63
841	5 May	0008	41	1093	23 May	0142	64
855	6 May	0013	41	1106	24 May	0004	40
869	7 May	0018	43	1120	25 May	0009	41
883	8 May	0024	45	1134	26 May	0014	42
897	9 May	0029	46	1148	27 May	0019	43
911	10 May	0034	47	1162	28 May	0024	45
925	11 May	0039	48	1176	29 May	0030	46
939	12 May	0044	50	1190	30 May	0035	47
953	13 May	0050	51	1204	31 May	0040	49
967	14 May	0055	52				
981	15 May	0100	54				
995	16 May	0105	54				
1009	17 May	0100	56				
1023	18 May	0116	58				

Updated orbital information can be obtained from W1AW bulletins. For further information, see "Operating News," page 82.

A first — computerization of the 1978-1979 *ARRL Repeater Directory.* Editor WA1LOU is shown here proofing and duping the computer printout. This free membership service is now available from Headquarters for a 6 × 9-inch s.a.s.e. (46-cents U.S. postage). *(W1YL photo)*



Sunspots and the HW-16

What have sunspots done to that HW-16? Retired when 15 meters became quiet as church on a Sunday afternoon? Well, 15 is alive! So revitalize your sweet '16!

By Earl R. Savage,* K4SDS

To a considerable extent, attitudes of many radio amateurs toward sunspots reflect individual interests in particular bands. For instance, I enjoy operation on 15 and 20 meters because of the DX possibilities. Both bands, however, are highly susceptible to solar activity with the result that entries in my log increase or decrease in number in direct relation to the intensity of that activity.

When sunspot conditions close a favorite band, the obvious alternative is to shift to frequencies that are open. For the owner of equipment with limited band coverage, such as the HW-16, sunspot variations can be particularly bothersome. Mind you, many of us old diehard cw operators think Heath's '16 is the nicest little rig to come off the assembly line or to be packaged in a kit box. (Just can't understand why Heath discontinued producing it!) This cw transceiver dandy is designed for 80-, 40- and 15-meter operation. The vulnerability of the set rests mainly with the latter band, for when that segment goes dead, operation becomes restricted to the two other bands. But let us not treat the HW-16 unkindly for this limitation. There can be an alternative. First, may we consider the assets of this transceiver?

Look through an HW-16 manual and you will note that this rig contains some outstanding features. It has full break-in cw provision, crystal control of the transmitter with provision for an external VFO, and the only tuning required when changing bands or frequency is adjusting the final-amplifier tuning capacitor. In the receiver section there is dual conversion with crystal control of the front end. Both the stability and selectivity are excellent. Antenna switching from transmit to receive and vice versa is accomplished internally. Operation limited to only three bands is the single disadvantage. What happens with solar activity determines in effect whether the HW-16 owner has a transceiver that may be engaged in communication on all three or just two bands.

*2503 Westerly Ave., Charlottesville, VA 22903.

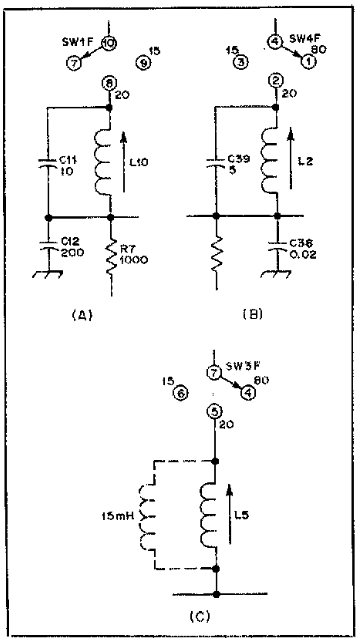


Fig. 1 — HW-16 component changes for operation on 20 meters as explained in text. Attention should be given to text notations concerning L5 as shown at C. Reference should also be made to the schematic diagram in the Heath HW-16 manual.

What to do when 15 becomes as dead as last Sunday's newspaper? One answer was provided by Bud Haake, WØMSV, in 1972 whose Technical Correspondence letter in *QST* for August provided a simple, neat way to change the HW-16 15-meter position so that it would cover the 20-meter segment. I, as well as many other HW-16 owners, followed Bud's instructions and *voila,* our cw transceivers again functioned on three usable bands. The results were indeed rewarding.

Time passes and eventually the sunspots show signs of increased activity. The lid appears to be coming off the 15-meter band. The news is welcome! But, now what? After having successfully converted the HW-16 to operate on 20 meters, does that mean a tormenting moment of decision is again at hand? Having grown fond of 20, how could I surrender this band to regain 15? Could I still have the cake and prove the cliche wrong in this case?

While pondering the several facets of the situation, I began asking myself "What good is 40 to me?" After all, it skips right over my friends around the state. Traffic nets are far from numerous, there is very little low-power DX and more than enough shortwave broadcast interference dominates the band afternoons and evenings. So, what else is new? Only this little gem . . . an inspiration to reverse Bud Haake's conversion, restoring the 15-meter operation as originally designed by Heath and then modifying the 40-meter circuit to function on the 20-meter band! To me, that thought became a showcase diamond, for thereby I would have three usable bands for my HW-16 including both DX bands, 15 and 20, and the other favorite, 80 meters. What more could I ask?

Undoing the WØMSV Conversion

With my goal fully in mind, the entire process of reworking the HW-16 became clear. There were to be two parts of the operation. One would be to restore the original 15-meter function and the other would be the modification of the 40-meter circuit for operation on the 20-meter band. Amateurs who may wish to consider my plan will need only to perform the second part if their HW-16s have not been converted previously by means of the WØMSV modification.

The "undoing" process is essentially a reversal of the steps outlined by Bud Haake. First replace the 12.545-MHz crystal with the 26.545-MHz unit previously removed for operation on 20 meters, and exchange the wires attached to points T and U on the circuit board, or exchange the wires attached to lugs 1 and 2 on section 3F of the bandswitch. (Disregard step 1 of the 40- to 20-meter modification below.)

Next, move the wire from the 20-meter tap on L12 back to the original 15-meter tap position. Move the wire from the 40-meter tap to the 20-meter tap. (Disregard step 2 of the 40- to 20-meter modification below.)

To complete the restoration, remove the 150-pF capacitor installed across driver coil L9, and remove the 6.5 turns added to rf coil L1. Then align L1, L4 and L9 on the 15-meter band according to the Heath HW-16 manual.

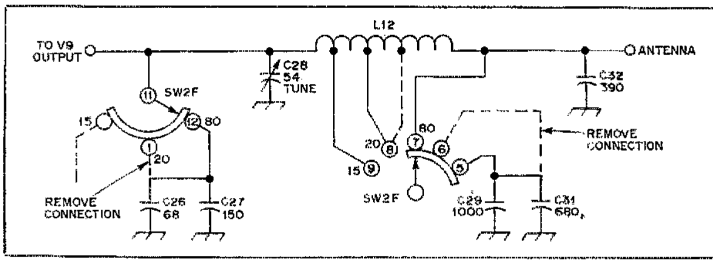


Fig. 2 — Modifications of the output circuit of the HW-16 enabling operation on 20 meters. Th 20-meter tap on L12 is placed midway between the 15-meter tap and the former 40-meter tap. Refe also to the schematic diagram in the HW-16 manual.

Doing the K4SDS Conversion

There are eight steps involved in modifying the HW-16 for converting the 40-meter operation to function on the 20-meter band. Only step 6 poses any difficulty because of the tightness involved.

Step 1: Replace the 12.545-MHz crystal with a 19.545-MHz crystal.

Step 2: Move the 40-meter tap on the PA coil, L12, to a point exactly halfway between the 15- and 40-meter taps.

Step 3: Replace the 36-pF capacitor across the driver coil, L10, with a 10-pF unit.

Step 4: Replace the 47-pF capacitor across the rf coil, L2, with a 5-pF unit.

Step 5: Connect a small 15-mH coil in parallel with the crystal oscillator coil L5 *or* rewind L5 to a value of approximately 7.5 mH.

Step 6: Disconnect the 680-pF capacitor, C31, from lug 6, section 2F, of the bandswitch and attach it to lug 5, paralleling C29.

Step 7: Disconnect the 68-pF capacitor C26 from lug 1, section 2F, of the bandswitch and attach it to lug 12 (to parallel C27). While this part of the modification is tight, it can be done without removing the bandswitch by careful use of forceps and extra-long, long-nose pliers.

Step 8: Align L2, L5 and L10 according to the Heath manual, but do it on the 20-meter band.

There you have it. That's all there is t modifying the HW-16 for operation o the 80-, 20- and 15-meter bands. I have n hesitation about recommending these sim ple changes to the cw owner/operator o an HW-16. They enable one to keep i touch with friends on 80 and still enjo the pleasures of DX on 20 and 15 meters The easy conversion provides anothe reason why I'm convinced the HW-16 is great rig. Actually, my '16 has more tha a dozen modifications . . . some simple . . some more involved. They are all incor porated to make this transceiver perforn for my convenience.* I find that I can di around in it and make it do just abou anything I want. I'd only trade it fo another. As time goes on I may well devis additional modifications. After all, wha ham wants a rig that does only what th manufacturer planned? Not this one! QST

*For information about other modifications, HW-1 lovers may write to the Printer's Devil Press, Bo 6301, Charlottesville, VA 22906.

Strays

THEY *DO* MAKE 'EM LIKE THEY USED TO

☐ It's been nearly 60 years since 8ADU came up with a suggestion that quite a few amateurs have since made use of. A brief item from *QST* cartoonist Donald Hoffman, 8ADU, in the August, 1919, issue went as follows: "Here's a little idea — run a suggestion that the fellows with long-distance ham receiving sets make themselves up a form for postcards something like this and send each time a new long-distance station is heard. In this way numerous relay possibilities will be discovered where some were careless and didn't notify stations heard formerly. Fellows receiving cards would keep them on file, etc. I used to do this and got a lot of thanks for it from the ones I wrote the cards to."

8ADU's proposed card had these categories: To . . . Heard your station . . . Dates . . . Hours . . . Audibilities . . . Working . . . Apparatus I use . . . Do you hear me? Call . . . .

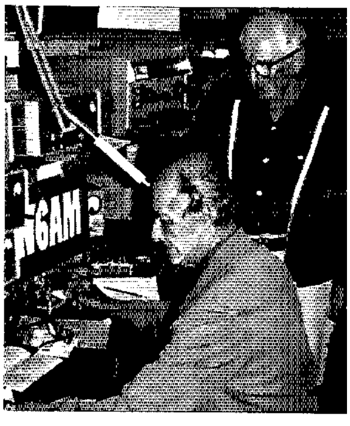
QSLs haven't changed all that much in 60 years, have they? — *WB9VAV*

SARL ASKS COOPERATION

☐ Lately, the South African Radio League has been inundated with QSL cards from all over the world, to be routed through SARL to countries outside South Africa!

"While we are flattered by the confidence these (amateurs) have in us . . . the handling of our own members' cards and authentic DX cards to our members is more than enough to cope with and we will not, in the future, forward these extra cards to amateurs and bureaus outside our boundaries who are not members of the SARL," says H. C. McCallum, ZS1MP, the QSL manager for SARL.

Amateurs are asked to QSL either directly or through the ARRL bureau. For more information, see "QSLs," *QST* for October, 1977.



"DXer no. 1." Don Wallace, W6AM, past ARRL Southwestern Division director, shows East Coaster and fellow past New England Division Director Robert York Chapman, W1QV, how signals sound on the end of the "rhombic farm." The occasion was Bob's visit to Don's home to discuss the merits of the ARRL Foundation.

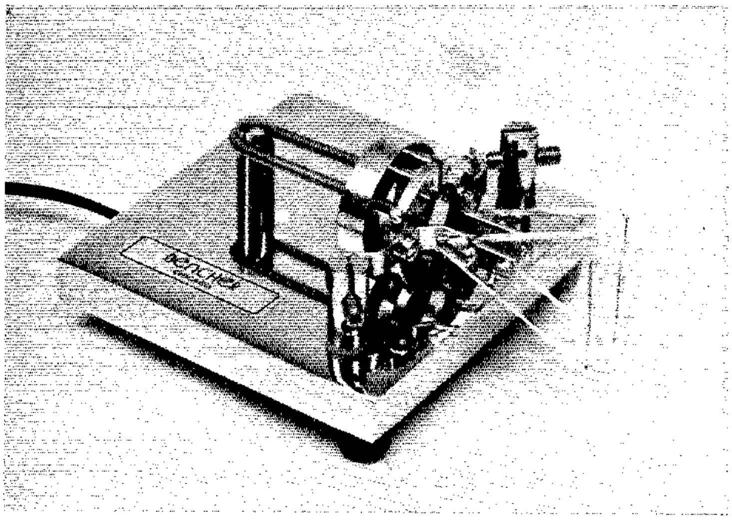
Product Review

The Bencher Paddle

Once upon a time, in the village of Dayton, state of Ohio, a man named Hills designed a keyer paddle. He called it the "FYO," after his W8 call sign. Although he ceased production soon enough to render his paddles both legendary and virtually unobtainable, W8FYO's ideas produced two descendants in the 15 years which followed. One son of FYO was made briefly during 1976 by HAL Communications, even using the name FYO. (A review of that HAL FYO appeared in *QST* for December, 1976.) The second son appeared late in 1977 and is called Bencher. This is its story.

The Bencher paddle is, like the FYO, a beautiful piece of work. In this day of sports cars with simulated everything and radios in plastic boxes, at last we have a paddle that's *heavy.* Either in its chrome configuration (as pictured) or its black steel finish (less money), it stays put on the table; cw addicts' complaint number one is answered.

Diehards will tell you that a properly adjusted paddle for high-speed work must be set by screwing the contact points in until they actually touch, mechanically and electrically. Then they should be backed out the tiniest bit until a breath of air on the handle will close the contacts; requirement number two. The Bencher passed this test of its pivot points with flying colors.



The Bencher paddle in gleaming chrome, grandson of the FYO paddle (1962) and son of the HAL FYO paddle (1976). The paddle levers pivot on needle bearings and can be adjusted so they close with a mere breath of air — literally.

Requirement number three, that the handles be adjustable for different fists, is met in a roundabout manner. While you can't move the handles, they are gigantic, so you can grab them high, grab them low, or grab them in the middle. By the way, those are *not* sharp edges on the clear plastic triangular handles. The edges are rounded smooth so they won't bruise or irritate your delicate fingers.

What you can adjust on the Bencher is the contact spacing and the spring tension. The latter is accomplished in the same manner as the HAL version but completely different from the original FYO design. This is because the original was a single-lever model; the two sons are double lever. An Allen wrench is provided for the contact points, and a small screwdriver will be needed for the spring adjustment. You'll also need a stereo phone plug and a hunk of wire or cable to hook the Bencher up. You can probably get that from the other paddle you've been using.

As their ads say, the Bencher paddle features nylon and brass self-adjusting needle bearings and solid-silver contact points. What they don't say is that the unit has a nice "feel." That's up to the judgment of the user. If it makes any difference, this reviewer liked it, and I won't say that about very many keyer paddles (only three come to mind).

The Bencher paddle is manufactured by Bencher, Inc., 333 W. Lake St., Chicago, IL 60606. Price class is $40 for the steel base, $50 for chrome plus $2 shipping. Money-back guarantee. — *K1TN*

SINCLAIR CAMBRIDGE PROGRAMMABLE CALCULATOR

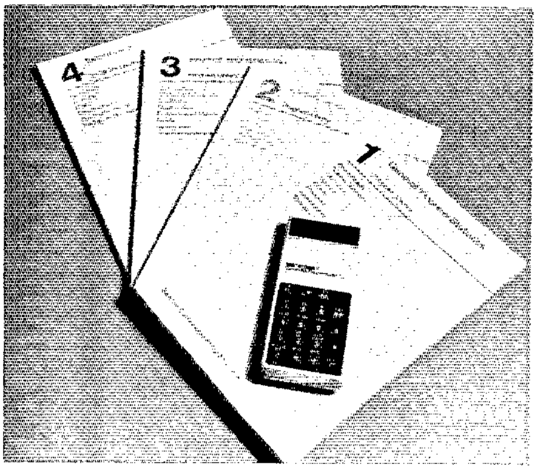
Add two variables together, take the square root of the product, multiply by twice the value of π, then take the inverse of the whole thing and multiply by 1000. Now do all of that again using 50 different sets of variables. Sound easy? Probably not, unless you are the proud owner of a programmable calculator.

Until recently, these devices were between $70 and $500 retail, making them a luxury item for most hams. The price barrier was broken, however, when Sinclair Radionics introduced their new Cambridge 35-step programmable calculator at $30!

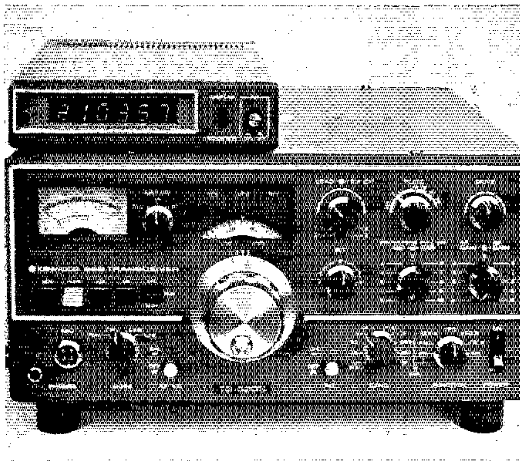
If you figured out the aforementioned problem, you probably recognized it as a form of the LC-to-frequency formula. It doesn't really contain any steps that *require* a programmable calculator to perform, but having one of these little wonders can make the task much easier. When using a programmable calculator, you first determine exactly how you want to solve the problem at hand. After you have the problem-solving steps in the proper order (as I did above, for example), the calculator is placed in the *learn* mode.

Then the problem is calculated in a manner similar to the way it would be on a standard calculator. But while you are pressing the keys, the calculator is storing the keystroke information in memory. When you are finished with the calculation, the machine is placed back in the *standard* mode of operation. Now, when you enter the necessary variables and press the *run* key, the calculator "punches the keys" for you and the problem is completed almost instantaneously!

Different sets of variables can be entered, and each time the *run* button is depressed, the calculator will spit out the appropriate answer. Neat, right? Of course, there are many differences between the Cambridge programmable and more expensive programmables, but this new Sinclair provides basic programming as well as log, algebraic and trigonometric functions, and all at an attractive price.



Shown here is the Sinclair Cambridge with optional program library. The four-book library contains equations and program steps for numerous problems.



Look closely for the differences between this Kenwood TS-520S and predecessor, the TS-520. The smaller unit is the optional DG-5 LED fr quency readout.

The Cambridge uses algebraic logic on a 19-button keyboard. Entries and answers are all displayed on an eight-digit LED display which emits a reddish-purple light. One limitation of the display is its narrow viewing field. This is caused by the use of small convex lenses inside the calculator case which are used to magnify the LED display. The result is a display that is difficult to read when the calculator is placed on a table in front of the user. Handheld use is not impaired.

Other limitations of the Cambridge include its sine, cosine and tangent functions. These calculations can only be performed on the Cambridge programmable when using numbers in the first and fourth quadrants. This doesn't actually keep you from performing any calculations, but just means that if you have obtuse angles, you have to reduce them to what this machine will handle prior to doing the trig functions. In addition, there is some loss of accuracy on tangent calculations as ±1.57 radians is approached. Also, the trig functions on the Cambridge normally operate in the radian mode, not the more common degree mode. This means that for many calculations, you must first hit the proper buttons to obtain degrees before beginning trig functions.

On the plus side, Sinclair has done considerable work on applications and software. That is to say, they have a four-volume program library containing equations, keystroke sequence, and execution of hundreds of programs. The program library, numbered volumes one through four, covers respectively general/finance/statistics, mathematics, physics/engineering, and electronics.

With all of these programs and an inexpensive, handheld programmable calculator, you could amuse yourself for quite a while — but you would still have to punch each program into the calculator. Now if they could only . . . — *K1TX*

The Sinclair Cambridge Programmable Calculator

Description: 35-step programmable calculator, algebraic notation.
Dimensions: 4-1/2 × 2 × 1 inches (114 × 51 × 25 mm) HWD.
Operating voltage: 9 volts, from transistor battery or optional ac-line adaptor.
Display: 8-digit LED (red).
Keyboard: 19 keys, with algebraic, log, trig and inverse trig functions. Tactile feedback on keyboard buttons.
Price class: $30.
Accessories: Program library (four books) at $10 for the set, or $4 each.
9-volt ac line adaptor at $5.
Manufactured by: Sinclair Radionics, Inc., Galleria; 115 E. 57th St.; New York, NY 10022; Tel. 212-355-5005.

KENWOOD TS-520S TRANSCEIVER

You're probably curious concerning what's different about the latest model of an old friend to amateur radio, the TS-520. Well, there are a number of changes found in the current "S" version of that popular gray box! This report treats the circuit alterations and improvements which occurred since the TS-520 was reviewed in *QST* for September, 1974. The general circuit and the outward appearance of the equipment remains unchanged.

Perhaps one of the most severe natural environments for amateur-equipment testing is the tropics. Because a two-week DXpedition was planned by the reviewer, his XYL (W1CKK) and ARRL Technical Secretary, Marian Anderson (WB1FSB), it seemed appropriate that the new TS-520S be taken along on holiday to the island of Antigua. With the kind permission of Trio-Kenwood, the 35-pound rig was hand-carried to that beautiful island in the Caribbean during November of 1977.

It always seems that if trouble with an amateur station is going to take place, it will happen on a field trip where repair facilities and parts are scarce. We were counting on the reliability of the TS-520S, for no spare co ponents were carried on the trip, except fo pair of 6146Bs and a 12BY7A. No tu replacements were necessary, however, nor failures of any type occur despite the hi temperatures and humidity of the tropics. T transceiver was used for two weeks on an op veranda, just 70 feet from the seashore. R and salt air reached the rig many times, but t only problem encountered was with the ke paddle (eternally dirty contacts). Operati was carried out on cw and ssb from 1.8 to MHz. Quality reports for both modes were cellent. A Curtis keyer was used during work and a late-model, Turner handh ceramic microphone was utilized wh operating ssb. The only obstacle to W1FB/VP2A operation came each eveni when the line voltage at Half Moon B dropped to approximately 95. Maximum inp power to the transmitter was frozen at watts, but performance was otherwise cellent.

Circuit Differences

These are the circuit modifications made the original '520 circuit: (1) The unit conta an audio speech processor. A pull switch on t front panel engages the processor and alters agc time constant. (2) Receiver gain has b lowered on 80 and 40 meters to red overloading problems. (3) A 20-dB rf tenuator has been added. It is actuated fr the front panel. (4) Provisions have been add (jacks on rear) for attaching an access digital readout head (DG-5). (5) The 160-m band has been added, providing ham-ba coverage from 1.8 to 30 MHz. (6) This mode ac operated, only. An accessory dc-to-dc c verter is required for mobile use. (7) A vern drive has been added to the PA tuning. (8) phone-patch jack has been added to the r apron of the transceiver. (9) An extern receiver jack is located on the rear of the ri

Provisions remain for the use of the exter Kenwood VFO and vhf transverters. T makes the '520S a practical nucleus for amateur who wishes to operate the bands fr

160 through 2 meters. The transceiver alone is ideal for mobile or portable use in combination with the separate dc-to-dc converter (DS-1A) when 12-volt dc operation is required.

Receiver dynamic-range measurements made in the ARRL lab show that the noise floor is −133 dBm, blocking (1 dB of compression) occurs at 104 dB above the noise floor and IMD is 69 dB above the noise floor, at 14 MHz. Measurements were made in accordance with the W7ZOI technique described in *QST* for July, 1975.

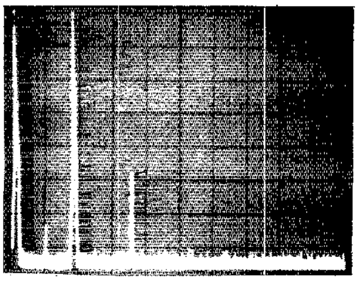
The accompanying spectral displays illustrate the level of spurious output and the transmitter IMD traits. Tests were performed in the ARRL lab by means of an HP-8553B analyzer.

Although no TVI has been observed when using the '520S in the Hartford/Newington area (channels 3, 5, 8, 18, 22, 24, 30 and 40), some incidental radiation of vhf energy was noted when "sniffing" around the cabinet with a probe. If TVI is encountered it will probably happen in TV fringe locations. A simple remedy will be to scrape the paint from mating surfaces of the cabinet, put a screen over the blower orifice, and bypass the ac line from the blower motor. We hope that Kenwood and other manufacturers of amateur equipment will pay *particular* attention to rf shielding of their cabinets in the future, because incidental rf radiation can sometimes cause more TVI than a lack of spectral purity from the transmitter. It should be noted that many brands of amateur gear need improvement in this area, with special emphasis on cabinet bonding and lead decoupling.

In the opinion of the reviewer, the TS-520S is a slick little box that can provide plenty of trouble-free operation. The competitive price should appeal to newcomers and seasoned operators, alike! — *W1FB*

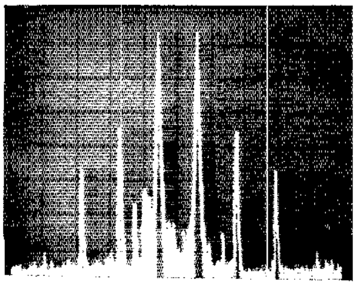
Trio-Kenwood TS-520S Transceiver

Frequency range: 1.8-to-29.7 MHz amateur bands, plus 15-MHz WWV.
Modes: Cw, usb and lsb, plus tune position.
Maximum power input: 200 W PEP for ssb, 160 W for cw.
Stability of VFO: Less than 300-Hz drift, from cold start to one hour later, at 72°F (22°C).
Selectivity at 6-dB points: 2.4 kHz for ssb, 0.5 kHz for optional cw filter.
Audio output: 1 W at 8 ohms; suitable for loads from 4 to 16 ohms.
Tubes: 12BY7A driver, two 6146A tubes in PA.
Power requirements: 117/234 V ac 50/60 Hz; 13.8-V dc operation with dc power supply accessory. Transmit, 280-W consumption.
Dimensions (HWD): 5.9 × 13.2 × 13.2 inches (150 × 335 × 335 mm). Weight, 35 pounds (16 kg).
Color: Two-tone gray with brushed aluminum.
Price class: $650.
U.S. office: Trio-Kenwood Communications Inc., 1111 W. Walnut, Compton, CA 90220.



3.5-MHz, full-power cw spectral display of the TS-520S. The tall pip at the extreme left of the photo is generated in the analyzer and represents 0 MHz. Vertical scale is 10 dB per division; horizontal 2 MHz per division.

Spectral analysis photo of the TS-520S showing the full-power, 3.5-MHz, two-tone test. Each vertical division is 10 dB and each horizontal division equals 1 kHz.



THE SPECTRUM INTERNATIONAL 1296-MHz LOOP YAGI

Perhaps the biggest problem faced by amateur Yagi builders is developing a driven element that at once provides a good match to the feed line and efficiently illuminates the rest of the array. The problem is *especially critical* at vhf and uhf. Accurate SWR indicators and antenna-test ranges are beyond the capability of many hams. Relief has been offered in the literature,[1,2] but the hours of trial and error may be more than some hams can bear. It is essential that all element lengths and spacings be held within critical tolerances to yield best performance. The quagi antenna uses a loop driven element and reflector to provide for easier matching.[3] A full-wavelength loop properly positioned in a Yagi array has a feed impedance close to 50 ohms, as opposed to the very low impedance of a rod element similarly located. This fact makes impedance-transformation devices, such as the gamma match, unnecessary in a quad or loop array. It appears that the two loops may illuminate the directors more effectively than is the case in a true Yagi, as commercial Yagis with loops replacing the original driven element and reflector measure slightly higher gain than the original antenna.

G8AZM presented the dimensions for a 34-element Yagi having loops instead of rods for the driven element and reflector, in 1971.[4] Both the G8AZM and K6YNB/N6NB designs use rod-type directors and *square* loops for the reflector and driven element.

In January, 1975, a 1296-MHz antenna was described which used *circular* loops for *all* elements.[5] This particular design had 26 elements and an aluminum-mesh reflector mounted three inches (7.6 cm) behind the loop reflector. It was manufactured commercially in England, and imported into the U.S. by Spectrum International. In 1976, the British manufacturer stopped shipping this antenna to the U.S. A partial redesign was done and Spectrum International began manufacturing the new version locally. There are two readily apparent differences between the old design and the new. The mesh reflector, which tended to act as a sail in the wind, has been eliminated. Older models of the loop Yagi were constructed on a 1/2-inch (1.3-cm) boom, while the current antennas have a 3/4-inch (1.9-cm) boom. The boom has been extended beyond the reflector to permit mounting from the rear.

Assembly

Installing 26 balky aluminum loops on the boom is somewhat time consuming, but patience is the only prerequisite for successful assembly of the loop Yagi. Connection to the driven element is through a short piece of semi-rigid coaxial line. A type N *male* connector is supplied, which mates with the feed line. The male connector at first seemed incongruous, as most antennas are supplied with female terminations. The connector turned out to be quite useful when the system was installed, as will be seen later.

Carrying the antenna up the tower resulted in a few loops being knocked out of round, but the soft aluminum was easily straightened afterward. A boom-to-mast bracket was fabricated from a piece of 1/8-inch aluminum rack panel, as none was supplied with the antenna. The bracket was intentionally made larger than required. To reduce feed-line losses, the entire 23-cm rf system, consisting of a receiving converter, receive preamp, varactor tripler and three antenna relays, was mounted immediately behind the antenna on the bracket. The male connector on the antenna mated directly to the changeover relay. No signal-wasting coaxial cable or adaptors were required. Power output from the varactor multiplier was approximately 10 watts. During the 1977 June VHF QSO Party, which was certainly not blessed with good tropo conditions, no trouble was had working W1DC/1, nearly 100 miles (165 km) away. W2CNS/3 in Delaware, about 300 miles (500 km) away, was heard, but unfortunately, not worked.

Each year, in August, the East Coast VHF Society holds an antenna gain-measuring contest on the grounds of Trenton (NJ) State College. The loop Yagi was taken to this competition, to see how it performed in comparison with other antennas. It should be noted that this was the only 1296-MHz antenna tested that was specifically designed for amateur use. The other commercial antennas were parabolic reflectors with homemade feeds. Compared with a reference horn assumed to have a gain of 15.4 dB over an isotropic source, the loop Yagi measured a gain of 16.4 dBi. For comparison purposes, a three-foot (0.92 meter) dish has a theoretical maximum gain of 19 dBi at 1296 MHz.[6] A four-foot (1.23-meter) dish with dipole-and-splasher feed tested by the reviewer had a measured gain of 18.9 dBi.[7] The theoretical maximum gain for a four-foot dish at 1296 MHz is 22 dBi. The loop Yagi appeared to perform about as well as a typical three-foot dish.

At the time of this review, the Spectrum International loop Yagi is the only commercially made antenna for 1296 MHz available in the U.S. As such, it may appeal to amateurs wishing to operate on this band but who do not wish to build their own antennas. Price class of the antenna is $55. It may be ordered from Spectrum International, Inc., Concord, MA 01742. — *W1XZ*

References

[2]McMullen, "The Line Sampler," *QST*, April, 1972. Also appears in current editions of the ARRL *VHF Manual*.

[3]Knadle, "UHF Antenna Ratiometry," *QST*, Feb., 1976.

[4]Evans, "Microwaves — 1000 MHz and Up," *Radio Communication*, Aug., 1971.

[5]Evans, "Microwaves — 1000 MHz and Up," *Radio Communication*, Jan., 1975.

[6]*Microwave Antenna System Computer*, Andrew Corp., Orland Park, IL 1974.

[7]Vilardi, "Easily Constructed Antennas for 1296 MHz," *QST*, June, 1969.

SUPERTEX INC., POWER MOSFETS

As we approach the day when power FETs replace the bipolar transistor for hefty applications, Supertex, Inc., offers an interesting line of these newer devices. A family of p- and n-channel enhancement, V-groove, power MOSFETs are available in TO-39, TO-202, TO-92 and TO-220 packages. Ratings, depending upon the device selected, range up to 60 volts at 2 amperes.

The upper frequency ratings are 900 and 700 MHz for the n- and p-channel types, respectively. A high-speed switching characteristic of four nanoseconds is typical at 1 ampere of drain current.

Significant among the features of these power FETs is that there is no thermal runaway or second-breakdown problem to contend with. Data sheets and prices are available from the manufacturer — Supertex Inc., 1225 Bordeaux Dr., Sunnyvale, CA 94086, or from ESP Co., P. O. Box 1712, Lowell, MA 01853. — *W1FB*

NEW BOOKS

The Zapping of America — Microwaves, Their Deadly Risk, and The Cover-Up, by Paul Brodeur. Published by W. W. Norton and Co., New York, 1977. Hardcover volume, 7 × 10 inches, 343 pages. Price: $11.95.

The somewhat ominous title of this book is, of course, intended to stimulate sales to environmentally conscious laymen. The hazards of microwaves are being given considerable emphasis, no doubt resulting from a series of articles in the *New Yorker*, which were expanded to form this book. A weekly CBS TV program, "60 Minutes," devoted a recent segment to this subject, and articles have appeared in many newspapers across the country. While this book was not written with the radio amateur in mind, its content is of interest to hams, especially those who operate on the vhf and microwave bands.

According to the jacket-liner notes, Brodeur, whose specialty is writing about environmental and occupational medicine, is a staff writer for the *New Yorker*. He's also published two novels and a collection of short stories. This background may bias a science-oriented reader who would prefer to see the subject covered by a more knowledgeable person. These points, in combination with the "Madison Avenue" title, may cause some skepticism. Brodeur's lack of experience in the field of electronics results in some rambling in the text and several technical errors. For example, mention is made of the proliferation of CB radios, which should not be considered as radiators of microwave energy. Later in the book, Brodeur talks about an industrial heating machine which operated at 27 MHz. The latter is alleged to have caused its operators severe medical problems. Whether it did or not, this device was not a microwave generator, and it certainly bears no resemblance to microwave equipment in current use.

Much of the book is devoted to case studies of persons injured in some way by exposure to extremely high levels of microwave energy, such as that found at commercial TV stations (tens of kilowatts). The potentially dangerous heating effects of such energy were well known before Brodeur entered the picture, so there is hardly any new information there. Frankly, the reviewer finds it difficult to believe that a technician would look into the open end of a transmission line carrying rf power. Rather than decry the hazards of microwave energy in general, as the author does, it would seem that more intelligent operating procedures are required in the microwave industries involved. While Brodeur claims that a cover-up is in progress, he was only able to turn up a handful of alleged injuries. Either his research was faulty, or the situation isn't as bad as he claims.

Who's Watching the Oven?

Microwave ovens are an unmistakable part of our vocabulary and our lifestyle. While most users may feel there is no microwave leakage from their ovens, a certain amount of leakage is allowed by the government. It would be possible to prevent all leakage only if the glass door were replaced by a solid metal shield. This would prevent the chef from watching as the meal cooked. Brodeur, and his "expert," a Dr. Zaret, seem to imply that the long-term effects of this low-level leakage could be dangerous. Zaret is an ophthalmologist, and claims some expertise in treating victims of *high-level* radiation. The distinction is important because the effects of high-level microwave radiation are quite different from those of low-level energy.

Rf energy absorbed by the body is converted to heat. Microwave energy is used for cooking and for some industrial processes because it is easier to concentrate in a small beam than rf at lower frequencies. The cooking compartment of a microwave oven functions as a tuned circuit, to stretch an analogy. If living tissue is exposed to microwave energy, the absorbed power will heat the tissue. As warm-blooded animals, our bodies have the ability to dissipate a fair amount of externally applied heat in any form, thanks to our efficient circulatory system. The maximum continuous level of microwave exposure for the whole body allowed in the U.S. corresponds to a radiation intensity of 10 mW/cm^2. Our bodies are capable of absorbing this much energy on a continuous basis without noticeable effect. In fact, if the exposure period is shorter, the level could be higher without being dangerous.

The long-term effects of high-level radiation are more severe. When the body's ability to counter the heating effect of high-level microwave radiation is exceeded, the result is a burning of tissue. The burn is no different than that from any heat source. Medical doctors and physicists at several universities have performed research in this area for many year No one to this writer's knowledge has report any danger from long-term exposure to leve at or below the American standard. In one ca where an effect was thought to exist, it w found to be as a result of a metal temperatur sensing probe inserted in the body. The prob acted to concentrate the energy, increasing i density near the probe. Brodeur is not able t provide proof of any long-term effects eithe of course. He merely hints at them.

In fact, his book constantly alludes to poss ble dangers but never proves them. His unsu ported insinuations will do little except to te rify laymen who read the book. Sever newspapers and magazines have published a ticles which relate material from the book. As result, we may expect to see environmentalis and so-called concerned citizens seeking to pr vent the expansion of microwave communic tions and industrial equipment. Thanks Brodeur's inability to differentiate betwe proton accelerators, radar, high-pow microwave sources and hf communicatio equipment, hams and CBers may find their a tivities curtailed by local citizens who are afra of being "zapped."

As an example of the myths arising fro Brodeur's work, one popular magazine recen ly published an article dealing with the boo The author of this particular article advises t readers that they are constantly being zapp by CBers. It seems that the "microwave from a CB rig may be drawn into your car your steering wheel has a metal rim, suppose ly increasing the danger! This reviewer is n aware of *any* class of CB equipment which m be termed "microwave." The attractive featu of a metal steering wheel is a new one, too might be worth investigating as an adjunct weak-signal reception!

This reviewer is tempted to go on and o citing the abundant fabrications and distc tions contained in *The Zapping of America*. would also be worthwhile to investigate t antitechnology movement in this country. Tl is a subject perhaps better left to sociologis We are left with a book which is almost total bogus, but which is being given wide publicit Worse yet, many laymen believe the book to truthful. One would hope that the journalis who ride the coattails of this book, if not t one who wrote it, will take the time to discov the truth. The research which Brodeur a Zaret claim is needed has, in fact, been dor Some of this material has been published by t U.S. Government. We are grateful to N3N who provided copies of the documents listed the references. — *W1XZ*

References

Moore, *Biological Aspects of Microwave Radiatic* U.S. Department of Health, Education and W fare, Rockville, MD, 1972.

Smith and Brown, *Radiofrequency and Microwa Radiation Levels Resulting From Man-Ma Sources in the Washington, DC Area*, U.S. Depa ment of Health, Education and Welfare, Rockvi MD, 1971.

U.S. Department of Defense and U.S. Department Health, Education and Welfare, *A Partial Inv tory Of Microwave Towers, Broadcasting Tra mitters, And Fixed Radar By States And Regio* 1971. Available from the U.S. Department Health, Education and Welfare, Rockville, M 20852. Contains a five-page appendix titled "Pot tial Biological Hazards."

Johnson and Shore, ed., *Biological Effects of Elect magnetic Waves*, in two volumes. Selected pap of the USNC/URSI annual meeting, October, 19 Also available from HEW.

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

CRYSTALS — FROM A TO X TO Y

☐ I just finished reading, "Crystals Inside Out" (January 1978 *QST*). It contains good information, but there are some points which I would like to clarify. I'll take them in the order in which they appear in the article.

Quartz is indeed the "most widely used radio crystal material," but it is just as brittle as Rochelle salt. The advantage of quartz is that it is more chemically and mechanically stable. Rochelle salt is also highly water soluble, making it difficult to work with.

Although "a tuned circuit with a high Q has very little dc resistance," it is not the dc resistance that determines Q but rather the resistive component of the impedance. Quartz has very high dc resistance.

Although crystal frequency *is* dependent on thickness, electrode configuration and the angle of cut, the *most* important consideration is the mode of vibration.

AT cuts are used almost exclusively these days. X and Y cuts have not been used for frequency control since WW II. Today, Y cuts are used for thermometers and X cuts as high-frequency transducers.

Even overtones are normally not obtainable. However, they can be driven with crystals not operating in thickness modes by using suitable electrode arrangements.

Crystals can and do operate in fundamental and overtone modes (or other unrelated modes) simultaneously, but not by design. They may also start on one or the other at random in some poor oscillator circuits.

The left diagram in Fig. 4 of the article is a picture of a clamped flexure, not a longitudinal mode.

To avoid confusion caused by incomplete information when ordering crystals, the crystal operating frequency and fundamental *or* overtone operation should be indicated. The fundamental frequency of an overtone crystal should *not* be mentioned. Too many people don't know the difference between overtone and harmonic.

Guaranteeing that an ordered crystal will be "close enough" for your purposes, by specifying the radio it is to be used in, does not always work. Crystal manufacturers cannot keep up with all the new gear being released (if they ever did). Most new gear has information in the instruction manual telling how to order the crystals, and that is the best method. If that is not available, then the *QST* article advice applies.

Temperature coefficient and temperature drift should not be used interchangeably. They are related, but different. A coefficient by definition is a ratio, X/Y. In low-drift crystals it is not a constant, so it should be used only over very short ranges. Temperature (drift) tolerance can be stated as X percent from T_1 to T_2 or in parts/million maximum deviation between T_1 and T_2 or, better yet, as the frequency tolerance in hertz at the crystal frequency and temperature range.

Finally, tourmaline (mentioned in footnote 1 of the article) is no longer used in frequency-control crystals. It is not especially strong and usually full of flaws. — *John D. Holmbeck, W9KZO, President, Northern Engineering Laboratories, 357 Beloit St., Burlington, WI 53105*

ECHOES: AN AMATEUR OBSERVATION AND A PROFESSIONAL REPLY

☐ Worked All Continents on 432 MHz was the goal during schedules I had last spring with ZE5JJ in Rhodesia. Not only did I achieve that goal, but a side benefit was observation of some long-delayed echoes on both my signals and those of ZE5JJ, which I recorded both on tape and on a chart recorder.

I usually have only a tape recorder going during EME (earth-moon-earth) work. Prior to my schedule with ZE5JJ on April 1, 1977 (not an April Fool, because I had been hearing LDEs on my signal throughout March), I ran some echo tests to be sure my system was working properly. I did hear normal (approximately 2.5-second-delayed) echoes on my signal. However, on several occasions I got two sets of echoes (2.5 and 6 seconds) and sometimes only one echo at about 6 seconds.

I quickly rigged up a time reference signal to my stereo tape machine and made a strip-chart recording. I did not have as much time to spend recording LDEs that night because my first interest was working ZE5JJ for my first African QSO.

Although I did complete a contact with Peter, things became rather confusing when I began hearing LDEs on *his* signal. When copying ZE5JJ, I was confronted with two signals sending the same data on slightly different frequencies with one slightly delayed in time from the other. To make things worse, the two signals would fade at different times and sometimes be the same strength. Needless to say, I was very confused!

ZE5JJ tells me that he heard no LDEs on his end. It is very possible that he was listening on the other side of zero beat, thus placing the LDE at zero beat or out of the passband of his receiver. Another thought (both just speculation on my part) is that LDEs are not reciprocal.

The accompanying drawing shows my set-up for recording the LDEs. The audio is routed through a narrow audio filter to enhance the signal-to-noise ratio. This also suppressed any first echo (due to different Doppler shift). I might add that my receiver is never muted. This is done to enable the pitch of the transmitted

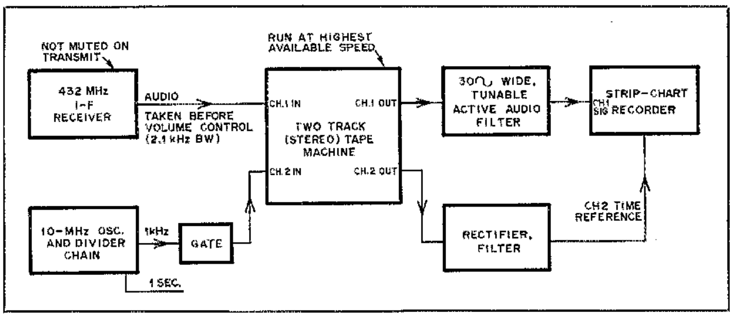
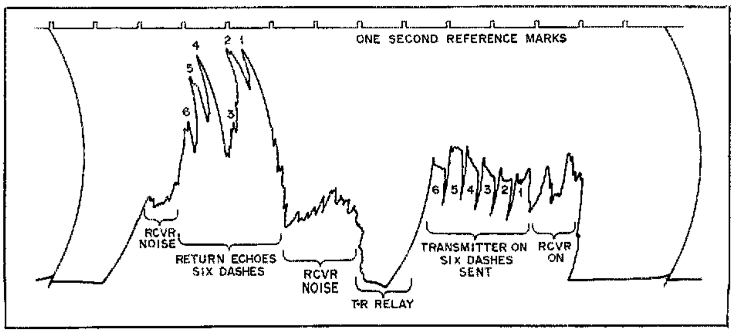


Fig. 1 — K3PGP used this setup to graphically and aurally record 432-MHz, long-delayed echoes during March and April, 1977.

Fig. 2 — K3PGP's strip-chart recording of 432-MHz, long-delayed echoes, April 1, 1977.



signal to be recorded on tape for Doppler measurements.

Although I observed LDEs on and off throughout March and April, 1977, to date no other station has reported a single LDE during those two months. However, I was spending a considerable amount of time specifically looking for LDEs. It is possible to miss LDEs entirely because of circumstances I described in reference to ZE5JJ not hearing any. I have heard no LDEs since the middle of April, 1977. — *John Yurek, K3PGP, RD 6, Box 413, Irwin, PA 15642*

— And a Reply

☐ To K3PGP: We scaled the time delay from your strip chart at 5.75 ±0.1 seconds. Since the delay for two round trips to the moon at maximum distance (406,700 km) is 5.43 seconds, we feel the echo you recorded was not likely a double moon echo.

Our computer says that for April 1, 1977, at 2320Z the one-way, 432-MHz Doppler shift was +533 Hz and the one-way time delay predicted is 1.229767 seconds for a two-way round trip value of 2132 Hz and 4.92 seconds respectively. The calculations are based on data in the *American Ephemeris and Nautical Almanac* and included the changing relative distance between the earth and moon as well as effects of the rotating earth.

We are thus at a loss to explain your "twice-delayed moon echoes" based on any known geophysical phenomena. There remain, of course, the cosmic and earth-based repeater hypotheses [February 1978 *QST* — Ed.].

By the way, the fact that the first set of echoes can disappear should not be taken as necessarily difficult to explain. As you know, lunar echoes fade a great deal in any event, owing to the roughness of the lunar surface and, at least at the lower frequencies, polarization on rotation in the ionosphere. So it does seem that it would be entirely possible for the first echo to be momentarily wiped out, while the second echo (which would very likely follow a different path) might be strongly audible.

We think it would be a good idea to publish your observations and see if any of the amateur fraternity can come up with answers or similar observations. — *Victor R. Frank, K6FV, James M. Lomasney, WA6NIL and Oswald G. Villard, Jr., W6QYT, Stanford Research Institute, Menlo Park, CA 94025*

HOW I DISCOVERED THAT THERE'S POLARITY IN ALTERNATING CURRENT

☐ High-power tube filaments and voltage regulators can be sensitive to low or high line voltage and lead length. The *Handbook* advises that in low-power applications, heater voltage may vary ±10 percent. But in high-power, filament-type tubes, the voltage should be held much more closely, with the rated voltage as a minimum and five percent above the rating as a maximum. This condition is not always easily met, and seems to be rarely considered by the designer or builder as important.

As an example, I built a 2-kW PEP, 1-kW cw amplifier of my own design using a pair of 4-400As in a parallel, grounded-grid configuration. I found that with the filament wiring permanent and the tubes in place, I had 4.5 volts at the tube socket, measured with a one-percent ac voltmeter. A pair of 4-400As requires 5 volts at 29 amperes. The filament transformer I used was government surplus, and no doubt it was conservatively rated at 5 volts center-tapped at 30 A. The line voltage measured at the transformer primary was 114 V, and the voltage drop across the filament choke and associated wiring was 0.5 V, indicating a resistance of 0.017 ohm between the filament transformer and the tube socket.

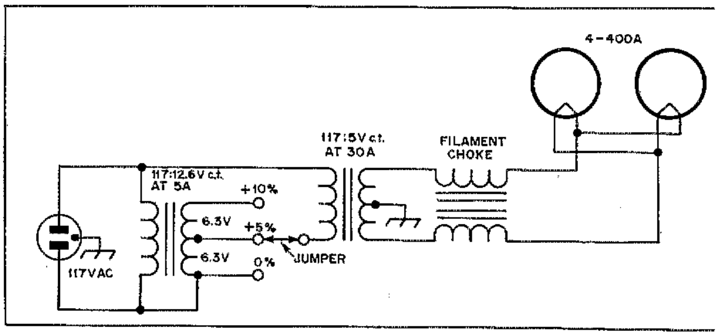


Fig. 3 — W2JDH's scheme for boosting heater voltages to high-power transmitting tubes.

A line voltage of 114 seems adequate, but my line voltage has been known to drop to 105-108 at peak load periods. This would further lower the voltage at the tube socket. Some of the less conservatively rated filament transformers available would only add to the problem.

Since I didn't anticipate line voltage in excess of 120, I incorporated the circuit in Fig. 3. That enabled me to select either (by moving a jumper) straight-through voltage, five-percent boost, or 10-percent boost, using a 12.6-V, 5-A, filament transformer. Using the 10-percent boost, my filament voltage came up to 5.1 with the tubes installed. Considering the going price for amplifier tubes, staying within the ratings should extend tube life and avoid costly replacement.

And Now, AC Polarity

Instrument transformers, widely used by electric utility companies for protecting relay schemes, are clearly marked with polarity or designations to indicate winding direction. These transformers can be hooked up in many configurations to achieve the desired result, because the winding direction and the fact that the transformer is additive or subtractive is known. There's some pretty fancy theory explaining why transformers work the way they do, using terms such as flux, counter emf and induced primary current. It should be sufficient to say there is polarity in ac, which loosely refers to current flow, because your electric meter always runs one way — in the power company's favor!

Transformers used in electronic equipment rarely indicate polarity, but hooking them up in additive or subtractive fashion can solve a number of problems encountered because of line-voltage variation or low-voltage situations. The easiest way to identify the leads coming out of your filament transformer is with an ac voltmeter and a clip-lead jumper.

As shown in Fig. 4, first measure the input or line voltage to the primary of the transformer. Apply the jumper between either primary lead and one of the secondary leads. Attach your voltmeter to the remaining primary lead. If th voltmeter reads 12.6 V (nominal) higher tha the input voltage, the hookup is additive. If it' 12.6 V lower, the configuration is subtractive Leaving the jumper on the primary lead an switching it to the *other* secondary lead wi reverse the result. Remember to move you voltmeter lead also; the voltmeter shoul always be attached to the primary and second ary lead that the jumper is *not* attached to.

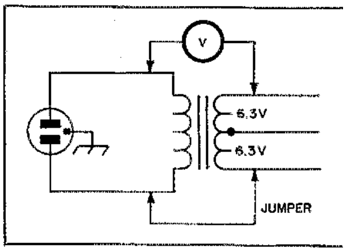


Fig. 4 — Determining whether a transformer is installed "additive" or "subtractive."

A 12.6-V filament transformer is convenien to use because its ratio is roughly 10:1, whic lends itself nicely to a 10-percent boost o "buck" application. Actually, any transforme can be used to add or subtract its primary an secondary voltage.

Fig. 3 shows a pair of 4-400As drawin about 30 A at 5 V. The primary current of th 5-V filament transformer will be in the vicinit of 1 A. Therefore, the transformer used t "boost" the line voltage should be comfort ably rated at more than 1 A at 12.6 V. I dislik hot transformers, so I used a husky 5-A 12.6-V one. The center tap conveniently pro vides a half-voltage point that may be used t "buck" or "boost" by five percent. A center tapped transformer is by no means a prereq uisite. No attempt was made in Fig. 4 t schematically indicate either winding directio or "polarity."

What you're ending up with here is actuall an extremely low-cost autotransformer wit many applications. One which comes to min would be boosting the line voltage to you television set to fill out the picture tube in low voltage areas. Others can probably think o more applications. — *Walt Peterson, W2JDH 13 Hemlock Drive, Parlin, NJ 08859*

Hints and Kinks

THE K7YY SLIDER IMPEDANCE MATCHER

Shocked that my new Kenwood TS-820 would not drive my new homemade grounded-grid amplifier ("Junker Amplifier," October 1970 *QST*), I decided to construct a slider impedance matcher to compensate for an apparently serious mismatch. Ease of tuning even when band hopping was considered essential to construction.

The junk box yielded a surplus inductor and two variable capacitors (a 500-pF unit and one rated at 220 pF). These components were to be the basic elements of the matcher.

Different circuits were tried, including the pi, L (step-up and down) and the double L. All of these worked on some portions of the bands required (20, 40 and 80 meters) but none would match the amplifier to the exciter over all of these frequencies. The pi network worked well for the 20- and 40-meter bands, plus covering 3700 kHz to 4000 kHz.

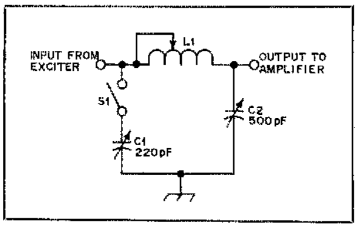
The L step-up network worked well from 3500 kHz to 3700 kHz. As a result, I decided to build the pi network with an spst switch to remove C1 from the circuit when the L network was wanted.

To house the matcher, I made a plywood box to hold the components and allow room for the slider. The base and lid were made from 3/4-inch (19-mm) plywood and the sides were made with 1/2-inch (12.7-mm) material. The lid had to have sufficient weight to cause the slider to make good contact with the coil.

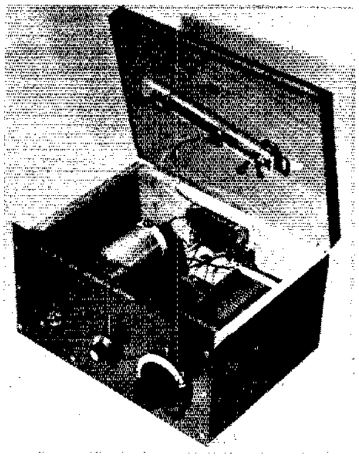
Length of the slider had to be six inches from the pivot point to the contact in order for the arc of travel of the contact point to be sufficiently shallow to make contact with the coil at all times. A space of 1-1/2 inches (38 mm) will allow for mounting the slider on the lid. Inside box dimensions are 7 × 9-1/4 × 4 inches (178 × 235 × 102 mm). The brass spring contact should be well centered over the coil.

I placed a tie point centered above the coaxial connectors at the rear of the cabinet to keep the flexible lead from dragging across the capacitors. Washers and nuts on the stove bolt provide shaft rigidity. Small bolts at the ends of the coil will prevent the slider from falling off the ends.

Setting of C2 is somewhat critical. A surplus Velvet Vernier dial is ideal for tuning the capacitor. The slider provides faster tuning than a roller. My transceiver now excites the amplifier with an SWR of never more than 1.5:1 and usually much less. I am very pleased with the performance of this matcher. — *Al Lafky, K7YY*

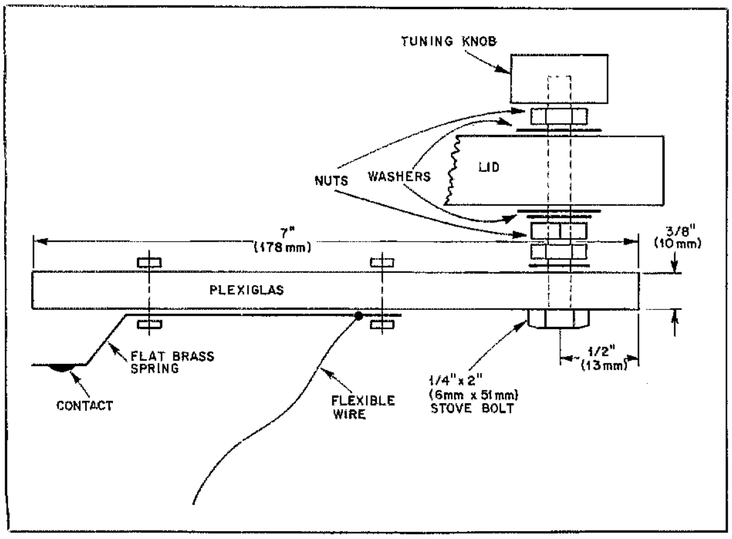


Circuit for the K7YY impedance matching system. A pi or L network may be selected with S1, an spst switch. L1 consists of approximately 32 turns of no. 14 wire on a 2-1/2-inch (63.5-mm) diameter form.



The K7YY slider impedance matcher. Attached to the lid is the Plexiglas slider assembly. C1 and C2 are controlled from the front. The switch disables C1. A knob atop the lid controls the slider.

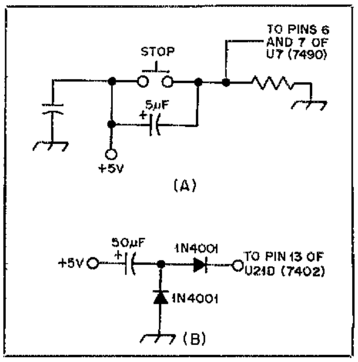
Mechanical construction of the K7YY impedance-matcher slider. Width of Plexiglas arm is 3/4 inch (19 mm).



CAPACITOR FOR THE ACCU-MEMORY

A 5-μF capacitor connected across the STOP button of the Accu-Memory will prevent the keyer from sending at random when first turned on. By adding the 50-μF capacitor and the two diodes shown in the illustration, the display will automatically set to 000 when first turned on. — *Jerry Fitch, WB4PUB*

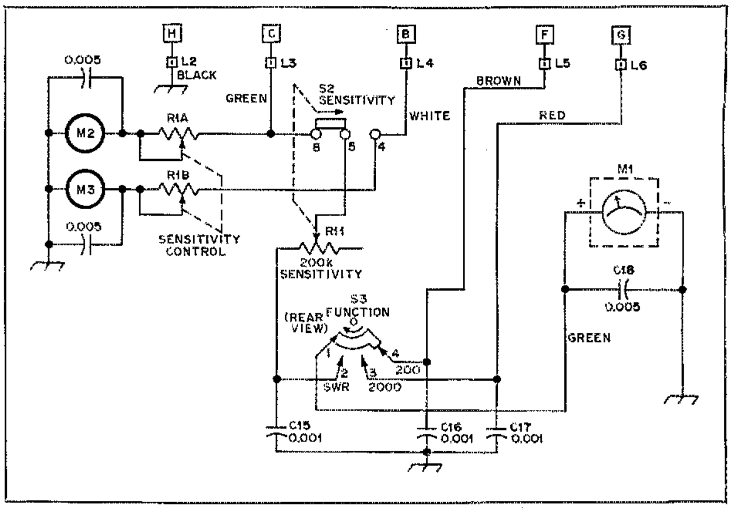
Two modifications for the Accu-Memory.



EXTRA METERS FOR THE HM-102

Adding one or, better, two indicating meters to the Heath HM-102 wattmeter/SWR bridge provides greater flexibility for the operator who likes to change frequency often. This is particularly helpful when separate antenna tuners are being used. The additional meter or meters will avoid possible misinterpretation of the SWR reading.

With two meters installed as indicated by the diagram, operation is more convenient. This arrangement permits the Heath HM-102 meter to be set in the power-output position while one of the additional meters shows forward energy and the other reflected power. The scales on the two additional meters may be hand-inked. Full-scale reference is obtained on the forward power meter. The scale on the second meter is used to indicate the SWR. A dual edgewise meter makes reading particularly convenient. Once the extra meters are put into operation, adjustment of the transmitter and antenna tuner is done quickly and easily. — *Holt Harris, W1WP*



The Heath HM-102 rf power meter can be modified as above to provide individual meters for forward and reverse energy and power output. A dual 200-kΩ potentiometer is used for R1A/R1B. M2 and M3 are combined on a dual-movement, 100-μA edgewise meter, or they may be separate 100-μA meters.

THE W3IRZ HF AND LF OSCILLATORS

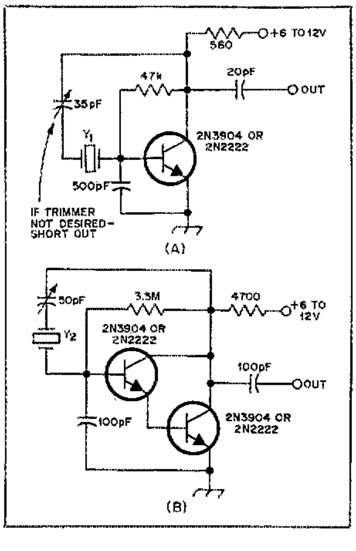
Of the two useful oscillator circuits I am submitting, the first (A) is my own "standard" universal crystal oscillator design. It provides ample output for adjusting nearby equipment on the workbench such as a GE Prog Line receiver. I even found it helpful in the final stages of building my $30 counter.

A 12-channel deck was constructed for 2-meter fm by arranging 12 of these circuits with a common 1000-ohm emitter resistor. Channel switching is accomplished in the collector circuit. My design has the output derived from the emitter resistor. Crystals may range from 3 MHz upward. I have used 7-MHz crystals on the seventh overtone by replacing the collector resistor with a tuned circuit.

The second circuit (B) is for low-frequency crystals such as those for 100 kHz and FT-241 types. A Darlington pair is employed to provide extra gain.

Notice that there are no coils or chokes in these circuits. The transistors include the common npn silicon 2N3904 and 2N2222 types. — *Mike Branca, W3IRZ*

The W3IRZ hf- and lf-oscillator circuits. Crystal frequencies for Y1 in the high-frequency oscillator (A) may range from 3 MHz upward. For the low-frequency oscillator (B) FT-241 and 100-kHz crystals may be used for Y2.



COUPLER FORMULA

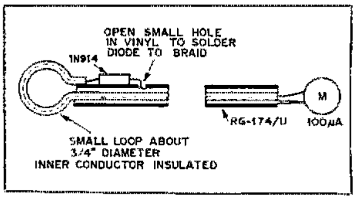
Recently, I built the Ultimate Transmatch with surplus variable capacitors and a surplus variable inductor. The unit would not operate properly on 10 and 15 meters, a condition which seemed related to incorrect and unknown capacitance values. I knew *The Radio Amateur's Handbook* offered a formula for calculating the inductance value, but I wasn't aware of any for air-variable capacitors. After some searching, I found the needed information [page 24 in any recent *Handbook* edition — *Ed.*], and I'd like to pass it on for those amateurs who may be interested:

$$C = 0.224 \frac{KA}{d} (n - 1) \text{ pF}$$

where

K = dielectric constant (air = 1.0)
A = meshed plate area (inch^2)
n = no. of plates
d = dielectric thickness (inches)

The equation, when applied to my coupler, indicated that twice the load capacitance I originally provided was necessary. The Transmatch is now working well on all bands, 80 through 10 meters. The equation saved much trial-and-error labor. — *David R. Malley, K1NYK*



For hard-to-reach places, this tuning aid is a practical device.

FOR HARD-TO-REACH LOCATIONS

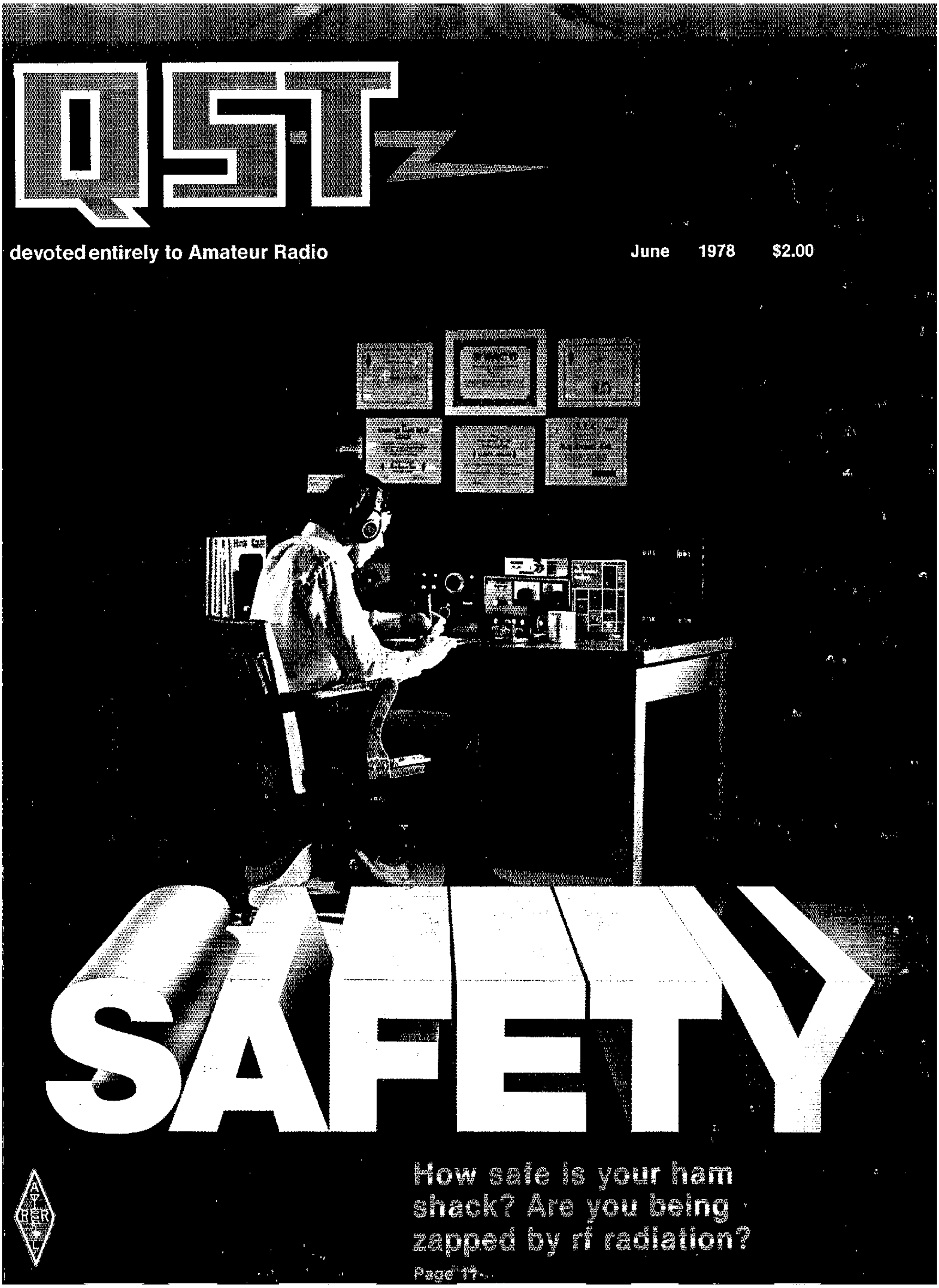
I made this useful gadget for tuning up commercial equipment on uhf. The idea was not new to me except for the way I assembled it. I used a four-foot piece of miniature coaxial cable (RG-174/U) and a 1N914 diode connected to a microammeter (0-100 μA).

It is an excellent aid for adjusting high-frequency tuned circuits in crystal oscillators and transistor multipliers. Variation of the amount of coupling controls the sharpness of the tuning indicator.

After the loop is formed as illustrated and the diode is soldered in place, wrap vinyl tape from the end of the loop, across the diode, and to a point beyond where the diode is soldered to the cable sheath. The diameter of the loop may be varied as needed. The polarity of the meter leads is determined by the polarity of the diode. — *Arnold G. Wilson, W2EVD*

HINT

☐ Need a housing for the VHF Engineering TX-144? Obtain a Calectro H4-742 chassis box made by General Cement Company. The fit is perfect. — *Emil Carver, K3MZO*


QST
devoted entirely to Amateur Radio
June 1978 $2.00
SAFETY
How safe is your ham shack? Are you being zapped by rf radiation?
Page 11
ARRL

June 1978
Volume LXII Number 6

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

A three-part series on a subject we all can stand to learn more about begins on page 11.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

How Safe Is Your Ham Shack?

Part 1: We'd all like to be safe, but often don't know how to prepare for apparent — or subtle — hazards. This series will explore the dangers to hams from radiation, chemicals and electricity, and how you can deal with them. Subject of this first part — nonionizing radiation.

By Nickolaus Leggett,* N3NL

Strong rf fields, which many amateurs encounter almost daily, can be harmful. How harmful? That has not been fully resolved, and recent media coverage of the subject has served only to alarm the public, often needlessly. A member of the IEEE's Committee on Man and Radiation (COMAR), Dr. John M. Osepchuk, recently told the U.S. Senate Committee on Commerce, Science and Transportation that the mass media have often exhibited serious misinformation and embellishments of the truth that tend to highly exaggerate the degree and nature of the hazard. The two articles that follow discuss the nature and extent of the hazards — to amateurs as well as their neighbors — of nonionizing radiation. They agree that commonsense precautions can virtually eliminate its effects.

How safe is your amateur station? No, I am not talking about how well-grounded your station is. The question here is concerned with your exposure to radio waves. Throughout the history of radio communication, most sources of radio waves were thought to be harmless (unless you foolishly touched the antenna). This view has been changing with growing concern about the health impact of radio waves, or nonionizing radiation.

The spectrum of nonionizing radiation is essentially bounded on one side by 60 Hz, the frequency of household electricity, and on the other side by optical frequencies corresponding to infrared and visible light. The chart on this page shows where the amateur bands — as well as the greatest potential hazards — lie in the wide spectrum between these limits.

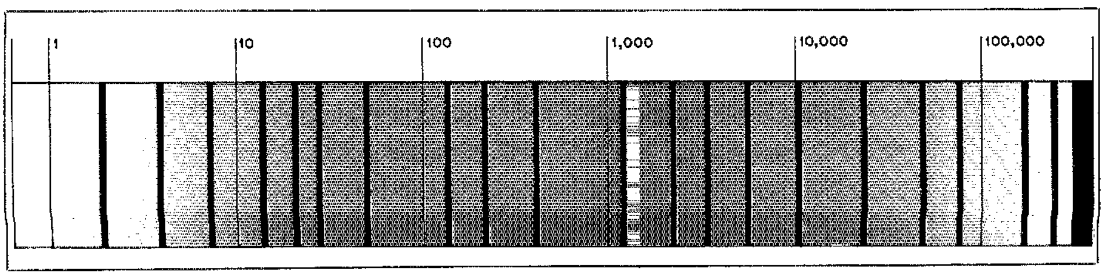
Cause of Biological Damage

The mechanism by which strong radio waves can cause biological damage is dielectric heating. In this process, the molecules of the body are agitated by the rapidly changing electric field of the radio wave. This agitation causes the body to heat up. This is the physical principle that is used in microwave ovens, most of which operate on a frequency of 2450 MHz. For this heating to be noticeable, the radio waves have to be quite strong.

The biological research community agrees that dielectric heating damage of the body can occur at power densities well above 10 milliwatts for each exposed square centimeter of surface area (10 mW/cm^2). However, there is a great controversy about possible biological effects of weaker power densities. The Soviet Union and the Eastern European Nations

*International Research and Technology Corp., 7655 Old Springhouse Rd., McLean, VA 22101

Electromagnetic spectrum, with the amateur bands designated by vertical bars. The frequency range of maximum deep heating is colored red and decreases in intensity as you go higher or lower. The actual frequency range of absorption of electromagnetic energy will also vary with body size and shape — the smaller the body, the higher the frequency. The scale is semi-logarithmic and calibrated in MHz.



report physiological and psychological effects at much weaker power densities which have not yet been widely accepted by western researchers.[1] This disagreement on the biological impact of non-ionizing radiation is reflected in the different national standards for radio wave exposure. For example, the Soviets have a standard of 0.01 mW/cm² for people who work with radio; the U.S. occupational standard[2] is 10 mW/cm².

Radio Waves in the Environment

As a result of the increasing interest in the ecological impact of radio waves, the FCC, the Bureau of Radiological Health (HEW), and the Environmental Protection Agency have made surveys of radio wave exposure. EPA has made surveys in seven cities using a mobile receiving system that sums up signal strengths over many frequency bands within the radio spectrum.[3] This system thus allows them to compute the total exposure of citizens to radio signals of many frequencies.

The total strength of the signals reaching the population as a whole is very weak. Indeed, the EPA reports[4] that for 99 percent of the urban population the total exposure is less than 0.001 mW/cm². That is, the exposure is less than one-millionth of a watt for each square centimeter of area. This is low compared to the current U.S. occupational standard of one one-hundredth of a watt for each square centimeter of area (10 mW/cm²).

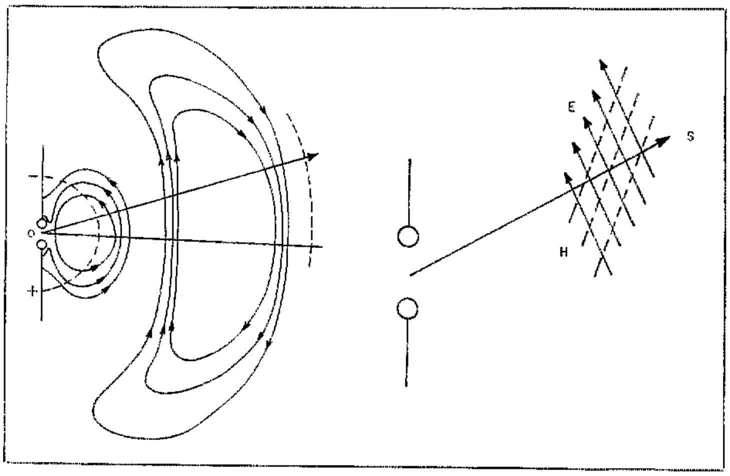
Broadcast stations (fm and TV) were found to be the most significant sources. The nearest stations contribute almost all of the ambient exposure. This is to be expected in view of the rapid weakening of radio signals with distance. Radar stations were found to be very weak sources of ambient radio frequency energy.[5] This was somewhat surprising in view of the high peak power of a radar transmitter. Two factors weaken the strength of the radar signals. Most of the time the radar set is not transmitting at all but rather, it is looking for radio echoes. When it is transmitting it is powerful but the long periods of silence reduce the *average* power to a low level.

Exposures Close to the Antenna

The above findings do not mean that all exposures to radio waves are harmless. The situation of very low signal strengths does not necessarily hold for locations that are very close to a source of radio waves. If you are very close to an operating broadcast antenna, you can receive an exposure that greatly exceeds the U.S. occupational limit[6] of 10 mW/cm². To become overexposed in this manner, generally one has to be employed in the servicing of such radio equipment.

Amateur Power Density

Obviously, an amateur radio station has a strong field in the immediate proximity of its antenna too. But the extent of the strong field is less because of the much lower output power in the amateur service. In order to examine the strength of this field, it is necessary to distinguish between the *near field* and the *far field* of an antenna.



The near-field (left) and far-field patterns around a vertical dipole are illustrated with an ac voltage applied to its terminals. Near-field power density is difficult to measure due to the disorganized field caused by components moving transversely as well as in the direction of the wave front. In the far field, power density is more easily measured since only the transverse component of either the magnetic (h) or electric field (e) is significant.

As shown in the illustration, the near field is the field close to the antenna. The approximate extent of the near field for large antennas can be found by using the simple formula:[7]

$$\text{Distance in meters} = \frac{2\,D^2}{\lambda}$$

where

D = maximum dimension of antenna in meters

λ = wavelength in meters

Using this equation for a half-wave dipole on the popular 2-meter band yields a near field radius of about one meter.

Beyond this one-meter distance is the far field of your antenna. In the far field of your antenna, the familiar inverse square law operates and the strength of the radio waves is easy to calculate. The following equation allows you to compute the power density in the far field.[8]

$$X = \frac{P \cdot G}{4\pi R^2}$$

X = power density in mW/cm² along the main beam

G = gain of the antenna expressed as a power ratio (i.e., a gain of 5 dB equals a power ratio of 3.162)

P = output power of your transmitter in milliwatts (1000 mW = 1 W)

R = distance from the antenna in centimeters (100 cm = 1 M)

Calculations of approximate far-field power densities for amateur installations are shown in Table 1. The power density is quite low in many amateur stations, but there can be situations where the power density is too high.

The situations where high power densities are involved would usually involve *very* high gain antennas with quite high transmitter output powers. Thus, operators doing high power work should review the cited references and compute their power density. If the power density reaching occupied areas is higher than about 0.5 mW/cm², the amateur should consider rearranging the system to lower the exposure. The value of 0.5 mW/cm² is chosen to match the probable, future U.S. standard for exposure of the general population to a continuously operating source.

Unfortunately, it is not easy to calculate the near field about an antenna. The near field is complex because of the interference patterns created by signals arriving from different parts of the antenna with differing phase relationships. This complexity is a great limitation because most of the biologically significant exposures will be in the near field. A

Table 1

Approximate far-field densities in milliwatts per square centimeter (mW/cm²) at a distance of 10 meters from a uhf antenna

Antenna Gain	*Transmitter CW Output Power* 10 watts	50 watts	500 watts
10 dB	0.00796	0.0398	0.398
15 dB	0.0252	0.126	1.26
18 dB	0.0502	0.251	2.51

[1]Footnotes appear on page 13.

cautious approach would be to mount your antenna so that people will not be passing through its near field. This precaution should not greatly inconvenience the uhf operator, who more than likely follows it already by mounting his antenna high and clear to get maximum DX.

References

[1]Glaser et al., "Biomedical Aspects of Radio Frequency and Microwave Radiation: A Review of Selected Soviet, East European and Western References," *Biological Effects of Electromagnetic Waves*, Vol. 1, U.S. Department of Health, Education and Welfare (Bureau of Radiological Health), Rockville, MD, December 1976.

[2]Tell and Nelson, *Calculated Field Intensities Near a High Power UHF Broadcast Installation*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, July 1974.

[3]Janes, Jr., *The EPA Environmental Radio — Frequency Radiation Program* (Electromagnetic Interference Workshop — National Bureau of Standards, July 1977).

[4]Ibid.

[5]Tell, *An Analysis of Radar Exposure in the San Francisco Area*, U.S. Environmental Protection Agency — Office of Radiation Programs (Electromagnetic Radiation Analysis Branch), Las Vegas, NV, March 1977 (Technical Note ORP/EAD-77-3), p. 8.

[6]Tell, *A Measurement of RF Field Intensities in the Immediate Vicinity of an FM Broadcast Station Antenna*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, January 1976 (Technical Note OPR/EAD-76-2).

[7]Tell, *Reference Data for Radiofrequency Emission Hazard Analysis*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, June 1972 (ORP/SID-72-3), p. 24.

[8]Ibid., p. 4.

RF Heating in the Ham Bands

By A. Peter Ruderman, Ph.D.,* VE1PZ

An amateur license is a license to transmit rf energy. When you key your transmitter you generate electromagnetic and electrostatic fields around your antenna; when you receive you are tapping the far weaker fields that started at the output of someone else's transmitter. We are immersed all the time in the very weak fields of all the transmitters in operation anywhere in the community: those of other hams, commercial stations, CBers, airport control towers, paging systems, microwave ovens and even 60-Hz power transmission lines.

Rf radiation is often referred to as nonionizing radiation in order to distinguish it from the ionizing radiation that is associated with X-ray equipment and nuclear power plants. There are important differences: Ionizing radiation, for example, can have a cumulative effect. (This is why atomic plant employees and uranium miners have a lifetime total safe dose to worry about.)

Nonionizing radiation can hurt people when it causes a buildup of heat by agitating the molecules in some part of the body. An increase of 2 degrees C in the temperature of the testicles can cause temporary sterility. An increase of 10 degrees C in the temperature of the eye can cause cataracts to form. This damage is permanent. Greater increases in temperature can be fatal by literally cooking your insides.

Normally, the effect of rf exposure is not cumulative unless tissue damage occurs, since whatever heats up can cool down. The damage caused by rf radiation depends on the amount of power, distance of the individual from the power source, amount of shielding and above all the frequency. The frequency determines how much heat will be generated in the body from a given amount of rf power. It takes only some simple commonsense precautions to protect hams from rf damage in most cases.

*Dalhousie University, Halifax, NS B3H 4H8

A Look at the Ham Bands

From 1.8-30 MHz most of the radiation passes right through you without any aftereffects. Only a small amount is converted to heat. If you consider that a 1 degree C rise in temperature is tolerable (i.e., like the low fever of a mild cold), you might have to spend an hour or more just three feet away from the feed point of an antenna radiating 500 watts of power at 8 MHz to achieve this effect.

At 144 MHz enough energy is absorbed to cause more rapid heating, and a body close to the energy source at moderate power over a prolonged period can suffer harm.

At 420 MHz about half of the rf energy is converted to heat in the body. This is probably a real danger point.

From 1000-3000 MHz the rf energy is almost completely absorbed in the body. Microwave ovens fall in this range.

At 10,000 MHz we are back to half the energy being absorbed. Still higher frequencies tend to be reflected instead of passing through, as at communication frequencies. The wavelength is such that the energy can just hit the nerve endings in the skin and provide nature's warning signal of feeling the heat.

Safety Standards

If you are operating in the 10-meter band with 1 kW of radiated power, and the operating position is 10 meters from the antenna, the power density on the operator would be about 0.8 mW/cm^2. This looks safe enough, and in fact the radiation pattern from the vertical, dipole or beam, would be such that a ham 10 meters below the feed point would be receiving less than the theoretical radiation.

Unless there were serious leaks, poor shielding, lots of rf in the shack from radiating feed lines, unbypassed leads, etc., there does not seem to be much of a problem.

2 Meters and Up

At 144 MHz and higher, the picture is quite different. First of all, more of the rf energy is converted to heat in the body. Second, although power is generally lower, a mobile antenna on the car roof is very close to the operator. And a handie-talkie wih a built-in microphone brings the operator within a couple of inches of the antenna.

If a mobile operator were transmitting with 10 watts of radiated power, and the antenna was on the left front fender, less than one meter from the driver's seat, you could easily get a power density of 10 mW/cm^2, which might be hazardous in the case of long uninterrupted transmissions. With a handie-talkie, a built-in microphone, and only one watt of radiated power, the density would be three or four times as great.

The safety precautions should be obvious. Avoid rf in the shack by using shielded or field-canceling feed lines. Use a roof-mounted antenna for mobile work in the vhf range, if possible. Avoid prolonged use of handie-talkies and use power in the milliwatt range whenever possible.

If you are sensible, and understand the frequency related nature of rf fields, you will not be at risk. I operate happily from 1.8-148 MHz myself.

Low-Noise GaAs FET UHF Preamplifiers

At last! Low-noise preamps for 432 and 1296 for about $50.

By Paul Wade,* WA2ZZF and Allen Katz,** K2UYH

Gallium-arsenide field-effect transistors (GaAs FETs) have recently come into use as low-noise microwave amplifiers. Amateur experimentation has shown that they can provide excellent performance on the uhf and lower microwave amateur bands. These devices, described in a recent article,[1] are rather expensive, particularly the ones characterized as C-band and X-band (4-12 GHz) microwave low-noise amplifiers. However, other GaAs FETs, characterized as *power amplifiers* for low and medium-power (up to 1/4 watt) microwave applications will provide almost the same noise figure at uhf and are being made available to amateurs. The power devices also have wide dynamic range, providing less intermodulation distortion and lower susceptibility to burnout. The receiver preamplifiers to be described are relatively simple to construct and have sufficient tuning range for almost any GaAs FET available.

*153 Woods Rd., Somerville, NJ 08876
**RFD 4 — Old Trenton Rd., Trenton, NJ 08691

[1]Wade, "Introduction To GaAs Field Effect Transistors," *ham radio*, January, 1978, p. 74.

Construction

These preamps for 432 MHz (Fig. 1) and 1296 MHz (Fig. 2) use power GaAs FETs made by Microwave Semiconductor Corp.; however, devices made by NEC (Nippon Electric Co.) perform at least as well, and many similar devices will also certainly work. Construction details may be seen in the photographs and schematic diagrams. The 432-MHz preamp constructed by K2UYH is built in a 2-1/4 × 1-1/2 × 1-inch (57 × 38 × 25-mm) box made of double-sided printed-circuit board. A cover plate is recommended but does not significantly affect tuning. The GaAs FET source is soldered to the central shield board with the drain lead projecting through a hole. Several other versions have been constructed; in one of these, the wire inductors are replaced by straps placed parallel to the bottom plate, and spaced approximately 1/8 inch (3 mm) above it; a typical strap dimension would be 3 inches (76.2 mm) long by 1/2-inch (13 mm) wide.

The 1296-MHz preamp built by WA2ZZF is constructed in a 2-3/4 × 2-1/8 × 1-5/8-inch (70 × 54 × 41-mm) Minibox (BUD CU-3000A or equivalent). The GaAs FET is bolted between two pieces of 1/16-inch (1.6 mm) printed-circuit board, using 0-80 screws (available at many hobby shops). The lead height is just right to sit on top of the 50-Ω lines printed on these boards. The ground connection for the tuning capacitors is provided by mounting screws and by copper foil soldered around one edge of each board. The groundplane sides of the board are smoothly tinned to reduce copper-to-aluminum corrosion.

Handling Precautions

The MSC GaAs FETs have static-resistant gold gates, and are only susceptible to damage from overvoltage or excess heating. Some other types, particularly those of Japanese manufacture, have aluminum gates which are very sensitive to static burnout, and should be handled in the same manner as unprotected MOS devices. In any case, work quickly when soldering the devices and use a grounded

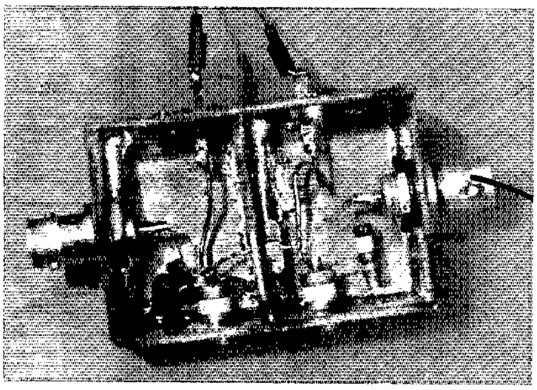


Fig. 1 — A 432-MHz GaAs FET preamplifier built by K2UYH. The transistor is mounted to the central shield by soldering the source lead directly to the copper foil. The drain lead of the transistor passes through a hole in the shield.

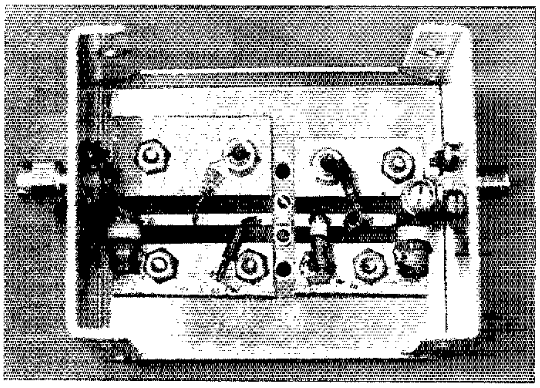


Fig. 2 — A 1296-MHz GaAs FET preamplifier built by WA2ZZF. In this model, the transistor is connected to striplines etched on glass-epoxy board. SMA-type coaxial connectors are shown, although type N or BNC connectors may be used.

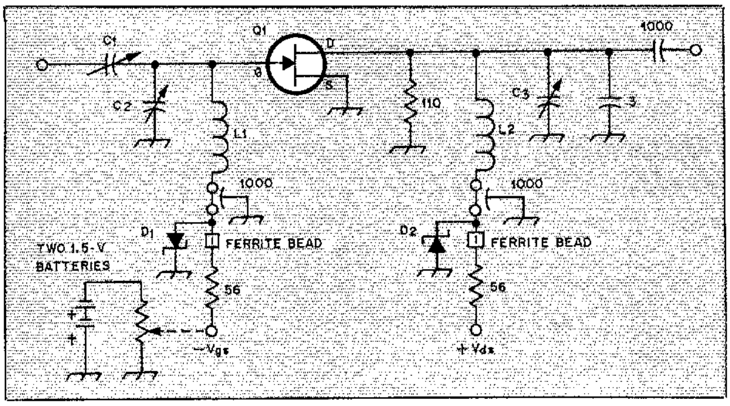


Fig. 3 — Schematic diagram of the 432-MHz preamplifier.
C1 — 0.3- to 3.5-pF piston trimmer (Johanson or JFD).
C2, C3 — 0.8- to 10-pF piston trimmer (Johanson or JFD).
D1, D2 — Zener diode, 5.6 volts (4.7 to 6.2 volts usable).
L1 — 1 turn no. 18 wire (see photo) or stripline (see text).
L2 — No. 18 wire, 0.9 inch (23 mm) long.
Q1 — GaAs FET (see text).

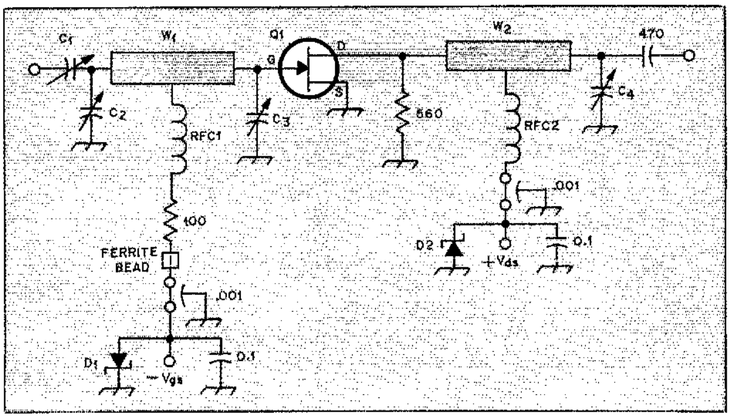


Fig. 4 — Schematic diagram of the 1296-MHz preamplifier.
C1, C2, C4 — 0.8- to 10-pF piston trimmer (Johanson or JFD). Note: C1 may be replaced by a fixed low-inductance capacitor of 10 pF or more.
C3 — 0.3- to 3.5-pF piston trimmer (Johanson or JFD).
D1, D2 — Zener diode, 5.6 V (4.7 to 6.2 V usable).
Q1 — GaAs FET (see text).
RFC1 — 3 turns, 1/16-in. (1.6 mm) ID, in lead of resistor, spaced wire diameter.
RFC2 — 5 turns no. 32 wire, 1/16-in. (1.6 mm) ID, spaced two wire diameters.
W1 — 50-Ω microstripline, 0.105 in. (2.7 mm) wide by 0.9 in. (23 mm) long on 1/16-in. (1.6 mm) thick double-sided G-10 printed-circuit board.
W2 — 50-Ω microstripline, 0.105 in. (2.7 mm) wide by 1.1-in. (28 mm) long on 1/16-in. (1.6 mm) thick double-sided G-10 printed-circuit board.

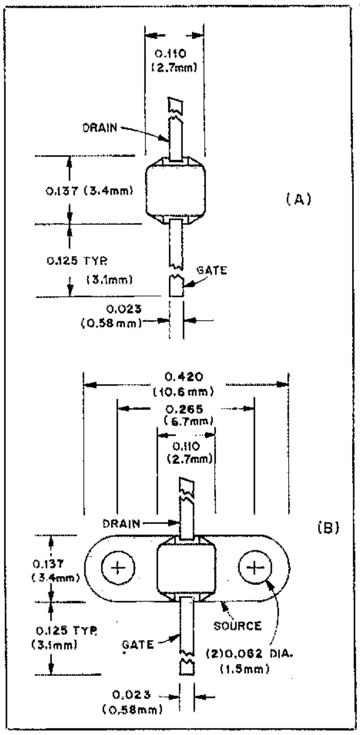


Fig. 5 — Dimensional information for the GaAs FET packages supplied by MSC. At A, case style 98, top view, and at B, top view of case style 97. Drain and source leads are spaced 0.065 inch (1.65 mm) above the bottom of the case. MSC designation for these case styles is Flipac.

or cordless soldering iron. After assembly, the Zener diodes shown should protect the device in normal operation. Of course, it should be realized that these devices are physically small and require reasonably careful handling.

Adjustment and Performance

Normal operating voltages are V_{DS} = 1.5 to 3 V, V_{GS} = −0.5 to −2 V; gate current is negligible and may be supplied from a battery. Peak the tuning capacitors on a strong signal, then trim them and adjust the drain and gate voltages with the aid of a noise-figure meter or weak-signal source. Minimum noise figure occurs near the tuning for maximum gain. Output tuning should have little effect, but the noise figure is sensitive to the input tuning and gate voltage; varying the drain voltage should give a broad peaking of noise figure. Drain current is controlled by gate voltage. After peaking up the preamp, drain current will probably be between 20 and 100 mA.

It should be emphasized that these devices have extremely high gain at uhf and will readily oscillate unless adequate precautions are taken. Stability is obtained by the use of the resistor connected *directly* from the drain to ground, at the expense of some gain reduction. The values shown should provide adequate stability if good bypassing is used; gain will be around 20 dB at 432 MHz and 15 dB at 1296 MHz. Any increase in the value of these stabilizing resistors is at your own risk!

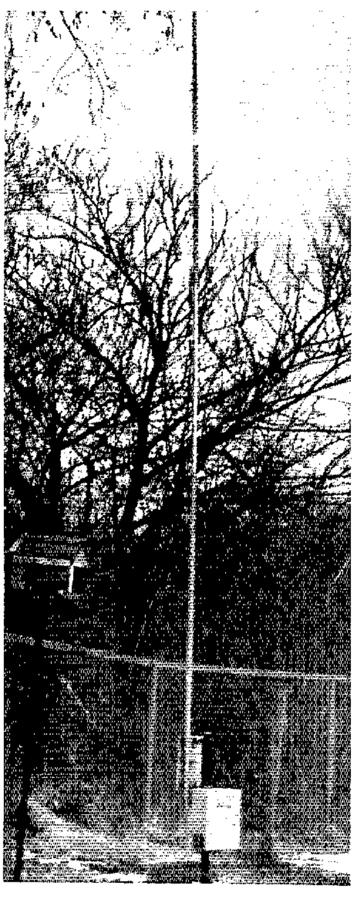
Typical noise figures to be expected with these preamps are on the order of 1 dB at 432 MHz and 3 dB or less at 1296 MHz. The devices are capable of even better performance than this; significant improvements are obtainable at 1296 MHz with attention to good uhf construction techniques and low-loss circuitry. However, the circuits shown are easily reproduced and still provide excellent performance. QST

[Editor's Note: GaAs FETs selected for amateur use are being made available to amateurs by Microwave Semiconductor Corp. at a special amateur price of $40. These devices, designated MSC H001, are available only to licensed amateurs in quantity one to 10 units. To order, send certified check or money order (no cash) payable to HAM TRANS, P. O. Box 383, South Bound Brook, NJ 08880. Be sure to include your call sign with your order. *Please do not call* about these devices since this special offer is made possible by elimination of normal administrative costs. No phone orders will be accepted.]

Build This Novice Four-Band Vertical

Basic Amateur Radio: Putting your first amateur station together can be an expensive proposition. One way to cut costs is to keep the antenna simple. Here's how I shaved the price and provided four-band operation.

By Marian Anderson,* WB1FSB



Is operation with one antenna acceptable if it covers the 80-, 40-, 15- and 10-meter bands? For a new Novice that's a reasonable approach, I decided. My backyard is smaller than that of most urban homes, so full-size dipole or inverted-V antennas were out of the question. I don't own a tower (yet!), so it seemed that a ground-mounted vertical antenna would be worth trying.

After reading the *ARRL Antenna Book*, I decided that a ground-mounted vertical antenna would be easiest to build. Some radial wires could be buried, and the metal fence which encloses the backyard could also be hooked up to enlarge the ground system. I preferred this type of antenna to one installed above ground, because radials of specific lengths for each of the four bands would have been needed for a roof-mounted, groundplane type of vertical. The buried wires for the ground-mounted antenna could be any convenient length, as long as the available space would permit. From what I have read about these antennas, I believe that reasonable performance can be had even if the ground radials aren't numerous and long, although generally the more you have, the better.

With the help of W1FB I purchased some used aluminum tubing that would telescope together and give me a 25-foot (7.62-meter) antenna. The wall thickness of the tubing is 0.058 inch (1.5 mm). Three 10-foot (3.1-m) sections are used. The largest diameter is 1 inch (25.4 mm). The center telescoping section has a diameter of 7/8 inch (22.2 mm) and the top piece of tubing has a 3/4-inch (19-mm) diameter. This material, plus hose clamps for holding the sections together, came to $8. An old ceramic rotary switch, a coaxial connector, a feed-through bushing, and a piece of Air Dux coil stock were acquired at a flea market for an additional $3. Two medium-size, ceramic standoff insulators were donated by W1FB. He said they cost him 50 cents each at a swap session. All that remained to collect was a weatherproof box for the loading coil, some 50-ohm coaxial cable and six U bolts. My OM, Bob, found some used 1-1/2-inch steel pipe (38 mm) which is 7 feet (2.13 m) long. It is used as a support for the vertical.

Constructing the Antenna

A lawn-edger tool was used to make slits in the lawn, out from the base of the antenna toward the edges of the backyard. The slits were cut to a depth of 2 inches (51 mm). A total of 10 radials were buried in the slits. Some are only 15 feet (4.57 m) in length, while others are 25 feet (7.62 m) long. The metal yard fence was bonded together as needed, using wire jumpers between the fence sections. A single buried wire joined the fence to the common ground point at the base of the antenna.

My OM drove the steel pipe into the ground to a depth of 4 feet (1.22 m), leaving 3 feet (0.91 m) above ground for attaching the vertical antenna and weatherproof box. Construction details are shown in Fig. 1.

Although a wooden box could have been used to house the loading coil, switch

*Technical Secretary, ARRL

and other hardware, I used an old electrical housing that my OM had in his junk box (Fig. 2). It was drilled and punched on the bottom surface to hold the feed-through bushing, coaxial connector, switch and ground terminal for the radials.

W1FB designed the antenna, but he wasn't sure that an acceptable impedance match could be had on all four bands without a complex matching network. We decided to try his idea, so the installation was completed.

Adjusting the Vertical

I helped my OM install the antenna, then called W1FB for some assistance in tuning the system. He thought we could tune the vertical for 40 meters and make it work okay as a 3/4-wavelength vertical on 15 meters. For use on 80 meters it would be fairly short (63 feet or 19.20 m is the correct length for 3.7 MHz). With base loading it should offer adequate service out to a few hundred miles on 80 meters. Finally, it would operate as a 3/4-wavelength vertical on 10 meters.

We hooked a homemade SWR indicator in the coaxial line at the base of the vertical.[1] A small amount of transmitter power (5 W) was applied at 3725 kHz and the 80-meter switch lead was touched on the turns of the coil until minimum reflected power was indicated (Fig. 3). An SWR of 1:1 was obtained. The wire was then soldered in place on the coil. Next we fed power to the antenna on 7125 kHz and touched the 40-meter switch lead to the coil turns until an SWR of 1:1 was read. While using the same coil tap we fed power to the antenna on 21.1 MHz and checked the SWR. It was approximately 3:1. By moving the coil tap just one turn we were able to get an SWR of 1.5:1 on 15 meters. A recheck on 40 meters followed. The SWR for that band was less than 2:1 — not a bad compromise! The coil was bypassed entirely for operation on 10 meters: An SWR of 2:1 was indicated at 28,100 kHz. The length of the overall antenna for operation on 28,100 kHz should be 25 feet or 7.62 m (3/4-wavelength radiator). However, the switch leads inside the coil housing add to the antenna length. If an SWR of less than 2:1 is desired, break the 10-meter switch lead and insert a 100-pF air variable capacitor. The unwanted reactance can be tuned out by this means and a low SWR will result.

Opening and closing the cover of the metal box had only a minor effect on the SWR. We were ready at last for an on-the-

[1] DeMaw, "A QRP Man's RF Power Meter," *QST*, June, 1973.

Fig. 1 — Dimensional drawing of the four-band Novice antenna. The top ends of the two lower tubing sections are slit four times each by means of a hack saw. This permits a tight joint when the hose clamp is compressed. The vertical is attached to one metal plate with U bolts. The large standoff insulators with metal feet connect this plate to a pair of small ones. The latter are attached to the steel support pipe by means of two U bolts. The metal box is also affixed to the steel pipe with two U bolts. The band switch is a single-pole three-position ceramic wafer type. L1 can be a 5-inch (127-mm) length of B & W 3029 Miniductor, 2-1/2 inches (64 mm) in diameter, 6 turns per inch of no. 12 wire. See text for alternative mounting methods.

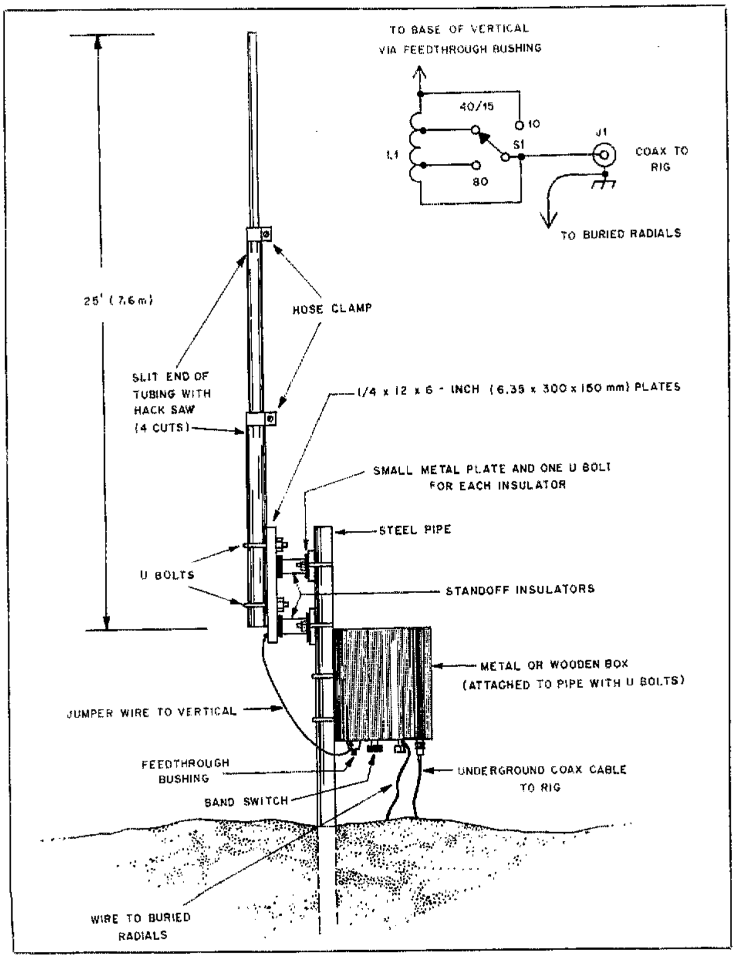
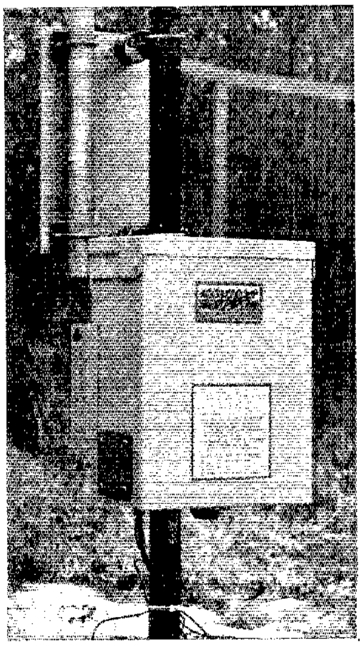


Fig. 2 — Closeup view of the base of the vertical. The aluminum tubing is affixed to a metal plate. The latter is attached to the iron support pipe by means of two surplus standoff insulators. Small aluminum plates are attached to the ends of the insulators to permit them to be fastened to the iron pipe by means of U bolts. The radial wires are connected to the bottom of the coil-housing box.



air test of the system. Fig. 4 shows the interior of the coil and switch housing.

Results

Good signal reports have been received on all bands. The first QSO on 40 meters netted an RST 599 report from North Carolina and many similar reports followed on 80, 15 and 10 meters. I feel that my WAS award is not too far away now that this antenna is in operation.

An Alternative

There are many ways you can duplicate this design using substitute materials. For example, electrical conduit with couplers between the sections should be satisfactory in place of the aluminum tubing. The entire structure could be made from 2 × 4 (50 × 100 mm) lumber. If that is done, the radiator could even be a 25-foot (7.62 m) piece of no. 10 wire, supported on the side of the wood with standoff insulators.

Instead of the mounting method shown in Fig. 1, the vertical pipe could probably be inserted into a 2-foot (0.61-m) length of PVC tubing, then clamped to the mounting plate. This would eliminate the need for the two standoff insulators. Better still, four or five wraps of Teflon sheeting (10 mil or 0.25 mm thickness) could be placed over the bottom end of the vertical before clamping it in place on the mounting plate. Teflon can be purchased at most plastic-supply houses.

Fig. 3 — The author checks the SWR of the antenna during final adjustment of the system.

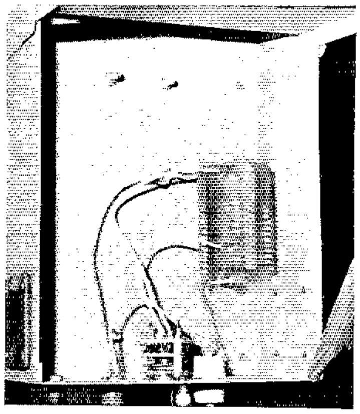


Fig. 4 — Interior view of the coil housing showing the switch, feedthrough bushing, coaxial connector, and ground post for the radials. The coil shown is a piece of Air Dux stock with a tapered pitch. It was obtained at a flea market.

I hope this idea is useful to other Novices who are trying to keep the budget within reasonable limits. I like the way my antenna is working. Others should have good luck with this antenna also. Oh, by the way, the ground radials are made from various scraps of wire. The size isn't important, and they can be insulated or bare. I have quite an assortment of wire types buried in my lawn!

Basic Antenna Concepts

Advanced antenna theory requires knowledge of some very esoteric mathematics. But the reason even many basic ideas are so hard to understand is that they are so hard to believe!

By Tony Dorbuck,* K1FM

Alf had tried everything and was at his wit's end. His shack looked like a wholesaler's warehouse with baluns, tuners, wire, and even the remains of a gigantic roll of coax scattered about the room. The coax was really annoying to Alf since it represented his latest disappointment.

"Build this small-sized, broadband, sturdy antenna," the article had said. Well, Alf did, and about all you could say was that it was sturdy, since he used no. 12 Copperweld. While the author of the article collected his royalty, and Heath sold another Cantenna (this was the main element used in the broadbanding scheme), Alf was left with another turkey to clutter his shack. The prime insult came when a ham who lived down the street said he thought his signal strength was about 20 dB under S1!

Alf went back to a commercial antenna model that seemed to work about the best for him. It was an all-band, trap, folded unipole that was *supposed* to give you 24 dB gain on all frequencies and in all directions except at the low end of 160 where the gain was specified at 23.5 dB. Even Alf was skeptical about the manufacturer's figures, but then the antenna was better than nothing. He was listening to the local roundtable net one night when he realized something he hadn't noticed before: The old Prof's signal was a lot stronger than everybody else's. But come to think about it, that's the way it always seemed.

*1650 Stanley St., New Britain, CT 06053

Someone else noticed this also, and mentioned it to the Prof. When asked what he attributed this to, the Prof said he thought it was his antenna system . . . which he said was the best he could muster under the circumstances. Needless to say, Alf was all ears. During the course of the roundtable, Alf tried as diplomatically as possible to find out what the Prof was using. "Oh nothing exciting. But why don't you come over and see it sometime."

Alf Pays a Visit

About an hour and a half later, a somewhat amused Prof found Alf knocking at his door. "Would have gotten here sooner, but I couldn't find the house right away." (Alf had driven up and down the street a number of times looking for a big antenna tower. Finally, checking the street number the Prof had given him, Alf found a dwelling that appeared much the same as the rest of those in the little university town.)

Alf was further perplexed when he was ushered into the Prof's shack. "Perhaps he's got a big amplifier somewhere," thought Alf. But there was only an ordinary-looking transceiver. "Maybe it's the tuner he's using." And then he caught sight of the homeliest looking contraption he had ever laid eyes on. Sitting on a shelf by the window was the Prof's "tuner." There were no glittering knobs or fancy components; in fact, it looked like something out of a flea-market vendor's junk box! To Alf's surprise, the Prof said that was exactly where the coils and capacitors came from.

The antenna itself consisted of a wire going out to a tree in the backyard, and a ground stake which the Prof said was for "cosmetic purposes."

"But where's your balun? Where's your radial system? And I don't see a trap anwhere? How do you get that thing to work on *all* bands and keep the *SWR below* 1:1?" cried Alf.

At the last comment, the Prof seemed to bristle a bit and Alf thought he better start listening instead of expounding his own antenna theories. After all, that was what he came for, to learn something. Before the evening was over, learn he did.

The Prof Explains

"First of all, let's clear up this confusion about SWR," said the Prof. "That's what the tuner, Transmatch, matching network, or whatever you want to call it, is for: to match an unknown antenna impedance to the nominal 50-Ω output of your transmitter. But you could just as easily cut a dipole to a half wavelength and feed it directly with either 50- or 75-Ω line. Most likely, the SWR will be low enough so that no further matching is necessary."

Alf thought about this for awhile and said, "But that's not what I saw in your yard. It looked like a long piece of wire fed at the end rather than in the middle the way you would feed a dipole"

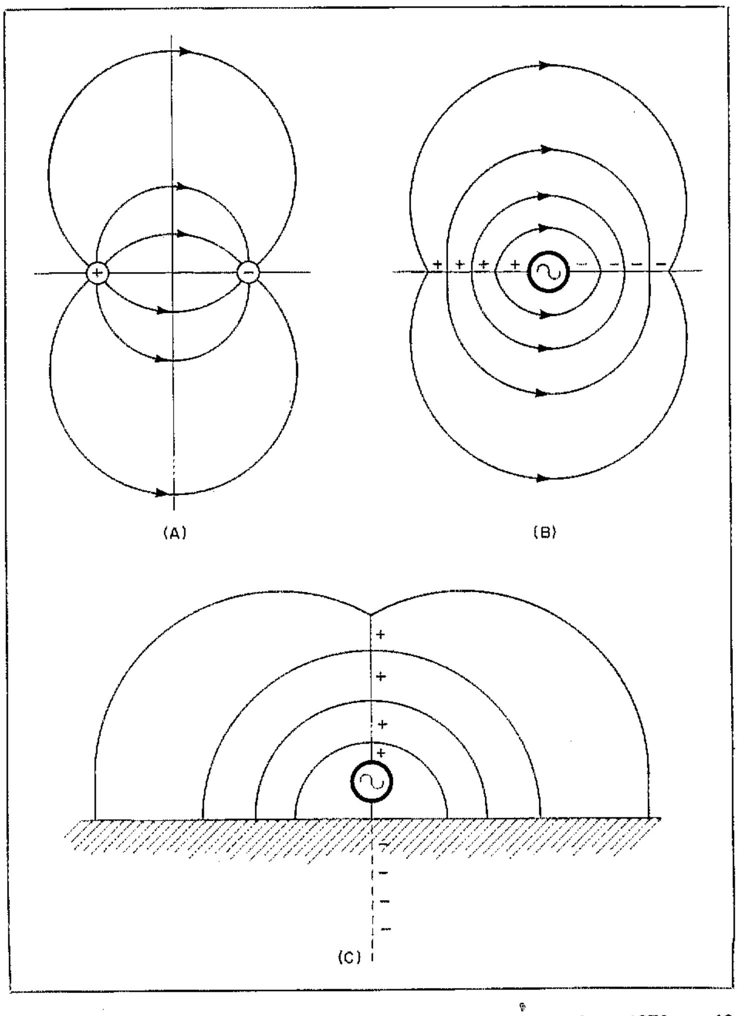
"Well, that's what I use on 75 and 40 since I don't have room for a center-fed antenna," said the Prof. "But there is almost always room for a dipole on the higher bands. I even used an indoor antenna on 20 when I lived in an apartment. Actually, what I'm using on 75 and 40 is still a dipole anyway."

Alf looked really confused and the Prof said, "All right, one question before I continue."

"Well, I thought a dipole was a center-fed wire antenna that was *always* a half-wavelength long. Yours is neither," said Alf. To help him explain, the Prof drew the sketch shown in Fig. 1.

"Actually, the term dipole has more uses than just in antenna theory," he began. "For instance, if you said 'dipole' to a chemist, he might think you were referring to a form of molecule. But it all concerns a charge configuration as I have drawn. A plus and a minus charge are arranged along a line and the field plot then appears as I have shown (Fig. 1A). This is a dipole. However, if you connected a generator to a pair of wires (Fig. 1B), you would also have approximately the same field plot. Furthermore, connecting one side of the generator to ground (Fig. 1C) still gives you a dipole field above the ground. It was just as though another wire extended below the generator forming an image of the wire above it. While this picture has to be modified somewhat in actual antenna applications, the important thing to keep in mind is that almost all simple wire antennas can be thought of as

Fig. 1 — "Dipole" fields of two point charges (A), a charged wire (B), and a charged wire over a perfectly conducting ground (C).



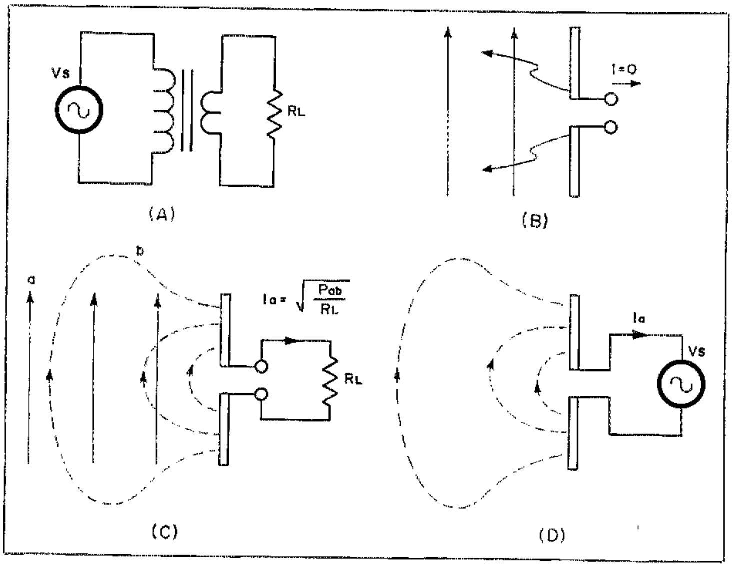


Fig. 2 — A transmitting-receiving antenna combination has many similarities to ordinary coupled circuits (A). An incident plane wave induces a voltage across the antenna terminals (B) but no power is absorbed unless a load is connected (C). However, the field produced by the current in the load is indistinguishable from one caused by an actual source (D).

some form of dipole as far as their basic operation is concerned."

The Going Gets Tougher

By this time, Alf was beginning to get a new picture of how antennas work; one that never occurred to him before. For instance, there seemed to be a lot of really significant things happening in the space *surrounding* the antenna. He had always thought of an antenna as just a collection of wires and insulators that had to be big enough to squirt out the rf energy, as water squirts out of a hose. (Well, not quite.) But one thing always bothered Alf. What part of the antenna did the most radiating? Was it the ends? Was it the middle? Someone once told him the ends of the antenna weren't important since the current there was low and you had to have current in order to get radiation. If this was so, why not cut them off and keep making the antenna shorter and shorter. Wouldn't it still work just as well?

When Alf asked the Prof this question, the Prof really dropped a bomb — he said this was true! A one-foot dipole would work almost as well on 80 meters as one that was a half-wavelength long! Alf didn't believe him, so the Prof gave him an example. "Suppose we put 100 watts of power into a half-wavelength dipole. Where does the power go?" Alf said that was easy, it gets radiated. "Well, suppose we make the antenna only half that size. We will need a good matching network in order to tune out the reactance and then match the antenna resistance to 50 Ω." Alf said that was okay; that was how he thought his mobile antenna worked. "Well, suppose we keep on making the antenna shorter."

Alf looked like a man who saw a checkmate coming in a chess game, and tried to change the subject. "By the way, Prof, did you work that new DX station that was on last night?"

"You didn't answer my question. If we made the dipole only a foot long and put 100 watts into it, where would the power go?"

"Well, it also gets radiated, I guess," said Alf very quietly. A lot of his cherished notions were going down the drain. But Alf thought he'd stump the Prof on the next one. "That's acceptable for a transmitting antenna, but a one-foot dipole sure wouldn't be very good for receiving on 80 meters," he said.

Then Alf went on to explain his concepts of receiving antennas while the Prof listened. "You know," he said, "a receiving antenna has to be long enough to catch all the power in a passing radio wave. It's just like a pond in a rainstorm. The bigger the pond, the more rain you'll catch; it's the same with antennas. The bigger the antenna area, the more power the receiving antenna is going to collect."

"That's fine, but there is *no such thing* as a receiving antenna," said the Prof.

No Receiving Antennas!

The room suddenly became very quiet. Up till now, Alf had been taking the Prof quite seriously. But now he began to have his doubts. The Prof let him think about it for awhile, before explaining what he meant with the aid of more drawings (Fig. 2).

"Suppose we put another antenna in the fields of any of the types we have discussed previously. At a great distance, the curvature of the field lines would become less and less until the wave front appeared as a series of straight lines (Fig. 2B). Assuming for the moment that no load (no receiver) was connected to the antenna terminals, some energy would be reflected from the antenna (solid jagged lines). But no power would be absorbed since the current at the antenna terminals would be zero.

"On the other hand, suppose we connected a load (Fig. 2C) across the antenna terminals. Then a current would flow and power would be absorbed (P_{ab}) by R_L. But since the current that produces this power also flows through the antenna terminals, it must set up a field just as though a power source was connected there instead of a load (Fig. 2D).

"But the problem now is how do we tell whether or not the antenna current, I_a, is caused by a source or by power being absorbed by a load. The two conditions are indistinguishable, which is why I said there is no such thing as a receiving antenna. But I might also add that there is no such thing as a *transmitting* antenna either since, as we see, we can't really tell the difference.

"Of course, this picture is oversimplified and perhaps a third diagram (Fig. 2A) will clear matters a bit. Here we have an ordinary transformer connected between a source and a load. We often talk about the primary and secondary windings, but not the sending and receiving ends of the coil configuration. We realize the source and load could be interchanged, and, provided their values were adjusted properly, the transformer could be used in the reverse direction. Transmitting and receiving antennas spaced some distance apart work in much the same manner, with one important exception. Not all the power emitted from the transmitting antenna is absorbed by the load connected to the receiving antenna. Some of it, as we saw, gets reradiated from the receiving antenna and some of it is propagated in directions other than the one where the receiving antenna is located. Of course, most of *this* energy never gets to the receiving antenna. The latter effect becomes more pronounced as the distance between the two antennas is increased, and is called the inverse-square law. This is because the ratio of power delivered to the receiving-antenna load to the power radiated from the transmitting antenna diminishes proportionately with the inverse of the square of the distance."

But What About Gain?

A lot of the questions that had always bothered Alf began to be cleared up. Not that the Prof had answered all of them, but Alf realized he had been asking the wrong ones! For instance, the actual physical size of an antenna was not as important as how well it excited the fields in the surrounding space — especially those fields responsible for the radiation of energy. In essence, the antenna merely acted as a transition or coupling probe rather than as a source of radiation directly.

Alf also began to suspect there was a great deal more to the subject of antennas than the Prof was letting on. However, he also started to realize that the Prof had a habit of getting his point across by first oversimplifying matters and considering more sophisticated factors later.

The Prof then went on to explain that the one-foot dipole probably wasn't practical on 80 meters since its radiation resistance was so low and the Q would be too high. However, he pointed out that efficient antennas became practical very rapidly for longer lengths. He didn't elaborate on how the radiation resistance was calculated or that we could tell a transmitting antenna from a receiving one just by examining the fields around it (assuming we weren't permitted to see what was connected to its terminals).

Alf was also taken to task a bit for his concern (shared by many other amateurs) for antenna bandwidth. He didn't like the idea of having to adjust a matching network or change antennas to go from one frequency to another, or even from band to band. He wanted ease and simplicity of tuning in spite of the fact that some severe technical complexities would arise, defeating his intended goal. Things got more complicated rather than easier. The Prof's philosophy was to get things straightened out on one band at a time instead of trying to tackle them all at once. This was particularly important if only limited space was available for an antenna system. The Prof said he had spent a considerable amount of time on his own antenna before he came up with one that had suitable performance. For instance, he had started out with a quarter-wavelength piece of wire, but a radial system wasn't practical. Sure, the antenna loaded up fine, but it was uncritical with regard to frequency change, which made the Prof suspicious. Sure enough, signal reports were very poor and other stations sounded rather anemic on his receiver.

Some homework and theory sessions brought out the fact that an end-fed wire that approached a half wavelength might be a better choice since the impedance was higher than a shorter version. This would offset somewhat the effect of not having a low-impedance ground system. Whatever ground resistance there was would be in series with many thousands of ohms rather than 36 ohms as in the case of a quarter-wavelength wire. This system seemed to work much better, especially since it was also possible to get a greater portion of the antenna up higher by running it over a tree.

More Surprises

The Prof and Alf enjoyed their talk and both agreed to visit again sometime. But Alf had one last lesson to learn — perhaps the most important of all. He was getting ready to leave when the Prof saw him examining the old tuner very carefully. "That looks like a very interesting gadget. The trouble is a lot of this theory business is too technical for me. Maybe if I had the exact component values and the right dimensions of your antenna system, I could build a better one too. It's one thing for you engineers to design this stuff but what about us ordinary hams?"

"There's your old habit, Alf, jumping to conclusions again. Who said anything about engineering? As I have been saying, a good bit of my antenna background came through experience over the years. Also, a lot of study at home, talking with other hams, or listening to speakers at club talks and hamfests. I doubt if any single source could teach you *all* there is to know about antennas, or any other subject for that matter. You just have to do some digging and experimenting on your own."

"But if you don't teach engineering at the college here, why do they call you Prof? I thought . . ."

"Yes, jumping to conclusions along with preconceived ideas that you then accept as fact. If the theory doesn't fit the experiment, then the *experiment* is wrong. It couldn't be that your theory is wrong or that you are applying the wrong theory. Sure, I teach at the school, but it's not exactly engineering. I've been an agriculture instructor there for the last 25 years. Perhaps you ought to pay us a visit sometime. With a name like Alfalfa, I would think you would be interested in growing things. We've developed some of the biggest pumpkins that you ever saw." Alf wondered to himself if the biggest one was between his ears at times. QST

Strays

I would like to get in touch with . . .

☐ anyone with an instruction manual or information for a Jefferson-Travis 350AT transceiver, which vaguely resembles a Hammarlund Super-Pro receiver, ca. WW II. Gene Conway, WD4OKK, 2525 Fox Hall Lane, College Park, GA 30349.

AMERICAN-ITALIAN ROUNDTABLE

☐ At the suggestion of W2NHB, the American-Italian Roundtable has been reinstituted for daily, informal meetings among Italians and Americans of Italian descent. They now meet from 1130 to 1330 UTC on 14.305 MHz. Italian is spoken most of the time, though many of the amateurs in Italy enjoy practicing their English. In fact, the group invites participation by all hams interested in contacting Italians all around Italy. AIR's present officers are (USA) Enrico Davoli, WB4GKN, president; Amilcare Persichetty, W2NHB, vice president; Vincent Persico, WB2DXE, secretary; (Italy) Carlo Camerini, I2CUK, president; Libero Massoni, I1VHQ, vice president; and Carmelo Ricosta, I8RLT, secretary.

The USA officers of the American-Italian Roundtable gathered during the ninth annual AIR dinner at the home of former QCWA President W2ALS. (Left to right) WB2DXE, WB4GKN, W2ALS and W2NHB.

A Low-Cost Dot-Memory Keyer

Ready to move up to an electronic keyer? Here's a weekend project that won't bankrupt you.

By James M. Rohler,* WBØLHE and William J. Vancura,** WB9OBB

Electronic keyers are popular home projects because they provide amateurs with a quality instrument with which to send perfect cw. The cw operator will appreciate the ease of building this keyer and take pride in designing his own enclosure and power supply. There is room for a personal touch to this project. All components for the keyer are readily available from mail-order suppliers and local electronic parts houses.

Operational Characteristics

The heart of the keyer is the 555 IC timer, thanks to its ability to operate over several decades of speed range without modification or component changes. Other clocks built from one-shot ICs or discrete components will usually only operate over a 6 to 10:1 speed range before components or timing capacitors require changing or operation fails completely. The timer in this circuit is wired in a nonstandard, inverted-output mode so that keying will be smooth and uniform, even on the first dot, with uniform spacing between characters.

The keyer has dot memory, which is particularly useful when using a single-lever paddle. The memory allows loading a dot while a dash is still being sent. Then after a space the dot will be sent perfectly. This eliminates the choppiness found in operating many nondot-memory keyers.

Dot insertion is available when using a "squeeze" paddle with the dot-memory keyer. The dot paddle will insert dots between or after dashes, even though the dash paddle is not released. Dot memory is convenient when forming characters like K, X or $\overline{BT}$. The dot is sent first when both paddles are squeezed.

The KEY-TUNE input is particularly useful, not only for tuning the rig but also for playing messages that are stored in some form of digital memory for contests or code practice. The input may also be used with a straight key or in conjunction with the dot input to simulate a mechanical "bug" key.

The Heart of the Keyer: The Clock

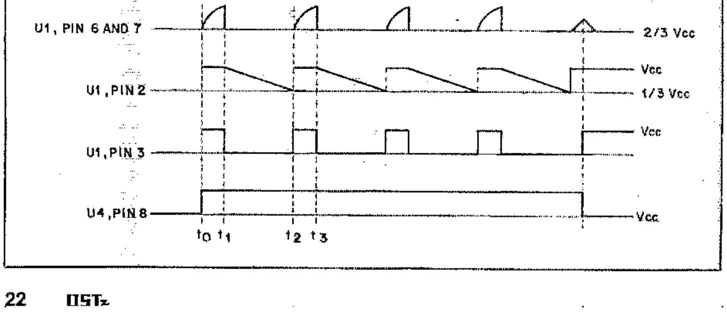
The clock is made up of the 555 timer IC and associated components. Operation of the clock can best be described by the timing diagram, Fig. 1. The actual circuit is shown in Fig. 2.

In the unkeyed state, pin 8 of U4A is in the low state. When keyed, $t = t_0$, and pin 8 goes high, quickly charging capacitor C10 through R3 until time t_1. Time t_1 occurs when the threshold, pin 6, reaches two-thirds Vcc and causes pins 3 and 7 to be pulled low and initiate two control events. First, pin 3 toggles the keyer and enables the variable time-out period $(t_2 - t_1)$, determined by R13 and C4 through D1. Second, pin 7 "resets" R3 and C10 for the next clock cycle.

The interval between t_1 and t_2 is an important timing interval, because it determines the clock speed and guarantees uniform clock pulses and character spacing. At t_1 the period $t_2 - t_1$ is governed by the time constant $R_T C4$, where R_T = R13 + R12 and by the 555, pin 2. Since D1 isolates the positive voltage on the charged capacitor, C4, from pin 3, the only discharge path is through the timing

*1967 Bristol Dr., Bettendorf, IA 52722
**4115 35th Ave., Moline, IL 61265

Fig. 1 — Timing diagram for the dot-memory keyer (see text).



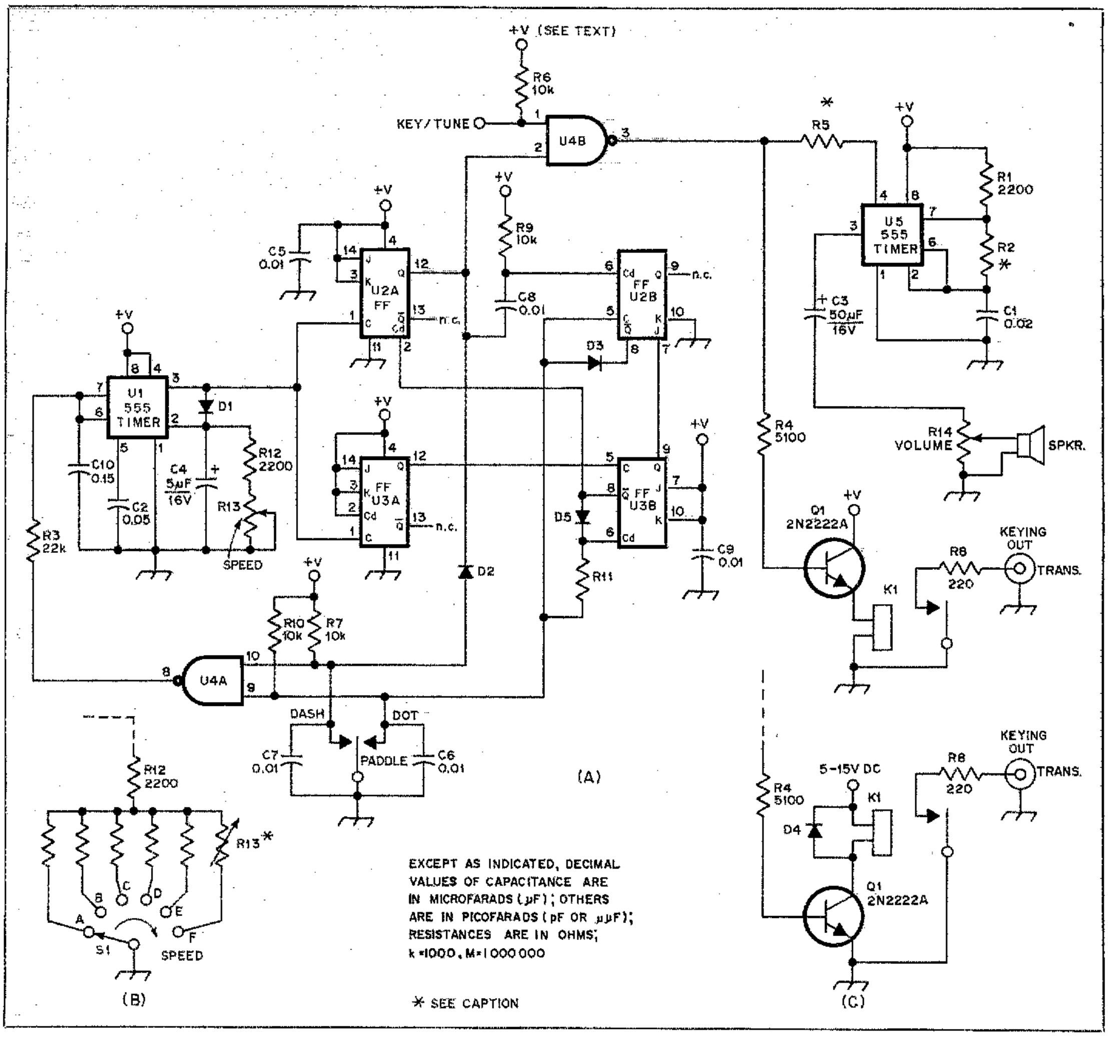


Fig. 2 — Schematic diagram of the low-cost, dot-memory keyer. Shown at B is an alternative speed-control arrangement, which may replace R12 and R13 at A. C shows the suggested circuit for reed relays requiring a higher coil voltage (see text). All resistors are 1/4 watt. Capacitors are disk ceramic except for those with polarity marked, which are electrolytic. Parts not listed below are identified on the diagram for aid in parts placement.

D1, D2, D3, D5 — 1N191, 1N4001 or any silicon diode rated at a minimum of 10 mA at 15 V.
D4 — Silicon rectifier diode, 1N4001 or equiv.
K1 — Any 5- to 12-V reed relay (see text).
LS1 — Any 8- to 40-Ω speaker.
R2 — 39 kΩ fixed, or 50 kΩ variable for tone adjustment.
R5 — 47 kΩ to 150 kΩ; see text.
R11 — 470 Ω (TTL) or 15 kΩ (CMOS).
R13 — 50 kΩ variable (reverse audio taper if available) or for option B:
R13A — 45.8 kΩ for 5 wpm.
R13B — 19.8 kΩ for 10 wpm.
R13C — 12.4 kΩ for 15 wpm.
R13D — 8920 Ω for 20 wpm.
R13E — 5300 Ω for 30 wpm.
R13F — Same as R13 above.
R14 — 1000-Ω variable, audio taper if available; linear taper suitable.
S1 — 6-position slide or rotary switch.
U1, U5 — 555 timer IC.
U2, U3 — 7473 TTL or 74C73 CMOS dual J-K flip-flop IC.
U4 — 7400 TTL or 74C00 CMOS quad 2-input NAND gate IC (2 sections unused).

resistance, R_T. Pin 2, the trigger input, sets the output of the 555 high when the capacitor voltage drops below one-third Vcc. The cycle then repeats itself after resetting of the 555 at t_2.

U5 is also a 555 timer. This is a more conventional application of the 555, making use of its capability to provide up to 200 mA of current for driving the speaker. R2, between pins 6 and 7, can be selected for the operator's preferred tone pitch or may be replaced by a pot for changing the tone at will. R5 virtually eliminates the sidetone clicking normally encountered with gated oscillators. Its optimum value will depend on the supply voltage.

Two output keying circuits are offered, the choice depending upon your approach for providing the reed relay. The circuit shown in the main diagram of Fig. 2 is particularly suitable if one winds his own reed-relay coil. By winding coil resistances of 100 to 200 ohms with fine coil wire on miniature relays, one obtains a satisfactory circuit combination. However, for those who purchase a commercial reed relay with existing coils, the rated coil voltages are usually above 5 volts. The circuit of Fig. 2C, using the common-emitter amplifier, allows any voltage reed relay which is connected to an appropriate supply voltage to be used.

The alternate timing resistor arrangement shown in B of Fig. 2 offers one set of values for a six-position stepping switch; the sixth position of the switch allows conventional analog control of the keying speeds.

Packaging

Let your imagination be your guide in packaging this keyer. The small size of integrated circuitry offers remarkable savings in package size compared to vacuum tubes or discrete components. The photo illustrates several alternate methods of packaging used by the authors. Ready-made circuit boards are available.[1]

Because the CMOS and 555 integrated timer chips can operate from between 5 and 15 volts, the power supply possibilities are varied. Operating mobile suggests use of the auto's supply. A battery pack, dc adapter, or simple dc supply are other possible power sources.

The photo also illustrates various physical enclosures. Homemade scrap aluminum and contact paper are useful items. Dry-transfer labeling adds a professional touch. Finally, placement of controls, jacks and labels is up to the individual constructor. However you do it, the result will be *you*.

[1]For those wishing to avail themselves, ready-made circuit boards are available from William Vancura, 4115 35th Ave., Moline, IL 61265. Enclose an s.a.s.e. with your request; price is $4.

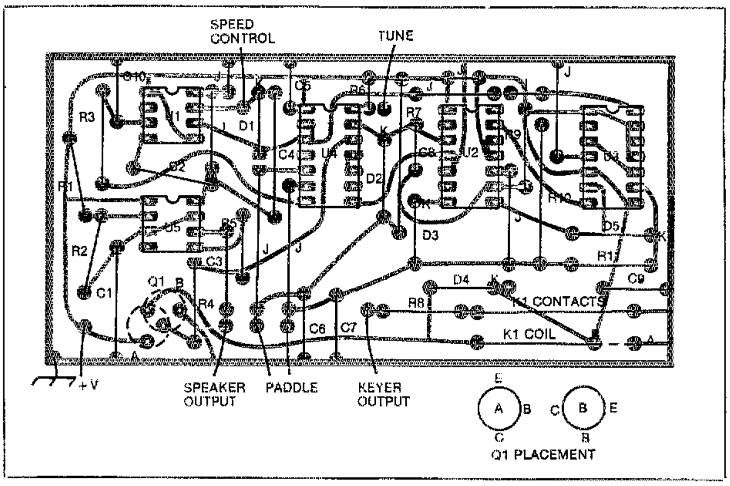
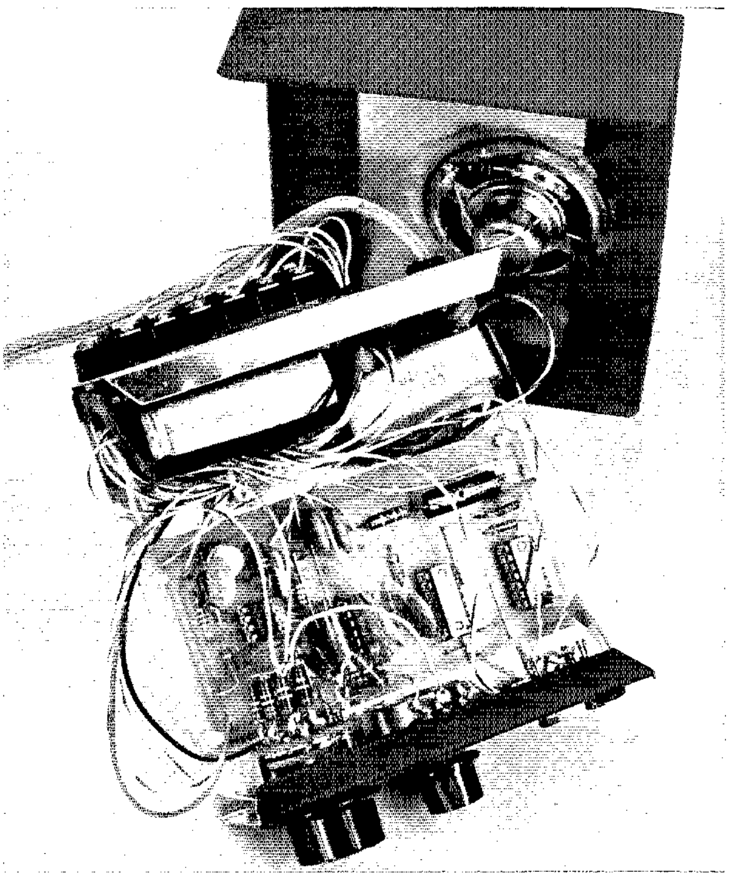


Fig. 3 — Actual size pc-board template for the dot-memory keyer. The pattern is shown from the foil side of the board, with the shaded area representing copper. J = wire jumper; K = cathode. The board pattern will accept installation of Q1 and K1 for either emitter-follower operation (A), or common-emitter amplifier operation (B). See text.

Interior view of one version of the keyer. Note that leads to the circuit board are left long, to allow the board to be lifted from the cabinet without disconnecting it.



Even if you use ready-made circuit boards, there's plenty of opportunity for originality in packaging this keyer. Here are three different versions constructed by the authors.

Transmitter Design — Emphasis on Anatomy

Part 2: A VFO by itself doesn't offer much when it comes to transmitting, so let's proceed with the physical structure of our two-band transmitter. Here is some useful information on the frequency doubler and cw break-in delay circuits.†

By Doug DeMaw,* W1FB

Perchance you're wondering why our VFO described earlier couldn't be made to operate on 14 MHz as well as on 7 MHz. Well, there's no reason why the L and C components couldn't be modified to provide two-band coverage. In such an example a band switch would be included in the VFO module for the purpose of selecting the 7- or 14-MHz coils and capacitors. The disadvantages of that scheme are at least twofold. Mechanical instability is likely to result from the switch contacts and related leads. Also, the effects of oscillator pulling are more pronounced as the operating frequency is increased. Concerning the latter, it would be a difficult task to prevent chirp during 20-meter cw work if the VFO were operated at 14 MHz.

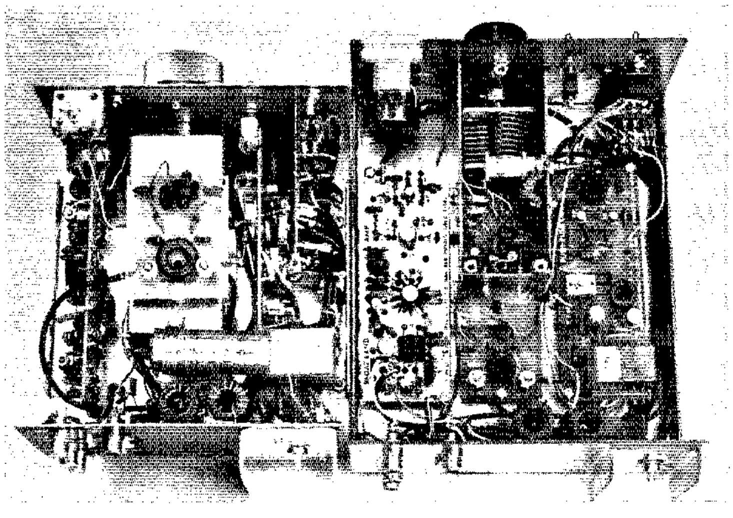
A more suitable technique at the higher operating frequencies is to employ the oscillator at one or more octaves below the desired excitation frequency, and utilize multiplication to obtain the required output frequency of the VFO chain. Through this process the mechanical instability is diminished greatly, and the frequency-multiplier stage or stages tend to isolate the oscillator from the load more effectively than would be the case with a straight-through buffer or amplifier.

Fig. 4 contains the circuit we will use for multiplication. Rather than follow the VFO chain with a single-ended frequency doubler (one transistor), we have elected to use what has long been known as a *push-push doubler.* Although the bases of the transistors are connected in push-pull by means of broadband transformer T1, the collectors are tied in parallel. In this manner the stage differs from a *push-pull* amplifier, as the latter would have the collectors as well as the bases in push-pull. A push-push amplifier favors *even* harmonics, whereas a push-pull amplifier does its best job with *odd* harmonics. Furthermore, a push-push doubler is practically as efficient as a straight-through amplifier. A single-ended doubler would exhibit a typical maximum efficiency of only 50 percent as opposed to a push-push doubler with a ball-park efficiency of 70 percent. There is no reason why a pair of JFETs couldn't be used at Q4 and Q5 of Fig. 4. If they were, however, the doubler output for this transmitter would be somewhat lower (inadequate) than with the 2N2222As we have employed.

Circuit Description

The VFO in Fig. 2 (Part 1, May *QST*) has a single-ended output terminal, so if we are to supply drive to the doubler of Fig. 4 it will be necessary to use a balun-

Interior views of the W1FB (left) and WAØUZO (right) versions of the transmitter. The push-push doubler/break-in delay module is at the far right in this photograph. The VFO and SWR-sensor modules are at the center of the WAØUZO unit, and the broadband amplifier may be seen at the left of his VFO. The PA stage is mounted on the rear wall (lower right) of each rig. The homemade heat sinks are visible on the back aprons of the enclosures.



†Part 1 appeared in *QST* for May, 1978

*Senior Technical Editor, ARRL

type transformer (T1). The energy reaching the bases of Q4 and Q5 must be of opposite phase to assure push-pull drive to the doubler. To accomplish this we have included T1, a trifilar-wound broadband transformer (three wires wound on the core at the same time). The black dots on the schematic diagram, at the top of T1, identify the phase relationship of the windings. It can be seen that one transistor base is fed 180 degrees out of phase with the other, thereby satisfying our need for push-pull drive. Forward bias is supplied to the doubler stage through the junction (C and F) of the two right-hand windings. A 0.01-μF bypass capacitor brings that point in the circuit to rf ground.

For proper operation of a frequency multiplier it is necessary to establish Class C operating conditions. The forward bias on Q4 and Q5 implies Class AB operation, but the output from the main VFO chain overrides the forward bias and drives the doubler into the Class C mode. Bias is applied only to make the doubler easier to drive.

In the interest of optimum doubler performance it is necessary to establish dynamic balance. Most discrete transistors of a given type number exhibit different electrical characteristics. In our application we are concerned mainly with any difference in transistor gain which might exist. Ideally, Q4 and Q5 should perform in an identical manner. A balancing control, R1 in Fig. 4, has been included to enable us to match the operating traits of the two devices. A 47-ohm resistor is used on each side of the control to prevent the emitters from going directly to ground if the control arm is set at either end of its range. R1 is adjusted so that the output waveform (14 MHz) is as pure as possible. If R1 is set incorrectly there will be a substantial amount of the 7-MHz driving energy present at the collectors of Q4 and Q5. The worse the imbalance, the greater the level of the 7-MHz energy.

A tuned circuit (C8 and L3) is used at the doubler output to increase the available rf output voltage. A pure waveform would be attainable if only the 1000-ohm shunting resistor was used, but the doubler output would be quite low because of the dc voltage drop across the resistor. L3 permits the full supply voltage (less the drop across the 33-ohm decoupling resistor) to reach the collectors of Q4 and Q5. Also, the 1000-ohm resistor broadens the tuned-circuit response to provide a nearly constant output level across the VFO tuning range. Fig. 5 provides the pc-board pattern and parts placement guide for the doubler and break-in delay circuits.

The Final Touches

Checkout for the doubler is an easy assignment. The VFO module is connected to points A and B of T1. A 56-ohm resistor is attached temporarily between the doubler output (to the right of the 27-pF output coupling capacitor) and ground. The 56-ohm resistor simulates the load presented by the broadband amplifier (to be described later).

A short length of hookup wire is attached to the junction of the 56-ohm resistor and the 27-pF capacitor. The opposite end of the wire is placed near the antenna terminal of a receiver which is tuned to 7 MHz. Next, operating voltage is applied to the VFO chain and doubler. R1 and C8 can now be adjusted by setting them for *minimum* signal response at 7 MHz, as noted on the receiver S meter. If an oscilloscope is available, connect the scope probe to the top of the 56-ohm load resistor and adjust R1 and C8 for the purest waveform obtainable at 14 MHz. There may be some interaction between the adjustments of R1 and C8, so the foregoing steps should be repeated two or three times to ensure premium doubler operation.

A low value of coupling capacitor (27 pF) is used to prevent the approximate 50-ohm input impedance of the broadband amplifier strip from loading C8 and L3 excessively. During 40-meter operation the push-push doubler is bypassed so that the VFO output goes directly to the broadband-amplifier module.

Break-In Delay Circuit

A cw break-in delay circuit is not an essential part of a transmitter, but it does provide an operating convenience which

Fig. 4 — Schematic diagram of the push-push doubler. Fixed-value capacitors are disk ceramic. Resistors are 1/2-W composition, except for R1 (see below).
C8 — 110-pF mica compression trimmer (Elmenco 406 suitable).
L3 — Toroidal inductor; 17 turns no. 26 enam. wire on a T50-2 powdered-iron toroid core.
R1 — Pc-board-mount carbon control.
T1 — 17 trifilar turns of no. 26 enam. wire on an FT-50-61 ferrite toroid core. Twist wires approximately eight twists per inch before winding on core.

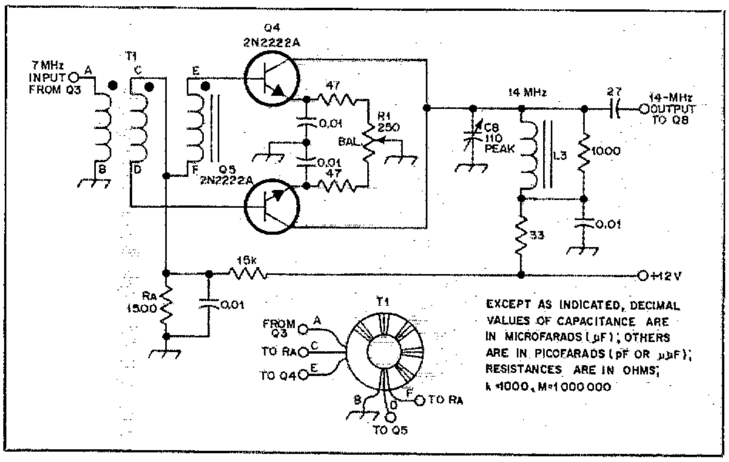
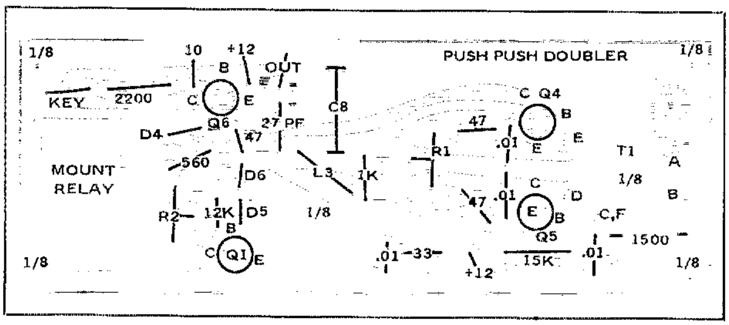


Fig. 5 — Scale layout and parts placement for the doubler/break-in delay board. View is from the component side of the board. Etching patterns for all circuit boards in this series will be published with Part 3; 1/8 indicates a 1/8-inch hole.



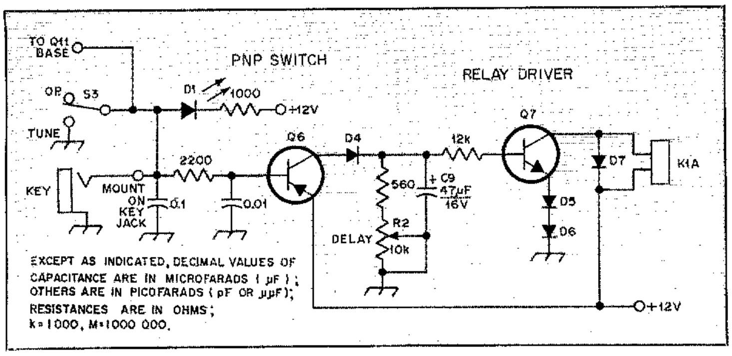


Fig. 6 — Schematic diagram of the break-in delay circuit. Disk-ceramic capacitors are used except for C9; it is electrolytic. Fixed-value resistors are 1/2-W composition. D4-D7, inclusive, are 1N914 silicon diodes. K1 is a dpdt 12-volt dc relay. A Potter & Brumfield 24-V dc relay (surplus) was used in the W1FB version of the transmitter. The spring was stretched to lessen the tension, enabling the relay to close satisfactorily at voltages as low as 11. The relay number is KHP17D12. A 12-volt version is available. Q6 is a 2N3906 or HEP715. Q7 is a 2N1711 or HEP736. R2 is a pc-board-mount carbon control.

makes it worth including. Manual switching could be used in place of the delay circuit to control the changeover relay, K1. Similarly, keying could be done by breaking the 12-volt supply to the keyed stages of the transmitter. The main advantage in utilizing a break-in delay system is that the operator has one less switch to manipulate between the transmit and receive modes. In some instances this permits faster mode changing than would be possible if mechanical switching was used.

Fig. 6 shows the break-in delay circuit. A straight key, bug or electronic keyer is connected to the input of Q6. When the circuit is completed, Q6 is effectively biased into conduction. At that time 12 volts appear at the Q6 collector to place a charge in C9. R2 is set for the desired discharge time of C9. The greater the resistance, the longer the period before C9 bleeds to ground. D4 is used in the collector lead of Q6 to serve as a one-way path for the dc voltage — a gate of sorts. This component was added after two transistors were destroyed at Q6 by a voltage peak which originated (after Q6) as the key was closed. D4 permits the +12 volts to flow into the charging network, but prevents positive-voltage transients from flowing back toward Q6.

When C9 is charged sufficiently to provide the forward bias necessary to turn on Q7, current flows through the field winding of K1, causing the relay contacts to close. As the voltage across C9 decays (key open), a point will be reached at which Q7 has insufficent forward bias to provide the collector current needed to keep K1 energized. At that time the relay will open. D7 is placed across the relay field coil to clip voltage spikes caused by the inductive "kick" when the relay field collapses. The spike, if great enough in amplitude, can travel along the 12-volt bus and damage transistors elsewhere in the transmitter. Damage could occur to Q7 as well.

The diodes in the emitter return of Q7 are used to establish approximately 1.4 volts of fixed-value bias for Q7. Depending on the transistor used as the relay driver, the resting current of Q7 may be high enough to keep K1 closed even though C9 has been nearly discharged. D5 and D6 prevent such an event from happening. The LED indicator used in parallel with the key was added by WAØUZO in his model of the transmitter, but it is not essential to the operation of the circuit. It illuminates when the key is closed, thus functioning as a *transmit* indicator (a frill).

The break-in delay module can be tested by merely applying operating voltage and shorting from the key terminal to ground. If all is as it should be, K1 will close. R2 can be set for the delay time desired. If wiring errors have been avoided, and if no defective components were used, the "Freddie syndrome" should have remained dormant so far!

Strays

TRAVELING ABROAD?

☐ The International Services Office of the Membership Services Department at Hq. is equipped to assist members in obtaining reciprocal operating permits and guest permits in more than 100 countries and territories around the world. In addition, it provides information on repeaters (vhf) in most of Europe and Latin America. If you have questions concerning amateur radio in other countries or are interested in joining the amateur societies of other nations, contact the International Services Office. They'll help you get the information you need. — *WA6IDN*

ARRL LAB ACQUIRES NEW TEST GEAR ITEM

☐ It is with deep gratitude that we acknowledge the goodwill and generosity of Trio-Kenwood Communications, Inc., and its sales manager, Barry Copeland, for the recent donation accepted by the ARRL Technical Department. Our long-standing need for a 2-meter, all-mode transceiver that could be used as laboratory test apparatus has been fulfilled by the Trio-Kenwood donation of a TS-700S. Its spectral purity makes it an ideal exciter for staff-developed 144-MHz amplifiers and higher-band transmitting converters. During off hours, the equipment is even used by the Headquarters Operators Club under our W1INF call! — *W1FB*

"WARC STATION" ON THE AIR AT 4U1ITU

☐ As mentioned in the April *QST* editorial, "Simple Equipment, and WARC," one of the operating positions at 4U1ITU in Geneva, Switzerland, is now equipped with a simple, homemade transmitter and receiver to show that it doesn't take a $1000 transceiver to enjoy amateur radio. During a February "open house" for International Telecommunication Union conference delegates, ARRL Assistant General Manager K1ZZ made the inaugural operation. Sharp-eared W1LY in Vermont was the first from this side of the Atlantic to hear the 10-watt rig. In the effort, he also earned a new DXCC country! Parts kits for the transmitter and receiver are being made available in less-developed countries to give amateurs and prospective hams there a way to get on the air at reasonable cost.

K1ZZ sends the first transmission from an operating position at 4U1ITU that uses simple, efficient, minimum-parts equipment. *(W4KFC photo)*

Predicting Radio Horizons at VHF

Knowing the line-of-sight horizon of your proposed repeater antenna as well as your station's own aerial can help you predict coverage before you pour the foundation.

By Billy Walker,* W5GFE

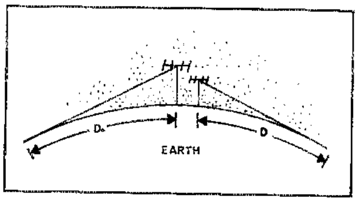
On vhf, the higher your antenna the greater the range, other factors being constant. Antenna height is *the* single most important factor, as all amateurs know. But, just how high do we need to place an antenna to produce a specified coverage area? This article covers a few of the many factors involved in answering this rather complicated question.

Obviously, a given station can have 100-percent reliable communication over paths that provide line of sight between the transmitting and receiving antennas. Although this is an *ideal* case, let us use it for an example.

Referring to Fig. 1, we observe that the line-of-sight distance, the distance to the horizon, from an antenna varies with the height of that antenna above ground. The distance (D) is measured along the ground from the base of the antenna support to the horizon. Using trigonometry, it is not difficult to solve for D in terms of the antenna height above ground. Of course, the shape of the earth enters heavily into the picture. For instance, if the transmitting antenna is located on the side of a mountain, the antenna functions better in one direction than in another because of the shielding effect of the mountain. For the sake of simplicity, we have assumed that the earth is conveniently round and, according to Webster, has a mean radius of 3959 miles (6371 km). We are also ignoring, for the sake of this discussion, obstructions such as hills and valleys.

*Dept. of Computer Information Systems, West Texas State University, Canyon, TX 79015.

Fig. 1 — Definition of line-of-sight distance (D).



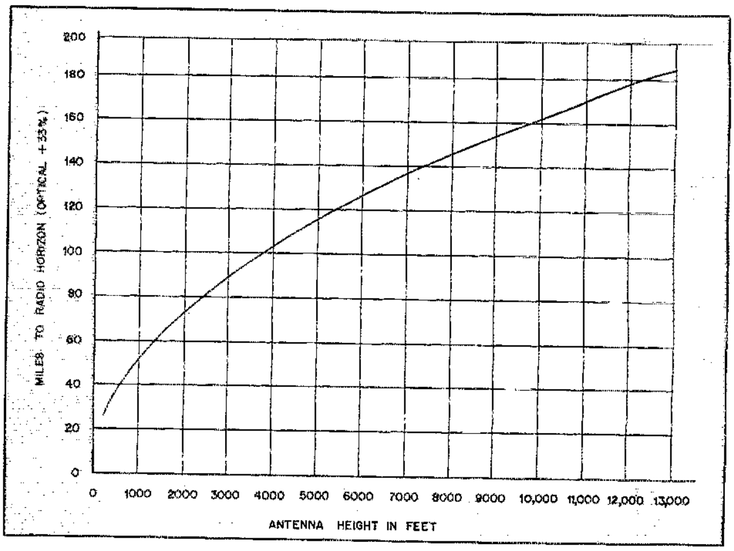
Computerized Optical Horizons

With these assumptions in mind, a DEC-10 computer was programmed to calculate the distance that a station with a given antenna height could "see." That is, to calculate the distance from the base of the antenna support to the optical horizon for the antenna. Fig. 2 provides a graph of these calculations, and is most informative. Fig. 2 reflects the computer-generated optical horizon and includes a factor of 33 percent additional distance, since radio waves tend to refract about that much more than light waves.

One first observes that the graph is not a straight line, but rather a curve which rises quite rapidly at first, tending to level off at greater antenna heights. Of course, the curve does not become flat at any practical antenna height but the tendency is obvious.

Fig. 2 was calculated with the repeater station in mind. Since repeaters are traditionally located at the best antenna location that can be arranged, the figures are reasonable for this application. For instance, a repeater located at an effective height of 500 feet (152 m) could expect an optical horizon of about 27 miles (43 km),

Fig. 2 — Miles to radio horizon for various antenna heights.



and a radio horizon of 36 miles (58 km). Height advantage falls off rapidly, however, and in order to double this coverage the antenna would have to be almost four times as high, or 2000 feet (610 m).

"But," you say, "I live more than 20 miles (32 km) from the repeater, and the repeater height is 250 feet (76 m) yet I can work it consistently. The graph says it is beyond my line of sight. Is that where the 33 percent factor comes in?"

The answer is yes, but the height of *your* antenna must also be considered. By referring to Table 1 you can calculate your own optical horizon. For instance, your 50-foot tower gives you an optical horizon of about 8.7 miles (14.0 km). This added to the repeater horizon of 19.4 miles (31.2 km) gives about 28-mile (45.1-km) actual line-of-sight coverage between your antenna and the repeater — that's more like it.

Finally, although your *mobile* antenna isn't at any 50 feet (15 m), you get greater coverage than expected because its effective height is probably about five feet (1.5 m). Thus, Table 1 shows that your mobile optical horizon is about 2.7 miles (4.3 km) which, when added to the repeater's horizon, yields 22.1-mile (35.6-km) coverage (29.5 miles or 47.4 km for radio waves). That's within our experience.

The Effect of Radio Wave Diffraction

Returning to that 33-percent factor, it is a result of a phenomenon known as diffraction. Essentially, this can be explained by mentioning that radio waves, like all electromagnetic waves, bend around solid objects (of which the earth is one). That is, waves encountering an obstacle will bend as they pass the edge of the obstacle, thus causing energy to appear in the shadow of the object. This may be seen in the behavior of light waves by placing a pinhole in a piece of cardboard and then looking at a distant light through the pinhole. There will appear to be concentric circles of light surrounding the pinhole. These circles are caused by light waves being bent at the edges of the pinhole, and then combining with other waves to produce patterns of bright circles where the various light rays happen to combine in such a way as to reinforce each other. This process is known as "interference."

One other factor must be kept in mind, a factor which makes the accompanying coverage calculations somewhat conservative. Most repeater antennas are configured so as to increase the amount of bending of the transmitted signal, further extending our range beyond the optical horizon.

The tables can be used to determine the necessary HAAT (height above average terrain) to employ when a given coverage is desired. If your friend Joe lives in the next town, which in Texas means up to 100 miles (161 km) away, you might want to devise an antenna system that will let you and Joe converse consistently. For instance, assume Joe lives about 80 miles (129 km) away. This distance may be covered in any of several ways. You can install a tower of sufficient height to cover the whole distance, like Superman, in a single bound. In this case, your antenna would have to be about 4500 feet (1372 m) in the air, considering optical horizons only, for line-of-sight communications. However, if Joe is willing to throw away his coat hanger and put up a real antenna, you can do better.

Junk Box Oil Derricks

Suppose Joe has an oil derrick in his junk box or lives on a mountain and can get his antenna 2500 feet (762 m) above the surrounding terrain. His optical horizon would be 61 miles (98 km); then *you* only need an antenna 250 feet (76.2 m) high for 100-percent communications. Note the total tower height is now only 2750 feet (838 m) compared with 4500 (1372 m) using the Superman approach.

As a more realistic example, consider two stations only 10 miles apart; Table 1 indicates a tower height of 65 feet (20 m) for the Superman approach, but if each station puts up a 20-foot (6.1-m) tower the distance can be covered with a total tower height of only 40 feet (12.2 m). The economics are obvious.

Remembering that factors such as antenna gain and pattern and atmospheric refraction add to the optical-horizon figures, one can estimate coverage for a given system using the optical-horizon information contained here. Computer studies of diffraction have been made on the DEC-10 computer, and work is continuing along these lines. In the meantime, this article should provide a working basis for those hams who want to determine conservatively their station capabilities and predict repeater coverage for that new machine. QST

Table 1

Optical horizons for antennas less than 100 ft high.

Height of Antenna		*Distance to Horizon*	
Feet	*Meters*	*Miles*	*Kilometers*
0	0.0	0.0	0.00
5	1.5	2.7	4.40
10	3.0	3.9	6.22
15	4.6	4.7	7.62
20	6.1	5.5	8.80
25	7.6	6.1	9.84
30	9.1	6.7	10.78
35	10.7	7.2	11.67
40	12.2	7.7	12.47
45	13.7	8.2	13.22
50	15.2	8.7	13.93
55	16.8	9.1	14.61
60	18.3	9.5	15.26
65	19.8	9.9	15.88
70	21.3	10.2	16.48
75	22.9	10.6	17.06
80	24.4	10.9	17.62
85	25.9	11.3	18.17
90	27.4	11.6	18.70
95	29.0	11.9	19.21
100	30.5	12.2	19.71

Strays

FIELD DAY IN KL7-LAND

☐ In a mosquito-infested clearing 61 miles north of Anchorage, the Matanuska Amateur Radio Association discovered the essence of Field Day in our first effort last year. We logged 175 contacts under emergency conditions, but Murphy struck time and again.

Being a new club, we all made sure the rig, beam and generator arrived safely. An inventory of our other supplies, however, revealed only three dozen hot dogs, one case of soda pop, 12 cans of insect repellent, and two rolls of Charmin.

After setting up KL7ILA's rig, we discovered the key had forgotten to come along. KL7MD homebrewed a combination soda-can-and-nail keyer, which really puzzled the operators on the other end.

Next, the generator fuel tank sprang a leak. We quickly borrowed a windshield-wiper solvent tank from KL7DOB's car and some hoses from the other vehicles to make a temporary fix. This worked fine except for the film of oil on our windshields.

All in all, we came through the whole exercise with a knowledge of abilities we didn't know we possessed. — *Bob Rivenburgh, KL7JCK*

It looks peaceful enough, but Murphy was to make our first Field Day one to remember!

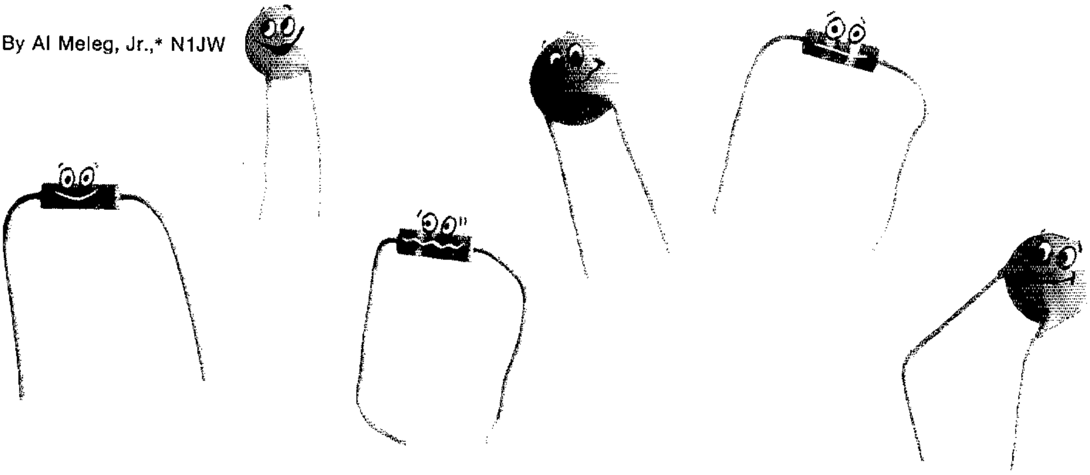
QST congratulates . . .

☐ Hans Tischer, KP4EBQ, selected for Honorable Mention recognition by the National Weather Association. He is an ARRL assistant emergency coordinator.

The ABC Active Filter

Meet this high-performance solid-state circuit for reducing noise and improving selectivity. You can expand it in building-block fashion.

By Al Meleg, Jr.,* N1JW



What is common between people and electronic filters? Probably nothing more than that each may be classified as either active or passive. In human affairs, we recognize these personal characteristics easily. But in electronics, what are active and passive filters? Whether active or passive, filters serve to remove, reduce or emphasize particular electrical waveform components that appear in a given circuit. For instance, hum may be filtered from a B + line. Noise in radio reception may be reduced. And certain desired frequency ranges may be emphasized in audio circuits such as bass boosting on a hi-fi system.

Well then, what about active and passive filters? The general purpose of either type filter can be the same, but the difference is that a passive filter lacks such active components as ICs, transistors or vacuum tubes. The components of a passive filter are generally confined to resistances, capacitances and inductances. While these components are also needed in active filters, the latter also contain a means of amplification that is provided by the active components mentioned above. One advantage of having amplification is that signal loss resulting from filter usage may be overcome. But there is another interesting aspect of amplification which applies to active filters such as the ABC. This will be explained.

*224 Oak St., E. Hartford, CT 06118

After several years of trying many different circuit configurations while also doing considerable research on filter systems, I devised the concept of what I call the ABC filter, a flexible electronic device that is expandable in building-block form. Additional stages may be cascaded, depending on how steep the filtering must be. The number of stages may range from one to eight.

Active filters have increased in popularity in recent years, not only because of their effectiveness, but also because of the abundance of inexpensive operational amplifiers that may be used in their construction. Many amateur operators firmly believe that when an active filter is used for improving receiver selectivity, the audio band-pass characteristics offer an advantage over filtering at the i-f level.

There is one drawback involved in the construction of some active filters; that is the problem of selecting proper component values. A one percent or better tolerance requirement may be in order. Is there an alternative? Yes, indeed! Let me introduce you to the ABC circuit.

Two General Configurations

While there are many commonly used configurations for active filters, they generally fall into one of two main categories. In one case, the feedback path returns to the negative, inverting input where the gain of the amplifier is usually presumed to be infinite. In the second arrangement, the feedback path returns to the positive, noninverting input where the gain is considered to be unity.

Single- and multiple-path configurations are to be found in each category. The circuit in Fig. 1 uses a single feedback path falling into the second category. The circuit Q is a function of all component values. Multipole filters are usually made by cascading several of these two-pole

$$Q = \frac{R1 \cdot R2}{R1 + R2} \cdot \sqrt{\frac{C1}{C2}}$$

$$(2\pi f)^2 = \frac{1}{R1 \cdot R2 \cdot C1 \cdot C2}$$

F = break frequency
Note: All values affect Q and gain.

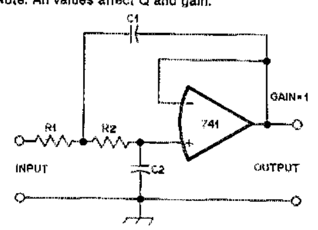


Fig. 1 — A popular active-filter circuit. The ICs in this circuit and those of Figs. 2 and 3 may be either a 741, general-purpose operational amplifier or a type LM-201A, high-performance, operational amplifier or equivalent. Fixed resistors, when used, are 1/4 watt. See text regarding Q and circuit values.

stages. Each stage usually requires a different Q. This amounts to employing different resistor and capacitor values for each stage. In other words, no two values are the same.

While playing with the circuit equations one day, an interesting situation became apparent. The Q of the circuit was found to be a function of stage gain when the gain is greater than unity. The break frequency (the frequency at which attenuation of the filter comes sharply into play) is not affected by stage gain. Therefore, the break frequency can be selected by chosing all resistors of equal value and all capacitors that have equal value. Adjusting the gain with R_g varies the Q. Refer to Fig. 2.

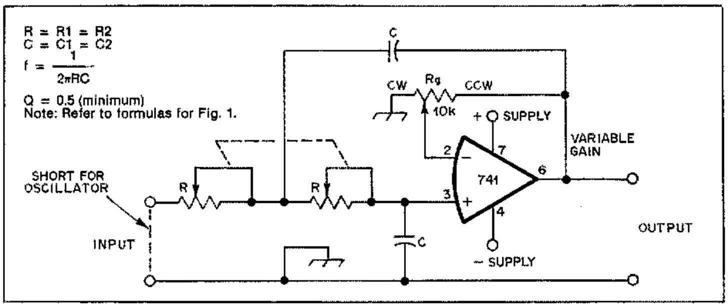


Fig. 2 — The ABC low-pass filter. Optional ganged variable resistors, as shown, provide the filter with a variable break frequency. By shorting the input connections, the ABC filter becomes an oscillator. Pin numbers shown above are for the 8-pin type 741 IC and apply also to Figs. 1 and 3. The dual polarity power supply returns are referenced to common. Voltages may range from 9 to 15 V.

Selecting Components

As you compare Figs. 1 and 2, you will observe that Fig. 2 represents an adaptation of Fig. 1. The formula associated with Fig. 1 may be considered the more complex case even though the configuration of this widely used circuit is simple. In Fig. 2, the two fixed resistors are labeled R, indicating that whatever value is selected for one resistor must apply also to the other resistor. Furthermore, both capacitors in Fig. 2 must have identical values.

With the unity-gain circuit of Fig. 1, component mismatch not only results in a change of break frequency but also a change of Q, which usually degrades circuit performance. Close tolerances are required. In contrast, the ABC circuit shown in Fig. 2 provides a means of counterbalancing a change in Q by the adjustment of R_g. In fact the Q is adjustable from one-half to such a high value that oscillation can be produced. By shorting the input, the ABC circuit may be made into a simple oscillator.

I have found the ABC circuit most handy for building constant-amplitude (Butterworth) filters which require equal break frequencies at each stage with only the Q values being different. (The Chebyshev filter, on the other hand, requires different break frequencies for each pole pair or stage.)

As a guideline to construction, one should keep in mind that the individual R values and the individual reactances of the capacitors should be kept within the range of 1000 to 100,000 ohms. An example of typical component values might be R = 5000 ohms and C = 0.1 μF. This combination will produce a break frequency of approximately 300 Hz. Likewise, a 3-kHz filter may be constructed with a 0.01-μF capacitor and an R value of 5000 ohms.

When applying the formula to the design of an ABC filter, choose a standard value for C. The chart on page 34 of *The Radio Amateur's Handbook* for 1978 can be helpful in making this selection. Next, solve the equation for R. The break frequency for the filter must be selected previously. Because the computed R value may be an odd figure, the nearest standard-value resistor should be used. If five-percent-tolerance components are to be installed in the filter, the completed unit can be expected to produce a break frequency that is likely to be within seven percent of the desired break frequency. No severe loss of performance is likely to occur, however, even if components have as much as a 20-percent tolerance. In the latter case, the break frequency will be slightly different from that of the calculated value.

Circuit Q

For both active and passive filters the circuit Q, and more particularly the Q of the capacitors, has a definite bearing on the operation of the filter. Where moderate-to-high selectivity is required from a filter, high-Q capacitors are desirable. This is true for tuned rf circuits as well as for audio-peaking or rejection applications.

Normally, one may expect capacitor Q to be relatively high because the losses of modern capacitors are generally low. Such is not true, however, for inductors. That is the main reason why in audio circuits RC active filters are preferred over the LC passive units.

How do you know when you have the proper Q? It can be calculated mathematically, but the easiest way is by trial and error. The procedure is simply to use a signal generator in conjunction with an ac VOM or an oscilloscope to observe the frequency response. Some of the inexpensive VOMs even have the meter scale calibrated in decibels.

For cascaded multistage configurations, a good design practice is to provide the first stage with the lowest Q and each following stage with a progressively higher Q. If the first stage should have the highest Q, some input signals may tend to overdrive succeeding stages.

In Conclusion

A good choice for the operational amplifier to be used in an active filter is the 741. What is particularly good about this IC is that it has internal compensation for increasing stability.

Interchanging R and C components results in a high-pass filter. Cascading low-pass and high-pass sections results in a band-pass filter. The upper frequency range is limited only by the characteristics of the amplifier being used.

The ganged variable resistors shown in Figs. 2 and 3 are optional. Their use provides a filter with a variable break frequency. Fig. 3 is presented simply to illustrate the high-pass filter configuration.

I have used the ABC design many times over in such applications as suggested at the beginning of this article. The frequency coverage has ranged from dc to 20 kHz. Results have always been most gratifying. For the amateur who has need for an active filter, I heartily recommend the ABC. Construction is as simple as that!

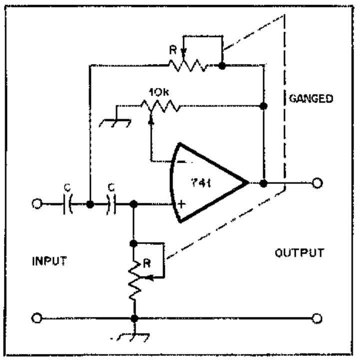


Fig. 3 — The ABC high-pass filter. Potentiometers may be ganged for a variable break frequency.

Producing Weather Satellite Pictures at Lower Cost

Get the FAX! Buy now! Pay later! Sounds almost like a sales pitch. Nevertheless, a Telefax machine will provide you with the main ingredient for producing easily affordable weather satellite pictures.

By Lindsay R. Winkler,* W7AVE (ex-W6WMI)

The fascination of seeing pictures from American and Russian weather satellites excites you. Back at the ranch, telephone in hand, you locate the needed facsimile equipment. Not many weeks later, the device delivered and installed, you see the first prints roll off the machine. Full satisfaction is apparent from your Cheshire-cat grin. In time, however, the resulting dent in the family budget grows. What to do? Cast dismay aside and read on!

My recent retirement at a time of sharply rising costs induced second thoughts about operating expenses at my very active APT (Automatic Picture Transmission) station. A careful study of cost factors led to the revitalization of a Western Union Telefax system described in *QST*[1] nearly three years ago, and in *Specialized Communications Techniques for the Radio Amateur.*[2] For superior picture reproduction, I switched to photographic paper, a move that led to side-by-side visual and infrared pictures. With three pairs of pictures being produced from each 8- × 10-inch photographic sheet, the cost of individual prints dropped to 9.3 cents. However, hum and noise plagued the pictures. The solution was delayed by a change of residence.

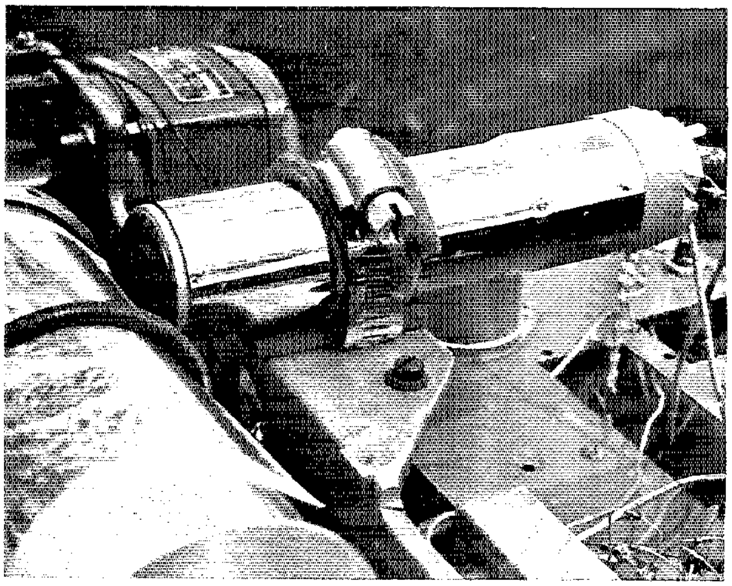
Reworking the Telefax System

Upon resumption of work on the Telefax system, unused wiring and components were removed from the chassis. A light gun was built around the rather expensive Sylvania R-1168 crater tube.[3] An old microscope eyepiece, labeled 50X, was mounted in a five-inch length of 1-1/4-inch brass sink tailpipe. The pipe interior was painted black to reduce reflections. Fortunately, the base of the R-1168 fits easily into the expanded end of the tailpipe, from which an octal socket protrudes. The microscope eyepiece (eye-end out) is placed at the opposite end of the tailpipe after increasing the diameter of the eyepiece with masking tape. No additional aperture is needed.

The light gun is supported by a stainless-steel worm-screw hose clamp, obtainable at hardware and automotive stores. Holes drilled into the band coincide with holes formerly used to hold the original Telefax telescope. A 1/8-inch Masonite spacer and a wrapping of felt protects the light gun from screws inserted to hold the band in place. The gun is clamped firmly in place by adjusting the worm screws after focusing.

While focusing, the light spot will appear slightly above the center of the drum. Focus should favor the violet end of the spectrum, which means the lens should be a bit closer than apparent focus. For the

The light-gun assembly on the author's modified Telefax unit. A Sylvania R-1168 crater tube and a 50X microscope eyepiece are housed in the chrome-plated enclosure.



*Rte. 1, Box 209, Walla Walla, WA 99362
[1]Footnotes appear on page 34.

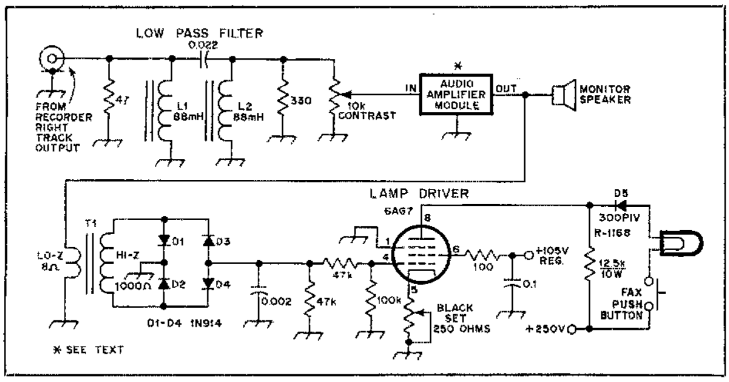


Fig. 1 — Hum and noise appearing in Telefax pictures are reduced by the filter section of this diagram. A 1-watt Radio Shack amplifier overcomes filter insertion loss. The lower portion illustrates the lamp driver circuit. Resistances are in ohms; k = 1000. Capacitances are in microfarads.

final test, odd pieces of photo paper should be used and then examined under a reading glass after processing. Sharp, nonoverlapping lines are needed for good, crisp pictures.

The electronic circuit in Fig. 1, constructed with original sockets and components, is built onto the FAX chassis. No changes were made in the power supply. With only minor socket rewiring, the 6V6 stylus driver is replaced by the rather obsolete 6AG7, which now serves as the lamp driver.

Several functions are handled by the push buttons. The green or incoming button controls the drum-advance motor and the R-1168 lamp. When the lamp is turned off (automatically or by means of the stop button), the buzzer is activated. The white button is used to deactivate the buzzer. The red button is seldom used.

Noise and Hum Suppression

Incorporation of a high-pass filter, constructed from data in *The Radio Amateur's Handbook*, suppressed the previously mentioned noise and hum. A 1-watt Radio Shack audio amplifier compensated for insertion losses from the filter. See Fig. 1.

Omission of the redundant infrared picture permits six pictures of snapshot size to be obtained from a 28-cent sheet of polycontrast rapid RC paper. This slides the cost per picture to 4.6 cents and each photograph can contain a 10-minute portion of a NOAA pass.

When preparing the unit for use, double-stick tape (Scotch) is aligned to the right of the index line. Two other short lengths are placed on the opposite side of the drum to catch the two corners of the half-sheet. The RC paper has a high affinity to fresh Scotch tape. Therefore, when new tape is applied, the tape should be rubbed with one's fingers to reduce this tendency.

Telemetry information appears at the right side of the picture when correct framing is achieved. This adjustment requires the use of an oscilloscope. Other operating tips include use of a low-power (10-25X) hand microscope to resolve cloud structure details. One should avoid limiting cloud peaks and washing out detail. Resist riding the video control like the plague! High-quality audio tape, such as Scotch 207, is a must for recording satellite transmissions.

Improving the Stylus Method

Satisfaction with the improved performance of the Telefax sparked more curiosity. What about the original Western Union stylus method of producing pictures? Could that be upgraded? W6KT and his son, W6JQR and I agreed on the possibility. From their drawing board came one modification design; from mine another. Each "remodulator" was different, but in the end the results were equivalent. Figs. 2 and 3 illustrate the difference.

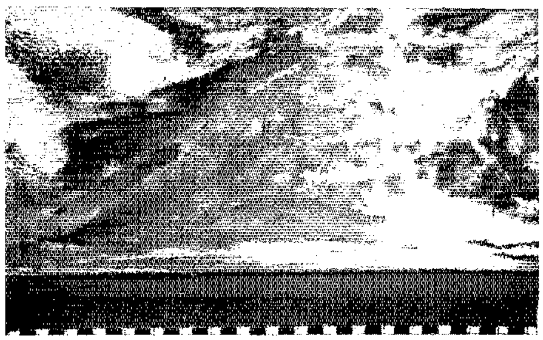
Preparation for this modification also requires removal of such components as the signal-line transformer, relays and those parts associated with the transmitting amplifier no longer needed. Refer to the schematic diagram on page 472 of *The Radio Amateur's Handbook* for 1977, or *Specialized Communications Techniques*, page 80.

The ac amplifiers of the Telefax require an ac subcarrier modulated opposite the satellite carrier. The answer: Provide a new 10- to 12-kHz subcarrier plus a remodulator and presto — white clouds appear.

Once completed, my transistorized remodulator was installed outside the Telefax between the filter output (Fig. 1) and the internal recording potentiometer of the Telefax. The unijunction oscillator, Q3, provides a new 10-kHz subcarrier that is fed to point X through Q2 and a 10-kΩ isolation resistor. Transistor Q1 is biased by R4 to the point where the 10-kHz sub-

A view of Baja California and Mexico through "Russian eyes." The twin 60-line pictures were made by the method described, using Teledeltos burn-off paper. (The right edge of each of these photos is the leading edge as it comes from the Telefax.) *(W6KT photo)*

Cloud-covered Sierras and Lake Tahoe appear in the north. The Sierras, Salton Sea, and the Gulf of California form a characteristic line. The Imperial Valley is visible between the Salton Sea and the Gulf. A reading glass makes these clear.



carrier measured at point X just begins to drop. The positive voltage from the APT signals, applied from the demodulator diodes to the base of Q1, increases conduction of Q1 to reduce the voltage at point X. In turn, the black produced at the stylus is diminished. Maximum APT signal produces minimum stylus current and white clouds in the pictures.

The Stylus Is the Key

Good picture results depend on the stylus. For clarity, the original WU 0.009-inch diameter stylus is strongly recommended.[4] Use of the original "burn-off" or thermal paper further reduces the expense of producing acceptable pictures. There is some reduction in picture quality by this method, but it does provide a rapid, no-development means of monitoring our NOAA and the Russian Meteor satellite transmissions.

Excellent pictures have been taken from Meteor 2-2, now functional on 137.3 MHz. The 120-line video is recorded at 1-7/8 in./s on the right track of the tape recorder, while the 20-Hz standard ac is recorded on the left track. Playback is at 7-1/2 in./s. This arrangement permits production of two side-by-side 60-line pictures of good quality.[5] The drum is turned at 240 rev./min by the amplified 80-Hz standard signal generated by playback of the 20-Hz recorded signal at four times the original recording speed.[6] The 2.5-µF capacitor in series with the winding of the Telefax "gray" motor must be exchanged for a 1.6-µF capacitor at this speed.

The original carriage-motor speed is maintained for printing on both photographic and burn-off versions with some acceptable length/width distortion visible. Carriage motors are synchronous, however, and W6KT modified the length/width ratio a bit by running the carriage motor at 50 Hz for the NOAA pictures and at 80 Hz for those from Meteor 2-2.[7] A voltage-controlled oscillator produces square waves which are converted to sine waves and amplified to the 117 volts required to operate the carriage motor — an optional refinement.

Pictures obtained through this process have high archival value. On a shorter-term basis, one quickly finds that friends and neighbors become enthusiastic to see "what's in the wind!"

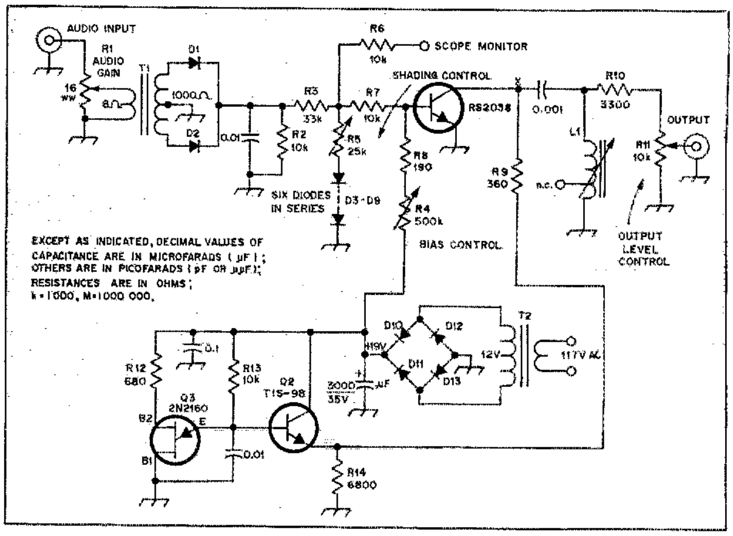


Fig. 2 — The W7AVE transistorized remodulator. Compensation for poor linearity of paper response is provided by this circuit, which has a shaping network consisting of R3, R5 and D3-D9, inclusive. R5 also controls amplification. The number of diodes in the series determines the knee position of the performance curve. L1 is adjustable for best results. Resistors are 1/4 watt.

D1-D9 — Switching, type 1N914.
D10-D13 — 1 A, 50 V. Radio Shack no. 276-1101, or equiv.
L1 — Variable 95-µH, Miller horizontal-oscillator coil no. H-1034 or equiv.
Q1 — Rf power amplifier, Radio Shack no. 276-2038 or equiv.
Q2 — Low-noise general-purpose npn amplifier, Texas Instruments no. TIS-98, Radio Shack no. 276-2009, or equiv.
Q3 — Unijunction oscillator, Texas Instruments no. 2N2160 or equiv.
T1 — Audio output, 1000 ct to 8 ohms, Radio Shack no. 273-1380 or equiv.
T2 — Miniature filament, 12 V, 300 mA, Radio Shack no. 273-1385 or equiv.

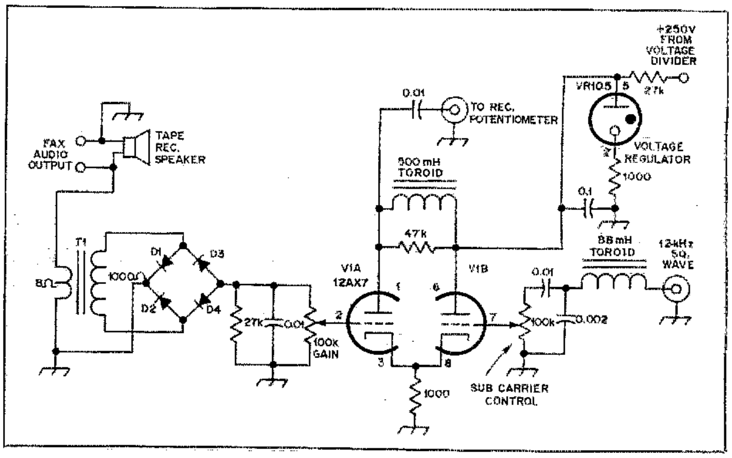


Fig. 3 — A tube version of the remodulator designed and built by W6KT and W6JQR. T1 is Radio Shack no. 273-1380. A 40-µF capacitor should be added to the Telefax power supply to reduce hum. Connect it between the 5Y3 filament ct and ground. D1-D4 are 1N914s. Refer to the original Telefax diagram as shown in *The Radio Amateurs Handbook* or *Specialized Communications Techniques*. Resistances are in ohms; k = 1000. Capacitances are in microfarads.

Footnotes

[1]Winkler, "Facsimile Transceiver for Weather Satellite Pictures," Technical Correspondence, *QST*, May, 1974. Also see "Feedback," *QST*, July, 1974.

[2]A three-speed, two-track tape recorder is essential to the operation of the system described therein. Speed changing is required.

[3]The R1130B is much cheaper than the R1168 and should be considered as a replacement. Lamps may be available from these suppliers: (Eastern U.S.) George W. Gates Co., Hempstead Tpke., Franklin Square, NY 11010, tel. 212-347-0787; Central Scientific, 2600 S. Kostner Ave., Chicago, IL 60023, tel. 312-277-8300; (Western U.S.) Universal Light Source, 1553 Folsom St., San Francisco, CA 94103, tel. 415-626-1213.

[4]Western Union styli are unavailable. Carbon steel wire no larger than 0.009-inch (from either a fine wire brush or a section of piano wire) or a guitar string may be used. The maximum size of 0.009 inch seems very important to good reproduction.

[5]Since one of the two identical pictures will always be entire, one need not phase the Meteor pictures. The "Magic Tape" method of splicing will make the second picture available as well.

[6]The Meteor synchronization method is essentially the same as that for the NOAA pictures. Compare this information with the more detailed description in Footnote 1 above.

[7]The 240-line Meteor mapping satellites on 137.15 MHz may be printed out by recording a 40-Hz tone along with the picture, then doubling the speed on printout. These satellites have excellent land/water resolution but are not always operational over North America.

A Low-Cost Burglar Alarm for Home or Car

How many times have you wanted to install a burglar alarm? Probably plenty! WA6MBP tells how you can at a savings of many bucks. And your spouse will think you are an electronics whiz.

By Jerry D. Arnold,* WA6MBP

After having my apartment broken into and my desk rifled (but fortunately, no ham gear stolen), I decided that it was time to install a burglar-alarm system. And, following a journey to a local vendor of such appliances, I was "alarmed" to find out some of the prices for systems. Necessity being the mother of saving the checkbook, I went to work to design something usable.

My ultimate design was to have an alarm that would (1) trigger automatically when any door or window was opened; (2) allow time to get inside and shut it off before sounding, *or* let the alleged thief get inside to "catch his hands in the cookie jar"; (3) sound the alarm for a preset period of time, then reset the entire system; and (4) (most important), save me a bundle!

With these features in mind, I almost decided to hire a trained German shepherd. But I continued to mull the problem over until I thought about an IC-timer chip or, more correctly, two timer chips. The design I came up with is so simple, I wondered why it hadn't appeared before. What I ended up with was two one-shot, or monostable timer chips (NE555), the first triggering the second and the second driving the alarm bell.

Circuit Details

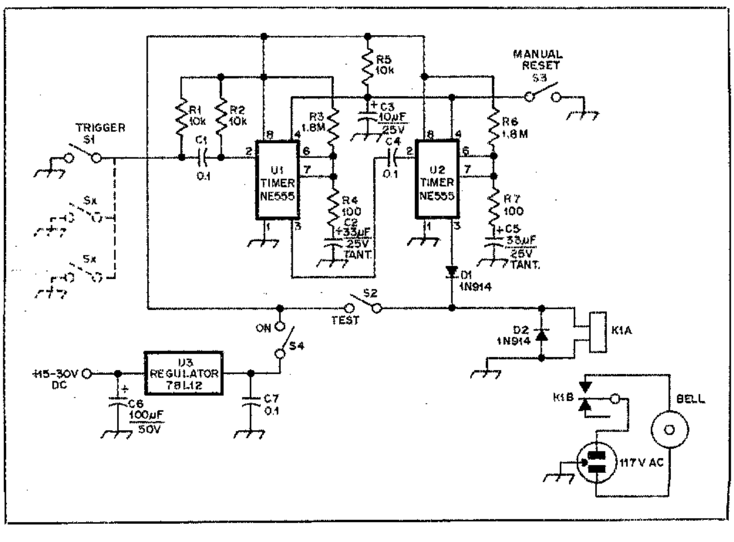
The basics of the circuit, Fig. 1, are like this. A negative-going pulse supplied by any door or window switch is coupled to pin 2 of U1, the trigger input, through C1, R1 and R2. This enables the first timer, which is the "entry delay time." I chose an RC time constant of approximately 20 seconds, C2 and R3. At the end of this 20-second time period, a negative pulse from pin 3 of U1 (output) is applied to the trigger input (pin 2) of U2 through C4. This enables the second timer, driving the output high. The output has a small low-current relay in series (K1), which is energized as the output goes high. The relay contacts have the necessary voltage for the alarm bell on them.

The time constant for the second timer (R6 and C5) is the "alarm sounding time." I chose about one minute, but this, like the first timer, can be altered to suit your own particular needs. I found that shorter than one minute did not seem to be long enough to attract attention from any appreciable distance. And longer than a minute-and-a-half to two minutes gets on people's nerves, regardless of whether they actually saw any thief.

Construction Details

The entire electronics package (minus the relay and bell) was housed in a small metal box and hidden under a sofa. The box has an on-off switch, a reset button, a test button, and connectors for the output and trigger input. In my particular setup I used a magnetic door switch to provide my negative pulse. The relay is located with the alarm bell (Radio Shack no. 273-020) in a weatherproof box outside. I did this because the bell was 117 V ac, and

Fig. 1 — Circuit diagram of the WA6MBP burglar alarm. See text for additional details.



*2012 Canada Blvd., Glendale, CA 91208

I didn't like the idea of running 117 V around through lightweight wire at the baseboard. The NE555 will drive a load up to 220 mA, so any small relay will suffice, such as Radio Shack no. 275-003.

For power I used a small battery-charger type of supply that I had on hand, but any small supply could be used as the current drain is very low. I also used a small three-terminal regulator, but this is really just a frill; very satisfactory results can be had without it, but I do not recommend higher than 18 V dc. I employed point-to-point wiring using a piece of Vectorbord, but, if desired, a pc board could be made.

A test button is included on the box to check alarm operation. All the switch does is apply voltage to the relay line to energize the relay, ringing the bell. A push-button switch is used to reset manually the entire system if it is desired to do so when returning to the house and wanting to leave the alarm system in operation. So far I have not caught any burglars, but I did have one scare: when I came home and forgot the alarm was on!

This article was not written to be a build-it-just-like-this project, but rather to give some food for thought on this subject, showing just one of the many possibilities from this type of IC. With the price of a commercial alarm system ranging anywhere from $50 to $300, it's nice to know that you can build an alarm system of your own that will do everything a commercial system does for under $25, even if everything is bought brand new. With people lamenting the fact that building is a dying art and that parts aren't available, I was able to find everything for this project at a local Radio Shack store. I first perused my junk box and came up with the power supply, relay, Vectorbord, switches and resistors, so all I had to buy were a couple of inexpensive tantalum capacitors, the 555s, bell and a Minibox.

I'm sure that many refinements could be added to this system, but for now, it fills the bill nicely. Try it yourself! QST

Feedback

☐ A review of the procedures used in checking the entries in the 1977 ARRL DX Competition has shown that in at least two instances, credit for a claimed contact was disallowed without there being sufficient evidence that the contact did not take place. At this late date, and in fairness to all participants, it has been concluded that the only practical way to proceed was to declare an amnesty for all entries which were disqualified in this competition.

All participants in the 1977 DX Competition were notified that they were eligible to participate in this year's contest. Additional awards will be made as appropriate.

Headquarters regrets the necessity of this action, and extends its apologies to the contest community.

See the tables at right for adjusted scores and ranks.

☐ In the "Crowbar-Proof 12-V Power Supply" (Watts, August 1977 *QST*, page 36), Q1 should be shown in Fig. 1 as a HEP type S5005, not a HEP 5003.

☐ The photos of Linda Fuller and Sharon Toal were inadvertently switched in "YL News" for April. Sharon is the one holding the Saint Bernard.

☐ The new call of ex-K8AKC, as reported in West Virginia "Station Activities" for April, is N8LW.

☐ In the April Public Service Diary of "Public Service," the aircraft search in Tell City, IN, involved the Owensboro, KY, ARES rather than the Evansville, IN, ARES.

Adjusted Scores (1977 ARRL International DX Competition)

CW

Single Operator

Eastern Massachusetts
W1ZA (K1EA, opr) 1,928,160-2080-309-C-88
N.Y.C.-L.I.
W2GGE 843,258-1138-247-C-56
WA2YHK 732,108-988-247-C-67
Northern New Jersey
K2BMI 1,381,788-1572-292-C-81
Eastern Pennsylvania
W3RJ (K3DZB, opr) 1,590,528-1744-304-C-81

Multi-Single

Eastern Pennsylvania
W3BGN (+ N3AD, W3IGQ) 2,200,380-2170-338-C-96
WA3YGH (+ K3JGI, WA3YHT) 922,554-1437-214-C-96
Northern Florida
WA4UFW (+ WB4YKU) 178,860-542-110-C-80
Santa Clara Valley
K6MA (+ WA7RKR, net) 401,811-887-151-C-45

Multi-Multi

Eastern Pennsylvania
K3WW (+ K3UEI, K3WJV, W3HXK, WA3LNM) 3,105,360-2724-380-C-96
Maryland
W3AU (+ CX1EK, WA2LQZ, K3EST, W3IN, WA3HRV) 5,030,880-3760-446-C-96
East Bay
WA6NGG (+ N6VV, K6PJY, WA6FWJ) 1,494,588-2111-236-C-96

Low Band

Connecticut
WA1LNQ 337,842-822-137-C-52

PHONE

Single Operator

Eastern Pennsylvania
W3WJD (WA3LRO, opr) 3,378,420-2740-411-C-88
W3RJ 2,617,776-2226-392-C-80
Los Angeles
W6RTT 393,588-754-174-C-20

Multi-Single

Eastern Massachusetts
W1ZA (+ K1EA, W1NJL) 2,605,932-2268-383-C-96

Adjusted Club Scores (1977 ARRL International DX Competition)

Club	*Score*	*Entries*	*Rank*
Potomac Valley RC	70,468,272	99	1st
Frankford RC	64,591,608	86	2nd
N.CA DX & Contest Coop.	37,438,881	101	4th
NE Contest Club	18,579,360	41	7th (was 8th)
Wireless Inst. of the NE	15,453,863	43	9th
S.CA Contest Club	11,193,219	22	10th
Order of Boiled Owls of NY	4,935,363	14	13th (was 15th)
NFL DX Assn.	1,143,414	9	30th (was 33rd)

Product Review

Radio Shack TRS-80 Microcomputer

Why review a computer in an amateur radio journal? Two reasons: There are some very practical day-to-day uses of computers in amateur stations (at least in some stations) and a growing number of ARRL members are expressing interest in "home" computer systems. The former reason includes esoterics such as satellite tracking, contest operation and remote control of repeaters, and the not-so-esoterics, such as simple logging. All can be done using methods other than computers, but computers can simplify the routine. The latter reason came out in a recent survey of U.S. amateurs which showed that many are now involved with "home" computers, while lots more are interested.

The TRS-80 is an appliance-operator's dream. When you remove it from the shipping carton, simply connect the proper cables, plug it in, turn it on, and begin programming (if you already know the BASIC language). BASIC is an acronym for Beginners All-purpose Symbolic Instruction Code, the form of computer language used with the TRS-80. BASIC uses English words or abbreviations and math symbols.

The system consists of the power supply, tape recorder, video display, keyboard/central-processing unit and, perhaps most important for the beginner, the user's manual. The manual is an excellent programmed-learning text that takes the beginner from ground zero through BASIC programming, debugging techniques and advanced subroutines. It is clear, concise and precise; but at the same time it has been written with enough charm and wit to enable the seasoned pro to speed through it without falling asleep. The author, Dr. David A. Lien, is to be congratulated for his text.

What Will It Do?

The TRS-80 with Level 1 language will handle any problem that can be solved using the BASIC statements shown in the table. These, combined with 26 possible number variables, up to 876 array locations, two string variables and the storage/retrieval cassette system, allow the user quite a bit of freedom in programming for a microcomputer in this price class. If you are used to a four-function $7 calculator, that probably seems like a lot; if you routinely tie up an IBM-370 for hours, then it will seem very inadequate.

The TRS-80 can best be described as adequate for most of the things that a typical "home" computer user would want to do. (There are options which make the system far more powerful.) Also included in the Level I BASIC are the standard logic operations including parentheses, IF-THEN, GOTO, GOSUB, etc. The manual contains complete programs for subroutines of square roots, exponentiation, logarithms, and exponential and trig functions if the need should arise. These subroutines are accurate to five or six decimal places over much of their allowable range, which is accurate enough for most applications (although not nearly as accurate as the other functions already built into the TRS-80 BASIC). Table 1 contains a listing of the TRS-80 Level I BASIC statements/commands.

The manual includes a number of programs

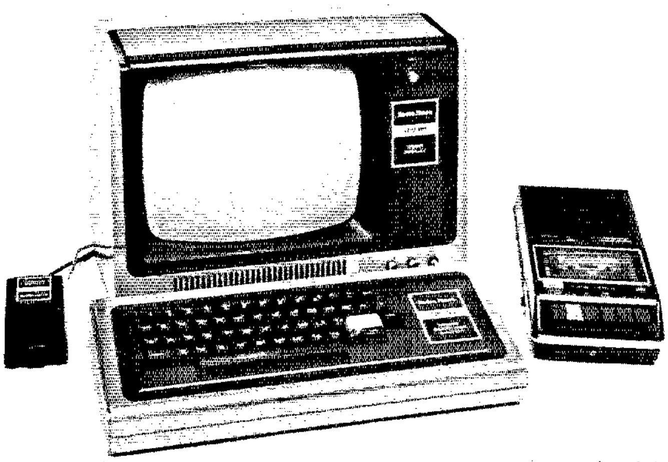
Table 1
Summary of Level I BASIC

Statements/ Commands	*Purpose*
NEW	Clears out all program lines stored in memory.
RUN	Starts program execution at lowest-numbered line.
RUN###	Starts program execution at specified line number.
LIST	Displays the first 12 program lines stored in memory, starting at lowest numbered line. Use ↑ key to display higher numbered lines (if any).
LIST###	Same as LIST, but starts at specified line number.
CONT	Continues program execution when BREAK AT ### is displayed.
PRINT	Prints value of a variable or expression; also prints whatever is inside quotes.
INPUT	Tells computer to let you enter data from the keyboard.
INPUT	Also has built-in PRINT capability.
READ	Reads data in DATA statement.
DATA	Holds data to be read by READ statement.
RESTORE	Causes next READ statement to start with first item in first DATA line.
LET	(Optional) Assigns a new value to variable on left of equals sign.
GOTO	Transfers program control to designated program line.

Statements/ Commands	*Purpose*
IF-THEN	Establishes a test point.
FOR-NEXT	Sets up a do-loop to be executed a specified number of times.
STEP	Specifies size of increment to be used in FOR-NEXT loops.
STOP	Stops program execution and prints BREAK AT ### message.
END	Ends program execution and sets program counter to zero.
GOSUB	Transfers program control to subroutine beginning at specified line.
RETURN	Ends subroutine execution and returns control to GOSUB line.
ON	Multiway branch used with GOTO and GOSUB.
AT	(Follows PRINT) Begins printing at specified location on display.
TAB	(Follows PRINT) Begins printing at specified number of spaces from left margin.
SET	Lights up a specified graphics location on display.
RESET	Turns off a specified graphics location on display.
POINT	Checks the specified graphics location; if point is "on," returns a 1; if "off," returns a 0.
CLS	Turns off all graphics locations (clears screen).

Statements/ Commands	*Purpose*
MEM	Returns the number of free bytes left in memory.
INT(X)	Returns the greatest integer which is less than or equal to X.
ABS(X)	Absolute value of X.
RND(Ø)	Returns a random number between 0 and 1.
RND(N)	Returns a random integer between 1 and N.
+	Addition
−	Subtraction
*	Multiplication
/	Division
=	Assigns value of right-hand side to variable on left-hand side.
<	Is less than
>	Is greater than
=	Is equal to
<=	Is less than or equal to
>=	Is greater than or equal to
<>	Is not equal to
A through Z	Take on number values.
A$ and B$	Take on string values
A(X)	Store the elements of a one-dimensional array.

Logical Operators	*Function*
*	AND
+	OR



The TRS-80 system consists of the video display (monitor) which has a 12-inch screen (measured on the diagonal), the keyboard control/processing unit (sitting in front of the video display), the power supply (left), and cassette tape recorder. (The instruction manual is not pictured here.) Programs and data may be stored on cassette tape.

ready to be typed into the TRS-80 including one for designing a cubical quad antenna. The program even computes theoretical gain figures! Several other game and business-related programs can be copied directly from the manual. We wrote a program to compile and sort data relating to the amount of time that Hq. employees spend on various tasks. These tabulations are needed for certain records that must be maintained. Additionally, we prepared a number of programs related to OSCAR 8 and its orbits. This was done with just the standard unit (4 kilobytes of RAM and BASIC Level I), although the program for OSCAR 8's orbits would have been simpler with the BASIC II option. Other programs written by Hq. staffers include "tic-tac-toe," "family budget," and some fancy graphics displays.

Overall Impressions

If you are a computer "appliance operator," then you will want to consider the TRS-80 system. The system is ready to go as soon as it is unpacked. Should the TRS-80 ever need servicing, Radio Shack has a complete service facility available. One word of warning, though: If you want to enjoy *your* TRS-80, don't let your spouse or children know how easy it is to use, or how much fun it can be!

Technical Stuff

The heart of the TRS-80 is a Z-80 microprocessor chip. ROMs (4096 bytes) contain the Level I BASIC, keyboard-scanning routines, video-display drivers and cassette-interface routines. Dynamic RAMs are used for the main storage area with the standard "4-k" unit providing 3583 bytes of usable storage. The video-display logic generates the necessary video and sync signals to form 16 lines of 64 alphanumeric characters. To allow for expansion of memory and the addition of options, an expansion port has been supplied.

Included in Radio Shack's BASIC Level I are some commands not usually found in "4-k BASIC." These additional functions control the graphics display formatting. Other than these unique commmands that have been added to the standard BASIC language to enchance its programming capability, there are a few differences (that we could find) between the TRS-80 BASIC and Dartmouth BASIC. The two languages are compatible, according to Radio Shack. Several optional shortcuts or "shorthand" commands have been provided in the TRS-80 BASIC, however, allowing the user to conserve memory space when writing programs.

A special feature of interest to those who are new to the world of computers is the TRS-80's automatic debugging scheme. This consists of preprogrammed software inside the computer which spits out WHAT, HOW and SORRY statements when you make a boo-boo. The system is almost foolproof! If you ask the computer (in a program statement) to do something that it cannot do, it simply returns with the appropriate statement. WHAT means it doesn't understand the command in question either because of improper grammar or because the command is not in the computer's vocabulary. HOW tells you that although the computer understands the command, it cannot carry out the action because you have exceeded some limit or because something is missing. An example would be telling the computer to GOTO a line number which is nonexistent. Finally, a SORRY reply informs you that you have run out of memory, and therefore can't continue to add program statements.

This nifty system of debugging not only saves you time when you are debugging new programs, it also teaches you what you can and cannot do, so you can practically "learn as you program."

It is possible that the radio amateur who plans to use the TRS-80 in conjunction with his ham station could encounter some problems. The writer noticed that the TRS-80 seemed to generate rf-noise which was quite pronounced on a 2-meter fm rig when the computer was operated within a few feet of the indoor 2-meter fm antenna. This noise was not detectable with the same receiver installed in the car when the car was parked roughly 35 feet from the computer. Although we lack the facilities at ARRL hq. to make quantitative measurements of rf-leakage radiation, a look at our spectrum analyzer with its input connected to a short antenna not far from the TRS-80 showed a broad band of noise-type energy extending to above 100 MHz. Depending on the location and the method of coupling the TRS-80 into the ham station, receivers could suffer when it comes to pulling in weak signals.

One staff member who used the TRS-80 in his home also mentioned that the video monitor of the system was sensitive to rf from amateur transmissions in the hf bands, and that on one occasion errors in the program itself were introduced during the presence of rf. On the other hand, the TRS-80 has been used here at ARRL hq. extensively with no noticeable aberrations in operation while the eight transmitters of W1AW are simultaneously on the air (W1AW does have a pronounced effect on some other office equipment). Presumably, installing extensive shielding and bypassing would alleviate both of these problems. Radio Shack Headquarters has been advised of these situations, so later production units may be improved in this regard.

One *important* caution should be stressed here. The TV monitor of the TRS-80 system is transformerless, with one side of the chassis connected directly to the 117-V ac line. A polarized power plug *is* installed on the end of the power cord and due warning regarding the "cheating" of this plug via extension cords and the like is provided in the instructions. But an isolation transformer should definitely be added if direct ground connections are made to the monitor when wiring in other amateur equipment.

Peripherals

As mentioned before, numerous peripherals are available that interface with the TRS-80 system. These include a line printer ($1300), a hobby printer (screen, electrostatic type, $600), Mini-Disk (mini floppy, $500), expansion interface module ($300), BASIC Level II ROM ($100), and 16-kilobyte (kB) RAM boards ($290). Radio Shack is also coming out with a sizable software library for the TRS-80, including payroll, personal finance, home recipe/conversion/directory, and Algebra I, to name a few. All of the above items are currently available.

The TRS-80 as supplied from Radio Shack can support up to 16 peripherals using its 40-pin expansion port located at the rear of the cabinet. If you are a prospective buyer of a TRS-80 system, you should be aware of the hardware and software necessary to support some of the accessories mentioned. The line printer and the Mini-Disk require and are supported by Level II BASIC. The expansion interface unit is also necessary before the line printer or Mini-Disk can be hooked up.

QST plans to carry a review of the TRS-80 Level II BASIC, but for those of you who are impatient, here are a few of the added features listed by the manufacturer: edit mode, PEEK, POKE, trig and scientific functions, 225 dimensional arrays, extended string functions and PRINT using format.

The TRS-80 system is capable of supporting a total of 12 kB of ROM and 48 kB of RAM including that contained both within and outside the keyboard/microprocessor cabinet. A total of 12 kB of ROM and 16 kB of RAM will fit inside the integral cabinet; additional RAM can be located inside the expansion-interface cabinet.

Additional products and programs are being developed by Radio Shack to augment the TRS-80. The current price class of the TRS-80 system shown is $600. For more information contact a Radio Shack store or write Tandy Computers National Advertising, 1 Tandy Center, Fort Worth, TX 76101. —*N1UM*

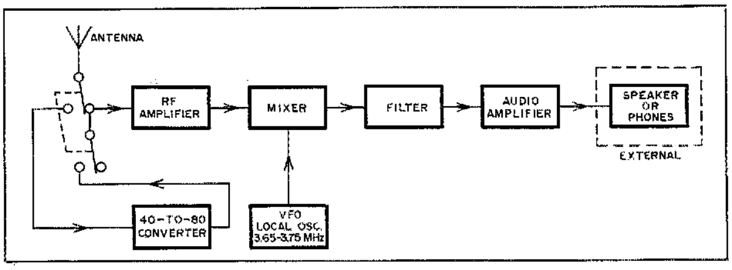


Fig. 1 — Block diagram of the 8040-B receiver.

KANTRONICS 8040-B RECEIVER

Billed as the "Lightweight Champ," the 8040-B receiver is an inexpensive alternative to the high prices of most new hf amateur gear. This direct-conversion receiver covers 100 kHz on each band, 80 and 40 meters, covering the entire Novice segment in each case.

Actually, the 8040-B converts frequency twice on 40 meters, as Fig. 1 illustrates. The incoming signal on, say, 7050 kHz, is routed to the 40-to-80 converter. There it is mixed with a 3.4-MHz signal using a dual-gate MOSFET mixer. The resulting 3.65-MHz output is fed to the tuned rf amplifier which serves as the first stage of the actual receiver. After amplification the 80-meter signal enters another dual-gate device, where it is beat against the signal from the 3.65- to 3.75-MHz variable-frequency oscillator (VFO).

The VFO in the 8040-B is of the Colpitts variety and uses an FET as the active device. It is designed to be relatively stable, utilizing polystyrene capacitors in the voltage divider section, and a negative temperature coefficient capacitor (NP0 type) in the tuning network. A 2- to 14-pF air variable capacitor tunes the VFO.

The output of the MOSFET mixer is a combination of the two input signals, the sum of those signals, and the difference between the signals. The difference is in the audio range, so a low-pass filtering network follows the mixer stage. This filter passes the audio while presenting a high impedance to the rf components of the mixer output.

The audio portion of the signal, containing the intelligence we wish to hear, is amplified by an integrated circuit and fed to the headphone jack on the rear apron. There is no internal speaker. The 8040-B has both audio and rf gain controls, with the former placed in the circuit between the audio filter and the IC amplifier and the latter just ahead of the rf amplifier stages.

Two 9-volt transistor batteries supply power to the receiver, and are mounted inside the enclosure. The antenna jack on the rear panel is of the Motorola type such as found on car radios. This makes quick connections somewhat difficult if one normally uses standard coaxial cable fittings.

Kantronics supplies a tuning wand with the 8040-B to tweak the tuned circuits in the converter and rf amplifier stages. The receiver is designed to operate with any low-impedance antenna, nominally 35-75 ohms, although it will of course work with reduced sensitivity using most anything for an aerial.

An aluminum chassis is used to enclose the 8040-B, the whole package being about the size of a small lunch box. State-of-the-art design is employed, with the use of one IC, one FET and three dual-gate MOSFETs. All components except switches, jacks, gain and tuning controls are mounted on a single pc board, which is attached to the chassis bottom.

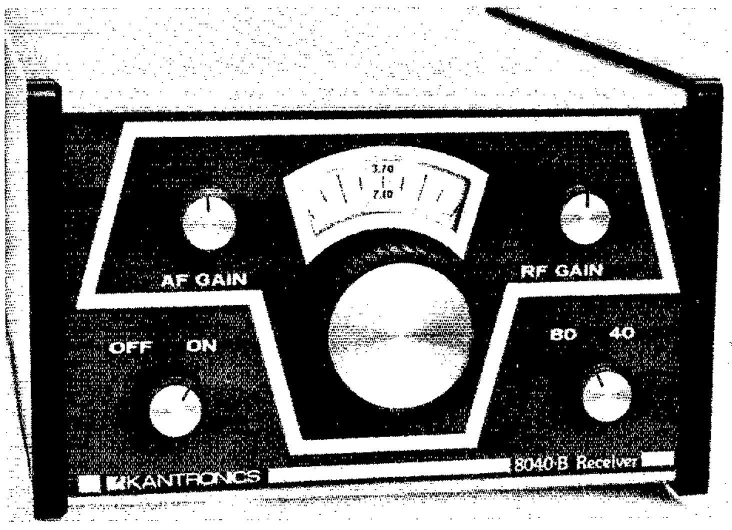
A comparison between this reviewer's Drake R4-B receiver and the 8040-B proved interesting. Few signals could be copied on the Drake receiver which could not be copied on the Kantronics, the main difference being in the selectivity. Of course the Drake, when new, cost five times the 8040-B's 1978 price of about $80.

Uses for this lightweight compact radio are limited only by the owner's imagination . . . mountaintopping, Field Day operations, something to listen to at the office during lunchtime. The 8040-B is manufactured by Kantronics, Inc., 1202 E. 23rd St., Lawrence, KS 66044, tel. 913-842-7745. — *K1TX*

Kantronics 8040-B Receiver

Frequency coverage: 3.65-3.75 MHz; 7.05-7.15 MHz.
Power requirements: Two 9-V batteries.
Dimensions: (HWD) 2.9 × 6.6 × 6.0 inches (74 × 168 × 152 mm).
Audio output: 8-ohm impedence, Motorola-type jack.
Tuning dial: Vernier type.
Sensitivity: One microvolt provides readable signals.*
Selectivity: 1 kHz at 6 dB down.*
*Verified in the ARRL laboratory.

Yes, the 8040-B receiver really is almost as small as it looks here. It weighs about as much as a loaf of bread.



HEATH AMATEUR RADIO NOVICE LICENSE COURSE

The Heathkit Individual Learning Program Novice course recently passed the "acid test" at ARRL headquarters. With absolutely no amateur radio background the Technical Department assistant secretary, Pam Guay, progressed to being Pam Guay, WB1GHH, in a few weeks' time.

Heath's course comes at a time when ARRL-supported license classes are being conducted the length and breadth of the land, so why is there a need for such a study program? It's especially helpful to those individuals who have no class available to them, or who cannot, for one reason or another, attend such classes.

Skepticism about such a course is natural, so Heath offers a clincher . . . a money-back guarantee if the purchaser fails to pass the FCC Novice exam. That's certainly a brave offer in a situation where the manufacturer has no control over *how* the course is utilized.

Aside from a little lunchtime help with the international Morse code, Pam studied at home exclusively, using the Heath course. Her interest increased as she progressed, and she's now on the air. The once pristine loose-leaf binder containing the written material is a little tattered, the pages dog-eared. Two cassette tapes included with the course are still functional. Thanks in part to the Heath Novice course, the ARRL Technical Department is now 100 percent licensed, and it looks as if we won't get our $25 back! This course *works* and is recommended to prospective amateurs who must "go it alone." Available from Heath, Inc., Benton Harbor, MI 49022. — *K1TX*

LOW-COST COLLINS MECHANICAL FILTER

Amateurs who build their own ssb generators and receivers will be heartened to learn that Collins Radio now has available a modestly priced mechanical filter. The component is intended primarily for the CB market, but the specifications indicate that amateurs should find many practical uses for the filter.

Actually, two filters of this type are available — upper- and lower-sideband types. The upper-sideband unit bears the number 526-9897-010. Center frequency is 456.45 kHz. The lower-sideband filter is designated 526-9939-010. Its center frequency is 453.55 kHz. There is also an a-m type of mechanical filter available, 526-9920-010, center frequency 455 kHz.

In terms of tolerance, the 3-dB bandwidth of the ssb filters is 1.95 to 2.2 kHz. The typical 60-dB bandwidth is rated at 4.5 kHz. The characteristic impedance for the sideband filters is 2700 ohms. A value of 12,000 ohms is specified for the a-m filter. The 3-dB bandwidth for the latter is 5 to 5.5 kHz. Insertion loss for the ssb filters is specified as 3.5 dB. For the a-m filter it is 8 dB. The typical passband ripple is 1 dB and 2.5 dB for the a-m unit. Resonating capacitors (two each) for all three filters are required. The correct value is 360 pF. The filters are designed with a balanced input for use with a balanced modulator and an unbalanced input.

Rockwell states that the lower-sideband filters are available off the shelf at a price class of $32. The international price class is $39 plus duty. These are band-pass types of mechanical filters, so upper- and low-sideband operation is possible by proper selection of the BFO frequency. The filters measure approximately 18 × 71 mm, and the height, excluding pins, about 21 mm. The manufacturer is Rockwell International, Electronics Devices Division, 4311 Jamboree Rd., Newport Beach, CA 92663. — *W1FB*

CLEGG FM-28 2-METER FM TRANSCEIVER

The Clegg FM-28 is a fully synthesized radio for 2-meter fm, covering the range of 144.0 to 147.995 MHz in 5-kHz steps. Featuring a power output of 25 watts "HI" and 0.25 to 4 watts "LO" (adjustable), the FM-28 provides versatile mobile as well as fixed-station capability.

Mobile use of the FM-28 is enhanced by its solid construction and such operator-oriented features as the mic jack located on the left side to maximize cord length. The illuminated frequency readout (four-digit LED plus two backlighted permanent numbers) is also oriented toward mobiling. The speaker is mounted pointing toward the bottom of the case for under-dash installation.

For fixed-station use the mobile bracket stays in the car, and a radio with clean rectangular lines goes indoors. A wire stand enables the user to "aim" the radio up from a desk or tabletop.

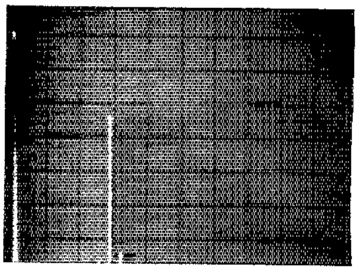
Inside the FM-28

The FM-28 is packed with circuitry, much of the room taken up by the 25-watt amplifier and the readout board. All circuits are well shielded and boards are easily accessible for servicing. The instruction manual provides a board-by-board description of purpose, design and location within the radio.

The synthesizer, a standard TTL design, utilizes a crystal-oscillator/mixing arrangement for switch selection of one of four 1-MHz ranges. Tens and hundreds of kilohertz are selected by means of BCD switches going to a programmable divider; the BCD output is also fed to decoder drivers for the LED display. The 5-kHz switch turns on the last LED digit as a five (it is normally off) and provides a voltage across a diode in the basic oscillator to change the frequency to produce a 5-kHz shift in frequency.

The FM-28 receiver is of straightforward design with a dual-conversion superhet layout for fm reception, a signal-strength meter and an output for a discriminator meter via the accessory plug on the back. The test unit did exhibit a slight hiss when the receiver was squelched in a quiet environment.

Output power from the transmitter is adjusted by limiting drive to the final amplifier and can be set for fairly low output. T-R switching is all solid state; there are no relays to be found. The final is SWR protected.



Spectrum-analyzer display of the FM-28 transmitter output (high power position). The vertical pip on the far left is generated internally in the analyzer. The vertical scale is 10 dB per division and the horizontal scale is 50 MHz per division. Measurements were made at 20 watts output, with the unmodulated carrier (tall pip) notched to enhance the dynamic range of the analyzer system. All spurious outputs are 75 dB down or greater, meeting current FCC regulations.

Big knobs and easy-to-read LEDs highlight the operator-oriented Clegg FM-28.

It's Convenient, Too

Operator convenience is excellent in the FM-28. Offset is selected by one switch and activated by another, handy if the operator does not move from one "split" to simplex to another split often. The kHz selector switches go 'round and 'round, which is nice when going from '88 to '91. As may be evident from the photo, all the controls are standard for 2-meter units. The radio can be turned on and used by someone unfamiliar with it with a minimum of head-scratching.

The FM-28 is manufactured by Clegg Communications Corp., 208 Centerville Rd., Lancaster, PA 17603. Their toll-free sales and service number is 800-233-0250. Price class of the FM-28 is $360. — *WA6RBE*

Clegg FM-28 2-Meter Transceiver

Dimensions (HWD) and Weight: 2-5/8 × 6-5/8 × 10-3/4 inches (67 × 168 × 273 mm), 7 pounds (3.18 kg).
Power requirements: 13.8 V dc at 7 A high-power transmit.
Frequency range: 144 to 147.995 MHz in 5-kHz steps, fm only.
Power output: 25 W (HI) or 0.25-4 W (LO).
Receiver i-f bandwidth: 14 kHz at −3 dB, 25 kHz at −70 dB.
Transmitter deviation: Factory-set at 5 kHz, adjustable from 3 to 15 kHz.

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

HOW TO TVI-PROOF YOUR GREENHOUSE

☐ The article entitled "TVI Sleuths at Work" in February 1977 *QST*, coupled with the punchy editorial in the same edition by Dick Baldwin, prompted me to grab the typewriter and put on record a TVI happening which was a trifle unusual here at G3FXB. I moved to the present location in the spring of 1974, fully aware that this was a channel 1 area with a relatively low field strength. Channel 1 in Great Britain uses a video carrier of 45 MHz and an audio carrier of 41.5 MHz. It will be immediately apparent that this channel poses a serious potential harmonic problem both from the second harmonic of 21 MHz and the third harmonic of 14 MHz. However it was felt that being a rural area with reasonable physical separation from one's neighbors and given commercial ham gear with reasonably low levels of harmonic output, no serious problems would be experienced.

Once the quad was up and operation commenced, a couple of problems became apparent, but both appeared to be simple overload of the front ends of the sets involved. In both cases the installation of a high-pass filter cured the problem. The domestic TV at G3FXB is uhf only (vhf channels are being phased out over here), but a vhf receiver was obtained and a check made for harmonics. The level seemed to be low so it was assumed that all was well. It was two years later in the long dry summer of '76 that an irate caller at the door during the WAE contest confirmed indeed that all was far from well. The caller came from a location some 120 yards down the lane and had a summer cottage which he only used for a few weeks of the year. Furthermore he pointed out that another neighbor also using vhf was experiencing a similar problem. A high-pass filter was fitted with no improvement, and it became fairly obvious that there was indeed a harmonic problem, despite the satisfactory checks two years earlier. It was agreed that I have the receiver at my QTH for a series of checks. With some apprehension the set was switched on to observe the problem firsthand.

The first thing that became apparent was the fact that there was serious TVI. The worst band seemed to be 14 MHz, and here even a few watts of rf were sufficient to cause a picture wipe-out even though the vhf receiver antenna was 150 feet from the quad. The first move was to try a high-pass filter on the TV, but it was of no benefit. TV feeders in Great Britain are all 72-ohm coax and in some cases a high-pass filter will be ineffective because the offending rf simply flows over it. The filter was therefore grounded directly to the tuner — again to no avail. The next move was to try a "braid breaker" on the coax just in the event that rf on the braid was in fact still the problem. It was not. The final move was the filtering of the ac line to the TV, but again the result was negative.

Attention was now turned to the transmitter, although it did not seem logical that harmonic content could have risen substantially in the past two years. The first move was to check the equipment on a dummy load. Basically the tests were satisfactory. There was a small amount of leakage through the screening of the FLDX-2000 linear at high power levels, which really seemed to have no bearing on the problem. The next move was to load the equipment up on the antenna again, but with a good-quality low-pass filter in circuit. Again there was no improvement. Things were now getting distinctly puzzling.

I have often read of the so-called "rusty bolt effect" in TVI, giving rise to contact rectification and harmonic generation, and I had tended to dismiss it fairly lightly. It looked now that this was an aspect of the situation that would have to be given serious consideration. Two facts tended to confirm that this was indeed the way to go. First, the TVI was at its worst when the transmitter was tuned for maximum output at the fundamental frequency. Such is not normally the case with pure harmonic radiation. More important was the second discovery, that the TVI was at its worst when the quad was beamed west, virtually side-on to the TV antenna. This gave strong support to the theory that the fundamental was the problem, insofar that the level of TVI was directly related to the directivity of the quad.

The garden at 'FXB contained some wire fences that looked like they could be the problem. When firing west the quad was pointed in their general direction, and the fences consisted of rusty wire attached not very securely to equally rusty angle irons. The lot was removed, but alas, the TVI still persisted.

At this stage it was fortunate that a fellow ham came forward with a portable detection device tunable from 40 MHz upward, with a visual as well as audible indication of output. As soon as this device was put into service things began to happen. Two things emerged — namely that the level of third harmonic from 14 MHz was far greater in the garden than it was either around the house or around the quad, confirming that the problem was a very bad dose of contact rectification. As you may well know, the English are a nation of gardeners. Unlike North America, a high percentage of English backyards boast a greenhouse for the propagation of plants and the growing of tomatoes, grapes and similar things that require that extra amount of heat and sunlight. Furthermore these greenhouses often boast a heating system. The 'FXB QTH was no exception. It boasted a rather old and decrepit greenhouse with a defunct heating system, and it was upon approaching the greenhouse with the detection device that the needle really wrapped itself around the stop. The whole place was a hotbed of contact rectification. For one thing the metal frame was strengthened by lengths of studding secured by nuts. In many cases the whole lot was rusty, yet the nut loose. Even worse the heating system consisted of two large iron pipes stacked one above the other. They ran a total length of 48 feet and were made up of three-foot sections with obviously a substantial number of joints. These two pipes and their brackets were a mass of rust, having never seen a coat of paint. Physical movement of any of these pipes or brackets was guaranteed to trigger off the most violent reaction on the detection device, which of course became even worse at higher power levels.

Whilst it was possible to remove the studding on the metal framework, clean all the surfaces, and tighten all the nuts, it was entirely impractical to do anything with the heating system. Fortunately it was not used and so it was entirely removed. With it went the TVI. What was left was the real harmonic that was generated by the transmitter directly, and which had previously been masked by the rusty-bolt radiation. This was of a low level and completely

G3FXB (left) and the gardener standing before the guilty greenhouse.

suppressed by the low-pass filter.

This experience highlights an interesting problem as outlined in "TVI Sleuths at Work." How would I have made out if that greenhouse had been in a neighbor's garden and not mine? — *Al Slater, G3FXB, Wynchwood, Park La., Maplehurst, Horhsam, West Sussex, RH 13 6LL, England*

TROPOSPHERIC PROPAGATION

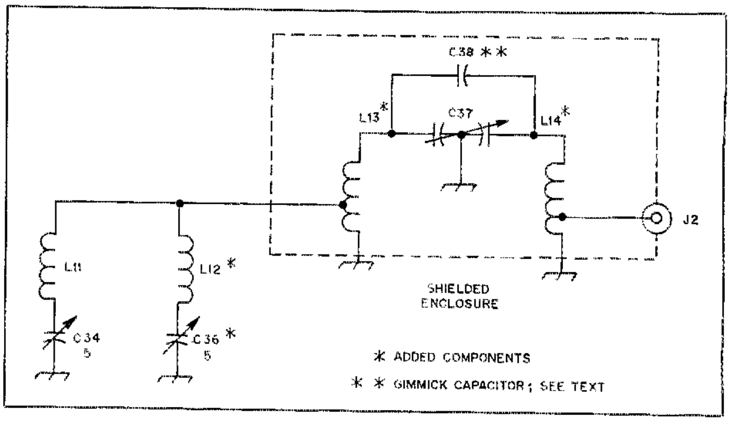
☐ I would like to offer one small correction to W1XZ's otherwise competent and educational article, "An Introduction to the World Above 50 MHz" (*QST*, November, 1977). In his discussion of meteorological phenomena which can enhance radio propagation on the 2-meter band, the author described a tropospheric "thermal inversion," capable of refracting (bending) radio signals, as "a cold-air mass sitting above an area of warm air." This is a common misconception; in fact, the situation is just the opposite.

For convenience in discussion, the earth's atmosphere is divided into regions on the basis of temperature trend with increasing altitude. Within the troposphere, the lowest region, the temperature normally drops steadily until the tropopause (the boundary between the troposphere and stratosphere) is reached at 8-12 km. Thus, it is normal for cold air to be sitting over warm air. Consider that high mountains remain snowcapped all year, even in equatorial regions.

Within the troposphere, the rate at which temperature decreases with altitude, or "lapse rate," varies considerably with latitude, time of day and year, and weather conditions. The colder the overlying air (large lapse rate) the greater the extent of mixing and turbulence, for the following reason. Picture a parcel of warm, low-level air. Warm air tends to rise, but as it does so it reaches a level of lower atmospheric pressure, so it expands. As it expands, it cools and becomes more dense. If, in rising to a higher level, this air parcel is still warmer and less dense than the air at the higher level, it will continue to rise. If it is now similar in temperature and density to the surrounding air, its upward motion will stop. If, however, it is colder and more dense than the air at that higher level, the imagined process would have not occurred in the first place.

When the lapse rate becomes low or negative (warm air overlying cold, more dense air), vertical motion ceases, except for diffusion. The latter case, warm air over cold, is what defines a tropospheric "thermal inversion." It is this sort of abnormal temperature and density profile that often traps air pollutants over cities, especially in valleys, and that occasionally provides a refracting medium for radio waves within the troposphere. The contact surface between the two layers of air can be quite well defined, extensive and persistent. Note that the tropopause is just a global, persistent thermal inversion which inhibits mixing of tropospheric and stratospheric air masses.

Whether or not the term "tropo" is a misnomer is a question of definition. If the radio-wave refraction process occurs in the troposphere, then the term may be appropriate. However, it should be understood that the medium for thermal-inversion propagation is a contact surface between air masses of different densities, rather than a region of high electron density as in ionospheric (D, E, F level) propagation, and that the phenomenon is the result of atmospheric *inactivity*. — *Dave Lewis, W2HMT, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309*



Schematic diagram of the W2GN converter modifications. C37, C38, L13 and L14 are enclosed in a small metal box mounted in place of output connector J2. L12 and C36 are mounted inside the enclosure housing the converter.

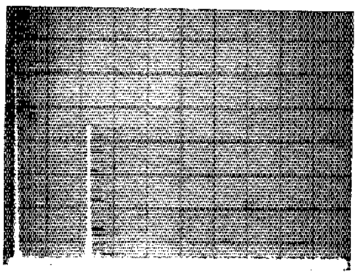
L12 — 9 turns no. 16 wire, air core, 1/4-inch (6.4-mm) diameter, 3/4-inch (19-mm) long.
L13, L14 — 10 turns no. 16 wire, air core, 1/4-inch diameter, 13/16-inch (21-mm long, tapped 1-3/4 turns from ground.
C36 — 5-pF air trimmer (Johnson 189-0564-001 or equiv.).
C37 — 3-pF butterfly air-variable (Johnson 160-203-001 or equivalent).
C38 — Approximately 1-pF gimmick capacitor, two parallel pieces of plastic-covered no. 18 wire 3/8-inch (9.5-mm) long. The wires should touch each other and lie flat against the top of C37.

REDUCING SPURIOUS OUTPUTS FROM THE W2GN 220-MHz TRANSVERTER

☐ I have learned that the spectral output of the W2GN 220-MHz transverter ("A 220-MHz Transmit Converter," January 1978 *QST*, page 16) has some spurious outputs which exceed the maximum levels permitted by FCC regulation. Corrective steps are given here.

A series-tuned trap takes out local-oscillator leakage and an external band-pass filter bolted to the top cover of the converter eliminates all other spurious outputs. Spectral output of the unit as modified is shown in the accompanying photograph. I mounted my band-pass filter in a 2-1/4 × 1-3/8 × 1-1/8-inch (57 × 35 × 29-mm) cast aluminum box (Pomona 2428) but an enclosure made from pc-board scrap will work as well. As modified, the transmit converter greatly exceeds all FCC requirements for spectral purity.

Spectral output of the transmitting converter as modified. Vertical lines on the graticule correspond to 100-MHz/division. Horizontal lines indicate 10-dB/division. The large pip 2.2 divisions from the left side of the display is the fundamental output of the converter, notched 35 dB to prevent overload of the spectrum analyzer mixer. Power output was measured at 4.6 watts during this test. Spurious responses are 68 dB or more below the fundamental.



Adjustment

If a spectrum analyzer is not available to aid in aligning the filters, an alternative method will work nearly as well. With the converter energized but not excited with a 28-MHz signal, an rf probe connnected to the output port should indicate the presence of 192-MHz LO leakage. C36 should be adjusted for minimum signal.

Connect the converter output to a dummy load through a directional wattmeter, or connect the rf probe in parallel with the dummy load. Apply a small amount of drive at 28 MHz and adjust C37 for maximum output. When the converter is properly aligned, it should be possible to obtain about 4.5 to 5 watts output.

The manufacturer's part number for C24, C26, C28 and C32 was incorrectly listed in the caption for Fig. 3, page 17. The correct part number is Johnson 160-208-001. — *Fred Merry, W2GN, 35 Highland Dr., E. Greenbush, NY 12061*

INTERFERENCE MANUAL

☐ An informative booklet concerning the problems of interference as it affects mobile radio equipment is available from the makers of Champion Spark Plugs. The booklet, entitled *Giving Two-Way Radio Its Voice*, offers a thorough treatment of the subject. A copy is available for $1 from the Champion Spark Plug Co., Box 910, Toledo, OH 43661. (Attn: Dept. M-2R Merchandising Order Processing.) — *W1JEC*

Hints and Kinks

A SIDETONE MONITOR-OSCILLATOR-AUDIO GENERATOR

In the process of replacing tubes with transistors and ICs to reduce heat in my SB-102 transceiver, a practical circuit came to mind for a tone generator. The circuit would be suitable for a sidetone monitor and a code-practice set. It would be designed around a Mostek MK5086N IC for the signal generator with an MPF102 FET for the audio amplifier. My finished product proved that the plan was good.

Voltage requirements are not critical. In this case, 12 V were obtained from the filament chain of the transceiver, rectified by means of a diode, and then filtered with a 1000-μF capacitor.

Choice of a crystal for the generator should be from the range of 2 to 3.5 MHz. Avoid selecting a frequency that radiates harmonics in the amateur bands. For example, a 2.5 MHz crystal meets these requirements for the 3.5- to 30-MHz bands.

Selection of one of four tones to suit the individual is obtained by means of S1. Actual tone frequencies may be determined by these simple formulas. Crystal frequencies are in Hz.

$$T1 = \frac{f_{(XTAL)}}{5120} \qquad T2 = \frac{f_{(XTAL)}}{4672}$$

$$T3 = \frac{f_{(XTAL)}}{4234} \qquad T4 = \frac{f_{(XTAL)}}{3776}$$

S2 deactivates the MK5086 when cw is not used. This switch is usually contained on most rigs. The Drake TR-3, for example, is supplied without connections to this switch. The SB-102 has a comparable switch wired for the existing sidetone monitor.

As shown by the diagram, the balance of the circuit is conventional. The gate voltage supplied through keying keeps the MPF102 inoperative while the key is open. When the key is closed the negative bias is removed.

Negative voltage (−V) is used for grid-block keying. R9 is internal for many tube-type transmitters and transceivers. R6 may be connected to the key jack. R10 is inserted to prevent loading the audio-amplifier stage.

The tones produced through my SB-102 sound nice and rock-solid. To use the device for a code-practice oscillator, simply ground the cw key switch and use a key in place of S2. — *James Garrett, K5BTV*

BRINGING ANTENNA LEADS INTO THE HOUSE

When I embarked upon the construction of my "dream station," shortly after moving into our newly purchased home, I needed to resolve the matter of how I should bring the antenna leads into the basement. Drilling holes in the walls or floors definitely was a no-no. My solution was to replace one of the glass panes in a basement window with a piece of Plexiglas on which feedthrough connectors, insulators and terminal strips were mounted.

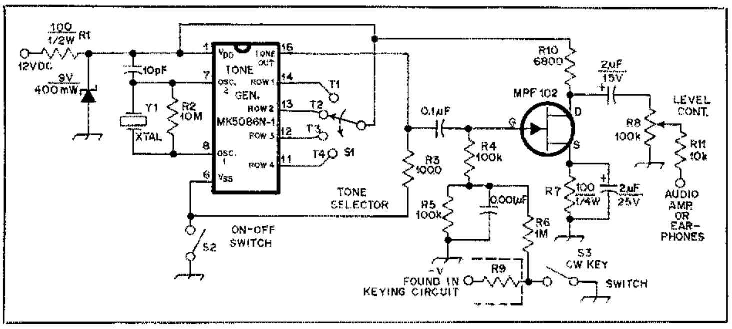
For those who may wish to spend about $3 to do the same, may I offer this advice. When drilling Plexiglas, start with small holes no larger than 1/4 inch (6 mm), then work your way up to the desired size. Use a reamer if you have one. A little such care will avoid cracking the Plexiglas. — *K1TX*

DIFFERENTIAL CAPACITOR IDEAS

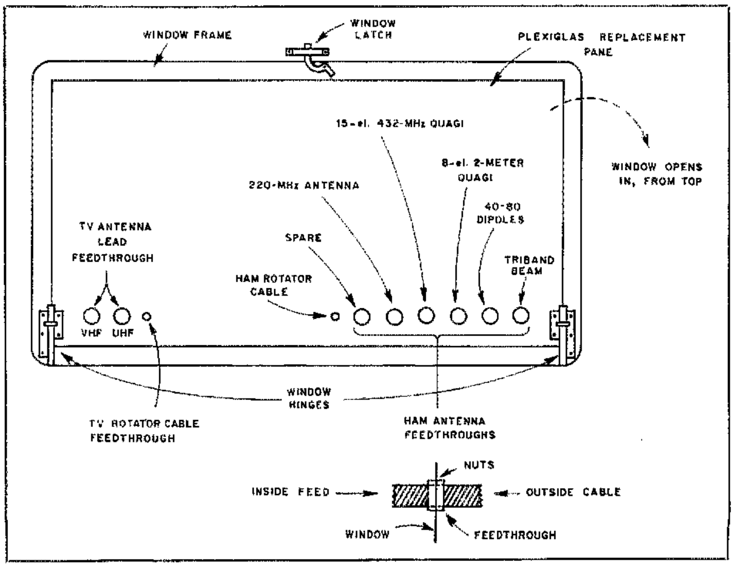
☐ Much work can be saved in making a differential capacitor (see November 1977 *QST*) if one obtains the military ARC-unit capacitors complete with connecting cable. Simply loosen the set screws on the large gear of one capacitor, rotate the plates approximately 180 degrees, and retighten the set screws. A flexible insulated coupling connected through the panel to a spinner knob will allow fast tuning.

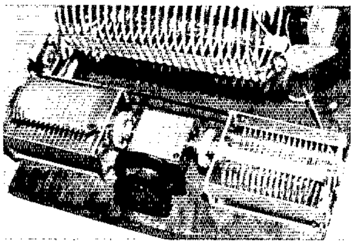
Some years ago, I built a Transmatch using these capacitors in the above manner. It has worked like a charm on all bands, 80 through 10 meters. The antennas have ranged from long wires, beams, quads to even wet strings!

A combination sidetone monitor/code-practice oscillator/audio generator using a Mostek MK5086N IC. R1 is 1/2 watt. All other resistors are 1/4 watt. R9 is generally found in the negative grid-block keying circuit of transceivers. A 10-kΩ series resistor connected in the line from the tap on R8 prevents loading the audio amplifier stage.



Replacing a basement windowpane with a piece of Plexiglas provides an easy way to bring antenna leads and control wires into the house. Feedthroughs may be mounted on the Plexiglas. There is no strain on the cables when the window is opened if a small amount of slack is provided.





A Millen right-angle drive shaft provides a nifty means for making a homemade differential capacitor.

There's nothing like the Transmatch to take the guesswork out of getting that low SWR. — *Don Berger, W7HPI*

☐ Concerning those homemade differential capacitors, I suggest employing the solution I have used for some time. The photograph with this article illustrates how I have obtained differential action by using a right-angle shaft drive mechanism made by Millen. Other sources of right-angle drives might be located by contacting gear manufacturers listed in telephone directories (Yellow Pages). Some hobby shops may also be able to make such a mechanism. — *William Barnard, W6ST*

BETTER S/N AND GAIN FOR SB SERIES

Owners of Heath SB-100 or SB-101 transceivers may find a noticeable improvement in set performance by substituting 6HS6 tubes for the 6AU6s in the rf (V-10) and mixer (V-11) stages. Noise levels are substantially reduced with this change and, because of the increased gain, lower audio gain-control settings may be used. The transconductance of the 6HS6 is almost double that of the 6AU6. Heath changed to the 6HS6 in the SB-102 model. All modifications mentioned in *QST* for April, 1968, were made before the tube change in my transceiver, but the substitution of the 6HS6 made the greatest change in signal-to-noise ratio. — *B. W. Southwell, W6OJW*

PONG GAME CAUSES TVI

Recently, severe TVI appeared on both TV sets in my home whenever I operated on 40-meter cw. Each set was equipped with Drake TV-300-HP filters. The kilowatt transmitter has a Drake TV-3300-LP low-pass filter. Interference was most severe when running full power, but was still present to a lesser degree when I used my Collins 32S-3 exciter alone. A spectrum analyzer proved the fault was not with the exciter.

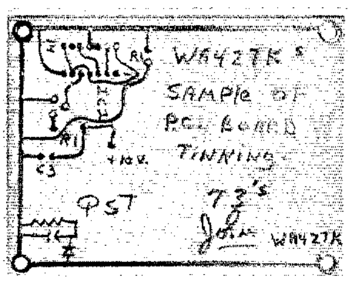
After much detective work, I found that a Super Pong IV TV game, which my sons had connected to the small TV set in their bedroom, was to blame. The power cord to the game had been unplugged and the remote antenna switch was in the TV position, thereby disconnecting the game from the TV antenna terminals. Yet the game was rectifying my 7-MHz signal and generating plenty of harmonic-type energy. When the cable from the game console was disconnected from the remote antenna switch, the TVI disappeared. Those amateurs who experience TVI in their homes should not overlook similar equipment as a possible source of such interference. — *D. A. Contini, N4SA*

TINNING CIRCUIT BOARDS

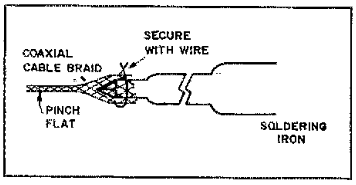
Your home-etched pc boards will have a more professional appearance and will be easier to solder if tinned in this manner. A 1-1/2-inch (38-mm) length of outer braid from a piece of RG214/U coax or equivalent is slipped over the tip of a 40-watt soldering iron. Secure the braid with a few turns of wire. Pinch the end flat. (See the drawing.)

The copper should be clean. Apply a thin layer of liquid rosin flux to the metal. After heating the iron, fill the braid with a good grade of rosin-flux solder. Then brush the solder onto the metal with slow, even motions. Don't overheat the board. Keep the braid filled with solder.

After tinning, clean the excess flux from the board with flux remover or alcohol, and then buff lightly with extra-fine steel wool. — *John W. Kmet, WA4TZK*



Circuit boards may be neatly tinned by using the WA4TZK brushing technique.



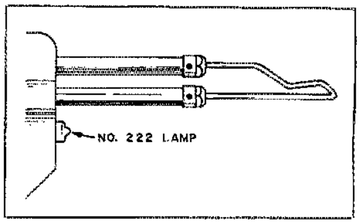
Coaxial cable braid slipped over the tip of a soldering iron provides a brush for tinning pc board circuits.

OBTAINING COPPER WIRE

The shops listed in the Yellow Pages of the telephone directory under "Electric Motors — Repairing" are good local sources of enamel-coated copper magnet wire. To avoid wearing out your welcome, try to anticipate your needs and buy in quantity. — *M. Evett, W6TQA*

SOLDERING-IRON TRICK AVOIDS SHADOW

I'm sure that many people who use Weller soldering guns install a new replacement tip with the bent portion inserted in the lower stud. Doing so, however, tends to cast a shadow on the work as the bulb is mounted beneath the lower stud. My suggestion is to install the new tip with the straight portion below the bent part as shown in the drawing. If you've encountered this problem, try this trick. Bet you'll like it! — *C. A. Chamberlain, W5RSH*



Installing the tip of a soldering gun in this manner avoids a shadow on the work.

CRIB SHEET FOR ICOM IC-22S

I find a "crib sheet" with channel, frequency and mode information is a handy reference item. One is fastened to the dashboard of my car and another is secured to the front panel of my 12-V dc supply for my base station ICOM-IC-22S. I attached these with rubber cement to make removal easy.

To make the crib sheet, I had the list typed, reduced on a photocopy machine, and then encased in a clear-plastic adhesive sheet available from a vending machine. In our area these machines are found in department and discount stores. Office supply firms are likely to have 8 × 10-inch (203 × 254 mm) sheets, if one should desire that size.

Another crib sheet that I use is for an external-programming diode box that I use with my '22S. This was printed out for me by an H-P printing programmable calculator. I put the tapes together, photocopied the whole thing, and encased it in the same plastic-sheet material. — *Jim Gandy, K4HPP*

CH	FREQ	MODE
1	16/76	A
2	34/94	A
3	22/82	A
4	28/88	A
5	52/52	SPX
6	31/91	A
7	04/64	A
8	58/58	SPX
9	10/70	A
10	37/97	A
11	07/67	A
12	25/85	A
13	40/00	A
14	19/79	A
15	46/46	SPX
16	66/06	B
17	01/61	A
18	785/785	SPX
19	665/665	SPX
20	81/21	B
21	94/94	SPX
22	49/49	SPX

A crib sheet like this makes a handy reference item for use with the ICOM IC-22S.

QST

devoted entirely to Amateur Radio

July 1978 $2.00

QST

July 1978
Volume LXII Number 7

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

Just before the first encounter of the eighth OSCAR with its launch vehicle, W9KDR caught Dick Daniels (l) and Jan King in a candid portrait. See page 39.

Contents

Technical

Basic Amateur Radio

General

Operating

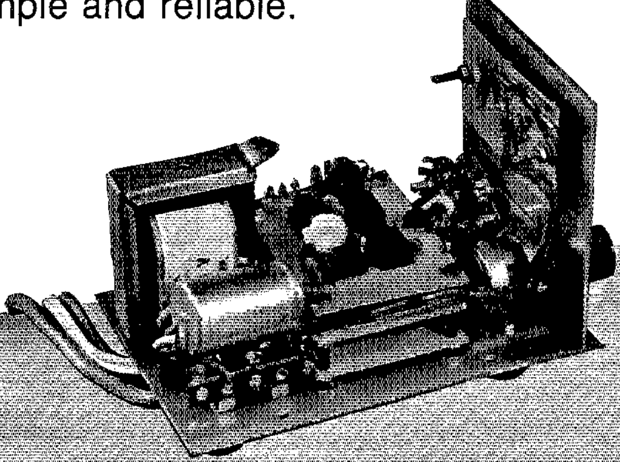
Organizational and Regulatory

Departments

A Digital Speed Readout for the Electronic Keyer

Say good-bye to guessing code speeds. This nifty digital counter tells at a glance the exact wpm you're sending. The circuit is simple and reliable.

By William B. Jones,* W7KGZ



Since incentive licensing was revived a few years ago, many amateurs have been working to upgrade their tickets. Upgrading often means another code test. Another code test means lots of practice at the correct speed if you are to get a shot at the written part of the exam. Until now determining the speed of transmitted code has been mainly a matter of guesswork. But with this simple digital speed readout for an electronic keyer, the guesswork can be cast aside; with a glance you know the precise speed at which characters are formed.

What's Inside Counts

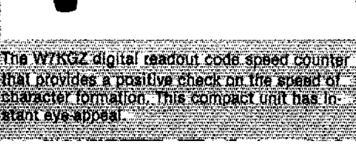
Converting clock pulses of a keyer into a numerical display is a very simple process. *The Radio Amateur's Handbook* tells us that most modern electronic keyers use a clock circuit which feeds a flip-flop dot generator and the code speed in wpm can be determined directly from the formula: wpm = 1.2 × clock frequency (Hz). To put it another way, if we count the number of clock pulses in exactly 1.2 seconds, the readouts will show the code speed directly in words per minute.

The schematic diagram in Fig. 1 clearly indicates the simplicity of the system. The three ICs (7490, 7475 and 7447) associated with the DL-747 readouts perform the necessary counting, storage and decoding functions. The series of articles in *QST*[2] about working with integrated circuits will give the reader an understanding of how this part of the circuit works.

The three remaining ICs establish the 1.2-second time base as well as generate the latch and reset pulses necessary to update the readouts. The 555 timer (U9) is wired as an astable multivibrator. The time interval between each negative-going transition is set by means of the 100-kΩ potentiometer calibration control. More about this later.

Latch and reset pulses are derived from the 7474 edge-triggered D-type flip-flop. This part of the circuit is taken from the *TTL Cookbook*.[3] As the 555 switches from a logic one to a logic zero, a pulse is generated from pin 5 of the 7474. The pulse is differentiated and fed to one section of the 7400 quad NAND gate. The NAND gate inverts the pulse which is then fed to the 7475 quad latches. Bringing the 7475 enable lines from low to high allows the display to update.

Reset pulses are derived the same way as the latch pulses except that now the low-to-high transition from the 555 is used to generate an output from the $\bar{Q}$ pin of the 7474. Again, the pulse is differentiated, inverted and fed to the zero-reset inputs of the 7490 decade counter. This system is simple and most reliable.



The W7KGZ digital readout code speed counter that provides a positive check on the speed of character formation. This compact unit has instant eye-appeal.

If you have followed the logic to this point, then the need for a continuous series of pulses to count should seem obvious. Some electronic keyers use a keyed clock; in other words the clock is only running while a character is being generated. The keyer used with the prototype digital speed readout performed this way but an alternative was to construct a copy of the keyer clock and wire it so that it ran continuously. The output from *this* clock is actually the one being counted. To arrange for the two clocks to run at the same speed, identical timing components are used and the speed control is a dual pot with identical values and tapers. Naturally, the accuracy of the readout is dependent upon the matching of the speed-control components. Tantalum capacitors and quality potentiometers are recommended. Tracking

*12104 N.E. 76th St., Vancouver, WA 98662
[1]References appear on page 13.

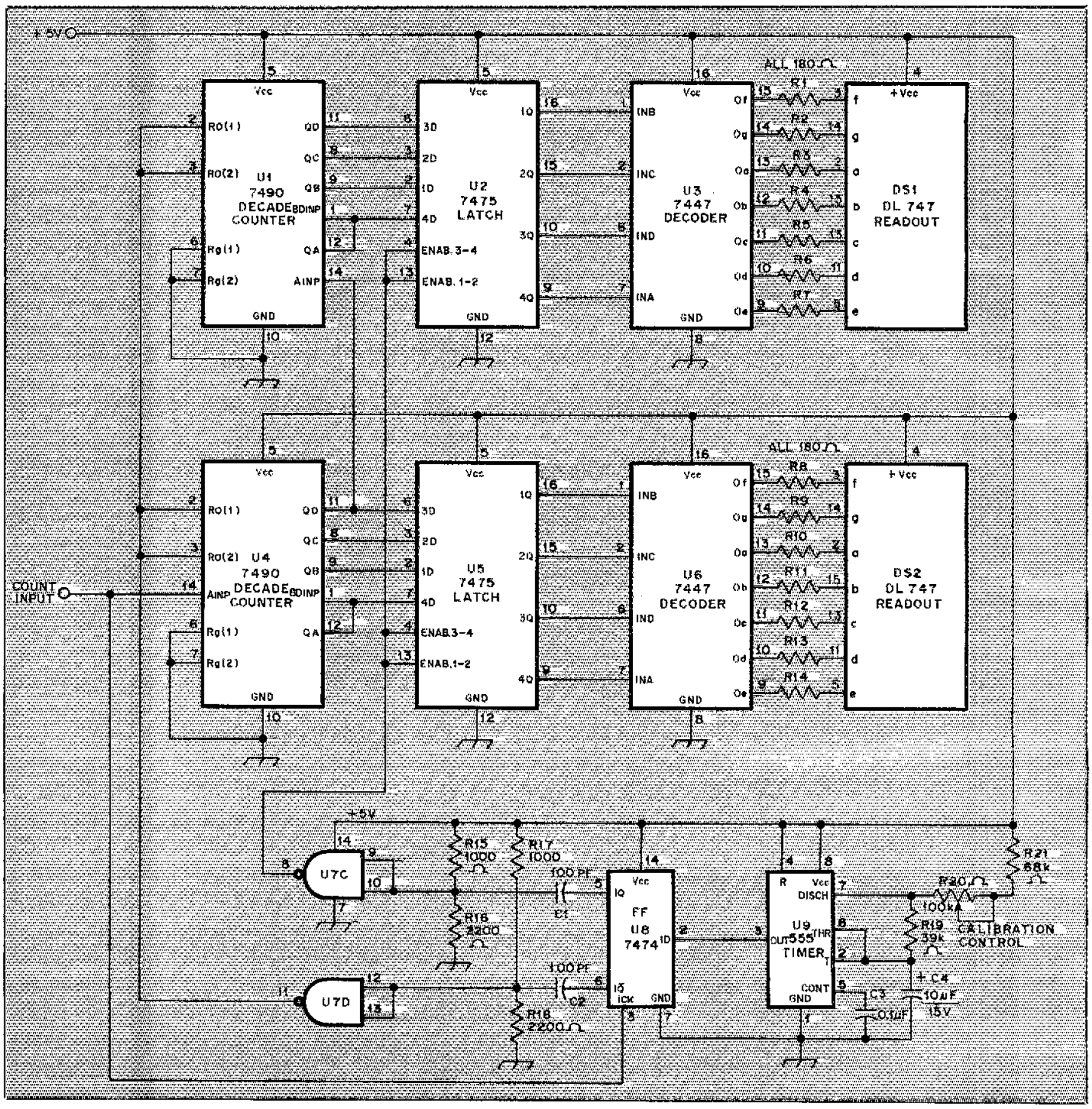


Fig. 1 — Schematic diagram for the digital speed readout. The three ICs associated with each DL-747 LED perform the counting, storage and decoding functions. Resistance values are in ohms and all fixed resistors are 1/4 watt. R1-R14, incl., are 180 ohms. R20 is a 100-kΩ miniature linear-taper potentiometer. The 555 is wired as an astable multivibrator. No connections are made to IC pin numbers not shown. Capacitors with polarity indicated are electrolytic.

DS1, DS2 — Seven-segment common anode LED digital display readout, Litronix type DL-747 or equiv.
U1, U4 — TTL decade counter, type 7490.
U2, U5 — TTL 4-bit bistable latch, type 7475.
U3, U6 — TTL BCD to seven-segment decoder/driver, type 7447.
U7 — TTL quadruple 2-input positive NAND gate, type 7400; two sections unused.
U8 — TTL dual D-type positive edge-triggered flip-flop with preset and clear, type 7474.
U9 — Timer IC, 555.

was within one word per minute throughout the entire speed range on the prototype. The readout has since been adapted for use with the author's keyboard keyer which has a continuously running clock. Of course it was not necessary to build a duplicate clock in that case.

In the version shown in the photograph, the actual keyer is built into the same case as the digital display. The keyer was described in *QST* for January, 1975.[3] It is a superb performer, the third in a series built by the author. All worked perfectly upon initial testing.

Perfboard construction was used throughout as a means of saving time and also for the sake of neatness. Because troubleshooting a defective IC can be difficult, the installation of IC sockets in the circuit seems well worth the small investment. Teflon insulated wire interconnects the various pins of the sockets and other components.

The prototype was constructed on three separate pieces of perfboard cut to the same size for stacking. The keyer was built first. After testing, it was set aside while assembly of the display part of the project took place. The third board contains the 555 timer, 7474 flip-flop and the 7400 gates. After each module had peformed properly, they were all stacked, using long machine screws and metal spacers or nuts to hold the boards in position. Small loops of tinned no. 16 wire inserted in the perfboard serve as terminal connections. Common connections for each board, such as ground and Vcc, are positioned directly over each other in order to provide the shortest possible connection. Although not shown in the schematic diagram, each module has a 0.01-μF disk ceramic capacitor connected directly between the ground bus and the +5-volt supply line. In addition, the cable to the paddles and the power supply wires are similarly bypassed to prevent rf from entering the cabinet.

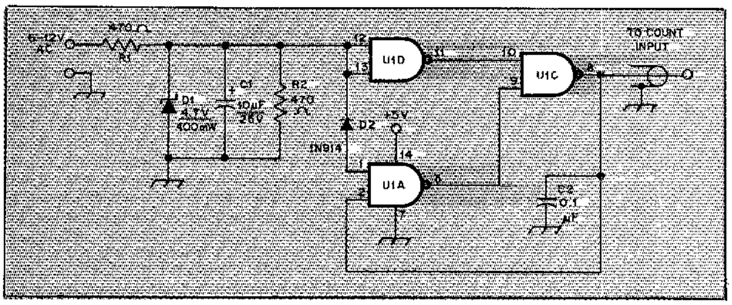


Fig. 2 — This circuit provides a means of obtaining a calibration signal for the digital speed readout unit. It squares the sine wave from the 60-Hz ac line, clipping the negative part and is therefore TTL compatible.

D1 — Zener diode, 4.7 V, 400 mW, 1N750 or equiv.
D2 — Silicon diode, 1N914 or equiv.
R1, R2 — 470 ohm, 1/4-watt resistors.
U1 — TTL quadruple 2-input positive NAND gate, type 7400; one section unused.

Calibration

After all the boards are interconnected and working correctly, calibrating the unit is the next task. Probably the simplest and most accurate method of calibration is to sample the 60-hertz line frequency. The circuit of Fig. 2 is taken from Calectro's *Digital Handbook.*[4] It serves to square the sine wave and clip the negative part in order to assure TTL compatibility. With the "count input" lead of the display temporarily connected to the output of the calibrator, the 100-kΩ calibration control is adjusted for a reading of 72 on the readouts. This corresponds to exactly 1.2 seconds for the time base. The calibrator can be made a permanent part of the unit if so desired. The 555 is quite stable over long periods of time although recalibration can be accomplished every few months for the sake of the purist. An spdt toggle switch can be used to connect either the calibrator or keyer to the readout.

The digital speed readout has been in use at W7KGZ for many months, becoming a most valuable addition to the station. When sending at the higher speeds, as with a keyboard keyer, there is reassurance in knowing exactly at what speed the characters are being formed. Progress in code speed can be measured directly in wpm and when the guy on the other end of a QSO says he can copy 40, you can find out for sure!

References

[1]Hall and Watts, "Learning to Work with Integrated Circuits," *QST* for January through July and November, 1976, and June, 1977. The series has also been published in booklet form (ARRL Publication no. 32) and is available for $2 per copy (in USA) from ARRL Headquarters, 225 Main St., Newington, CT 06111.

[2]Lancaster, *TTL Cookbook*, First Edition, Howard W. Sams and Co., Inc. 1974, p. 212.

[3]Fox, "An Integrated Keyer/TR Switch," *QST* for January, 1975.

[4]*Digital Handbook*, Catalog no. FR 169, G. C. Electronics, 400 S. Wyman St., Rockford, IL 61101.

Feedback

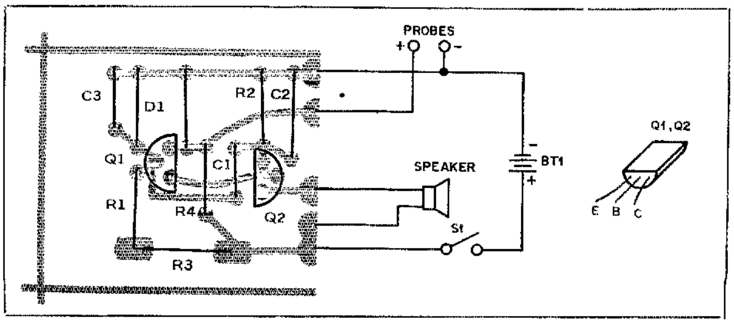
☐ The feedback information which appeared on page 85 of May 1978 *QST* shows the solid black etching pattern for the 20-Meter High-Performance Direct-Conversion Receiver (Rusgrove, April 1978 *QST*, page 11) inverted from the way it should appear. The shaded pattern with the parts information overprinted in orange is correctly shown from the *foil* side of the board. No big problem if you make a transparency for exposing a circuit board, though. Simply invert the transparency before making the board exposure.

☐ Are you duplicating the DoppleScAnt (Rogers, page 24 of May 1978 *QST*)? If so, you should know that a number of errors appear in the schematic diagram, Fig. 4. The nature of the errors makes it difficult to describe corrections adequately in words, and limited space prevents us from republishing the diagram in *QST*. A corrected schematic is available upon request (no charge) from ARRL, Dept. TDSC, 225 Main St., Newington, CT 06111. A stamped return envelope will expedite the handling. The corrected diagram contains component numbers, required if you're working with the etching templates. (We'll be including the corrected diagram with future template orders.) See the footnote on page 28 of May *QST* regarding template availability.

☐ In "An Audio Continuity Tester" (May 1978 *QST*, page 21), author K1TX advises that the transistor shown in Fig. 1 should be diagramed as shown below.

☐ In the "Modular Control Unit — Just for Repeaters" (Shriner, May 1978 *QST*, page 11), the presentation of the etching patterns in Fig. 3 requires clarification. The board is *double-sided;* each pattern correctly shows the foil. Components are mounted on the side with the lettering, REPEATER CONTROL.

Parts placement guide for the Audio Continuity Tester with corrected transistor-basing diagram.



Series-Section Transmission-Line Impedance Matching

Nearly everyone who's worked with antennas knows about stub matching. But series-section matching has a number of advantages over stub tuning. Here's how it's done.

By Frank A. Regier,* OD5CG

Series-section matching may be a strange term to you, but the principle is probably a familiar one. Let's say you have put together a 35-Ω antenna system, perhaps an array of elements for a repeater, and you want to feed it with 75-Ω hardline. How would you make the impedance transformation from 35 to 75 ohms? There are a number of ways, of course — an rf impedance transformer and stub matching, to name two. But in this case perhaps the simplest would be to use a quarter-wavelength line transformer at the antenna. The impedance required for the matching-line section may be calculated from the equation

$$Z1 = \sqrt{Z_{load} \times Z_{line}}$$

where Z1 is the impedance needed for the 1/4-λ matching section and Z_{load} is the purely resistive impedance to be matched to Z_{line}. In this example the value for Z1 conveniently works out to be 51.2 Ω, and a line having a nominal impedance of 50 to 53 ohms may be used. But what happens when the load is not purely resistive, or when the required impedance for Z1 is some uncommon value? In these cases it may be necessary to use another form of matching.

This article introduces a new impedance-matching system called the series-section transformer. It has worthwhile advantages over either stub tuning or the 1/4-λ transformer. The series-section transformer is illustrated in Fig. 1 and bears considerable resemblance to the 1/4-λ transformer. (Actually the 1/4-λ transformer is a special case of the series-section transformer.) The important differences are, first, that the matching section may not be located exactly at the load, second, that it may be less than a quarter wavelength long, and third and

*Dept. of Electrical Engineering, American University of Beirut, Beirut, Lebanon

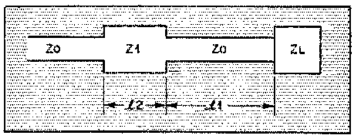


Fig. 1 — Series-section transformer, Z1, for matching transmission-line Zo to load, Z_L.

most important, that there is great freedom in the choice of the characteristic impedance of the matching section.

In fact, the matching section can have *any* characteristic impedance that is not too close to that of the main line. Because of this freedom, it is almost always possible to find a length of commercially available line that will be suitable as a matching section. As an example, consider a 75-Ω line, a 300-Ω matching section, and a pure-resistance load (example only; complex loads can also be matched). It can be shown that such a section may be used to match *any* resistance between 5 Ω and 1200 Ω to the main line.

The design of a series-section transformer consists of determining the length ℓ2 of the series or matching section and the distance ℓ1 from the load to the point where the section should be inserted into the main line. Three quantities must be known. These are the characteristic impedances of the main line and of the matching section, both assumed purely resistive, and the complex-load impedance. Either of two design methods may be used. One is algebraic, and the other is a graphical method using the Smith Chart. You can take your choice.

Algebraic Design Method

The two lengths ℓ1 and ℓ2 are to be determined from the characteristic impedances of the main line and the matching section, Zo and Z1 respectively, and the load impedance $Z_L = R_L + jX_L$. The derivation may be found elsewhere.[1,2] Only the essential results are presented here.

The first step is to determine the normalized impedances.

$$n = \frac{Z1}{Zo} \quad \text{(Eq. 1a)}$$

$$r = \frac{R_L}{Zo} \quad \text{(Eq. 1b)}$$

$$x = \frac{X_L}{Zo} \quad \text{(Eq. 1c)}$$

Next, ℓ2 and ℓ1 are determined from the relations

$$\tan \ell 2 = B = \pm \sqrt{\frac{(r-1)^2 + x^2}{r\left(n - \frac{1}{n}\right)^2 - (r-1)^2 - x^2}} \quad \text{(Eq. 2)}$$

$$\tan \ell 1 = A = \frac{\left(n - \frac{r}{n}\right)B + x}{r + xnB - 1} \quad \text{(Eq. 3)}$$

Lengths ℓ2 and ℓ1 thus determined are electrical lengths in degrees. Actual lengths are obtained by dividing by 360° and multiplying by the wavelength measured along the line (main line or matching section, as the case may be), taking the velocity factor of the line into account.

In Eq. 2 the sign of B may be chosen either positive or negative, but the positive sign is preferred because it results in a shorter matching section. In Eq. 3 the sign of A may not be chosen but can turn out to be either positive or negative. If a negative sign occurs and an electronic calculator is then used to determine ℓ1, a negative electrical length will result. If this happens, add 180°. The resultant electrical length will be correct both physically and mathematically.

[1]References appear on page 16.

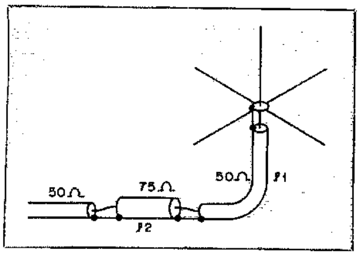


Fig. 2 — Example of series-section matching. A 38-Ω antenna is matched to 50-Ω coax by means of a length of 75-Ω cable.

In calculating B from Eq. 2, it can happen that the quantity under the radical is negative, leading to an imaginary value for B. This would mean that Z1, the impedance of the matching section, is too close to Zo and should be changed.

Limits on the characteristic impedance of Z1 may be calculated in terms of the standing-wave ratio produced by the load on the main line without matching. For matching to occur, Z1 should either be greater than $Zo\sqrt{SWR}$ or less than $Zo/\sqrt{SWR}$.

An Example

As an example, suppose we want to feed a 29-MHz groundplane vertical antenna with RG-58-type foam-dielectric coax (Fig. 2). We'll assume the antenna impedance to be 38 ohms, pure resistance, and use a length of RG-59/U foam-dielectric coax as the series section.

Zo is 50 ohms, Z1 is 75 ohms, and both cables have a velocity factor of 0.79. (From above, Z1 must have an impedance greater than 57.4 Ω or less than 43.6 Ω.) The design steps are as follows.

From Eqs. 1a through 1c,
$n = 1.5$, $r = 0.76$, and $x = 0$.

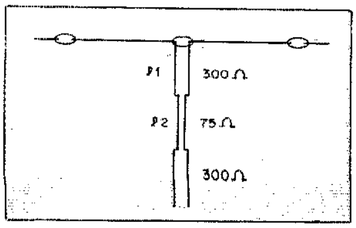
From Eq. 2, $B = 0.3500$ (positive sign chosen) and $\ell 2 = 19.29°$.

From Eq. 3, $A = -1.4486$. Calculating $\ell 1$ yields $-55.38°$. Adding 180° to obtain a positive result gives $\ell 1 = 124.62°$.

To find the physical lengths $\ell 1'$ and $\ell 2'$ we first find the free-space wavelength.

$$\lambda o = \frac{984}{f_{MHz}} \text{ feet}$$

Fig. 3 — Another example of series-section matching.



and the transmission-line wavelength

$\lambda = \lambda o \times$ velocity factor

In the present case we find $\lambda = 26.81$ ft. Finally we have

$$\ell 1' = \frac{\ell 1 \times \lambda}{360} = 9.28 \text{ ft, and}$$

$$\ell 2' = \frac{\ell 2 \times \lambda}{360} = 1.44 \text{ ft}$$

This completes the calculations. Construction consists of cutting the main coax at a point 9.28 ft from the antenna and adding a 1.44-ft length of the 75-Ω cable.

The Quarter-Wave Transformer

The antenna in the preceding example could have been matched by a 1/4-λ transformer at the load. Such a transformer would have a characteristic impedance of 43.6 Ω (from the equation at the beginning of this article). It is interesting to see what happens in the design of a series-section transformer if this value is chosen as the characteristic impedance of the series section.

Following the same steps as before, we find $n = 0.872$, $r = 0.76$, and $x = 0$.

From these values and Eq. 2 we find $B = \infty$ and $\ell 2 = 90°$. Further, $A = 0$ and $\ell 1 = 0°$. These results represent a quarter-wave section at the load, and indicate that, as stated earlier, the quarter-wave transformer is indeed a special case of the series-section transformer.

Another Example

Fig. 3 shows another example, in which a series-section of 75-Ω twin lead is used to match the 75-Ω center impedance of a resonant dipole to a 300-Ω line. Following the same steps once again, we find
$n = 0.25$, $r = 0.25$, and $x = 0$.
From Eq. 2,
$B = 0.4364$ and $\ell 2 = 23.58°$
and from Eq. 3,
$A = 0.4364$ and $\ell 1 = 23.58°$.

Note that $\ell 1 = \ell 2$. This always occurs when $n = r$ and $x = 0$, and characterizes the *alternated-line transformer*,[3] used for matching two cables of different impedance (the antenna could just as well have been a 75-Ω cable), using displaced sections of the two cables being matched.

Lengths $\ell 1$ and $\ell 2$ in this case can be determined either in the usual way, or from the simplified relationship:

$$\ell 1 = \ell 2 = \tan^{-1}\sqrt{\frac{n(n-1)}{n^3-1}}$$

Smith-Chart Solution

A series-section transformer can be designed graphically with the aid of a Smith Chart, but this requires the use of the chart in its unfamiliar off-center mode. This mode is described in the next two paragraphs.

Fig. 4 shows the Smith Chart used in its familiar centered mode, with all impedances normalized to that of the transmission line, in this case 75 ohms, and all constant-SWR circles concentric with the normalized value $r = 1$ at the chart center. An actual impedance is recovered by multiplying a chart reading by the normalizing impedance of 75 ohms. If the actual (unnormalized) impedances represented by a constant-SWR circle in Fig. 4 are instead divided by a normalizing impedance of 300 ohms, a different picture results. A Smith Chart shows all possible impedances, and so a closed path such as a constant-SWR circle in Fig. 4 must again be represented by a closed path. In fact, it can be shown that the path remains a circle, but that the

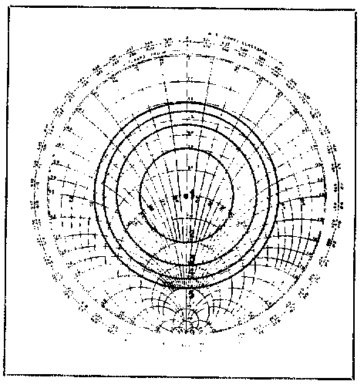


Fig. 4 — Constant-SWR circles for SWR = 2, 3, 4 and 5, showing impedance variation along 75-Ω line, normalized to 75 Ω. Actual impedance is obtained by multiplying chart reading by 75 ohms.

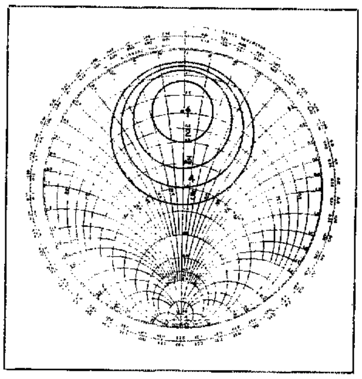


Fig. 5 — Paths of constant SWR for SWR = 2, 3, 4 and 5, showing impedance variation along 75-Ω line, normalized to 300 Ω. Normalized impedances differ from those in Fig. 4, but actual impedances are obtained by multiplying chart readings by 300 ohms and are the same as those corresponding in Fig. 4. Paths remain circles but are no longer concentric. One, the matching circle, SWR = 4 in this case, passes through the chart center and is thus the locus of all impedances which can be matched to a 300-Ω line.

constant-SWR circles are no longer concentric. Fig. 5 shows the circles which result when the impedances along a mismatched 75-Ω line are normalized by dividing by 300 ohms instead of 75. The constant-SWR circles still surround the point corresponding to the characteristic impedance of the line (r = 0.25) but are no longer concentric with it. Note that the normalized impedances read from corresponding points on Figs. 4 and 5 are different but that the actual, unnormalized, impedances are exactly the same.

Let's turn now to the example shown in Fig. 6. A complex load of $Z_L = 600 + j900$ ohms is to be fed with 300-Ω line, and a 75-Ω series section is to be used. These characteristic impedances agree with those used in Fig. 5, and thus Fig. 5 can be used to find the impedance variation along the 75-Ω series section. In particular, the constant-SWR circle which passes through the chart center, SWR = 4 in this case, passes through all the impedances (normalized to 300 ohms) which the 75-Ω series section is able to match to the 300-Ω main line. The length $\ell 1$ of 300-Ω line has the job of transforming the load impedance to some impedance on this matching circle.

Fig. 7 shows the whole process more clearly, with all impedances normalized to 300 Ω. Here the normalized load impedance $z_L = 2 + j3$ is shown at R, and the matching circle appears centered on the real axis and passing through the points r = 1 and $r = n^2 = 0.0625$. A constant-SWR circle is drawn from R to an intersection with the matching circle at Q or Q′ and the corresponding length $\ell 1$ (or $\ell 1'$) can be read directly from the Smith Chart.

Although the impedance locus from Q to P is shown in Fig. 7, the length $\ell 2$ cannot be determined directly from this chart. This is because the matching circle is not concentric with the chart center, as it must be if the length indications on the periphery of the Smith Chart are to be used. This problem is overcome by forming Fig. 8, which is the same as Fig. 7 except that all impedances have been divided by n = 0.25, resulting in a Smith Chart normalized to 75 ohms instead of 300. The matching circle and the chart center are now concentric, and the series-section length $\ell 2$, the distance between Q and P, can be taken directly from the chart.

In fact it is not necessary to construct the entire impedance locus shown in Fig. 8. It is sufficient to plot Z_Q/n (Z_Q is read from Fig. 7) and $Z_P/n = 1/n$, connect them by a circular arc centered on the chart center, and to determine the arc length $\ell 2$ from the Smith Chart.

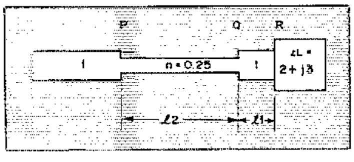


Fig. 6 — Example for solution by Smith Chart. All impedances are normalized to 300 ohms.

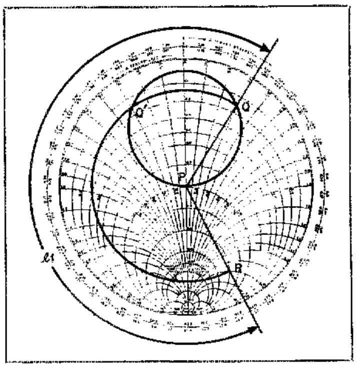


Fig. 7 — Smith Chart representation of example shown in Fig. 6. Impedance locus always has clockwise direction from load to generator, first along constant-SWR circle from load at R to intersection with matching circle at Q or Q′, then along matching circle to chart center at P. Length $\ell 1$ can be determined directly from chart.

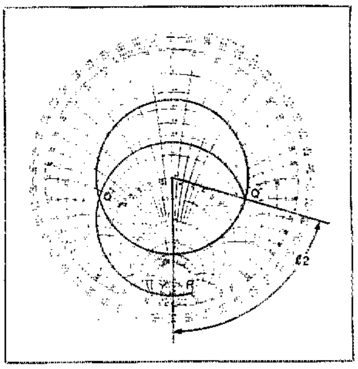


Fig. 8 — Same impedance locus as shown in Fig. 7 except normalized to 75 ohms instead of 300. The matching circle is now concentric with chart center, and $\ell 2$ can be determined directly from chart. In this example, $\ell 1 = 0.332\,\lambda$ and $\ell 2 = 0.102\,\lambda$.

The steps necessary to design a series-section transformer by means of the Smith Chart can now be listed:

1) Normalize all impedances by dividing by the characteristic impedance of the main line.

2) On a Smith Chart plot the normalized load impedance z_L at R and construct the matching circle so that its center is on the real axis and it passes through the points r = 1 and $r = n^2$.

3) Construct a constant-SWR circle centered on the chart center through point R. This circle should intersect the matching circle at two points. One of these points, normally the one resulting in the shorter clockwise distance along the matching circle to the chart center, is chosen as point Q, and the clockwise distance from R to Q is read from the chart and taken to be $\ell 1$.

4) Read the impedance Z_Q from the chart, calculate Z_Q/n and plot it as point Q on a second Smith Chart. Also plot r = 1/n as point P.

5) On this second chart construct a circular arc, centered on the chart center, clockwise from Q to P. The length of this arc, read from the chart, represents $\ell 2$. The design of the transformer is now complete.

The Smith Chart construction shows that two design solutions are usually possible, corresponding to the two intersections of the load constant-SWR circle with the matching circle, and also corresponding to positive and negative values of the square-root radical in Eq. 2. It may happen, however, that the load circle misses the matching circle completely, in which case no solution is possible. The cure is to enlarge the matching circle by choosing a series section whose impedance departs more from that of the main line.

A final possibility is that, rather than intersecting the matching circle, the load circle is tangent to it. There is then but one solution — that of the 1/4-λ transformer.

In conclusion, the series-section transformer is a convenient form of matching. It consists of a line section of not over a quarter-wavelength inserted into the main line at some point within a half-wavelength of the load. The characteristic impedance of the series section, Z1, can be either greater than or less than Zo, the characteristic impedance of the main line. The only restriction on the choice of Z1 is that it should not be too near Zo.

For a given Z1 it can be shown that a 1/4-λ matching section can handle the greatest mismatch. Lesser mismatches require shorter matching sections.

Several well-known matching arrangements turn out to be special cases of series-section matching. In addition to the quarter-wave transformer and the alternated-line transformer, it can be shown,[3] by allowing Z1 to approach zero, that stub-matching, too, is a special form of the series-section transformer.

Of the two design methods presented, the algebraic method is probably the easier if an electronic calculator is available. The Smith Chart method is a practical alternative and does provide additional insight into the operation of the series-section transformer.

References

[1]Regier, "Impedance Matching with a Series Transmission Line Section," *Proc. IEEE*, Vol. 59, No. 7, July 1971, pp. 1133-1134.

[2]Regier, "The Series-Section Transformer," *Electronic Eng.*, Vol. 45, August 1973, pp. 33-34.

[3]Bramham, "A Convenient Transformer for Matching Coaxial Lines," *Electronic Eng.*, Vol. 33, Jan. 1961, pp. 42-44.

Put Your All-Mode 2-Meter Rig on 220!

Tired of crystal-controlled, fm-only, 220 rigs? This transceiving converter will make your "do-everything," 2-meter rig do it on 220!

By Wayne Overbeck,* K6YNB/N6NB

Of all our vhf bands, 220 MHz may be the most promising. For fm enthusiasts, it offers the same reliable mobile communications possibilities as 2 meters, but without the crowds. And for ssb/cw enthusiasts, it's an exciting new world of DX possibilities. Veteran 220-MHz DXers say the tropospheric propagation is often much better than it is on 2 meters — and yet the high-gain antennas needed for serious DXing are fully a third smaller than on 2 meters!

This article describes a self-contained unit that will put any of the popular 2-meter fm or ssb/cw rigs on 220. It will deliver about 30 watts of power output on 220. The receiver section offers a noise figure about 2 dB — better than most commercial 2-meter units. By itself, this transverter is ideal for local and medium-range work on fm, ssb or cw. For serious DXing, it offers sufficient output to drive an external amplifier to the legal limit.

Design Approach

In this transverter the main goal was to keep things as simple as possible by staying with proven conventional circuits. In most stages tubes are used instead of solid-state devices. The dual tetrode specified here is self-neutralized, which makes it suitable for stable circuits that are somewhat forgiving of inexact construction methods and incorrect tuning. Also, these tube types are often found in surplus uhf-fm equipment, which means "pullouts" can often be bought at low prices. Moreover, the high-Q circuits built around these tubes are much less prone to have objectionable spurs than would be true in a solid-state design using the same conversion scheme.

Circuit and Construction Details

A 7-1/2 × 11 × 8-inch (190 × 280 × 200-mm) cabinet houses the whole works, although a slightly larger enclosure may

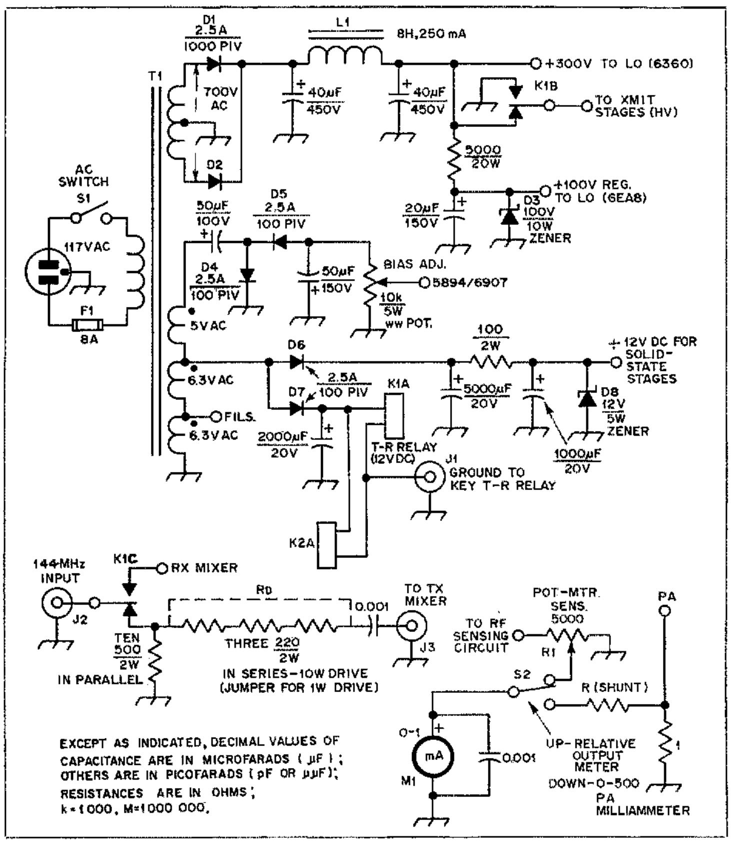


Fig. 1 — Power supply, control and metering circuits. T1 may be a TV-receiver power transformer or equivalent, provided the secondary can handle 450 to 500 mA. The shunt resistor (R shunt) in the metering circuit has a value determined by R_s = 500 ohms less the internal resistance of the meter. The series-drive resistor, R_d, consists of three 220-ohm 2-watt resistors in series for a 10-watt drive. A jumper across these resistors is used for 1-watt drive. Placing S2 in the up position permits the meter to read relative output. In the down position the meter serves as a 0- to 500-mA meter for the PA. See Fig. 3 for other connections for K2.

D1, D2 — Diode rectifier, 2.5 A, 1000 PIV.
D3 — Zener diode, 100 V, 10 W.
D4-D7, incl. — Diode rectifier, 3A, 100 PIV.
D8 — Zener diode, 12 V, 5 W.
J1-J3, incl. — BNC connector.
L1 — Filter choke, 8 H, 250 mA.
M1 — 0-1 milliammeter.
R1 — 5000-ohm, linear taper, carbon potentiometer.

*Contributing Editor, *QST*

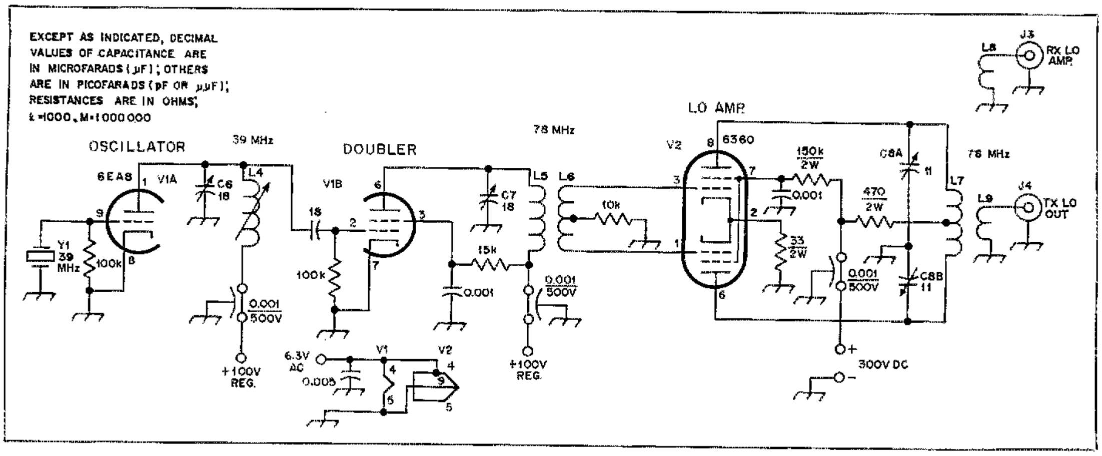


Fig. 2 — The transceiving converter local-oscillator chain. The 39-MHz crystal may be obtained from sources appearing in the *QST* Ham-Ads.

C6, C7 — 2- to 18-pF variable capacitor (E. F. Johnson type 160-110 or equiv.).
C8 — 2- to 11-pF butterfly variable capacitor (E. F. Johnson type 160-211 or equiv.).
J3, J4 — BNC connector.
L4 — 7 turns, no. 28 enam. on 3/8-inch dia form, ceramic, iron core.
L5 — 3 turns, no. 18 solid-covered, 5/8-inch dia, air wound.
L6 — 5 turns, no. 18, solid covered, air wound, 5/8-inch dia, center tapped.
L7 — 8 turns, no. 18, solid covered, air wound, 5/8-inch dia, center tapped.
L8 — 1 turn, no. 18, solid covered, 3/4-inch from either end of L7.
L9 — 2 turns, no. 18, solid covered, 3/4-inch dia around L7.
Y1 — 39-MHz crystal.

simplify the packaging job. The power-supply components are the dominant influence on the cabinet dimensions.

A good place to start in a project such as this is to build the power supply and relay circuitry as a foundation for the more critical rf work to follow. As Fig. 1 shows, the power supply uses a television-replacement power transformer that has two 6-volt filament windings along with its 5-volt winding. These windings should be connected in series to derive 12 and 17 volts ac. These voltages are rectified (and the 17 volts is doubled) for the relay, receiver and bias supplies. A simple ground-to-transmit T-R switching arrangement is used which is compatible with most multimode transceivers. When the T-R relay is energized, high voltage is applied to the transmit stages, the 2-meter input is switched, and a coaxial relay switches for antenna changeover.

The input swamping network shown in Fig. 1 is suitable for 10 to 15 watts of drive. The three 200-ohm resistors in series may be jumpered for use with 1-watt rigs.

Once the power supply and relay systems are working, build the local oscillator chain, as shown in Fig. 2. Select a suitable crystal frequency from Table 1 and build the chain in a small box. The author made all the boxes for his subassemblies by soldering together pieces of double-sided pc board. The LO circuitry is generally noncritical, except that the 6360 output should be isolated from the input with a shield across the tube socket — just as is done in the transmitter stages shown in the accompanying photograph.

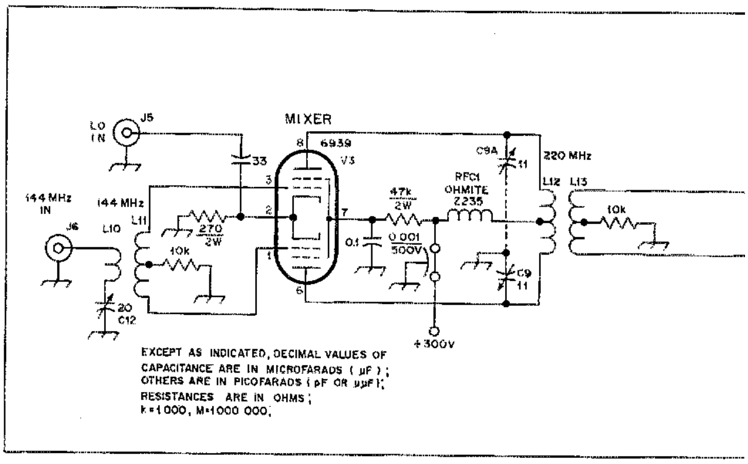
Table 1
Local Oscillator Crystal Plan

For output on:	*With an i-f of:*	*Use xtal for:*
220.0 MHz[1]	144.0 MHz	38.0 MHz
224.0	148.0	38.0
222.0	144.0	39.0
225.0	147.0	39.0
223.5[2]	146.52	38.49

Note 1: Most ssb/cw activity is at 220 MHz on the East Coast, but at 222 MHz on the West Coast.
Note 2: 223.5 is the national simplex frequency.

Fig. 3 — Transmitting stages of the 220-MHz transverter. The screen resistor may be adjusted to keep the screen voltage for the 6907/5894 at the rated level. All plate rf chokes are Ohmite type Z235. See Fig. 1 for other connections for K2.

C9, C10 — 2-11 pF per section butterfly variable capacitor (E. F. Johnson type 160-211 or equiv.).
C11 — 2-10 pF per section butterfly variable capacitor (E. F. Johnson type 167-201 or equiv.).
C12, C13 — 2-20 pF single-section variable capacitor (E. F. Johnson type 160-110).



In building the entire transverter, follow normal vhf construction practices. Keep all leads as short as possible and separate input and output tuned circuits as much as possible in each stage. There are two output loops for the 6360 LO amplifier stage — a tightly coupled one for the transmit mixer and one loosely coupled for the receive mixer.

The receiving mixer is a prepackaged broadbanded unit. One suitable model is the SRA-1, sold by Mini-Circuits Laboratory, 2625 East 14th Street, Brooklyn, NY 11235, at $9.95 each (at the time of this printing) in single quantities. The receiving preamplifier consists of two WB6NMT grounded-source JFET stages.[1]

The transmitter section should be built with a layout similar to that shown in the photograph, using a shield across each tube. If this layout is followed, there should be no instability problems. The author used a 3 × 3 × 11-inch (76 × 76 × 280-mm) sub-chassis for the transmitter section with a small enclosure on top for the final amplifier plate circuitry.

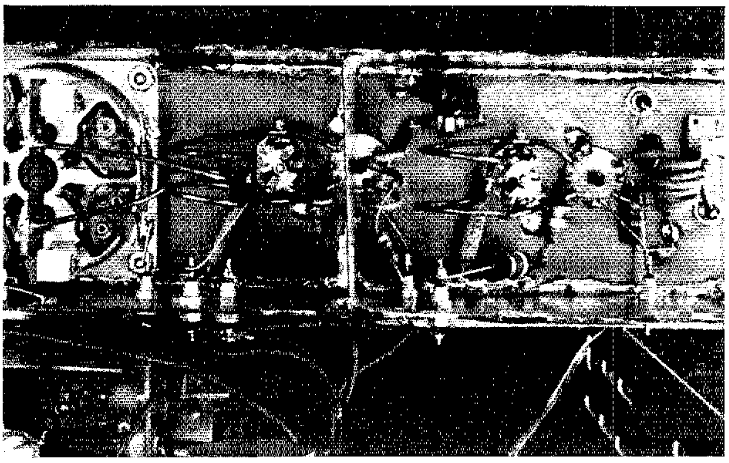
In the transmit mixer stage, it is important to inject the LO signal at the cathode and not at the more sensitive control grid. This is to help suppress the third harmonic of the LO, which falls near 234 MHz. Care must also be exercised in the tune-up process to avoid the false peak at that frequency. With proper tune-up, the spur is attenuated sufficiently to satisfy the "good engineering practice" requirement.

A 5894 tube with 600 volts on the plates can be used in the PA instead of the 6907 shown here. About 75 watts output is attainable with this configuration, although the PA enclosure will have to be enlarged to accommodate the taller tube.

The metering circuitry uses a 0- to 1-mA meter as a final amplifier cathode current monitor and a relative output indicator. Meter shunt values are determined from information given in the measurements section of *The Radio Amateur's Handbook.*

Tune-up and Initial Testing

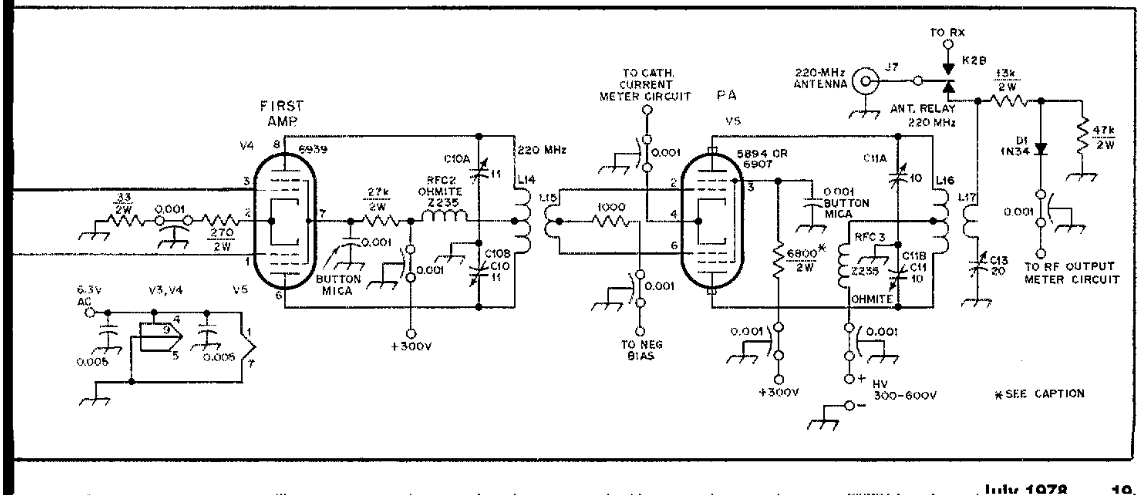
As soon as the power supply and local oscillator chain are built, testing can begin. With a dip meter, set the tuned circuits to the correct frequency and apply dc power. Place the meter in the diode-detector mode. Check for the 38-MHz oscillator signal. Adjust C6 and L4 for the point of maximum output that does not cause the stage to stop oscillating. Next, peak C7 and C8 for maximum indicated output at 78 MHz. The 6360 LO amplifier should deliver 1-3 watts for the transmit mixer and about 5 mW (+7 dBm) for the receive mixer. It may be necessary to adjust the output links to obtain these output levels. If in doubt, couple the LO output very loosely to the receive mixer at first, and only increase the coupling if the LO injection is clearly inadequate. The



Construction of the transmit mixer (left), and driver circuitry. Note the manner in which the i-f signal is coupled into the mixer grids. The LO signal is capacitively coupled to the cathode of the 6939. Several feedthrough capacitors are soldered to the pc board to provide low inductance rf ground paths. The 6939 driver stage is loosely coupled to the mixer plate circuit.

[1] "WB6NMT Low-Noise 220-MHz Preamplifier," The World Above 50 Mc., *QST*, March, 1972, page 100.

D1 — Signal diode, 1N34.
J5, J6 — BNC connector.
L10 — 1 turn, no. 18, 1/2-inch dia, closely coupled to L11.
L11 — 4 turns, no. 18, 3/8-inch dia, center tapped.
L12, L14, L16 — 2 turns, no. 12 solid copper, 1-1/8-inch dia, spaced 1/2 inch, center tapped.
L13 — 3 turns, no. 18, 3/8-inch dia, center tapped.
L15 — 1 turn no. 12, 1-inch dia.
L17 — 1 turn, no. 18, 7/8-inch dia, closely coupled to L16.
RFC1-RFC3, incl. — Ohmite no. Z235.



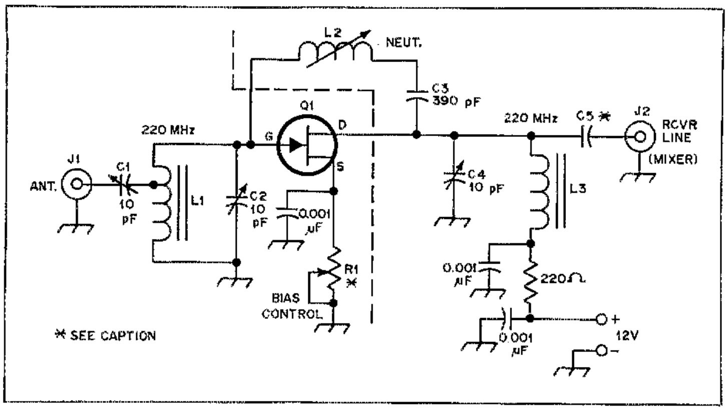


Fig. 4 — The WB6NMT low-noise 220-MHz preamplifier (March 1972 *QST*). Two of these are required, as shown in the block diagram.

C1 — 0.8 or 1- to 10-pF glass trimmer (Johanson 2950 or JFD VAM or MVM series).
C2 — Like C1, or Corning Direct Traverse CGW, 0.8 to 10 pF.
C3 — 390-pF, silver mica.
C4 — Like C1, C2 or less-expensive type with 1- to 10-pF range.
C5 — Experiment with values 1 to 5 pF, for maximum gain in system as it will be used.
J1, J2 — BNC connector.
L1 — 4 turns no. 22 enam. wire on Micrometals T-30-0 toroid core (Amidon Associates). Tap one turn from top, subject to adjustment for lowest NF. (Air-wound coils also usable, but toroids preferred.)
L2 — 9 turns no. 28 enam. wire on 1/4-inch, (6 mm) slugtuned form (Miller 4500, brass slug). Do not ground the slug.
L3 — Like L1, but no tap.
Q1 — 2N5245, 2N5486, MPF107 or TIS-88.
R1 — 200- or 250-ohm control, linear taper potentiometer, 1 watt.

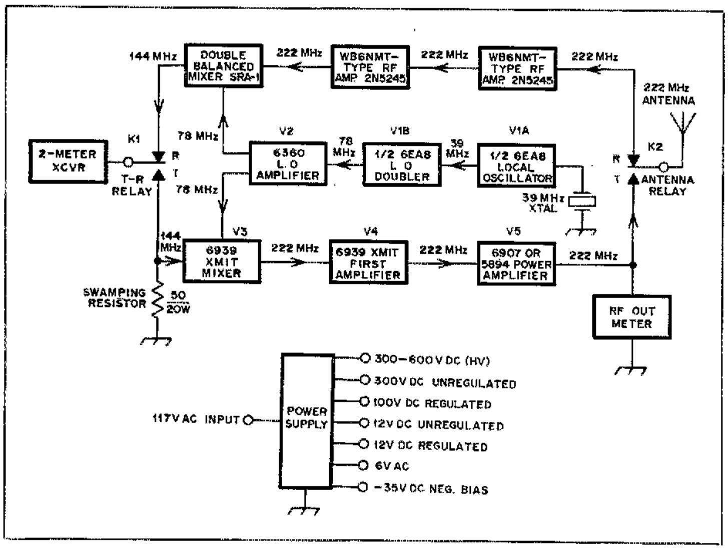


Fig. 5 — This block diagram of the 144- to 220-MHz transverter is a fourth-generation design, the latest in a series of transverters the author has built over a number of years. High-Q circuits reduce the possibility of objectionable spurs.

mixer can be destroyed by excessive LO input. As a final check of the LO chain, unplug the crystal. The output should disappear completely, indicating freedom from spurious oscillations.

When the transmitter section has been constructed and the tubes plugged in, resonate each tuned circuit to 220 MHz while observing the dip meter. Then connect the LO and i-f injection cables and a dummy load. Now key the T-R relay with no drive present and quickly adjust the final amplifier bias to produce 50 mA of idling current. Apply a 144-MHz signal and tune the mixer plate circuit for maximum indicated signal at 220 MHz, again using the dip meter as a detector. Peak each transmitter stage in succession for maximum output at 220 MHz, varying the interstage coupling if necessary. Once a wattmeter indicates substantial power output, remove the drive and be sure there is no indicated output. If there is, you have probably tuned up on the third harmonic of the LO. If this has happened, increase the capacitance in all LC circuits and go through the tuning process again.

Operating and Application Notes

After it is properly tuned up on the desired frequency, the transverter may be moved up or down about 500 kHz without retuning the transmit or receive stages. Those wishing broadband coverage at the expense of maximum power output and receiver sensitivity may want to stagger-tune the transmit and receive rf stages.

If the unit is to be used primarily to work through fm repeaters, it may be desirable to peak the transmit stages around 223 MHz while peaking the receive stages 1.6 MHz higher. To access repeaters using the 1.6-MHz split, there are two approaches with this unit. One is to add a second local oscillator at a frequency 1.6 MHz higher than the one used for transmitting. For occasional repeater users, a simpler method is to set the 2-meter rig for a 600-kHz offset and then switch the megahertz dial on the transceiver one position when going from transmit to receive.

For DX work, most operators will probably prefer to mount the receiving preamplifier at the antenna relay of a kilowatt final and disable the antenna changeover relay in the transverter. This avoids the losses inherent in the additional cabling and relays.

Conclusion

Should someone offer you an all-mode all-frequency 220-MHz rig with the performance range of your new 2-meter pride and joy, you most assuredly would not turn the offer down. The likelihood of such a generous proposition becoming a reality in your amateur radio life, in all probability, may be rather remote. Nevertheless, if the concept of having your "do everything" 2-meter rig do its thing on 220 MHz appeals to you, then begin your equipment building plans now. The rewards justify the effort. In fairness, however, I must caution that this is not an endeavor for the beginner.

What has been described here is not a one-evening project, but neither should it be overwhelming if the builder attacks one section at a time. As 220-MHz DX enthusiasts and those who have discovered the quiet world of 220 fm will tell you, building such a system is well worth the effort!

Power Relations and the Decibel Made Painless

For those of you who just walked in, those numbers over S9 on your S meter are not really called pounds.

By Eufemio S. Flores,* C2IEF/DU6ESF/9M2CS

On the amateur bands hardly a contact is made where there is not mention made of the decibel. It may be used as a signal report (you are coming in here 10 dB above S9), as a figure for signal-strength changes (your signal has gone up 2 dB), or as a figure of merit for antenna gain performance (8-dB-gain antenna). It may be worthwhile to review the *decibel* and its relationship to power ratios, voltage ratios, and circuit losses. Let's also examine its derivation and its proper usage. We'll use an approach that will be practical and eliminate confusion in its use and interpretation.

The author does not claim full originality in this presentation. This is actually only a summary and adaptation of notes gathered from experience as a student of electronics and communications, and as an active amateur. In this presentation a minimal reference to mathematical methods is made. However, practical knowledge in the use and interpretation of simple logarithmic equations will be an asset to the new ham as he studies antennas, amplifiers, transmission lines, etc.

The *decibel* is probably the most widely used unit in communications engineering. This is one tenth (deci) of the original international transmission unit which is the *bel*, adapted in honor of Alexander Graham Bell, the inventor of the telephone. The abbreviation for decibel is dB.

In audio and communications work, it is quite logical to relate power ratios to the inherent response of the human ear to sound-intensity variations. It has been determined that the ear is much more sensitive to changes in volume at low sound levels than at high sound intensities or levels. The human ear responds logarithmically to variations in sound intensity, and a difference of one decibel between two sound levels is just about the least a person can hear. (It is interesting to note that Dr. Alexander Bell was reported to be hard of hearing due to an ear ailment.)

*P. O. Box 267, Republic of Nauru

The Logarithmic System

What is a logarithm? The logarithm of a number has been defined as that power to which another number, called the base, must be raised in order to equal the first number. For example, if we use as a base the number 2, the logarithm of number 4 to the base 2 is 2, i.e., $4 = 2^2$. It is standard practice to use the number 10 as a base in logarithmic work for calculations with sound and power relationships. A logarithm to the base 10 is referred to as a *common logarithm*. For example, it is necessary to raise 10 to the second power, or to square it (10^2), to get 100.

By definition, therefore, the logarithm (abbreviated *log*) of 100 is 2. Similarly the logarithm of 1000 is 3. We will not get much more involved in logarithms. Just be aware that the log of any number *between* 100 and 1000 must be a value between 2 and 3 — 2 plus a decimal fraction. And the log of numbers between 10 and 100 would be 1 plus a decimal. For example, the log of 250 (common logarithm) is 2.39794; of 25 is 1.39794; of 2.5 is 0.39794. Note that in each case the value to the right of the decimal point is the same. (This is because we are using the base 10, and the numbers used in the example are related to each other by a factor of 10.) These decimal values can all be taken from a log table.

You can see that as the numbers get smaller, their logarithms also get smaller. The logarithm of 1 is 0, because 10 raised to the 0 power equals 1 — $10^0 = 1$. What about the logarithms of positive values less than one? Here it gets complicated, because the logarithms must assume a negative value.

The decibel (one tenth of a bel) has been set by definition as:

$$dB = 10 \log \frac{P2}{P1}$$

where P2/P1 is the ratio of the two powers being compared. In decibel computations, it is convenient to place the larger power value on top of the ratio as the numerator (P2 the larger power and P1 the smaller power). This way, the result will always be greater than one and the logarithm of the ratio P2/P1 will always be a positive value. Thus the use of complicated negative logarithms is avoided. It will be obvious in each of the power relationship problems that either a gain (+) or a loss (−) in decibels will result. The negative sign can be inserted before the decibel value if a loss is indicated. This will become quite apparent as power-relationship problems or exercises are worked out.

Table 1 illustrates the relationships between power, voltage and current ratios, and the decibel. In this table, reference of course is made to the elementary relationship that power (P) is equal to I times E (current multiplied by voltage), and also that in the computation of decibels involving voltage or current ratios, it is usual to assume a *common impedance*. You may wish to check on the figures indicated in

Table 1 as an exercise, by referring to a table of common logarithms (base 10).

A brief analysis of Table 1 will show the following approximate observations in values:

1) A 1-dB gain or loss is equal to a power ratio of 1.259, which we can round off to 1.26 without affecting relative values appreciably and for practical application.

2) A 2-dB change is equal to a power ratio of 1.585.

3) It will be noted that 1.585 is the result of raising 1.26 to the second power ($1.26 \times 1.26 \approx 1.58$).

4) A 3-dB gain or loss represents a power ratio of about 2.00, or 1.26 raised to the third power.

5) A very simple and approximate rule therefore to convert decibels to equivalent power ratios is to raise the figure 1.26 to the power (exponent) equal to the number of decibels involved.

As mentioned earlier, in working with decibel computations, gain (+) or loss (−) can be indicated in an analysis of overall system performance. Decibels can be added arithmetically, while the ratios will multiply. Let us consider as an example the problem of converting 25 decibels to its equivalent power ratio, namely 25 dB = 10 dB + 10 dB + 5 dB. Converting to equivalent power ratios we have $10 \times 10 \times 3.162 = 316.2$. Since decibels represent ratios only, a positive 25 dB would imply a gain ratio of 316 to 1, while a negative 25 dB would represent a value 1/316 of the original.

Let us take another example and convert 12 dB to its equivalent power ratio: 12 dB = 3 dB + 3 dB + 3 dB + 3 dB. Converting to equivalent power ratios, $2 \times 2 \times 2 \times 2 = 16$. Therefore 12 dB represents a power ratio of about 16 to 1.

Table 1
Relationships of Ratios to Decibels

Power Ratios		*Transmission Units In Decibels (dB)*
1	$(= 10^0)$	0 (= 10 log 1)
1.259	$(= 10^{0.1})$	1 (= 10 log 1.259)
1.585	$(= 10^{0.2})$	2 (= 10 log 1.585)
1.995	$(= 10^{0.3})$	3 (= 10 log 1.995)
3.162	$(= 10^{0.5})$	5 (= 10 log 3.162)
10	$(= 10^1)$	10 (= 10 log 10)
100	$(= 10^2)$	20 (= 10 log 100)
1,000	$(= 10^3)$	30 (= 10 log 1000)
10,000	$(= 10^4)$	40 (= 10 log 10,000)

Voltage or Current Ratios	*Transmission Units In Decibels (dB)*
0.001	−60.00
0.005	−46.02
0.01	−40.00
0.05	−26.02
0.1	−20.00
0.2	−13.98
0.5	−6.02
1.0	0.00
2.0	+6.02
5.0	+13.98
10	+20.00
20	+26.02
50	+33.98
100	+40.00
500	+53.98
1000	+60.00

Some Practical Examples

Expressing gains or losses of various circuits or components in terms of decibels eliminates the computing of gains or losses by laborious multiplication or division. The total gain or loss of a circuit can be calculated by adding the individual decibel gains and losses of the various circuit components (using a plus sign to indicate gain and a negative sign to indicate loss). Let's try this example. A high-impedance dynamic microphone with an output of +2 dB (we'll take up reference levels later) is connected to a speech processor with a gain of 40 dB. The output of the speech processor is connected to an audio-control pad with a loss of 10 dB, and from there to the equipment speech amplifier with a gain of 80 dB. What is the total gain? In this example, all dB values were assumed from a common reference level of 0 dB. As the microphone output is 2 dB above the reference level, the speech processor brings the combined level up to +2 dB + 40 dB = +42 dB. The audio-control pad brings down the level to +42 − 10 = +32 dB. And finally the speech amplifier effects a gain of 80 dB, and +32 + 80 = +112 dB. The overall gain of the system is therefore simply the algebraic sum of the decibel gains and losses of the individual circuit components.

Let us take another example. A receiver utilizes a power transistor in a final audio stage that delivers 4 watts to an audio-output transformer. You are considering modifying the circuit in order to substitute a larger audio power transistor that will deliver 6 watts to the audio transformer. You ask yourself, "Is the expected power gain sufficient to warrant the expense of making this change?" Changing the audio-output transistor causes a ratio increase of 1.5, or a 50 percent increase in audio power. At first this would appear to be a very substantial increase. But let us express the power ratio in terms of decibels as we find it in our log tables and formula:

$$dB = 10 \log \frac{P2}{P1} = 10 \log \frac{6}{4}$$

$$= 10 \log 1.5 = 10 \times 0.17609$$

$$= 1.76 \text{ dB}$$

Such an increase in audio power would hardly be noticeable, as far as the ear is concerned. Hence, the audio gain expected is actually very minimal.

Reference Levels

Now let's discuss reference levels. In as much as the decibel is an expression of power ratio, it would be meaningless to say that an amplifier or an antenna has an output or gain of so many decibels unless that output or gain is referred to some standard or predetermined level. Several decibel reference levels are in use in communications. In telephone and audio amplifiers, 0.006 watts or 6 milliwatts is used as the reference or 0-dB level. This means that if an audio amplifier is rated at 40 dB, its power-output capability is 40 dB above a reference level of 6 milliwatts. The amplifier therefore has an audio power output of 60 watts. (You can check this very quickly by referring to Table 1.)

Gain is often used as a figure of merit for an antenna, especially a directional type, and is usually expressed in decibels. What is really meant when we say, "My beam has a gain of 8 dB," or, "A 2-element beam is rated at 6 dB"? Here the idea of a reference level becomes readily apparent. Say that we supply a specific amount of power to the antenna and observe the received signal strength at some distant point in the desired direction. The gain of the antenna in dB is determined from the ratio of this specific power to that which must be supplied to a standard-comparison antenna in order to produce the same signal strength at the distant point. It follows that the gain of one antenna over another could be taken as the ratio of their respective radiated fields. Here again, the stipulations of the reference-level condition is important, because if conditions are not the same the analysis is meaningless.

In amateur antenna analysis, the generally accepted reference or standard is a half-wavelength dipole. Suppose 100 watts is supplied to a Yagi beam, resulting in an rf voltage at the terminals of a distant receiving antenna of 20 microvolts. And suppose that with a simple half-wave dipole used instead of the Yagi, a power of 300 watts must be used to produce the same reading (20 microvolts) at the receiving location. It will be noted that in as much as the same antenna is used for receiving and that the voltage delivered by the antenna to the receiver is the same in each case, the same amount of power is delivered to the receiver for both transmissions. Therefore the gain of the Yagi may be found from the ratio of the transmitted powers.

$$\text{Gain} = 10 \log \frac{P2}{P1} = 10 \log \frac{300}{100}$$

$$= 10 \log 3 \approx 5 \text{ dB}$$

Or, if you prefer, Table 1 may be used to get the same approximate result.

A practical approach and an understanding of power relationships and the decibel can be used to replace fancy mathematics and involved logarithms, as has been shown. We hope that by reading this article and trying a few problems of your own that you will have a better understanding of the decibel.

Transmitter Design — Emphasis on Anatomy

Part 3: Broadband power amplifiers eliminate the need for complicated band-switching circuits. Some amateurs believe that they are mysterious and hard to build. 'Tain't so!†

By Doug DeMaw,* W1FB

It's unlikely that Freddie would have been able to design the broadband amplifier we are describing here, but he certainly should have enjoyed success in duplicating it and making it perform correctly. However, had something malfunctioned in his assembled module his chances of locating the anomaly would have been enhanced greatly by an understanding of how a broadband amplifier functions. Let's consider the subject of how one of these critters does its particular "thing."

A broadband amplifier is intended to do precisely the job its name implies — amplify signal energy over a broad slice of the frequency spectrum. In meeting this requirement the amplifier should provide reasonably uniform output power across the band of frequencies it is designed to accommodate. Thus, if the circuit was designed to cover from, say, 3.5 to 14 MHz, and deliver 5 watts of output, there should be 5 watts of output available (no more and no less) at any discrete frequency within that range. In practice it is difficult to obtain that kind of precision, but a variation in power no greater than ±10 percent can be realized in a carefully designed amateur circuit.

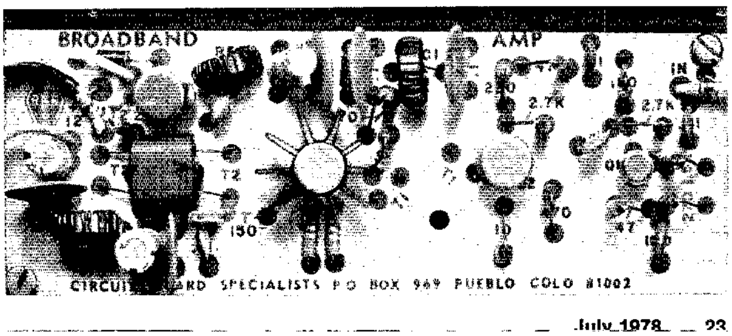
Solid-state amplifiers tend to supply increasing amounts of output power as the operating frequency is decreased. That is, a given transistor will exhibit more gain at 1.8 MHz than it will at 7 or 14 MHz. Therefore, in order to obtain a relatively flat frequency response from a solid-state, broadband amplifier it is necessary to use certain compensating elements to "taper" the overall gain downward toward the lower end of the amplifier operating range. The inclusion of feedback networks is the most common approach to this design criterion. The mathematical solutions to feedback design problems are beyond the scope of this article, but in-depth data on the subject are given in the ARRL book, *Solid State Design for the Radio Amateur.*

The required feedback for a broadband amplifier is usually introduced by means of R and C components between the collector and base of the transistor (negative feedback), and through the inclusion of degenerative feedback in the emitter circuit. Concerning the latter, the emitter bias resistor is bypassed for rf at the higher end of the amplifier frequency range (low-value capacitor), but is bypassed less effectively as the operating frequency is lowered. At the lowest end of the amplifier range the emitter may function as if no bypass capacitor was there at all. In ordinary language we are saying that the less effective the bypassing the lower will be the stage gain. This kind of frequency-response shaping can be further enhanced by selecting specific values of coupling capacitance between amplifier stages. That is, a low value of capacitance will be less effective as a coupling device at the low-frequency end of the range than it will at the high-frequency end of the range.

The feedback resistors and capacitors used between the collector and base of a broadband amplifier are chosen with the same design philosophy in mind. In this case the lower the operating frequency the greater the feedback voltage through a given value of base-to-collector resistor: The greater the feedback, the lower the stage gain. In cases where the feedback resistor is so low in value that excessive foward bias would reach the transistor base, a blocking capacitor is added in series with the resistor and forward bias is obtained by means of a separate resistive divider.

Broadband transformers are also used

Closeup view of the broadband linear amplifier.



†Parts 1 and 2 appeared in *QST* for May and June, 1978.

*Senior Technical Editor, ARRL

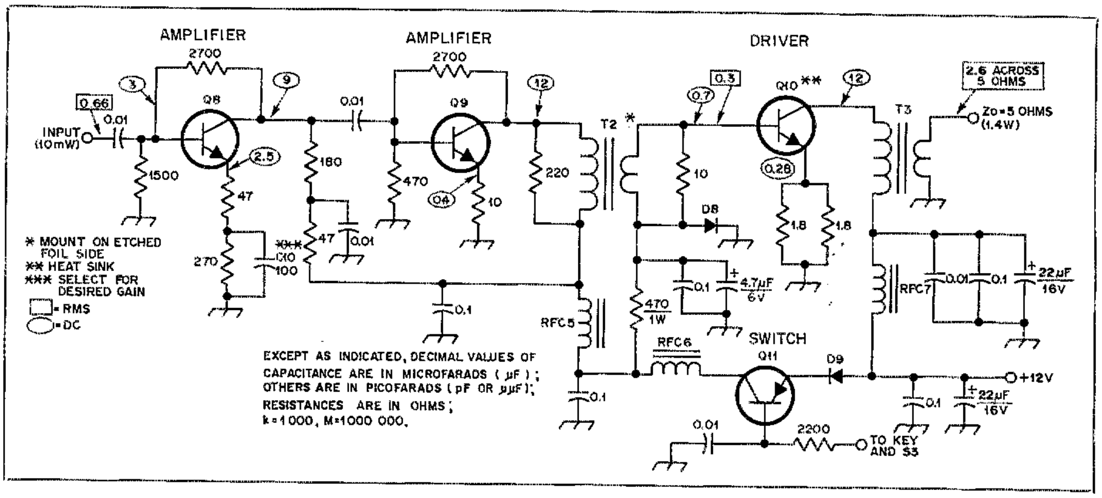


Fig. 7 — Schematic diagram of the broadband linear amplifier. Capacitors are disk ceramic except those with polarity marked, which are electrolytic or tantalum. Resistors are 1/2-W composition unless otherwise noted.

C10 — See text.
D8, D9 — 1-A, 50-PRV silicon (1N4003 suitable).
Q8 — 2N2222A or equivalent.
Q9 — 2N3866 or HEP S3008.
Q10 — 2N2270 or HEP S3001.
Q11 — 2N4037 or HEP S3012.
RFC5-RFC7, incl. — 18 turns of no. 28 enam. wire on FT-37-43 ferrite toroid core.
T2 — Primary has 30 turns of no. 28 enam. wire on a FT-50-43 ferrite toroid core. Secondary has 4 turns of no. 28 enam. wire wound over cold end of primary winding.
T3 — Primary has 16 turns of no. 28 enamel wire looped through a BLN-43-302 ferrite core. Secondary has four turns of no. 28 enam. wire looped through the same core. Primary leads come out of end of core opposite the secondary leads.

in the type of amplifier under discussion. They are designed to operate as untuned rf transformers with a turns ratio chosen to match the output of the amplifier stage to its load (collector of one stage to the base of a succeeding stage, for example). A deliberate mismatch is sometimes introduced by the designer to achieve amplifier stability. Another approach is to shunt one or both of the transformer windings with a resistor. This tends to lower the transformer Q, which in turn discourages self-oscillation. The trade-off is in reduced stage gain.

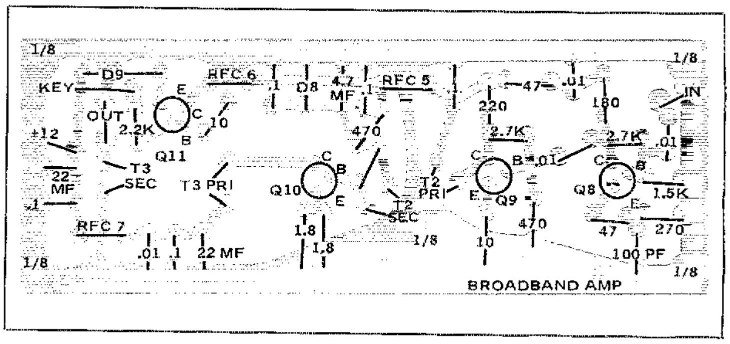


Fig. 8 — Parts placement guide for the amplifier pc board. The shaded area represents an X-ray view of the etched foil pattern; this view is from the component side of the board. (See Hints and Kinks in this issue for etching patterns.) Double-sided board is used for this module. The foil on the component side is used as a solid groundplane, having only clearance holes for the mounting of the components. The commercially made board shown in the photo also has component identification information etched on this side of the board. All mounting holes on pc board marked with a "1/8" should be drilled through with a 1/8-inch drill bit. The board can then be mounted to the chassis with 6-32 machine screws, spacers and nuts.

Examination of Our Circuit

The broadband amplifier used in our transmitter is shown in Fig. 7. It was inspired by a similar circuit in the Atlas 210X transceiver. With approximately 10 mW of driving power at the input to Q8, the amplifier output at Q10 will be roughly 1.4 watts at 7 and 14 MHz. The input impedance of the composite amplifier is close to 50 ohms.

Feedback is provided at Q8 and Q9 by means of the 2700-ohm resistors connected between the collector and base of each stage. Degenerative feedback for Q8 is obtained by leaving part of the emitter-bias resistance unbypassed (47-ohm resistor). No bypassing is used across the 10-ohm emitter resistor of Q9. The parallel 1.8-ohm resistors in the emitter return of Q10 serve two purposes: They are unbypassed to provide degenerative feedback, and they help to protect the transistor from drawing excessive current (thermal runaway).

T2 is a broadband toroidal-wound transformer. It is loaded on the primary by a 220-ohm resistor. A 10-ohm resistor is in parallel with the secondary winding. These resistors were added to reduce the drive to Q10, and to cure a low-level oscillation which occurred during the checkout period. T3 is also a broadband coupling transformer. It is wound on a ferrite core of the balun type. In the breadboard model of this amplifier an RCA 40082 transistor was used at Q10. Owing to its gain and f_T characteristics, it was somewhat more "lively" than the 2N2270 of Fig. 7. To obtain equal performance it was necessary to bridge the primary of T3 with a 150-ohm resistor. This ensured stability.

All three amplifiers are biased for linear operation (Class AB). This has no special value in a cw or fm transmitter, as Class C amplifiers are adequate for those modes. The primary advantage in using a linear amplifier in our transmitter is to lower the driving-power requirements (the transistors require less excitation voltage) and to lessen the occasion for harmonic generation in the stages (Class C amplifiers are richer in harmonic currents). The forward bias applied to Q10 is developed across D8, which regulates the bias by virtue of its barrier voltage (0.7 volt for a silicon diode). A 470-ohm dropping resistor is used between D8 and the 12-volt supply line to prevent the diode from consuming excessive current.

Decoupling networks are used in the 12-volt line between stages. This aids in preventing feedback (positive) from one stage to another. An excessive amount of feedback will cause self-oscillation of one or more of the stages. At Q8 a 47-ohm resistor and 0.01-μF capacitor comprise the decoupling circuit. RFC5, RFC6 and the two 0.1-μF bypass capacitors are used for this purpose at Q9. RFC7 and the related bypass capacitors are employed at Q10 to decouple the stage from the 12-volt line. High, medium and low values of capacitance are used at Q9 and Q10 to assure adequate decoupling at lf, hf and vhf. (The stages could self-oscillate at any of those frequencies.) Who needs or wants to be haunted by the "Freddie syndrome?"

A pnp bipolar switch (Q11) is shown in Fig. 7. It operates in the same manner as Q6 of Fig. 6. When the key is closed, Q11 conducts and permits +12 volts to reach Q9 and the bias network for Q10. A one-second oscillation occurred in the breadboard version of the transmitter, caused by the decoupling capacitors at Q9 and Q10. This formed a timing circuit which was triggered by a self-oscillation at Q11. The decoupling capacitors at Q9 and Q10 acted as a tuned-collector/tuned-emitter circuit for Q11. The oscillation caused the break-in-delay circuit to cycle at a one-second rate. This resulted in a repetitive cycling of the relay, K1. Insertion of D9 at Q11 cured the problem by providing a one-way gate in the feedback path. A crown type of heat sink is needed at Q10 to prevent damage to the transistor.

Amplifier Testing

Following completion of the assembly procedures given in Fig. 8, amplifier testing can be done. Tests can be performed first by connecting the VFO directly to the input of Q8 of Fig. 7 (40 meters). A 5-ohm, 2-watt load resistor should be attached across the secondary of T3. Apply operating voltage and short the keying line to ground. A VTVM and an rf probe can be used to compare the circuit voltages with those of Fig. 7. Approximately 2.6 volts rms will appear across the 5-ohm load resistor if the circuit is working correctly. If the overall amplifier gain is too low, increase the value of C10 experimentally. Although 100 pF was right for the circuits built by W1FB and WA0UZO, variations in transistor gain may require that less feedback be used at Q8. These tests can now be repeated at 20 meters, using the push-push doubler between the VFO and broadband amplifier.

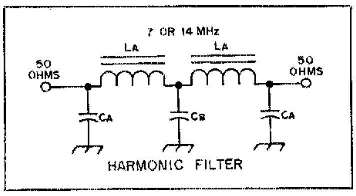


Fig. 9 — Diagram of the half-wave harmonic filter discussed in the text. For 7-MHz use, L_a is 1.1 μH (15 turns no. 26 enam. wire on a T50-2 toroid core). C_a is 470 pF and C_b is 910 pF. For 20-meter operation L_a is 0.55 μH (10 turns no. 26 enam. wire on a T50-2 toroid core). C_a is 240 pF and C_b is 470 pF.

This much of the transmitter can be put on the air if the builder likes true QRP work, but it should *not* be connected to an antenna unless a harmonic filter is placed in the output line from T3. Furthermore, the turns ratio for T3 will need to be changed to provide a match to a 50-ohm filter and antenna. The secondary winding of T3 will require 15 turns rather than four turns if this is done. Fig. 9 gives the details for half-wave filters which can be used at 7 and 14 MHz, respectively.

50 Years Ago

July, 1928

☐ The new 10-meter band is producing surprising DX, contrary to established theory; Editor Warner speculates on reasons, but doesn't mention sunspots.

☐ Ross Hull visited the Naval Research Laboratory and brings back a mouth-watering description of the equipment and techniques.

☐ In a brilliant treatise on radio law, General Counsel Segal concludes that an amateur can handle a message of *any* content only so long as he receives no valuable consideration for the task (a principle accepted even by the federal regulatory agency until it was scuttled a few years ago).

☐ Considerable propagation research is underway at the Massachusetts Institute of Technology's installation on the estate of Col. E. H. R. Green, on the Massachusetts coast.

☐ 8CMU says an oscillator-amplifier system, carefully neutralized and adjusted, can be modulated to produce a good phone signal and not one of those under heavy criticism for overmodulation and instability heard so often today.

☐ W. J. Halligan (pre-Hallicrafters) describes a new 4000-μfd. capacitor and associated choke to remove annoying hum from the filament supply.

☐ You can be sure each circuit of your gang-tuned receiver is in resonance if you use the testing system 1JJ outlines.

☐ W. H. Christie says his parallel-line circuit of copper tubing works fine on five meters, having stability without tricky adjustments.

☐ 6AM taught his Mrs. how to operate his rig in only 15 minutes.

☐ 8ZZ's cover cartoon shows an automatic CQ machine — left running so long it put the operator to sleep!

25 Years Ago

July, 1953

☐ You can be sure not only of getting the best signal-to-noise ratio in your v.h.f. receiver, but also can make comparative measurements on h.f. gear, with the simple noise generators described by W1HDQ.

☐ The Hq. has produced a sample script for use by a local club in presenting a television program explaining to the public the reasons for interference to TV reception.

☐ Sideband is still sufficiently new that many of us are not wholly certain of its principles, so W1PNB leads us by the hand through basic voice-transmission fundamentals.

☐ Also in down-to-earth style, but useful for the old-timer as well, is W1ICP's compilation of varied practical applications for the simple neon bulb.

☐ W4TKL folds his 75-meter mobile whip forward and feeds its tip (base end grounded) through a tuning setup which permits resonance changes.

☐ W2PAT obliges a number of requests by providing a frequency-shift keyer circuit we can use on the sub-bands recently opened to that mode.

☐ W2ZGP and W2TTU built a 420-Mc. control link to avoid daily winter treks to their snowbound hilltop primary station.

☐ W1HDA's formal paper in the professional *Proceedings* gives plenty of credit to amateur accomplishments in studies of ionospheric propagation.

☐ FCC had proposed to delete special call-sign provisions (two-letter calls, club calls in memoriam, etc.) but finally relented under heavy League protest and let the rules stand. — *W1RW*

CB to Ten Meters

Ten meters is alive and kicking! It's buzzing, too, with 5-watt voices from modified CB sets. Is yours one?

By Dennis Mudge,* WB6PGJ

A bevy of newer amateurs and oldsters may be tacitly giving the nod to a new lease on life for a less than "in" mode of amateur communication; "ancient modulation," some call it. Like a spot that won't go away, that name was dubbed on amplitude modulation soon after single sideband swung into popularity, and this somewhat disparaging epithet seems destined to last. A new lease on life, however, could be in the offing for a-m as the result of a bonus stemming from CB radio. So think a bit more kindly toward ancient modulation. You could be back in the act!

The death knell for the sale of 23-channel CB radios came at the end of 1977.† Manufacturers and dealers dumped their 23-channel equipment on the market in a bargain bonanza that dazzled the eyes not only of CBers, but also licensed radio amateurs who sensed a golden opportunity. Ways of converting CB equipment for 10-meter operation surely were no guarded secrets and at those giveaway prices, amateurs from coast to coast rationalized by asking, "How can we go wrong?" And so into the homes of these hams came CB transceivers destined for the modifications, often simple, that would convert them for 10 meters. Along with the bargain, however, came the amplitude-modulation systems with which a vast number of CB rigs had been equipped.

Curiosity

With the 10-meter band having opened up again, curiosity stirred me to see what it was offering. On the shelf was that faithful old Johnson Ranger. As I dusted it off and played around with it for a few minutes to see if it still worked, I thought "Would a CQ on 10 be in vain?" Only way to find out, I reasoned, was to give it a whirl. The response was immmediate and rewarding. Not only was I enjoying the experience but I also discovered that late morning to midafternoon proved ideal for a-m activity. What, perhaps, was a greater surprise to me was the number of new amateurs using converted CB sets that produced signals with plenty of punch. Under favorable conditions, many of those little 5-watt transceivers were being received Q5, peaking at times S8 to S9. That's armchair copy in my book!

Renewing my acquaintance with 10 meters, as I did, kindled my enthusiasm not only to become active again on this segment, but also to convert my own CB transceiver. With considerable band space and seemingly little QRM, conditions on 10 appeared to be ideal for working with low power.

*16001 P St., Mojave, CA 93501

†[Editor's Note: Since January 1, 1978, *no* 23-channel rigs may legally be sold in the U.S., either by dealers or by individuals. This ban applies to both new and used equipment. Similar restrictions apply to dealers (but not individual amateurs) in Canada.]

Table 1

Channel Frequency Chart. This table may serve as a guide for converting a CB set for 10-meter operation. Each frequency is 2.0 MHz above the corresponding CB channel.

Channel	*Freq. (MHz)*	*Channel*	*Freq. (MHz)*
1	28.965	21	29.215
2	28.975	22	29.225
3	28.985	23	29.255
4	29.005	24	29.235
5	29.015	25	29.245
6	29.025	26	29.265
7	29.035	27	29.275
8	29.055	28	29.285
9	29.065	29	29.295
10	29.075	30	29.305
11	29.085	31	29.315
12	29.105	32	29.325
13	29.115	33	29.335
14	29.125	34	29.345
15	29,135	35	29.355
16	29.155	36	29.365
17	29.165	37	29.375
18	29.175	38	29.385
19	29.185	39	29.395
20	29.205	40	29.405

About Modifications

Converting my Lafayette 525F synthesized CB rig mainly involved changing two crystals and retuning the stages for the 23 channels. Of course there were those tasks of using the signal generator, frequency counter and the VTVM for final adjustments. The tune-up and alignment instructions furnished by the manufacturer were of much help in performing those adjustments.

Not all CB sets, however, are that easily modified. Older CB rigs that operate with two crystals (transmit and receive) for each frequency would involve a much costlier conversion, provided the operator wanted many different channels. The newer type CB transceivers employ phase-locked-loop circuits. Converting these sets, likewise, is not a simple task.

A Band Plan

Anyone considering the conversion of a CB set for 10-meter operation will do well to arrange a band plan for channelized operation. Beside one's individual preference for specific operational frequencies, thought should be given to such uses as cw, ssb, a-m and OSCAR communications. Table 1 furnishes a plan that is currently employed by some equipment manufacturers. The frequencies selected are 2 MHz above the equivalent CB channels. Such a plan should be prepared before ordering crystals. Incidentally, I chose to refrain from operating in the lower portion of the 10-meter band where competition with the heavy amount of ssb activity would be rather futile for anyone operating with a low-power a-m transceiver.

Because many crystal manufacturers have technical specifications for various makes of CB equipment, they may, in some instances, be able to assist amateurs with correct crystal calculation and correlation. Therefore, when placing an order for crystals, include a note specifying the make and model set to be converted. Do furnish ample information.[1]

Other Angles

Naturally, with channelized operation of CB transceivers, tuning is restricted in comparison to a normal ham-band receiver. Most of these transceivers, however, do have a "delta" tuning adjustment that permits the operator to fine tune ±2 kHz. That amount of variation may not seem sufficient at times. For instance, let's say your set can transmit on channel 1 (28.965 MHz) and also on channel 2 (28.975 MHz) but a station is calling you on 28.970 MHz. What to do? In anticipation of a situation like this, one may install a multiple-deck, crystal-switch socket assembly to allow more coverage over the 10-meter band to include such off-frequency channels.

The Lafayette 525F, the B and K Cobra, model 19-21-29, and the Robyn T123-B may be converted to 10 meters by changing the original 11.275- and 11.730-MHz crystals. Substitute a 9.275-MHz crystal for the transmitting 11.275-MHz crystal. Replace the 11.730-MHz receiver crystal with one cut for 9.730 MHz. After alignment, the transceiver will perform with channel 1 at 28.965 MHz and channel 23 at 29.255 MHz.

For operation in the Novice segment of the 10-meter band (channel 9 through 16), replace the 11.275-MHz transmitting crystal with one cut for 10.235 MHz. Change the 11.730-MHz crystal for one cut to 10.690 MHz. As a result, channel 1 will be on 28.005 MHz and channel 23 will be set for 28.295 MHz.

Because a-m operated CB sets do not have a BFO, some external means of beat-frequency oscillation will have to be provided if the operator prefers to work cw. Keying can be accomplished by adapting the microphone push-button control circuit for cw operation.

Conversion of ssb sets such as the Pace models 1000B and 1000M, the Cobra Models 138 and 139, and the Midland 13-895 require changing only one crystal, provided that the crystal filter is also changed. The 7.8025-MHz crystal and filter are replaced by one for 9.8025 MHz. The stages are then retuned. With this conversion, channel 1 will be at 28.965 MHz and channel 23 will be set for 29.255 MHz.

A final step in modifying a CB set for 10-meter operation is correcting the antenna for the new band. In general, because the 10-meter band has a range of frequencies that are higher than the 11-meter CB band, the CB antenna should be made electrically shorter. For base-loaded antennas this may simply mean an adjustment for minimum SWR. A whip antenna may be shortened by removing the base spring, thus avoiding a need to cut the antenna itself.

While many amateurs may have feelings of reservation about CB operations as such, these same amateurs may wind up thankful for the bonus of equipment made available as a consequence of the events in the world of citizens band radio. And as for a-m, well, who knows?

[1]Bartlett, "Crystals Inside Out," January 1978 *QST*.

Strays

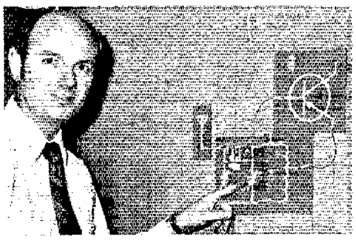
INSTRUCTOR OF THE YEAR AWARD

☐ The Lake County (IN) Amateur Radio Club, in cooperation with the ARRL Club and Training Department, is sponsoring the Herb S. Brier, W9AD, Memorial Award, to be given to an outstanding amateur radio instructor.

The longtime Novice editor for *CQ* magazine, Herb was often bedridden with arthritis from the age of 13. He devoted his life to amateur radio: tutoring students, writing articles, building equipment and operating. His dedication to helping newcomers enjoy amateur radio inspired the Lake County ARC award.

To apply for the award, send ARRL hq. a summary of your amateur radio instructional activities for the period September 1, 1977 to September 1, 1978. Include comments on publicity, dropout and success rates, percentage of students remaining active and upgrading, your own amateur radio activities (the good instructor is well-rounded in amateur radio) and a statement about your efforts from your sponsoring organization (if any). Also, encourage your students and graduates to send us letters supporting your application. Closing date is October 1, 1978.

The professional staff of the Club and Training Department will review the applications, and select the most outstanding amateur radio instructor of the year. The winner will receive a handsome plaque, donated by the Lake County ARC, and an announcement will be made in *QST*. Runners-up will also be announced. An application form is available from ARRL hq. We will also send one to your nominee for this award. — *WB2CHO*



Who will be the next "Herb Brier" Instructor of the Year? You? Your club member? Your instructor? Write Club and Training Department, ARRL hq. for full details.

YOU'RE BEING HEARD!

☐ Been on OSCARs 7 or 8 lately? If so, the chances are good that some of the thousands of students around the country who have had the opportunity to listen to OSCAR have heard you! The excitement in a classroom during a first OSCAR pass is hard to beat. It is often the first step a youngster takes on the road to becoming a ham operator. If you get an OSCAR SWL/QSL card request from a student or a class, please respond quickly with a brief personal note describing yourself and your activity. Many of you, knowingly or not, have already contributed immeasurably to the educational experiences of a lot of kids. — *WB1EYI*

VHF ANTENNA-GAIN CONTEST

☐ The 12th annual UHF Antenna-Gain Measuring Contest, sponsored by the East Coast VHF Society, will be held on July 23 at 10 A.M., at Trenton (NJ) State College, Ewing Township, NJ. Antennas for 432, 1296 and 2304 MHz will be measured at no charge. A flea market will also be held at no charge to buyers or sellers. Contact K2UYH or WA2ZZF for more information.

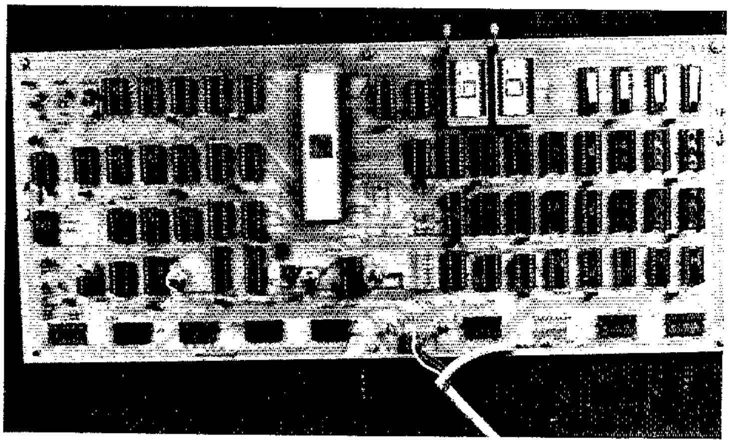
PLANNING TO UPGRADE?

☐ Let us know. The ARRL Club and Training Department will match your ZIP code to our instructor list to find a class or instructor in your area to help you upgrade. — *K1CD*

Product Review

The Technico TEC-9900-SS Computer Kit

The reader will find that this review is somewhat different than the normal one. Jim Schueckler, WB2YZL, is a pretty savvy ham when it comes to computers, so we asked him to review the Technico computer, a 16-bit unit. Most microprocessors are 8-bit units. We asked Jim to provide a little dissertation on the pros and cons of 16 versus 8 before the actual review. We hope you like this approach.



The wired TEC-9900-SS microcomputer ready to be connected to peripherals. That big white 64-pin IC near the center of the board is the Texas Instruments 16-bit TMS-9900 central processing unit.

Is a 16-Bit Computer Inherently Better Than an 8-Bit Computer?

Which is better, an 8-bit or a 16-bit computer? Minicomputer and microcomputer experts will argue about this question, but they will agree that the answer depends on the application. You wouldn't rent a bus when you really wanted to take a taxi, but the bus sure can carry more people. No pun on the word "bus," but the comparison is strikingly similar. An 8-bit computer often has to use several cycles to perform the same function that a 16-bit computer can perform in one cycle.

There are many factors to consider when comparing microcomputers or microprocessors. The most obvious factor is the "data word size" of the CPU (central processing unit). An 8-bit CPU performs operations on 8 binary digits (bits) at one time. A 16-bit CPU handles 16. The memory configuration and external data bus will have a corresponding 8 or 16 data lines (wires). An 8-bit register can represent 2 to the power of 8, or 256, combinations, usually representing numbers from 0 to 255. A 16-bit register can represent 2 to the power of 16, or 65,536 combinations (commonly called 64 k, where k = 1024). Therefore, two 8-bit registers must be combined to represent the same quantity as a 16-bit register. For an 8-bit computer to add two 16-bit numbers together, it must first add the two low 8-bit bytes together, store the result, then add the two high 8-bit bytes together, plus the carry, if any, from the first addition. The 16-bit computer can do this in one simple step.

If an 8- and 16-bit computer had the same architecture (structure of connections), the 8-bit computer would take 3 or 4 times as many clock cycles, and instructions, as the 16-bit computer to perform simple math operations. And since a 16-bit number can represent 256 times as many combinations as an 8-bit number, a 16-bit computer can have many more instructions. These additional instructions usually can take the place of several 8-bit instructions, such as indirect memory references and auto increment. Taking advantage of these instructions, and the faster math, a 16-bit computer can usually perform a complicated program more than 4 times faster. Such application as real-time SSTV image processing, digital signal filtering, or some real-time experiments where a lot of math is used, may require a 16-bit computer because of the speed.

But what if you really want a taxi? An 8-bit computer may be very sufficient for your application. Most amateur radio applications only need an 8-bit computer. Many hams' computers are used as controllers, turning single bits on and off, and moving ASCII characters around. Most human-to-computer and computer-to-computer communications are done with ASCII (American Standard Code for Information Interchange, the modern teleprinter code). The 7-bit ASCII code is very well suited to 8-bit computers. The 8-bit computer also does a very efficient job of Morse code reception, RTTY station control, controlling repeaters or antenna rotators, or decoding SSTV signals. A 16-bit computer would be overkill. Thousands of hobbyists are even using high-level languages, such as BASIC or FORTRAN on their 8-bit computers, and don't mind the few extra seconds a long program may require.

There are many factors to consider when selecting a microcomputer. A 16-bit computer is usually faster, more powerful, and more expensive than an 8-bit computer. The choice depends on the needs of the application.

The Technico TEC-9900-SS Computer Kit

At last, a 16-bit microcomputer is available at a price comparable to 8-bit computers! (Actually less than most 8-bit computers.) The TEC-9900-SS is a complete microcomputer kit which uses the Texas Instruments (TI) TMS-9900 CPU, considered by many to be the most powerful microprocessor available today. (It has on-chip multiply and divide.) With this kit, power supplies, and a teleprinter, you have a working computer system.

The TMS-9900 is very different from other microprocessors. Besides having a 16-bit dataword size, the architecture and instruction set are memory oriented, more like a minicomputer. The use of a "workspace pointer" allows any 16 consecutive memory locations to be used as registers by the program, but these

---

Technico TEC-9900-SS Computer Kit

Central Processing Unit: TI TMS 9900.
Memory: 1 k byte ROM, 512 bytes RAM.
Inputs: 16 input lines, one input bit for serial.
Outputs: 16 output lines, one output bit for serial; 8 vectored interrupts. Requires ASCII teleprinter for terminal.
Power Requirements: +5 volts at 1.5 A, −5 volts at 0.5 A, +12 volts at 0.5 A.
Programming Power: +28 volts at 40 mA.
Price Class: $300.
Programs Available: Instant input assembler, text editor.
Also Available (accessories): 32 k byte memory board, color TV terminal, tape cassette.

---

can be changed quickly to handle an interrupt. The TMS-9900 can use many different addressing modes including indexed, indirect, and indirect auto increment, which help make the instruction set "powerful." Input/output operations can be performed with several special I/O instructions. Single bits or groups of bits can be set, reset or tested, or the I/O devices could be memory mapped as with any other CPU. Sixteen vectored interrupts (directions the program may go after an interrupt request is received from peripheral equipment) are available, with on-chip logic that automatically handles some prioritizing (changeable by the program). Other instructions of the TMS-9900 also help make it powerful. Arithmetic and circular shifts (moving the individual bits of a word to the right or left and putting the displaced end digits at the opposite end of the word) can be performed with a variable shift count. Many instructions can perform 8-bit operations to store and manipulate ASCII characters or small numbers efficiently. The most powerful instructions are multiply and divide. They are done with "firmware" or a program loop. The CPU will multiply two 16-bit numbers together to give a 32-bit product with a single instruction, at a worse-case time of 17 microseconds. The longest time for a divide instruction is 44 microseconds. Both are about 10 times faster than the same operations on 8-bit computers.

The TEC-9900-SS is a complete computer kit, including sockets for all ICs. The on-board hardware provides 16 input lines, 16 output lines, 8 prioritized interrupts, and serial interface for a teleprinter or RS-232 terminal. All data and address buses are buffered in and out, and the on-board memory has its own buffers for flexibility and expansion. The computer comes with 256 words (256 by 16) of read/write memory (RAM), with sockets and decoding for 1024 words. Sockets for four fusible-link read-only memory (ROM) chips are provided (1024 words), two of them occupied by a powerful monitor program for program development, and an optional "instant input assembler" may be purchased which plugs into the other two sockets. There are sockets for two 2708 type, ultra-violet erasable, electrically programmable ROMs. In the normal mode, the 2708s that you plug in will appear as computer memory, but just connect +28 volts and turn on a special switch, and you can program those PROMs right in the same socket. No other computer presently has this feature.

The monitor program is extremely powerful and useful for debugging programs. Some of the functions are change memory, write tape, read tape, breakpoints, move data, input, output and others. The power of 16-bit instructions is apparent when such a powerful program uses only 512 words of ROM. The "instant input assembler" (an extra cost option) is also invaluable. As you type in each assembly language mnemonic, this program looks up the proper bit pattern, combines it with the bits for the addressing modes you are using, prints the result and puts it in memory. This can save hours of hand assembly or patching.

The computer was designed in a very professional manner. The thick epoxy circuit board itself is a work of art. The use of low-power Schottky TTL, extra buffering, fully decoded memory addressing, and properly documented schematics and manual are marks of excellence which place this kit far above the usual hobby computer, and above some commercial equipment too.

A very important part of any electronic system is the users manual, and Technico did a fine job here, also. There are 16 sections in a big notebook that comes with the kit, including step by step assembly and checkout instructions, a complete monitor listing, a TI manual on the TMS-9900 CPU, explanations of the hardware and instruction set, game program listings, and others. The monitor and assembler programs are well documented with explanations given so that the user can call many subroutines from his own programs. The section on programming has several examples, including a routine to calculate sine and cosine that uses only 43 program words! Technico uses the exact Texas Instruments instructions mnemonics. Most hobby computer companies like to make up their own, which is very confusing.

All is not gold, however. Technico used an R-C oscillator for the system clock, where the reviewer thinks they should have used a crystal, and they let the CPU time each serial input/output bit, where they could have used a UART. Technico has informed the reviewer that they now have a matching video display board and memory expansion board, so they do not need a UART on the CPU board.

The kit is not meant for a beginner in either hardware or programming. Anyone with experience on an 8-bit computer will find the Technico TEC-9900-SS microcomputer kit to be a very big, powerful, but inexpensive step above their 8-bit machine. The TEC-9900-SS Super Starter kit is available, as of this writing, at a price class of $300 from Technico, Incorporated, 9130 Red Branch Rd., Columbia, MD 21045, tel. 800-638-2893. The price class of the optional "Instant Input Assembler" is $50. — *WB2YZL*

HAMTRONICS CONVERTER KITS

Rochester, NY, has long been known as vhf heaven. With TV channels 8, 10 and 13 serving the area, the chance of TV interference from 6- and 2-meter rigs is small. The Rochester VHF Group has taken good advantage of this happy situation to engineer a hotbed of vhf activity in the area. The famed Rochester Converter is a product of this group, as is a fine showing year after year in the ARRL VHF Sweepstakes. And soon Rochester will be even more widely recognized as the home of a very fine set of vhf and uhf converter kits and other accessories, from the amateur-owned Hamtronics, Inc.

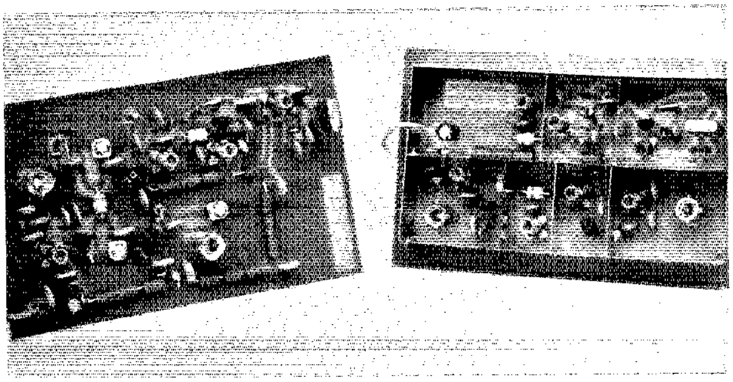
Heading the list of new Hamtronics products of special interest to amateur satellite enthusiasts is a hot uhf converter kit, the C432. It comes in several models, including a 435-MHz version with a 28- to 30-MHz i-f, especially for OSCAR 8. The straightforward circuit features 2N3563s in the oscillator-tripler chain and J308s in the rf and mixer stages. The design emphasizes stability, ease of construction and alignment, and trouble-free operation in every aspect. The junction field-effect transistors (JFETs) are wired in a grounded-gate configuration. Printed-circuit coils are used. Liberal use of decoupling ferrite beads eliminates troublesome interstage interaction while keeping gain and sensitivity high.

The Hamtronics kits are not the *step-by-step* type. The catalog explains, "Our kits are more like building a project from a magazine article than conventional kits, so you get more satisfaction and knowledge from building them." Yet construction is simple and direct. The high-Q, slug-tuned coils can be wound in minutes, and complete assembly should not take more than one hour. Alignment is facilitated by multiple "test points," complete with diode detectors. In fact, the most difficult part of the alignment is finding a signal source which is more stable than the converter. A strong, on-the-air signal is probably the best bet for amateurs without access to good test equipment. The only other equipment needed for the alignment is an electronic voltmeter. The procedure itself takes only a few minutes.

Sensitivity of the converter we built, using a standard transceiver as an i-f, far exceeded the 0.5-μV specification. In fact, the stray leakage from the signal generator, well below the 0.1-μV level, was fully copyable! Hamtronics also has a complete line of preamplifier kits, if this is not adequate!

The C432 converter is also available in 432-and 439.25-MHz versions, or for any other frequency in the 380- to 520-MHz range. Hamtronics has a similar vhf converter for the lower vhf amateur bands. Compartment shielding provides excellent isolation between stages, while maintaining the better-than-0.1-μV sen-

Hamtronics uhf (l) and vhf (r) converters, with outputs to left. Note extensive ferrite decoupling and shielding.



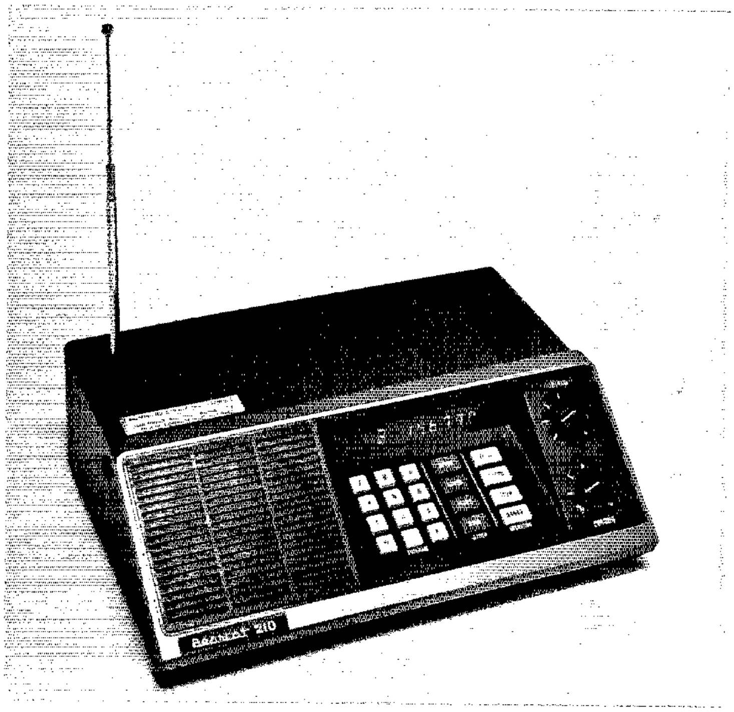
sitivity figure. A wide range of frequency combinations is available, as is a custom case with BNC connectors.

High performance, simplicity of construction and alignment and very low cost: it's tough to beat a combination like that! Satellite users can get a complete line of OSCAR accessories for their hf rig, including a new 2-meter transverter, vhf and uhf converters and 10-meter preamps, all from the same source.

All Hamtronics vhf/uhf units are available from Hamtronics, Inc., 182 Belmont Road, Rochester, NY 14612. Price class of the 432-2 kit is $35, also available wired and tested for $55. — *WB2CHO*

Hamtronics C432-2 UHF Receive Converter Kit Manufacturer Specifications:

Gain: 10 dB.
Sensitivity: Less than 0.5 μV with average receiver.
Bandwidth: Greater than 2 MHz without retuning.
Impedance: 50 ohms.
Input/Output Terminations: RCA type connectors.
Power Requirements: 13.6 V dc at 30 mA.
Size (HWD): 2-3/4 × 4-1/2 × 1 inch (70 × 114 × 25 mm).



The compact Bearcat 210 makes a nice addition to any ham shack, home or office. It can even be used mobile with the mobile mount accompanying it.

THE BEARCAT 210 SCANNER

The Bearcat 210 scanning receiver is what may be called the third generation of public-service-band receivers. The first of the receivers to cover these frequencies were manually tuned, although you had to be quick on the knob or you missed that transmission. Some of these had a few crystal-controlled positions available. This was nice if you wanted to listen to your volunteer fire department, but what if something else of interest was going on? The next generation was predominately crystal controlled. By knowing what was going on, and on what frequency, you could outfit one of these to eavesdrop on 'most anything in your community. And miracle of miracles, they even sampled a bit of what was happening on each channel and stopped whenever an active one was tuned. This was the birth of the scanner, and there are many scanning receivers still being sold today. The only major disadvantage is the high cost of outfitting this type of unit with crystals.

Enter the programmable-synthesized scanner, or in this case the Bearcat 210. The model 210 covers the range of 32 to 512 MHz in three distinct bands: 32-50 MHz, 146-174 MHz and 416-512 MHz. Any 10 channels within these ranges can be programmed into the scanner memory from the front-panel keyboard. The scanner will then either scan or bypass any of these programmed frequencies, again as directed from the keyboard. A two-second delay can also be programmed in so that the response to a transmission will not be missed. Also included is a search function. In this mode the scanner can be programmed to check every 5 kHz between an upper and lower frequency limit for active channels. Obviously, this is nice for locating unpublished repeater frequencies on the amateur 144- or 450-MHz bands, for example. As with most things in life there is no such thing as a free lunch, and the Bearcat 210 is no exception to this unwritten rule. The receiver does generate a number of spurious signals, or birdies, and will stop the search function whenever it receives one of them. The owners manual lists most of these frequencies so that you can program around them. Of particular annoyance was a birdie at 146.5 MHz which made it difficult to search the whole 2-meter band.

Another difficulty, which affects primarily the early production units, is radiation of LO energy (although within FCC limits). The LO leakage was high enough to cause interference with other services. The manufacturer has assured us that steps have been taken to reduce LO leakage by 10 dB. Production of the modified units began in late February, 1978. (The date of manufacture is printed on the back of the scanner.)

The appearance of the Bearcat 210 is aesthetically pleasing. It is housed in a small vinyl-clad steel cabinet with a sloping front panel, which contains the keyboard and a large LED display for indicating the programmed channel and frequency. Also on the front panel is a speaker grille and controls for volume and squelch. A telescoping antenna is built-in and there is provision on the rear of the unit for an external antenna. The external antenna connector is a Motorola type, probably to facilitate mobile installation. To this end a bracket to permit under-dash mounting is also included.

The Bearcat 210 has provided me with many very interesting hours of listening on the vhf and uhf public-service and amateur fm frequencies. The 210 is manufactured by the Electra Company, a division of Masco Corporation of Indiana, Cumberland, IN, 46229. The price class is $350. — *K1THP*

Bearcat 210 Scanner

Power Requirements: 117 V, 50/60 Hz ac, 11 W, or 13.8 V dc, 6 W.
Input Impedance: 50-70 ohms.
Scanning Rate: Approximately 20 channels per second.
Sensitivity: 0.6 μV/12 dB SINAD.
Frequency Coverage: 32-50 MHz, 146-174 MHz, 416-512 MHz.
Dimensions (HWD): 3.5 × 9 × 7 inches (89 × 229 × 178 mm).
Weight: 4.5 lbs (2.05 kg).

PARTS-PROCUREMENT CORNER

This month's writing represents the first of what we hope will become a short monthly piece on how and where to obtain radio components. Our ARRL Technical Information Service personnel answer some 7000 letters per year and the number is on the increase. Many of these letters are simple — tell me where I can buy such and such a component. Through this short column we hope to give you the benefit of several years' collective experience in the parts-procurement game. Since we could not possibly know each and every manufacturer or supplier of every component, we invite your input. Should you own a business that caters to hams, drop us a line. (See League Lines in this issue.)

While ordering components for the IARU receiver and transmitter program outlined in an editorial several months ago we became aware of the power of quantity buying. In the past we would stock our laboratory with a few parts from here, a few from there, parts from flea markets, etc. Some suppliers acted as though they were doing us a favor selling a handful of capacitors, diodes, coils or whatever. Sound familiar? As soon as we started buying in 100-or 200-lot quantities not only did the sales people become more friendly and helpful (seems proportional to commission) but the prices took a nose dive. One part in single-lot quantities might cost 75 cents, but as soon as you're talking 100 pieces the price might drop to 30 cents per copy. The higher the single-lot price, the more impressive the savings.

We are not suggesting that every individual buy in 100-lot quantities, as that would be absurd. However, with a group purchase from a club with a number of members interested in stocking up on the same components the savings can be spectacular. Let's take an example. Say your club is average in size and has about 40 members. Half of these people are interested in stocking their junk boxes with 1/4-watt resistors, 10 of each standard value. There are 56 standard values from 10 ohms to 10 megohms so each person would want 560 resistors. If you check out your local Radio Shack store these resistors are selling for approximately 8 cents apiece. The 560 resistors would require an outlay of $44.80. Ouch — not particularly appealing! On the other hand, if you were making a group purchase of 11,200 resistors (560 × 20 members) from a good supply house these resistors would cost 2 cents apiece, in that quantity. These are first-run, brand-name resistors. The cost for 560 resistors purchased in this manner would be $11.20, exactly one-fourth the price you would pay at Radio Shack!

Savings of this sort can be had on practically any item you wish to buy, and by the way, the parts *are* available. Variable capacitors, coil stock, vernier dials, toroid cores, coaxial cable and fittings, sheet aluminum, chassis, switches, polystyrene, mica and tantalum capacitors, knobs and relays are all available at reasonable prices. You just need a little patience and need to know where to look. In the next few months we are going to print the names and addresses of suppliers for various components. The exact method of doing this hasn't been decided yet — perhaps we'll highlight a certain component each month and list a number of suppliers. This is bound to get us into some hot water because no doubt we'll leave off the name of some manufacturer or supplier. If so, let us know and we'll include it in a subsequent listing.

The individual purchaser need not fret. We'll also be supplying the names and addresses of companies that sell in single-lot quantities. Of course, this method will be more expensive than group buys, however, the parts are available. Maybe it's time to elect someone in your club to the office of "Chief Parts Procurer"? — *W1VD*

New Books

The Design of Active Filters With Experiments, by Howard M. Berlin, W3HB, is published by E & L Instruments, Inc., Derby, CT. Soft-bound edition, 6 × 9 inches, 285 pages. Price: $8.50.

If you're like most hams, you've learned a lot about electronics by just reading. But sometimes it takes a little hands-on experience before the concepts take full meaning — that's why we go to school, right? You know, lab experiments and all that stuff! What we *really* need is a combination of theory and practical application.

This is the approach taken by *The Design of Active Filters With Experiments.* A recent addition to the "Bugbook" series published by E & L Instruments, Inc., this book provides the student with introduction to theory, implementation, and design of active filters using the 741 operational amplifier. The text is divided into nine chapters, each dealing with op amps in a different filter application. The first three chapters introduce the student to filters and explain the op amp's role in active-filter design. As each experiment is introduced, the author lists the procedure step by step. Even a person with extremely limited electronics background can easily follow the fast-moving theory/application mixture provided by Mr. Berlin.

All experiments are designed so as to require only a very modest investment in parts and tools. Accompanying schematics and scope patterns clearly illustrate points mentioned in the text. At the onset, the author suggests that construction of all experimental circuits be made on a breadboard of the spring-loaded type. Compliance with this advice should make completion of the "course" enjoyable, as well as economically feasible, since parts can be reused over and over, and no soldering is required. When one project is completed and it is time to begin another, all parts can be swiftly yanked from the breadboard, and a new circuit assembled.

The Design of Active Filters With Experiments is an excellent book for beginners as well as experts. With its unique style of presentation, it provides the reader with not only sample schematics and design formulas, but practical applications and component values as well. After serving as a teaching tool, this book can continue to benefit the owner by furnishing "just the circuit I was looking for" in the years to come — a welcome addition to any ham's electronics library. — *K1TX*

Solid State Basics, by Doug DeMaw and Jay Rusgrove. Published by ARRL, Newington, CT. Paperback edition, 8-1/2 × 11 inches, 160 pages. Price: $5 U.S. and $5.50 elsewhere. A new addition to the ARRL technical library, *Solid State Basics* is a revised anthology of material which has appeared in *QST.*

Here is a welcome and useful contribution to the working literature available to the radio amateur. As its title suggests, *Solid State Basics* is a comprehensive treatment in one handy volume of what amateurs need to know about solid-state technology and its practical applications to amateur radio today.

The book is arranged in six sections for convenient reference and use. The first, entitled "Let's Talk Transistors," covers basic semiconductor theory and related electronic principles. "Learning to Work with Semiconductors" deals with solid-state receivers and transmitters. The receiver section covers principles and applications, circuit evaluation and testing, the transistor as an oscillator, the solid-state mixer, solid-state i-f amplifiers, and the design and application of a solid-state BFO for a superheterodyne receiver for 80 meters.

The transmitter section includes a discussion of a 10-watt, 80-meter transmitter, rf power amplifier design, selecting the right transistor for a particular application, rf power amplifiers, power amplifier design and a solid-state VFO. Section 4, "Understanding Linear ICs," reviews theory and principles and provides an inside look at integrated circuitry. It describes building a 40-dB audio amplifier.

"Learning to Work with Integrated Circuits" deals with theory and provides a practical exercise in constructing an instrument which doubles as a digital voltmeter and a frequency counter. The final section discusses instructions on how to use Zener diodes, solid-state design fundamentals and how to debug a solid-state transmitter. — *WB1CUJ*

Radio Frequency Interference, by Bill Lowry, Doug DeMaw, Jay Rusgrove and Hal Steinman. Published by ARRL, Newington, CT. Paperback edition 8-1/2 × 11 inches, 64 pages. Price: $3 U.S. and $3.50 elsewhere.

A perennial problem in "good neighbor" relations for many amateurs, and a significant public relations problem for all amateurs, RFI has become a major issue on a number of fronts. It is just beginning to be recognized that hams are in reality victims rather than perpetrators of the problem. Attempts to put the responsibility where it logically belongs — on the manufacturers of RFI-susceptible electronic devices — have focused on legislative action in the form of the Vanik Bill which narrowly failed to come to the floor in the last session of the Congress and has been reintroduced in the current session.

In the meantime, hams have had to deal with the problem all too personally on the local scene, and how to do so effectively has sometimes been frustrating and baffling. Now there is practical help at the fingertip level. *Radio Frequency Interference* brings together in one convenient, practical source, just about everything needed to cope with the problem. Six nuts-and-bolts chapters cover every aspect of RFI from definition to solution. Chapter 1 explains in detail what RFI is and cites examples of effects ranging from the classic case of television interference to exotic instances such as hair dryers or even false teeth! Some of the background history is cited to establish the dimensions of the problem. Chapter 2 takes up the search for solutions, starting with making sure the ham station is "clean," how to zero in on the real problem, and what club-sponsored RFI committees can do. CBers have also become victims and occasional perpetrators of RFI, and Chapter 3 discusses the problem from the CB vantage point. Chapter 4 deals with transmitter-caused interference and what to do about it, including practical troubleshooting tips. Chapter 5 identifies a long list of non-amateur related sources of interference — sewing machines, electric lawn mowers, vacuum cleaners, neon signs and many more and provides ways of reducing or eliminating the effects in each case. Chapter 6 is a reprint of an FCC booklet that presents a step-by-step procedure to identify, localize and resolve specific radio-TV interference. — *WB1CUJ*

Hints and Kinks

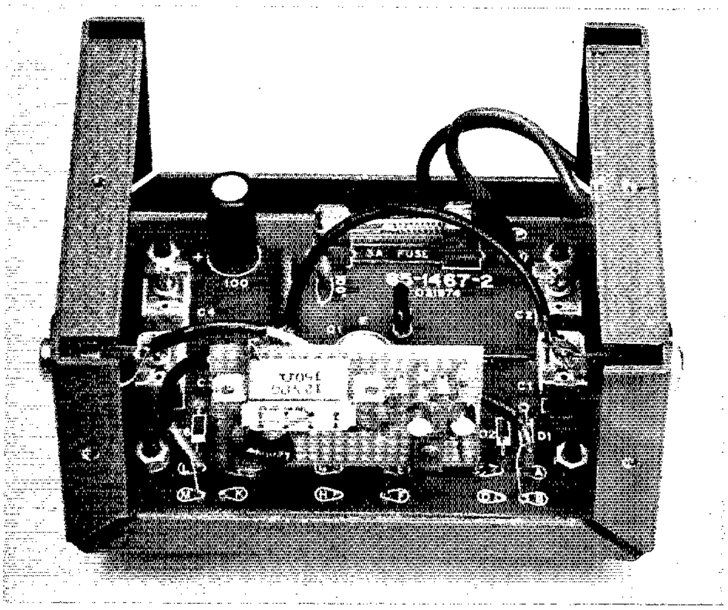
A COR FOR THE HA-201 AMPLIFIER

Interfacing our Drake TR-22C with a Heath HA-201 amplifier introduced several difficulties including a noticeable loss of output power, excursions in amplifier stability and a decline in receiver sensitivity. Insertion of a carrier-operated relay resolved these problems. The accompanying diagram illustrates the simple circuit we use.

The COR circuit, mounted on G-10 Vectorbord, fits conveniently in the space formerly containing T1 and T2. These coaxial-cable transformers are removed from the HA-201 along with the 1N4149 diodes D1 through D6 and capacitor C5. Three of the diodes may be used in construction of the COR. The removed coaxial cable (RG-174/U) may be reinstalled to link relay K1 to the HA-201. Cable shields are tied to a single point (one of the flea clips) close to K1. The +12-V lead from the COR is wired to the fused side of the 12-V supply line. A switch, S1, may be added to the line for the purpose of engaging or disengaging the HA-201.

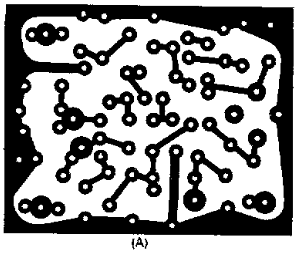
To accommodate the no. 6-32 spade bolts that support the COR board, mounting holes are drilled in the amplifier board at the right of hole J and hole E. One must be sure, however, that no live traces are shorted to the ground bus trace. If necessary, the traces may be trimmed with an Exacto knife.

Final adjustments are made after connecting the HA-201 to any exciter delivering from 1- to 3-watts drive power. The amplifier supply

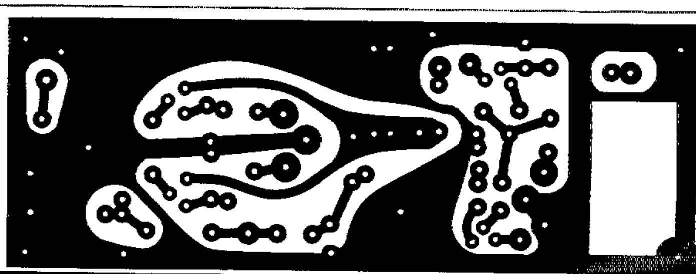


This Heath HA-201 amplifier has been modified to employ the carrier-operated relay circuit mounted on the vertical Vectorbord. Use of the COR simplifies interfacing the HA-201 with such equipment as the Drake TR-22C and other non-Heath sets.

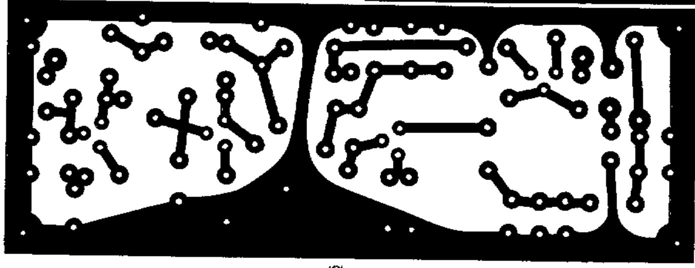
Circuit-board etching patterns for the 7- and 14-MHz cw transmitter (DeMaw, "Transmitter Design — Emphasis on Anatomy," in four parts). Black represents copper. All patterns are shown at actual size from the foil side of the circuit board. See the drawings referenced below for parts-layout information. At A, the VFO circuit board (Fig. 3, p. 19, May 1978 *QST*). At B, the doubler/break-in delay board (Fig. 5, p. 26, June 1978 *QST*). At C, the broadband-amplifier board (Fig. 8, p. 21, this issue). At D, the SWR sensor (Fig. 13, Part 4, in a subsequent *QST* issue).



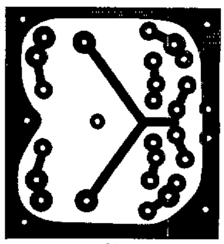
(A)



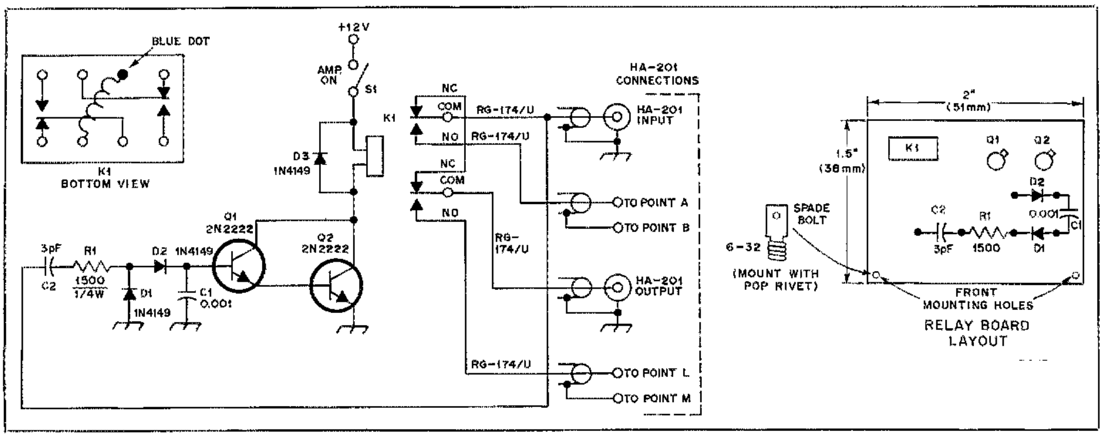
(B)



(C)



(D)



A carrier-operated relay circuit designed for interfacing the Drake TR-22C and the Heath HA-201. Terminal connections are shown for the Potter Brumfield HC-11D relay. The COR board layout is also illustrated.

C1 — 3-pF silver mica capacitor.
C2 — 0.001-μF disk ceramic capacitor.
D1-D3 — Signal diode, type 1N4149.
K1 — Potter and Brumfield HC-11D relay, 24 V dc, 814 ohm.
Q1, Q2 — Npn silicon transistor, 2N2222.
R1 — 1500 ohm, 1/4 watt.

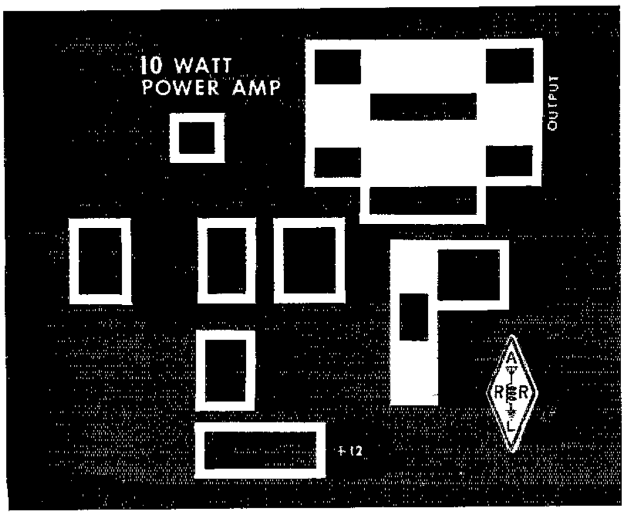
voltage should be 13.8 V dc. Feed the amplifier rf output into a 50-ohm load and wattmeter. When the mic switch is pressed, the COR relay is activated and normally there will be an indication on the wattmeter. C1 through C4 are adjusted for maximum output. Stable operation of the amplifier from 146 to 148 MHz, with an output of 10 to 12 watts should result. Some loss of output may be expected near the band edges.

For optimum results a wattmeter of known accuracy is recommended. Perform all tune-ups on 146.94 MHz and into a dummy load. — *Dave Karpiej, K1THP and Mark Starin, WA1TZK*

BALL-BEARING PROBLEM SOLVED

Recently, while I was reassembling my antenna rotator, the ball bearings and the bearing holder kept dropping out of the dome each time I turned the mechanism upside down. To remedy this problem I bedded the bearing holder and the bearings in place with white lithium grease. Then I placed the dome in the deep freeze for about two hours. This stiffened the grease and held the bearings and holder in place while I lowered the dome and fastened it down. — *Philip Wainwright, K2GV*

Circuit-board etching patterns for the 7- and 14-MHz cw transmitter (continued). Shown here is the power-amplifier circuit board, which will appear in Fig. 11, Part 4 of the series. This circuit board is double sided, the component-side foil being used only as a groundplane. That pattern is not shown, as it contains only clearance holes for the component leads.



PIN TERMINALS FOR CRYSTAL BOARD

Waldom pin terminals enabled me to make a nice mounting board for FT-243 crystals to be used in my sideband filter. They snap into place, holding firmly when installed in 1/8-inch stock. One might also secure them in place with epoxy cement.

These terminals are sold in packages containing 10 male and 10 female components and are available in either 0.093-inch (2.3-mm) or 0.062-inch (1.6-mm) diameter. The builder may select either a crimping type (to be used with a Waldom crimping tool HT-1919 or HT-1031-C) or a soldering type. I selected the larger diameter pin terminals. By pinching the 0.062-inch terminals, an HC6 (0.050-inch/1.3-mm pin) crystal may be accommodated.

Although I have not used pin terminals on circuit-board projects, they should be equally useful. — *Daniel G. Mackintosh, W6SPC*

NEOPRENE WASHERS FOR CABINET FEET

An easy way to provide feet for an experimenter's small chassis box is to use neoprene faucet washers. The size may be 0, 1/4 or 3/8. You must countersink the washer to accommodate the head of the screw in order to avoid marring the desk top after mounting. To countersink the washers use a pocketknife, or a hobbyist's drill with an appropriate accessory. I use 8-32 hardware to secure the washers to the cabinet. — *Kathleen M. Freeman, KL7IFF*

AMIDON PART IDENTIFICATIONS

After being off the air for some 20 years, I have recently become active again but find I'm dragging myself (scratching, not kicking!) into the semiconductor age. The *QST* articles are of great interest and assistance to me. My current projects, a VFO with output on 40 and 80 meters, and a small transmitter are being constructed along the lines outlined in articles by Doug DeMaw.

My plans included the use of Amidon beads and toroids but the manufacturer's sizes and mixes of the devices puzzled me. William Amidon was kind enough to provide me with the following information which clarified the matter and it may be helpful to others. He said, "At first, our ferrite-bead stock consisted of only one material and two different sizes, the larger of which was known as the Husky or Jumbo size. Later a part number was assigned to this bead and it is now known as the FB-43-801.

"Some time ago, the original part numbers for the ferrite toroids were changed for easier identification. For instance, the original part number FT-75-601 was changed to FT-82-75. FT for ferrite toroid, 82 for the 0.825-inch (21-mm) OD, and 75 for the type material.

"In any event, the proper core will be sent to the customer even though an older part number appears on the order."

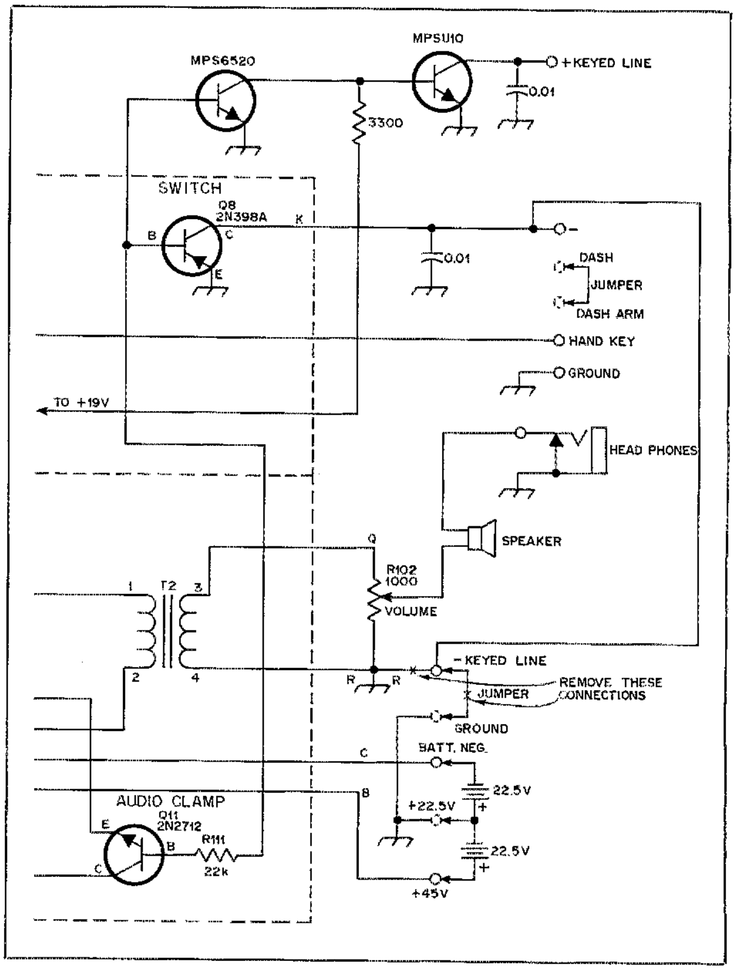
The response from Mr. Amidon was received through the assistance of Sandy Gerli of the ARRL Technical Information Service. — *Paul Binstock, W0DXG*

POSITIVE KEY LINE AND THE HD-10 KEYER

The HD-10 keyer was originally designed for negative-line keying. Such grid-block keying was used in the HW-16 cw transceiver. The newer solid-state transceivers use a positive-to-ground key line. The HD-10 cannot be operated with these sets without modification.

With the addition of two transistors, one resistor, and two bypass capacitors, one may have the choice of either positive or negative keying capability. The partial drawing of the HD-10 diagram indicates the additional components which may be mounted on a piece of Vectorbord or may be "flown" above the existing pc board. The transistors shown in the diagram were of junk box variety but almost any npn type may be used. The criteria for the MPSU10 replacement are (1) adequate voltage rating; (2) sufficient current rating for the keyed line.

Parts placement is not critical. The 0.01-µF bypass capacitors were added to prevent rf from entering the keyed line. The modified keyer is now being used with an HW-104 Heath transceiver. It performs very well with this set. — *Norman Bradshaw, W8EEF*



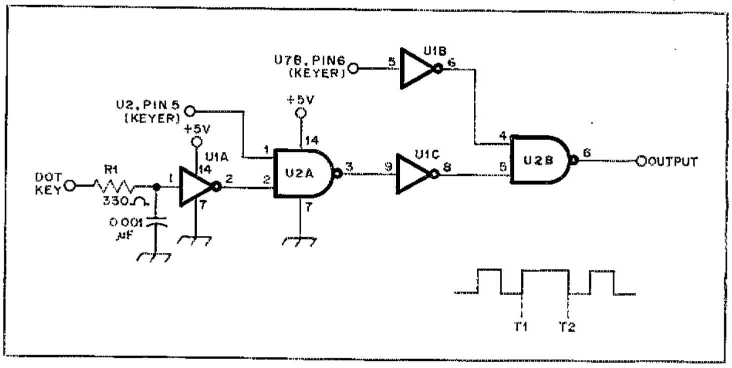
Modification of the HD-10 keyer for use with a positive-voltage key line. Disconnect jumper and lead between ground and volume control as indicated by X. Connect keyed-line transistor circuit to Q8 as shown. Insert a 0.01-µF capacitor from Q8 collector to ground. Ground R at low end of volume control.

ELIMINATING THE TRAILING DOT

I am now well pleased with my WB4VVF Accu-Keyer after making this modification which eliminates the trailing dot. Prior to making the change, if the dot paddle was held past time T1 (see drawing) another dot would be sent. An A, for instance, became an R.

With the two-chip addition shown in the illustration, the trailing-dot problem is cured (unless the dot paddle is held past T2). Dot insertion between dashes for letters like K is maintained. I also find that with this modification the keyer is much more forgiving of errors in timing. — *Ronald Hanthorn, K8AW*

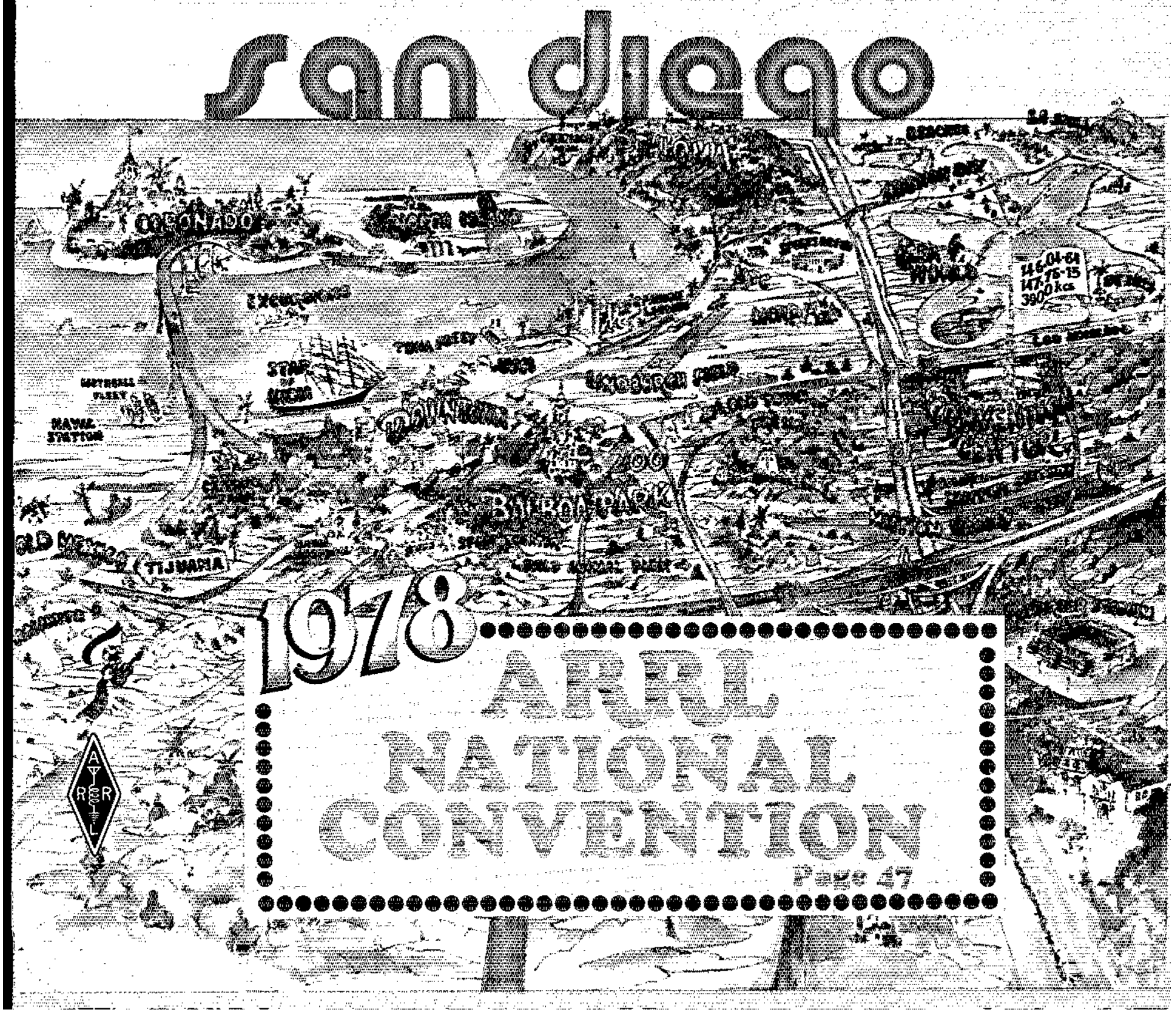
This modification of the WB4VVF Accu-Keyer is designed by K8AW to eliminate the trailing dot but maintain dot insertion for such letters as K. U1 is a TTL 7404 hex inverter. U2 is a 7400 quad dual-input positive NAND gate. R1 is 1/4 watt. The dot-input lead of the keyer should be disconnected from the key jack and wired to the output (pin 6) of U2B.



QST

devoted entirely to Amateur Radio

August 1978 $2.00



QST

August 1978
Volume LXII Number 8

Published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Richard L. Baldwin, W1RU
Editor

Staff

William I. Dunkerley, Jr., WA2INB
Managing Editor
Joel P. Kleinman, WA1ZUY
Editorial Supervisor
Gerald L. Hall, K1TD
Technical Editor
James Kearman, W1XZ, Stuart Leland, W1JEC
Assistant Technical Editors
Jim Bartlett, K1TX
Basic Radio Editor
Peter O'Dell, N1UM
Happenings & League Lines
Bruce Alan Johnson, WA6IDN
International
Bobbie J. Chamalian, WB1ADL
Correspondence
Marjorie C. Tenney, WB1FSN
Conventions
George Hart, W1NJM
Operating News
Ellen White, W1YL
Operating Events
Donald B. Search, W3AZD
DXCC
Tom Frenaye, K1KI
Contests
Robert J. Halprin, K1XA
Public Service
Ed Tilton, W1HDQ, Lewis McCoy, W1ICP, Louise Moreau, W3WRE, John Troster, W6ISQ, William A. Tynan, W3XO, Bill Lowry, W1VV
Contributing Editors
Julie A. MacGregor
Production Supervisor
Barbara Spear
Design Coordinator
Sue Fagan
Technical Illustrations
Lee Aurick, W1SE
Advertising Manager
George Barker, WB8PBC
Assistant Advertising Manager
John H. Nelson, W1GNC
Circulation Manager
Marion E. Bayrer
Assistant Circulation Manager

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

All roads lead to the ARRL National. See page 47.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A 2-Meter Frequency Synthesizer

Use one inexpensive "CB" chip and build this portable synthesizer for your 2-meter fm rig.

By David Gray,* WB8ZBA

I wanted an *inexpensive* synthesizer for my Drake TR-33C fm rig and I expect I'm not alone. I work as a two-way radio technician and thought one of the many CB PLL chips might fill the bill. The Uniden UPD858 PLL turned out to be the easiest to use. This chip was designed for and can be found in many 40-channel CB sets. I built a synthesizer around it for less than $50.

*732 Market St. Rear, Wheeling, WV 26003

Frequencies for the Drake TR-33C are easy to synthesize. The Drake triples the output of the synthesizer on receive and it adds either 10.7 MHz (simplex), 10.1 MHz (−600 kHz) or 11.3 MHz (+600 kHz) on transmit. Hence, much of the synthesizing is built-in before we begin. The size of the unit constructed for the TR-33C is only 1.25 × 4.5 × 3 inches (32 × 114 × 76 mm).

Synthesizer Circuitry

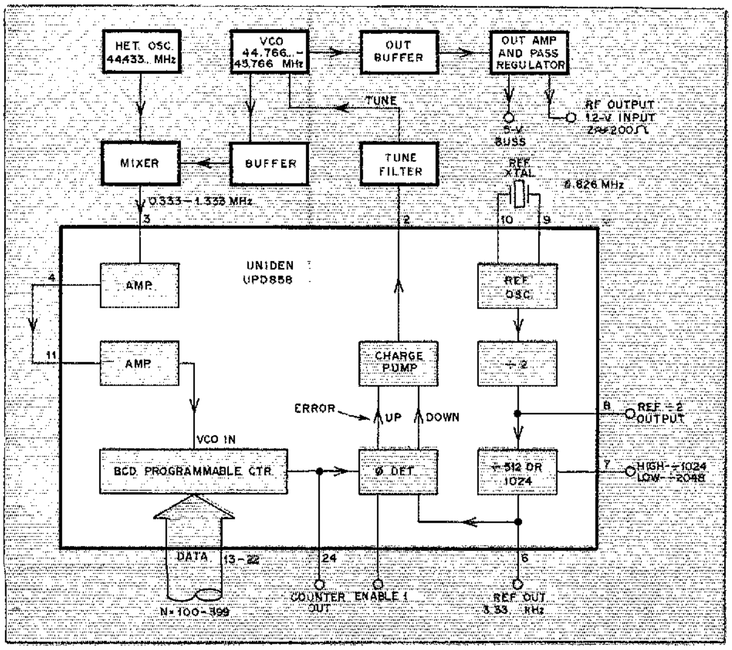
As Fig. 1 illustrates, the synthesizer is simple and all digital circuitry is on one chip. In addition, all the "garbage" (spurious harmonics from the counting waveforms) stays in the chip, where it belongs. This CMOS chip draws about 5 mA and the *entire* synthesizer draws only 10 mA. The pin-out of the chip is shown in Fig. 2.

Basic range of the unit is 144.5 to 148.0 MHz in 5-kHz steps. If desired, the heterodyne oscillator can be pulled with a varactor diode to add continuous coverage.

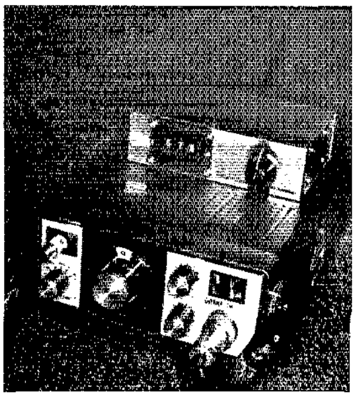
The interface circuit senses a dc level available on the TR-33C "Channel 12" crystal socket to turn on the synthesizer automatically. Tuning voltage on the VCO is about 0.2 to 4 volts. The emitter-follower buffers isolate the VCO, while an FET mixer helps keep the VCO output clean with its high-impedance input.

The VCO operates 0.1666 to 1.333

Fig. 1 — Block diagram of the inexpensive synthesizer.



Size of the author's homemade synthesizer may be seen in comparison to the 2-meter transceiver.



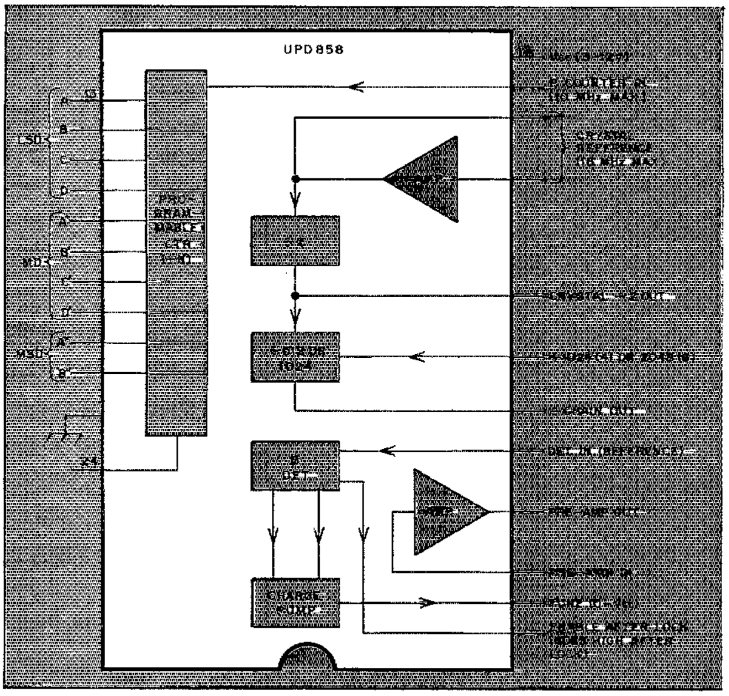


Fig. 2 — Logic diagram and pin connections of the Uniden UPD858 "CB" integrated circuit.

MHz higher than the heterodyne oscillator, and it is this difference which is counted by the chip. It is important to note that the VCO must not operate too close to the frequency of the heterodyne oscillator or the VCO may drift toward the other side of zero beat. If that happens the PLL will stay out of lock. For that reason T1 (which is shielded to keep out unwanted rf) is adjusted during alignment.

The 6.82666-MHz crystal is divided by 2048 to provide the 3.333 kHz reference. (This is 10 kHz divided by three.) Then the programmable counter multiplies this by 50 to 400, which results in 0.1666 to 1.333 MHz. This range of frequencies is added to the heterodyne oscillator at 44.4333 MHz to produce the output 44.6 to 45.7666 MHz. The TR-33C multiplies the output by three on receive to cover 133.8 to 137.3 MHz. Add the 10.7 MHz i-f to this and the TR-33C will receive on 144.5 to 148.0 MHz in 5-kHz steps.

The chip inputs are diode protected against static electricity, but as an extra precaution a 6-V Zener diode is added from pin 12 to ground. The FET is also diode protected but grounding the soldering iron tip to the ground bus of the circuit is still recommended when soldering to it or the chip.

Construction

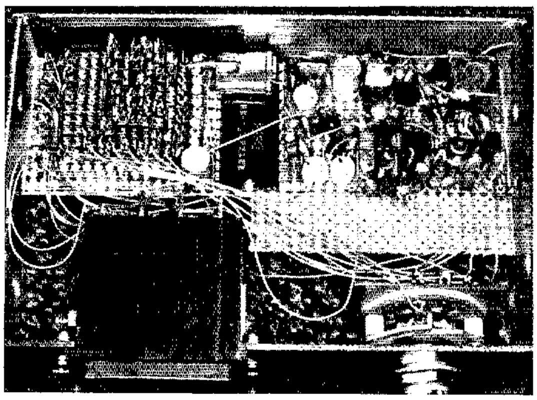
Either printed circuit or perforated-board construction may be used for the synthesizer. The only important precaution to observe is to keep the heterodyne oscillator shielded from the VCO and its amplifiers. An excellent groundplane is maintained by making several interconnecting ground loops on the board around the VCO and other stages, as shown in Fig. 3. A good policy is to surround each stage with a loop. The entire heterodyne oscillator should be isolated with its own ground loop connected to the rest of the circuit *only* near the mixer stage.

It is important to shield the two coils in the heterodyne oscillator to prevent inductive coupling in the other loops. Refer to the pictures of the circuit layout. Candle wax on the VCO transformer T1 eliminates microphonics.

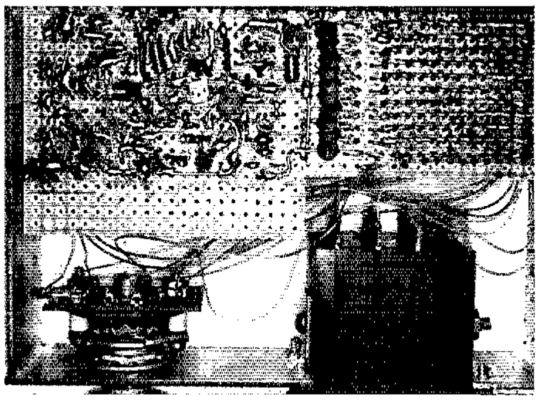
The circuit layout was developed on a large piece of perforated board and the excess board was trimmed off. It is worth mentioning that the circuit was operated with the TR-33C and no shielding before the pc box was ever built. No rf interference was noted even when using the built-in whip antenna on the TR-33C.

Molex connectors are used for the data rows in the diode matrix to make it easier to change frequencies in the matrix. Leave the top bars on the connectors and put a piece of tape between each row. The binary-coded decimal (BCD) input data code is simple . . . for a frequency of 144.5 MHz enter 050 to the programmable

Construction layout of the inexpensive synthesizer. The diode matrix is at the upper left. Note the copper foil shield around the heterodyne oscillator circuitry, right center.



Interior bottom view of the synthesizer. The diode matrix is at the upper right.



counter in the chip (0000 0101 0000). For 147.99 MHz enter 399 (0011 1001 1001). The 5-kHz data line is available in the diode matrix and selector switch. Fig. 4 shows the wiring of the diode matrix to the synthesizer chip, and Fig. 5 is the schematic of the complete synthesizer.

Alignment of the Synthesizer

Tune-up is initiated by setting all trimmers to middle range. Then set the thumbwheel switches to 144.50 MHz and adjust T1 for 0.25 V at pin 2 of the UPD858. Connect a frequency counter to pin 8 and adjust the reference oscillator to 3.4133 MHz. Then connect the counter to the transceiver output through a 0.01-μF capacitor to block the 12 volts. Set the thumbwheel switches to 146.00 and adjust the "0-kHz" trimmer on the heterodyne oscillator for a frequency of 45.1 MHz. Then dial up 146.005 MHz and adjust the +5 kHz trimmer for 45.101666 MHz. Repeat these last two adjustments as they may interact.

Interface for the TR-33C

The interface circuit, Fig. 6, is built on perf board and tucked above the selector switch. It allows automatic switching of power to the synthesizer so it is off when crystal control is used.

The TR-33C output is clean, with only one spurious response from the heterodyne oscillator, down 68 dB. No problems were noted while operating mobile or from an unregulated power supply. The extra jack in the back of the TR-33C makes the synthesizer easy to connect. The coaxial line from the synthesizer to the crystal compartment is made from RG-174/U, with the center conductor pulled out. Substituting a length of no. 28 wire-wrap wire makes the impedance of the coaxial line about 200 ohms.

Getting the Parts

The PLL chip can be ordered from New Tone Electronics, P. O. Box 1738A, Bloomfield, NJ 07003. The thumbwheel switches, perf board, capacitors, 1/4-watt resistors and Molex connectors can be ordered from James Electronics, P. O. Box 822, Belmont, CA 94022. Cost of the PLL chip, thumbwheel switches and crystals is about $35.

Adapting to Other Transceivers

Frequencies for the TR-33C are indeed easy to synthesize, and this is true also for most other transceivers. Fig. 7 illustrates a circuit to add to the original synthesizer which permits it to be used with the Drake TR-22 and radios such as the Heath HW-202 and surplus commercial rigs. The additional circuit can be placed on the same board as the synthesizer. One additional coaxial line is required for receive and one for transmit. Full switching is employed to route power only to where it is needed so that excessive battery drain is

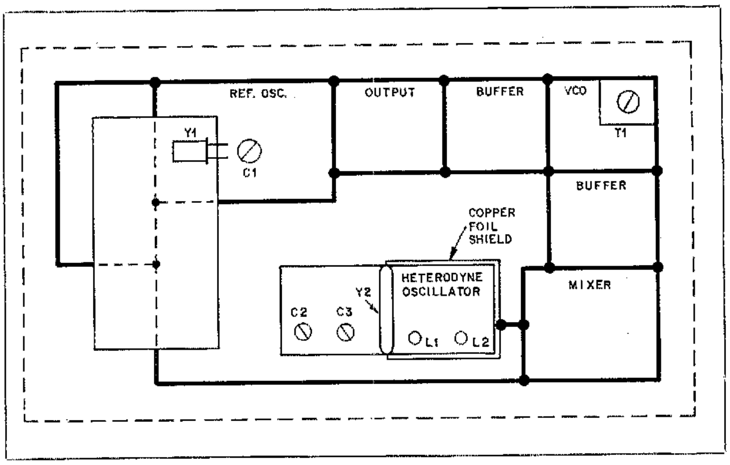
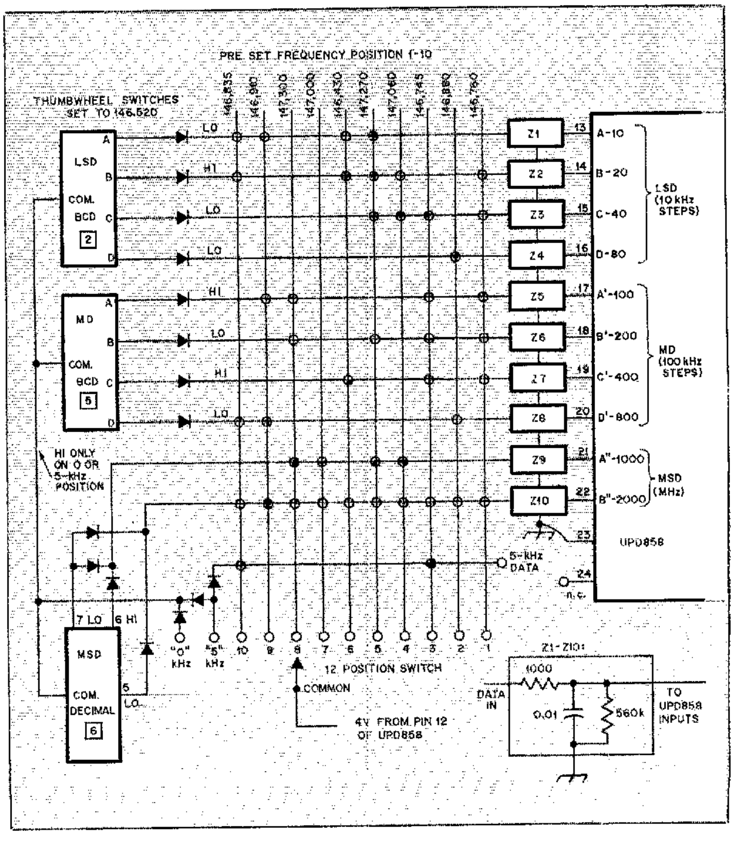


Fig. 3 — The grounding system used when constructing the synthesizer on perforated board.

Fig. 4 — Wiring of the diode matrix and thumbwheel switches to load the UPD858. The switch labeled MSD is a decimal-output-configured switch. The other two thumbwheel switches are BCD-configured types. The circles around crossed lines indicate where a plugged-in diode is inserted, cathode on horizontal lines and anode on vertical lines. Diodes may be any silicon switching diodes. The preset frequencies shown are for illustration purposes only.



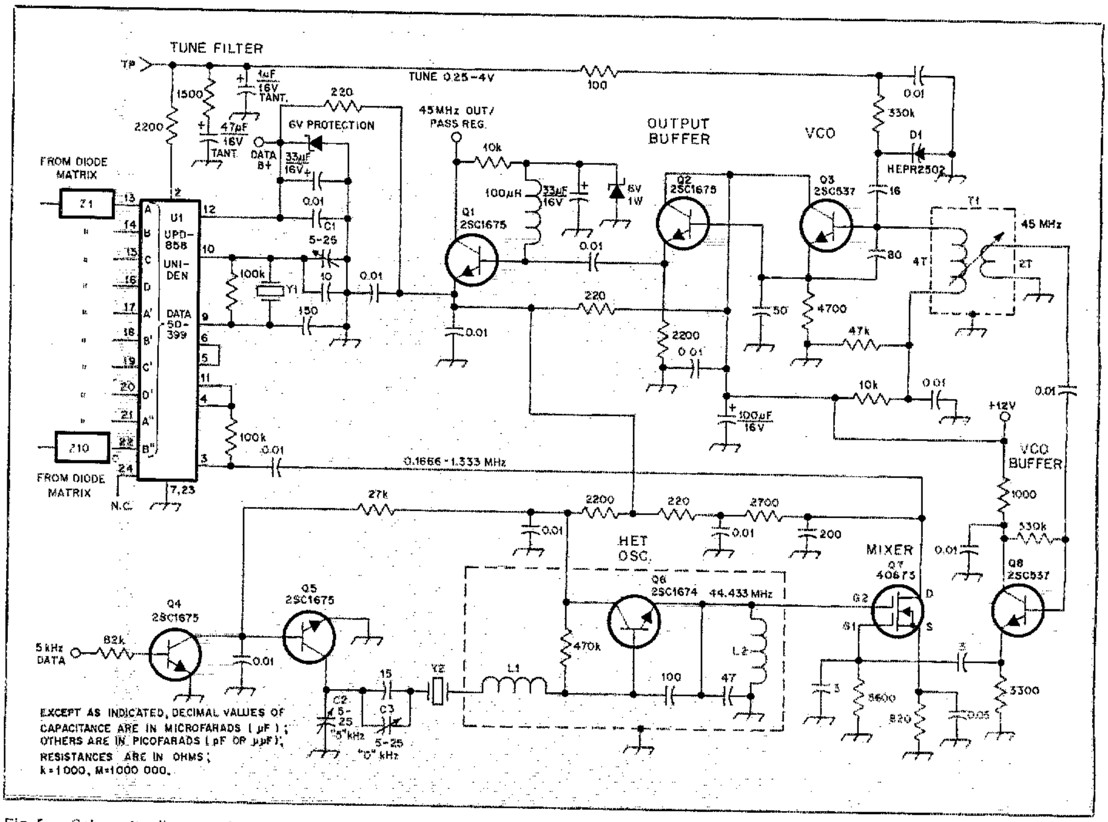


Fig. 5 — Schematic diagram of the synthesizer. Pin numbers not shown on ICs are not connected. Fixed resistors may be 1/4 or 1/2 watt.

D1 — Varactor-type diode, Motorola HEP R2505 or equiv.
L1, L2 — Inductor, 0.66 µH; 22 turns no. 28 enam. wire wound on form made from center insulation taken from RG-59/U.
Q1, Q2, Q4, Q5 — Npn silicon small-signal transistor, 2SC1675 or HEP S0015.
Q3, Q8 — Npn silicon small-signal transistor, 2SC537 or HEP S0016.
Q6 — Npn silicon small-signal transistor, 2SC1674 or HEP S0010.
Q7 — MOSFET, RCA 40673 or HEP F0024.
T1 — Rf transformer, pri. 4 turns, sec. 2 turns, no. 28 enam. wire wound on 10.7-MHz i-f transformer core.
U1 — Uniden UPD858.
Y1 — 6.82666-MHz crystal, parallel resonance, 24-pF load.
Y2 — 44.4333-MHz crystal, series resonance, 0.0025 percent. (Crystal for listening to 33.733 MHz on Fanon Scanfare VHFHL Scanner may be used.)

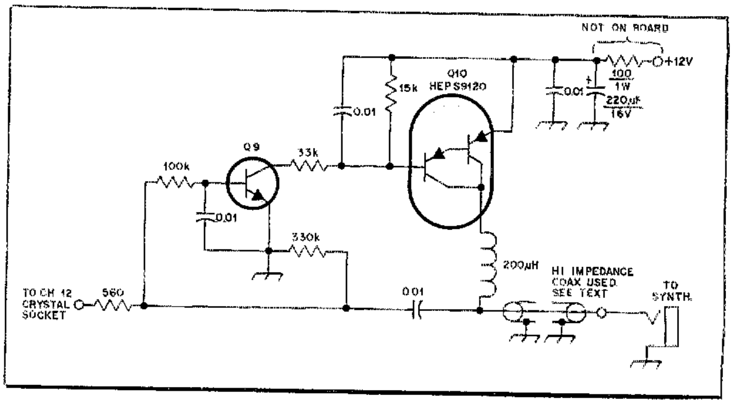
avoided. Two thumbwheel switch banks are used for transmit and receive so that any offset may be used. Most all rigs use the same receive frequency: (f − 10.7)/3 MHz, but if the transmit multiplier is 18 or 24 just use "6" or "8" on the transmit divider.

. . . And Some Afterthoughts

There is no reason why the synthesizer can't be made to scan on receive. Just add the normal logic that any scanner would use to the diode matrix to accomplish that. The tune filter is fast enough to allow three frequencies to be scanned per second.

There is no absolute need for the thumbwheel switches, diode matrix or rotary switch. If a really small synthesizer is your goal just add DIP switches next to the PLL chip and enter the BCD code.

Fig. 6 — This circuit will allow the synthesizer to interface with the Drake TR-33C.
Q9 — Npn silicon small-signal transistor, 2SC1675 or HEP S0015.
Q10 — Darlington transistor, HEP S9120.



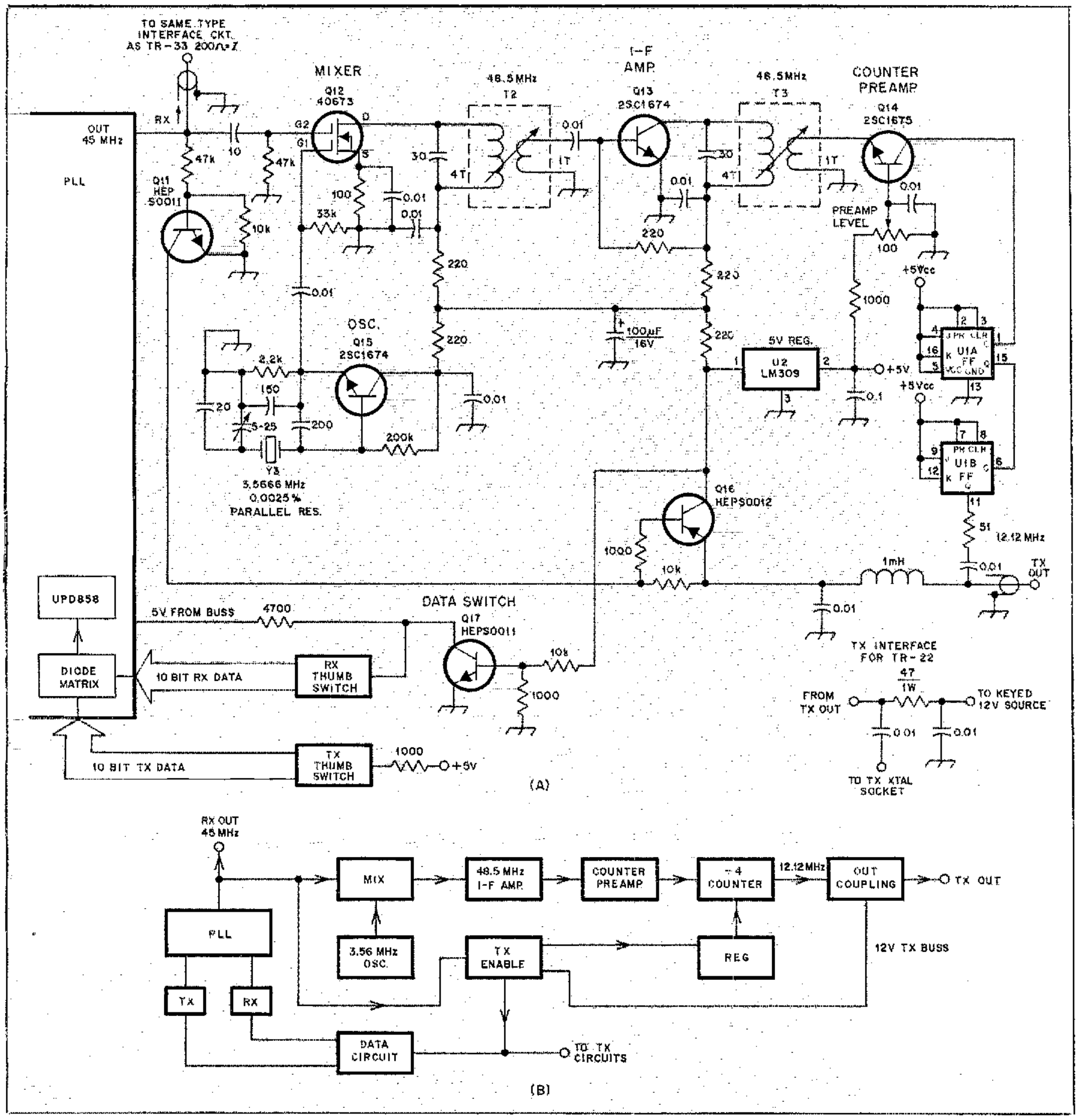


Fig. 7 — Interface to allow use of the synthesizer with the Drake TR-22.

Q11, Q17 — Npn silicon small-signal transistor, HEP-S0011.
Q12 — MOSFET, 40673 or HEP-F0024.
Q13, Q15 — Npn silicon small-signal transistor, 2SC1674 or HEP-S0010.
Q14 — Npn silicon small-signal transistor, 2SC1675 or HEP-S0015.
Q16 — Pnp silicon small-signal transistor, HEP-S0012.
T2, T3 — Rf transformer, pri. 4 turns, sec. 1 turn; no. 28 enam. wire wound on 10.7-MHz i-f transformer core.
U1 — TTL IC, dual J-K flip-flop, type 74S76.
U2 — 5-V voltage regulator, type LM309K.
Y3 — 3.5666-MHz crystal, 0.0025 percent, parallel resonant, 32 pF load.

Strays

HAWAIIAN HONORED AT 75

☐ Shouts of "Happy birthday, Kiyo!" and "Aloha!" replaced the traditional banzai toast for the 75th birthday luau of David Clement Kiyo Enomoto, KH6FF, of Kahului, Maui, HI. A special moment in the affair was the reading of a Maui County Council resolution recounting ". . . his greatest contribution to the people of Hawaii." Kiyo had operated his amateur station as the only radio link between U.S. Navy facilities at Puunene, Maui, and Pearl Harbor, Oahu, for 15 months after the December 7, 1941, attack until the Army and the Navy could set up an adequate system of their own. It required the utmost secrecy, and in September, 1963, the Navy recognized his patriotic effort with its highest award for such duty, Honorary Naval Communicator. "Maui no ka oi!" — Maui is the best!

Transmitter Design — Emphasis on Anatomy

Part 4: The final touches are applied to our transmitter by adding a 15-watt amplifier and an SWR indicator. If all goes well, we will become immune to the "Freddie syndrome"!†

By Doug DeMaw,* W1FB

It is unlikely that the 1.5 watts of output from our broadband amplifier (Fig. 7) would lead to the acquisition of five-band DXCC. But a few more decibels might make such an endeavor a reasonable assignment: The amplifier described in this section will help, as the cw signal should be increased some 10 dB in strength!

The final-amplifier stage is shown in Fig. 10. A 220-ohm feedback resistor is used between the base and collector of Q12. An 1800-pF blocking capacitor has been included to prevent the collector dc voltage from being shorted to ground via T3 of Fig. 7.

This amplifier has an input impedance of approximately 5 ohms at 7 and 14 MHz. The 10-ohm base resistor is used as a preventive measure against instability, but only if needed. To remove some vhf harmonics which appeared at the collector of Q12, it was necessary to include the 330-pF bypass capacitor. At 7 and 14 MHz the capacitor has negligible effect on circuit performance.

As was the case with the stages in our broadband amplifier, decoupling of the 12-volt bus is necessary at Q12. This is accomplished by means of RFC9 and the related bypass capacitors. Once again, bypassing is done for lf, hf and vhf.

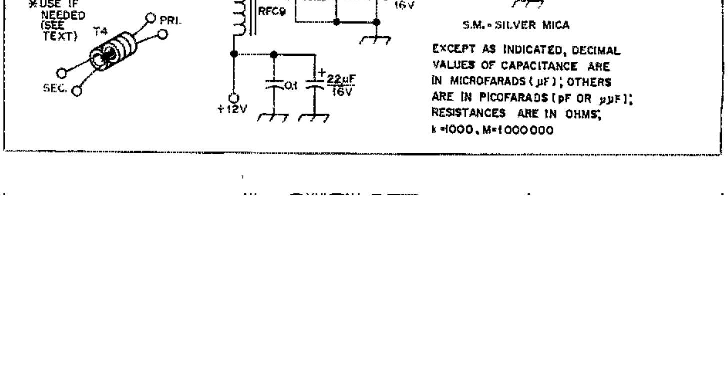
Since the amplifier is to operate in the Class C mode, no forward bias is used at the base of Q12. For all practical purposes, Q12 draws no current during key-up conditions. When drive is applied (key closed) the transistor is driven into the cutoff region to establish Class C operation.

The collector load impedance of Q12 is determined in the usual manner, where Zo = Vcc²/2Po. Thus, for a 12-volt collector supply and a power output of 15 watts, we obtain a collector load of 4.8 ohms. T4 is a broadband transformer which is made from six toroid cores (see inset drawing of Fig. 10). It must transform the collector impedance to 50 ohms so that a suitable match and power transfer to the T-network filters can be obtained. A 3:1 turns ratio will suffice despite the slight mismatch (9:1 impedance ratio).

In order to prevent excessive harmonic energy from reaching the antenna it is necessary to include a filter at the output of Q12. FL1 and FL2 are used for this purpose. Each is a T type of low-pass network. Energy above the operating frequency is attenuated by the filters, but energy below the filter cutoff frequency passes without impairment. A spectral analysis of this transmitter indicated that all spurious output energy was at least 40 dB below peak power at the fundamental frequency. Additional attenuation could be realized by cascading two such filters at the PA output. The characteristic impedance of the filters in Fig. 10 is 50 ohms.

Fig. 10 — Circuit for the 10- to 15-watt Class C power amplifier. Capacitors are disk or chip ceramic unless otherwise noted. Capacitors with polarity marked are electrolytic or tantalum.

L4 — 9 turns no. 18 enam. wire on a T68-6 toroid core.
L5 — 10 turns no. 18 enam. wire on a T68-6 toroid core.
L6 — 12 turns no. 18 enam. wire on a T68-2 toroid core.
L7 — 13 turns no. 18 enam. wire on a T68-2 toroid core.
Q12 — Motorola MRF449A stud-mount transistor.
RFC8, RFC9 — 8 turns no. 18 enam. wire on an FT-50-43 ferrite toroid core.
T4 — Two rows of three each FT-50-43 toroid cores. Join with epoxy cement as shown in the inset drawing. Primary has one turn of no. 18 wire (U shaped). Secondary uses 3 turns of no. 18 enam. or insulated hookup wire. Primary leads exit from core at end opposite to secondary leads.



†Parts 1 through 3 appeared in *QST* for May, June and July, 1978. This part concludes the series.

*Senior Technical Editor, ARRL

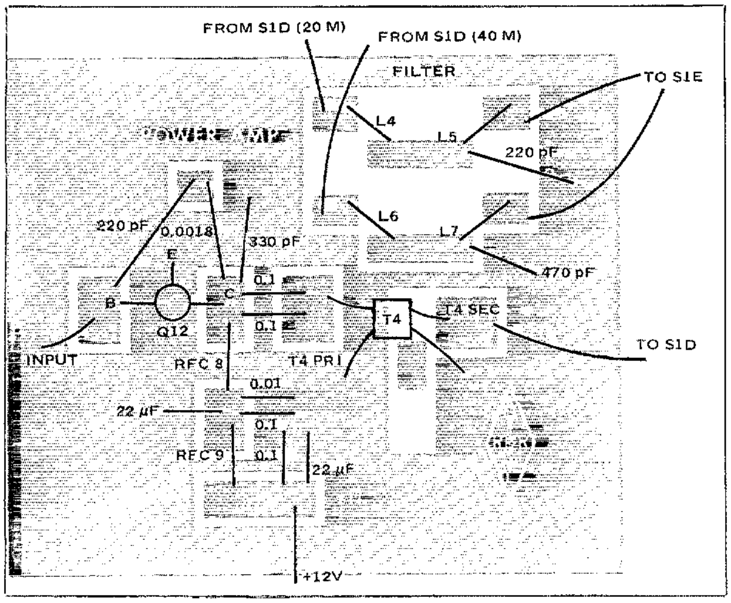


Fig. 11 — Parts-placement guide for the PA pc board. Parts are mounted on the pattern side of the board; the shaded area in this view represents the copper pattern on the component side, and the other side of the board is unetched copper groundplane. (The etching pattern for the component side appeared on page 33 of the July 1978 issue.) Decimal-value numbers alone represent capacitance in microfarads. Whole-number values with no units represent resistance in ohms.

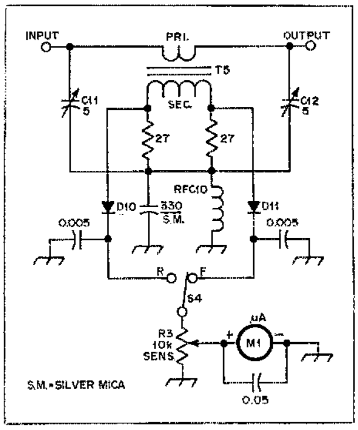


Fig. 12 — Circuit for the SWR sensor (see text). Fixed-value capacitors are disk ceramic. Fixed-value resistors are 1/2-W composition.
C11, C12 — 5-pF air variable, pc-board mount.
D10, D11 — 1N270 or 1N34A diode.
M1 — Small microampere meter. A 50-, 100- or 200-µA type will be satisfactory.
R3 — 10-kΩ, linear-taper, carbon control, panel mount.
RFC10 — Miniature 1-mH rf choke.
T5 — 50 turns no. 26 enam. wire on T50-2 toroid core. Primary has 2 turns of no. 26 enam. wire over center of secondary winding.

There are no special precautions to follow when assembling the amplifier, other than keeping the component leads as short as possible. Double-sided pc board should be used to minimize the chance for ground loops (feedback): They could cause amplifier instability.

The strip leads of Q12 should not be stressed when they are soldered in place. Allow a *slight* amount of slack for expansion when the transistor is heated during operation. Also, use care when tightening the transistor mounting nut. It should be drawn up just a "smidge" beyond the finger-tight point. A coating of silicone grease (heat-sink compound) should be placed on the transistor stud and metal face near the base of the stud. This will improve the transfer of heat between the heat sink and Q12. The heat sink is a homemade unit which has been bent into a U shape. It is made from a piece of 1/16-inch (1.6-mm) thick aluminum plate, 2-1/2 × 3 inches (64 × 76 mm) in size. Each lip is 1/2 inch (12.7 mm) high. The heat sink is affixed to the rear wall of the transmitter cabinet, and silicone grease is applied to the joining surfaces. The stud of Q12 and two no. 4-40 screws hold the heat sink firmly in place. This mounting method also holds the PA module in place on the inner surface of the rear wall of the cabinet. The pc-board layout is shown in Fig. 11.

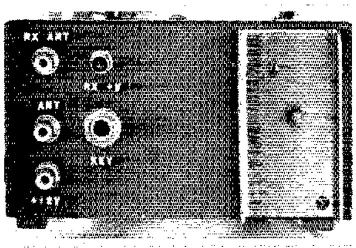
SWR Indicator

As a convenience gadget we have included the SWR bridge shown in Fig. 12. It not only enables the operator to adjust the antennas for a low SWR when using a Transmatch, but serves as a relative-power-output indicator when switched to the forward mode. A blow-by-blow circuit description will not be given here, as this design was treated earlier in *QST* ("A QRP Man's RF Power Meter," June, 1973).

Assembly Notes — Composite Transmitter

Double-sided pc-board material is used for the cabinet of the WA0UZO version of the transmitter. Aluminum sheeting was bent into a U shape to form the W1FB prototype. The latter (HWD) is 3-1/4 × 5-3/4 × 6 inches (83 × 146 × 152 mm). The cover is a U-shaped piece of perforated aluminum. Two metal L brackets are affixed on the lower surface of the main chassis to permit the box cover to be secured by means of no. 6 sheet-metal screws. The WA0UZO model of the transmitter is slightly larger than the W1FB version. He allowed room for mounting the modules horizontally. The vertical-mounting format makes it possible to realize greater miniaturization.

Our VFO is contained in a separate compartment. The enclosure is made from pc-board stock with the walls joined by means of solder. A U-shaped aluminum top cover is placed on the VFO assembly to prevent unwanted rf energy, moisture and dirt from entering. The



Rear view of the W1FB version of the transmitter. The heat sink is at the far right. The phono jacks and key jack are grouped at the left.

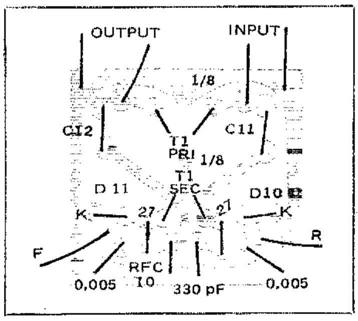


Fig. 13 — Parts placement guide for the SWR sensor. The etching pattern appeared in the "Hints and Kinks" section (page 32) of the July 1978 issue. K = the cathode end of a diode. Fractional markings such as "1/8" signify mounting holes to be drilled with that size bit.

cover is press-fitted over the box walls. In the author's unit the SWR-sensor module is bolted to the VFO top cover.

By this time you should have a pretty good "handle" on how the collection of subassemblies are connected together. The block diagram of Fig. 1 provides the essential information. All of the signal leads should be made of shielded cable if they are more than two inches (51 mm) in length. RG-174/U subminiature coaxial cable is excellent for the purpose.

The main-tuning dial is a vernier mechanism (Calectro or Philmore). A large knob can be used as a substitute for the one which comes with the dial, as the original is a bit small for those who have large fingers. A Kurz-Kasch aluminum knob was used on the prototype model after its depth was reduced on a lathe (courtesy of W1SL).

The front and rear panels of the W1FB unit were sprayed a dark green color. Green Dymo tape labels were used to identify the controls: A reasonably professional appearance results from using labels which are the same color as the panel. Finally, four adhesive-backed plastic feet were affixed to the bottom of the cabinet.

Closing Remarks

The toroid cores used in this project are available from Amidon Associates, G. R. Whitehouse and Palomar Engineers (check *QST* ads). It is suggested that the builder ask these suppliers for their catalogs, as some of the other components for the transmitter may be found in their product lines. It would also be prudent to scan the flea markets for parts.

The power supply for this transmitter should deliver 12 to 13 volts dc (regulated) at 3 amperes. Needless to say, a 12-volt car battery is suitable. A dry-battery pack is not recommended: The life span would be extremely short.

Motorola has included internal protection for their MRF449A transistor (Q12), so damage should not occur during short periods of operation when a mismatch greater than, say, 2:1 exists. This circuit has been tested into a dead short and a full-open load condition (key down) for periods of 30 seconds, and no damage to the PA stage resulted.

This two-band transmitter should provide many years of reliable operation. It is hoped that some useful information was passed along to those who aren't heavily immersed in solid-state design theory. If nothing more, let's hope we have negated the "Freddie syndrome" effectively.

Simple Ladder I-F Filter

Low-cost CB crystals serve in a four-pole ladder filter for ssb reception. Try this inexpensive circuit in your next homemade receiver.

Suffering from "burst-itis" of the coin purse these days? Certainly the cost of high-quality commercial i-f filters can contribute substantially to that malady if you're building a receiver of your own design.

The simple ladder filter of Fig. 1 was first described by F6BQP in *Radio REF* for May of 1976. This presentation is lifted from a reprint which is contained in *U.R.E. (Union de Radioaficionados Espanoles)* for January 1978, page 37. The details have been translated to English for use in *QST*.

The significant feature of this ladder type of filter is that the four quartz crystals are cut for the same frequency. They require no alignment after the circuit is assembled and the terminal impedance of the filter is 850 ohms, bilateral.

Four CB crystals (27 MHz) are employed as shown in Fig. 1. They operate on the fundamental mode (9 MHz). The 3-dB bandwidth of the filter is approximately 2.5 kHz. The necessary fixed values of capacitance are given in the diagram. It is recommended that silver-mica or other high-Q, stable capacitors be used. Those who have facilities for laboratory alignment of filters may elect to install ceramic trimmers in place of the fixed-value capacitors listed. This will permit precise tweaking of the filter. — *W1FB*

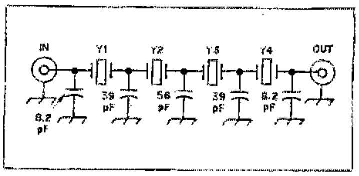


Fig. 1 — The simple ladder filter. All capacitors are dipped silver-mica types. Y1-Y4, incl. — 27-MHz CB transmit crystal (must all be same frequency).

Strays

HIS SEARCH SPANNED 50 YEARS

☐ A little detective work paid off recently for H. V. Noble, W8DGN, who recently rejoined the amateur ranks after an absence of more than 40 years. In casually looking through his old log from the late 1920s, he came across a couple of entries that brought him back half a century — 9EIW, Anamosa, IA, and 9EHN, Mechanicsville, IA. He kept skeds with them in those days, and recalled that they were sweethearts who did their courting by radio!

Determined to find them, Mr. Noble asked the League for help. Membership Services Assistant Mark Starin, WA1TZK, sent him photocopies of a couple of pages from a *callbook* of that era which listed their names (which W8DGN had long since forgotten). A letter to the Chamber of Commerce of each town brought no response, so Mr. Noble again turned to the League. Iowa SCM Max Otto, WØLFF, was anxious to assist, and placed a small ad in the Cedar Valley ARC newsletter, asking for information about the two old-timers. A nephew of 9EIW responded and gave her address as Mrs. Herman Gray, Grand Rapids, MI.

Since Herman Gray was 9EHN, Mr. Noble's search had ended as he hoped it might. He enclosed a 50-year-old QSL card from 9EIW with his first letter to his newly rediscovered friends.

The Audiobox — An Amplifier with a Twist

Solid-state modular design, a programmable attenuator, dc volume control and Class B power output stage make this amplifier worthy of attention.

By Eric J. Grabowski,* WA8HEB

A receiver for the serious fm-er? I had mulled that question over many times while working for my BSEE degree. Pounding the books, however, took priority over construction, delaying the day when that thought would become a reality. But, eventually, arrive it did, and the pungent aroma of rosin core soldering marked the beginning of a rewarding project.

The smoldering motivation behind this endeavor was a desire to design and build a unit simulating commercial performance. As a matter of personal choice I had restricted the physical size to being no greater than half the size of the Regency HR-2, with a cost ceiling being pegged at $100. More than a few sleepless nights were spent in preparations.

Although the building-block approach to construction is not novel, per se, some of the techniques applied to this design may well be. All boards of the receiver are housed in an easy-to-build, inexpensive, reusable enclosure, an adaptation of a practice used by the Atomic Energy Commission for nuclear-instrument modules. Each pc board performs a complete function so that redesigning a board does not affect the other boards in the project. A bonus derived from this arrangement is that a particular board may be employed in many projects.

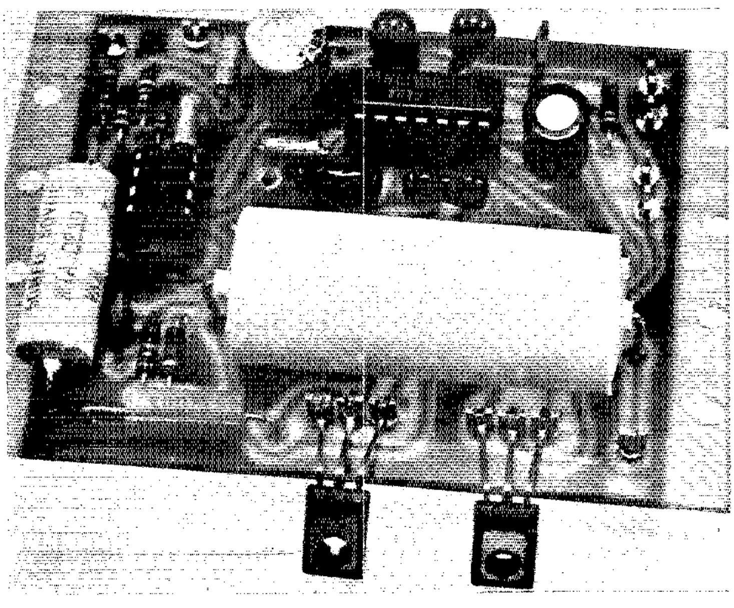
The rather odd size of the pc boards (3-5/8 inches or 92 mm wide) allows two boards to be mounted side-by-side with the total width equal to one-half of an EIA rack panel. Consequently, a 19-inch (483-mm) panel, when cut down, will provide a front and rear panel. Rails made from 1/4-inch (6.4-mm) aluminum stock are mounted on the panels, and the pc boards are, in turn, attached to the rails. A standard hole spacing is maintained on all pc boards to facilitate interchangeability.

The Audio Board

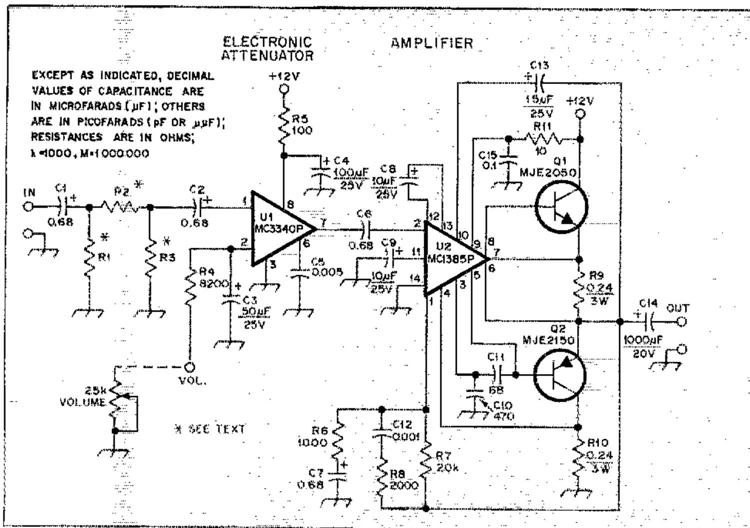
For identification purposes, the audio-amplifier application board has been labeled model 1001. It is intended for use as a complete audio section for communications receivers, public-address amplifiers or for general purposes. The board is one of seven different boards to be incorporated in a complete receiver.

According to plan, the audio section became the first of the receiver assembly units to be completed. The performance is indeed gratifying to me. I must admit that when I first shared my delight with other members of the local radio club by demonstrating the unit, I had some trepidation that others would show little more than casual interest. My feelings, however, were quickly dispelled as they pressed me for more details and literally swamped me with requests for pc boards.

Components for the WA8HEB audio amplifier are neatly arranged on this circuit board. Tie-point hardware for Q1, Q2 and the external leads, visible in the photograph, may be used by the builder. The metallic sides of Q1 and Q2 face away from C14. The transistors are then bent 180° to attach to the heat sink. Both must be insulated from the heat sink by insulated washers.



*30312 Arnold Rd., Willowick, OH 44094



C1, C2, C6, C7 — 0.68 µF, 16 V (Sprague no. 196D or equiv.). See text.
C3 — 50 µF, 25 V (Mallory no. MTA50E25 or equiv.).
C4 — 100 µF, 25 V (Mallory no. MTV100DB25 or equiv.).
C5 — 0.005 µF, ceramic disk.
C8, C9 — 10 µF, tantalum.
C10 — 470 pF, dipped mica.
C11 — 68 pF, dipped mica.
C12 — 0.001 µF, disk ceramic.
C13 — 15 µF, 25 V tantalum.
C14 — 1000 µF, 25-V electrolytic, Mallory no. MTA1000G25 or equiv.
C15 — 0.1 µF, disk ceramic.
Q1 — Complementary npn silicon power transistor, Motorola type MJE2050 or equiv.
Q2 — Complementary pnp silicon power transistor, Motorola type MJE2150 or equiv.
R1, R2, R3 — See text.
R4 — 8200 ohm.
R5 — 100 ohm.
R6 — 1000 ohm.
R7 — 20 kΩ.
R8 — 2000 ohm.
R9, R10 — Wirewound, 0.24-ohm, 3-watt. Ohmite no. 844-.24. Mount 1/16 inch (1.6 mm) above board for cooling.
R11 — 10 ohm.
U1 — Electronic attenuator, Motorola type MC3340P or equiv.
U2 — Class B driver IC, Motorola type MC1385P or equiv.

Fig. 1 — The WA8HEB audio amplifier schematic diagram. A pair of complementary-symmetry Class B silicon power transistors in the output stage is driven by an MC1385P containing a fixed-gain preamplifier, an output amplifier, a voltage regulator and a short-circuit protection network. Capacitors with polarity shown are electrolytic, except as noted below. Resistors are 1/4-watt composition, 5-percent tolerance, except as noted. Part numbers not listed above are assigned for identification in the circuit-board layout. The design of the audio output stage is based on the typical application circuit provided in the data supplied by Motorola for the MC1385.

Through the cooperation of a local board maker and printer, the demand for these boards was met. Orders were even received for future boards for the complete receiver.

The model 1001 audio amplifier application board contains an input attenuator, a dc volume control and a power amplifier. Using the board with several input-voltage ranges is facilitated by the programmable attenuator. The dc volume control eliminates the need for using shielded wire between the board and the volume-regulating potentiometer control. This feature is especially convenient for trunk-mounted equipment. Volume may be regulated by a dc voltage, such as that from the output of a microprocessor, making the function of a potentiometer unnecessary.

When this audio amplifier flexes those electronic muscles, it can provide up to 7 watts output with about 20 microwatts of drive. Frequency response is 300 to 3000 Hz at −3 dB. This response, chosen for voice communication, can be modified to provide a wider response from 20 to 20,000 Hz. Typical performance data are listed in Table 1.

Because of the high gain involved, the location of some components is somewhat critical. Printed-circuit construction is recommended. An industrial-quality, single-sided, plated and drilled board is available (less components)[1] to builders.

A Programmable Attenuator

Refer to Fig. 1 in connection with the following circuit descriptions: R1, R2 and

[1]Footnotes appear on page 21.

Fig. 2 — Parts-placement guide for the model 1001 amplifier. This view is from the component side of the board, with the shaded area representing an X-ray view of the foil. All components are mounted on the nonfoil side of the board.

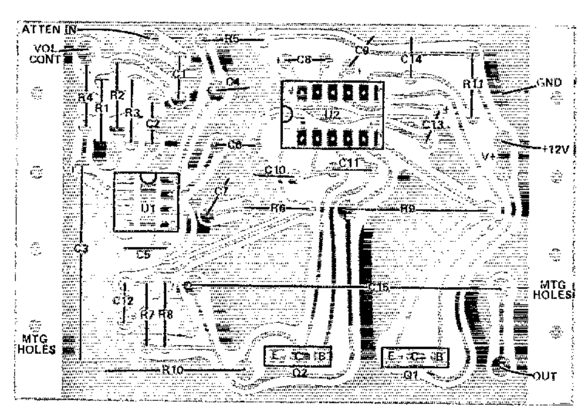


Table 1
Performance Data

Parameter	*Value*
Input	
Level	0 to 10 mV
Impedance	5000 ohms
Output	
P_{max}	5 watts minimum
Impedance	3.2 ohms
Control	
Resistive	25-kΩ potentiometer
Voltage	4.25 to 6.0 V dc at 2 mA
Thermal	Transistors require heat sink with 6°C/W thermal coefficient
Power	
Voltage	9 to 18 V dc; 12 V typical
Current	3 A max.; 1 A typical
Dimensions	
L × W	2.5 × 3.625 inches (64 × 92 mm)
H	Depends on components

Table 2
Resistor Values

Input	*Atten*	*R1, R3*	*R2*
0-10 mV	0 dB	Open	Short
0-100 mV	20 dB	6200 Ω	24 kΩ
0-1 V	40 dB	5100 Ω	240 kΩ

R3 form the pi-network attenuator. This network provides a convenient method of using the board with input signals greater than 10 mV while maintaining the input impedance at 5000 ohms.

Resistor values for some common input ranges are listed in Table 2. Other ranges are accommodated by calculating the resistances required according to information in the *ARRL electronics data book.*[2] A network impedance of 5000 ohms should be used in the calculation. Select the nearest standard commercial values. If the input attenuator feature is not required, omit R1 and R3 and use jumper wires in place of C1 and R2.

DC Volume Control

One of the more recent Motorola semiconductor devices that plays a key part in this amplifier is the MC3340P electronic attenuator (U1).[3] This IC is capable of providing gain, but because of the effect of R4, the device becomes a unity-gain amplifier. Volume is adjusted by changing the dc voltage at pin 2 by means of a potentiometer or an external dc source.

In applications where more input sensitivity is needed, R4 is replaced with a jumper wire. When this change is made U1 provides an additional gain of about 13 dB.

Low-frequency oscillations could occur in the amplifier if insufficient power-supply decoupling is present. This possibility is minimized by using a large-value capacitor for C4.

The Driver Amplifier

A pair of complementary-symmetry transistors, Q1 and Q2, is driven by the Motorola MC1385P[3] Class B driver, U2. This useful device contains a fixed-gain preamplifier, an output amplifier, a voltage regulator and a short-circuit-protection network.

Audio output from U1 is ac coupled to the preamp through C6. Output from the preamp is ac coupled to the output amplifier through C8.

The dc gain of the output amplifier is determined by the feedback voltage developed at the junction of R6 and R7. C7 determines the low-frequency gain. likewise, R8 and C12 in parallel with R7 determine the high-frequency gain. Should one so desire, the band-pass response can be changed by replacing these components with ones having other values. When making such changes, an oscilloscope and audio generator will be needed to facilitate component selection.

The output of U2 drives an npn/pnp (complementary symmetry) power-output stage operating in Class B. Maximum power output will be realized only when a low-impedance load is used. The output power decreases rapidly as load impedance increases. For example, power output decreases 50 percent when the speaker impedance is increased from 3.2 to 8 ohms.

Builders will appreciate the short-circuit-protection network guarding U2 and the power transistors from an over-current condition. This protection is provided by sampling the current flowing through R9 and R10 (see parts list). When the output current exceeds the design threshold, the U2 shuts down. Q1 and Q2 will be protected as long as a sufficient heat sink is used. The heat-sink requirement can be satisfied by using a piece of aluminum having a total surface area of 40 square inches (25,800 sq mm). A commercial heat sink may also be employed. Jumper wires installed in place of R9 and R10 will defeat the protection network.

Thoughts About Construction

A step-by-step construction sequence is beyond the scope of this brief presentation. Experienced builders, however, should have no difficulty assembling the board. Fig. 2 shows the parts layout, and Fig. 3 shows the etching pattern for the board.

Use of dipped tantalum capacitors will yield a cleaner looking board, but from a functional standpoint larger vertical electrolytics or axial-lead electrolytics mounted on end are just as good. Once the board is assembled, the insertion of all polarized components should be checked and the board inspected for solder bridges between foils. Values shown for C1, C2, C6 and C7 establish a band-pass characteristic suitable for voice communications. For high-fidelity response, these capacitors may be replaced by 10-μF units.

If the power-supply filter capacitor is located more than a few inches from the board, installation of a 470-μF capacitor across the positive and negative terminals at the board may prevent low-frequency oscillation from occurring.

For public-address application of the model 1001 audio amplifier, a low-impedance microphone is recommended. Compensation for low output from a particular microphone can be provided by replacing R4 with a jumper.

The 1/4-inch (6-mm) clear areas along each side of the board are suitable for drilling mounting holes. If the board is to be installed in a metal enclosure, insertion of standoff insulators will prevent the foils from shorting to the metal enclosure. Troubleshooting is easier if IC sockets are used, but this is strictly a builder's choice. Under no-signal conditions, about 10 mA of current flows through R5 and about 35 mA flows to U2, Q1 and Q2.

I've found a distinct pleasure in the performance of this amplifier. For this reason I'm delighted to share my design with other *QST* readers. "What about the rest of the receiver?" one might ask. In response, I'd simply say that the remainder of my fm project may be considered for a future *QST* article.

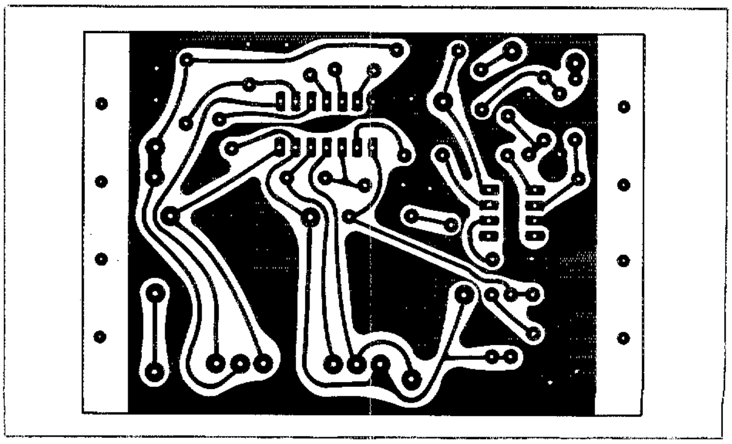
Footnotes

[1]Plated and drilled circuit boards, less components, are available for $3.50 postpaid, from Firstron Electronics, Box 151, Streetsboro, OH 44240. Price subject to change without notice.

[2]*ARRL electronics data book*, 1976, p. 32.

[3]Motorola data sheets are available from Motorola Semiconductor Products Inc., Box 20912, Phoenix, AZ 85036.

Fig. 3 — Circuit-board etching pattern for the Audiobox, shown at actual size. Black represents copper.



Updating Phased-Array Technology

Electrical? Mechanical? Both are ways of rotating directional antennas, whether on 80 meters or 432 MHz. This article may just lead you to a vertical phased array for your favorite band or bands.

By Dana W. Atchley Jr.,* W1CF

Worldwide DX on 40 meters has been an acknowledged fact for many years, and 80 meters has become a nightly haunt for countries chasers. As on other bands, the antenna is the most important factor in successful 40- and 80-meter DXing. Rotary beam antennas are, for all practical purposes, impossible on 80 and are more than many amateurs wish to tackle even on 40. For those wishing directive arrays on 40 and 80, electrically switched phased vertical arrays can provide a very cost-effective solution.

I have been heavily involved with such phased arrays for use in hf work since 1965. In that year a four-element, end-fire array for 3.5 MHz was constructed.[1] This array could be operated in three modes: unidirectional off either end or bidirectional broadside to the array. An article in April 1976 *QST*[2] showed the construction and operation of a more versatile antenna utilizing four elements in a diamond-shape array. That antenna is switchable over a full 360 degrees in 90-degree steps and is unidirectional.

Many DX-oriented amateurs have constructed the four-element array described in 1976, with excellent results on both 40 and 80 meters. The author has used such a system for over two years, working some very difficult paths (such as long path to Japan) from a mediocre geographic location. Such niceties as "instant" direction selection have become addictive.

*Vice-Chairman of the Board, M/A-Com Inc., Burlington, MA 01803

[1]Footnotes appear on page 25.

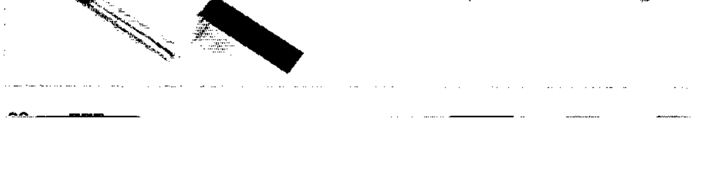
Recommended Circuits and Components

The April 1976 article discussed several recommended circuits and components for constructing 360-degree phased arrays. Two years of experimentation have taken place since that article was written. The *QST* article should be read for background information before one embarks on erection of such a phased array. The information in this article supersedes the circuits shown in 1976, which contained several errors.

Fig. 1 shows the recommended configurations for a four-element array, identical to that in the 1976 article. Fig. 2 illustrates recommended driving circuits, which have changed considerably since 1976 and have given excellent results. Front-to-back ratios on the order of 20 dB have been obtained on 80 meters. The method of power splitting most suitable is the Wilkinson power divider[3] since it increases the bandwidth capability of the array and always improves the impedance match seen from the transmitter.

Several builders have complained of difficulty in finding a source of noninductive, 100-Ω resistors. Microwave Associates manufactures the noninductive resistors shown. They are essentially nonreactive well into the microwave region and use a sputtered refractive metalization and hard brazing which makes them very reliable. Both 50- and 100-Ω units are being produced for the military and are now available to amateurs at reasonable prices. (See caption for Fig. 2.) If higher power dissipa-

Noninductive resistors, 50 ohm on the left, 100 ohm on the right. *(photos courtesy of Microwave Associates)*



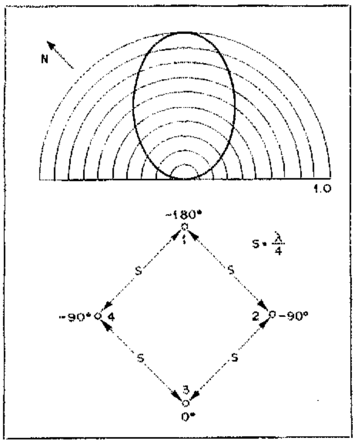


Fig. 1 — Polar plot of relative power and planar view of the 4-element diamond array showing the pattern obtained with no dc voltage on the switching relays, as in Fig. 2. Minor lobes are too far down to show on this scale.

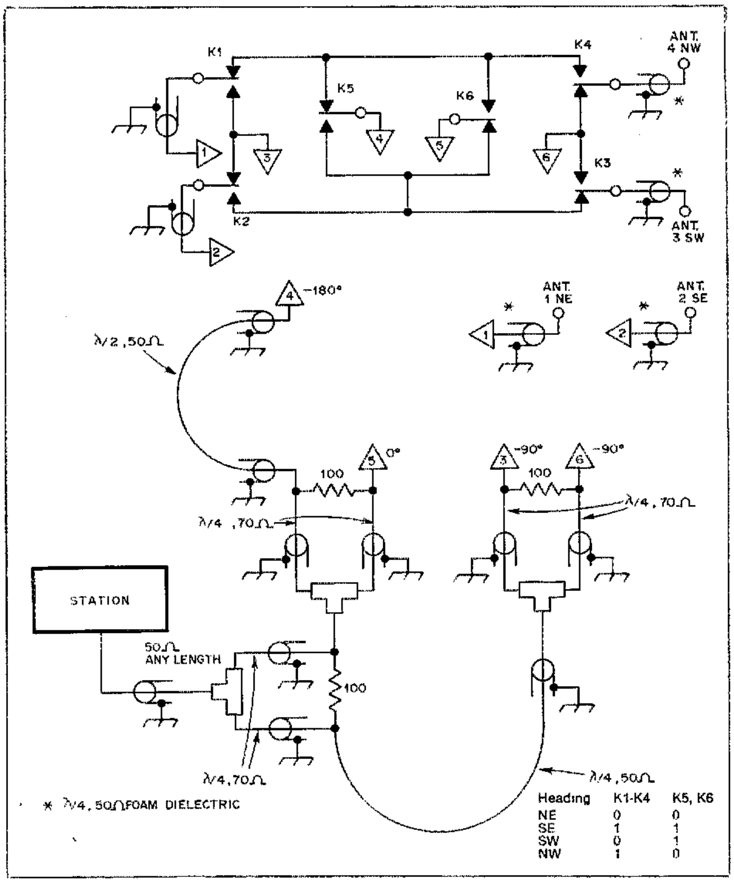


Fig. 2 — Schematic diagram of the Wilkinson power dividers, phasing lines, and switching relays (rf connections only) for the 4-element array. Dc switching commands for the four pattern headings are given at the lower right. See Table 1 for definitions of 0 and 1. All relay contacts are shown in the deenergized position. High-wattage noninductive resistors are available from G. R. Whitehouse, 11 Newberry Dr., Amherst, NH 03031, or from Microwave Associates GMBH, D-8000 Munchen 80 Welternburger Str. 33, Munich, W. Germany.

tion is necessary, series-parallel combinations may be constructed by the user without compromising the noninductive characteristics of the resistors.

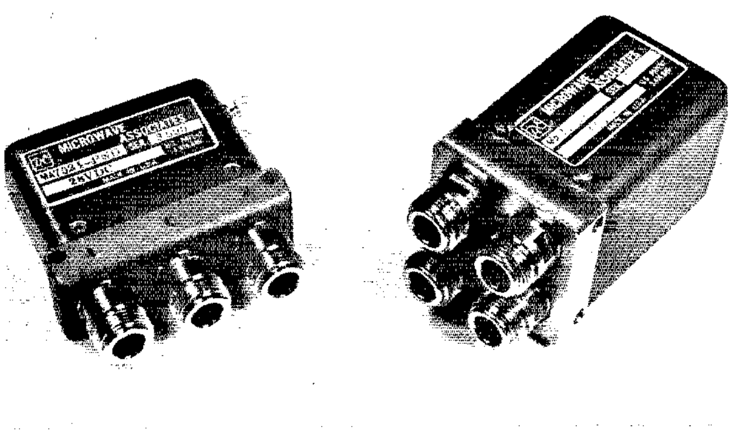
Various array builders have used different types of relays for switching the delay phasing lines. The writer has used MA-7524 spdt and MA-7525 four-port coaxial transfer switches for the past two years. Both switches pictured operate from 28 V dc. Since these switches are "flat" up to 12 GHz, they represent overkill. On the other hand, perhaps the excellent pattern achieved by the author's system is due in part to the fact that these relays have tremendous isolation.

Although they have not been used by the author, American Design Components Division[4] offers many coaxial switches suitable for use with the array. For instance, they list both transfer relays and spdt units at reasonable prices.

If economical, open-frame relays are used, there is a possibility of some unwanted coupling unless care is taken in the layout. In any case, the use of unreliable relays or inadequate drive voltage in long cable harnesses will completely negate the effectiveness of any array. Further, no matter how good your relay system is, do not tempt fate by "hot switching" the relay system (switching the beam while transmitting).

For those on a lower budget, the three-element triangle system should be considered. Although the author has not used such a system, listening to the signal from someone who does, WB6HSG, shows very good lobe switching and signal strength. Fig. 3 shows the WB6HSG arrangement on 3.8 MHz. The switching diagram in Fig. 4 is updated and corrected

Spdt (left) and four-port (right) coaxial transfer switches such as used in the W1CF array.



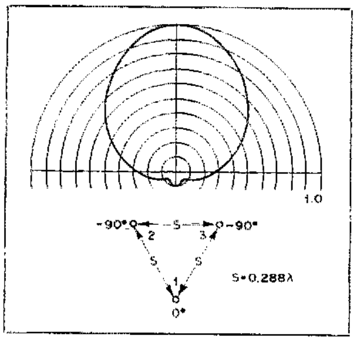


Fig. 3 — Polar plot and planar view of a 3-element phased array.

from the April 1976 article and shows the use of three Y-connected, noninductive resistors in a three-way Wilkinson power divider. Do *not* ground the junction of the three resistors as was shown in the original *QST* article.

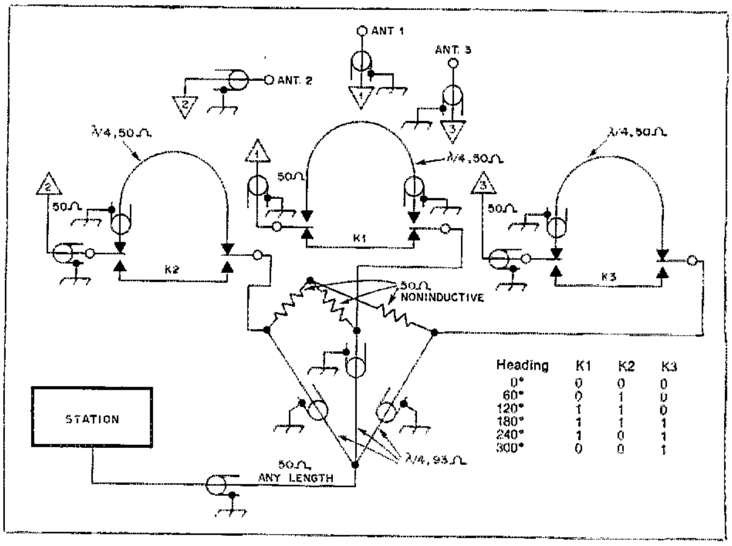


Fig. 4 — Switching diagram for a 3-element array. Note that the junction of the three noninductive resistors is *not* grounded. See Table 1 for definitions of 0 and 1.

Dual-Band Operation

Richard Moser, W8XM, was one of many amateurs who requested the ARRAY FORTRAN program mentioned in the 1976 article. He explored by computer modeling the possibility of dual-band operation using the four-element array technique. W8XM found that the diamond configuration with 2/10-wave element spacing at the fundamental (F) and 4/10 spacing at 2F would give the polar plot shown in Fig. 5.

Moser has constructed and successfully operated a dual-band array on 40 and 20 meters with excellent results. By the use of double-pole, double-throw relays he divided all delay lines and Wilkinsons by a factor of two when operating at 20 meters. When on 40, they are full length. The antennas used are four trap verticals operating against a radial system.

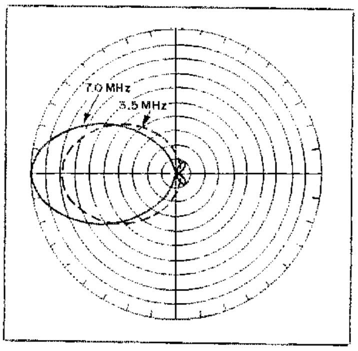


Fig. 5 — Polar plot of a 2-band, 4-element array.

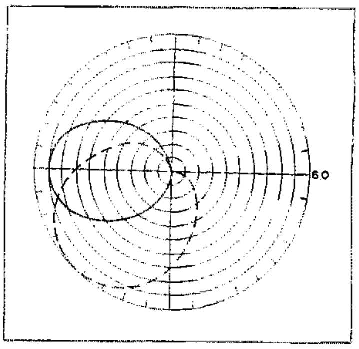


Fig. 6 — Computer-generated plot of a 4-element square array, 0.25-wavelength element spacing, using a four-way equal power split for 45-degree segment, 360-degree coverage. Table 1 lists appropriate switch states for the various element phasings.

45-Degree Switching Capability

The author has modified his 80-meter array to provide 45-degree switching capability. In this case, switching techniques are used which allow the four elements to be switched in the traditional −180° for the front element, two sides at −90° and the rear at 0°, which gives directivity along the diagonals of the array, or, alternatively, the two front elements at −90° and two rear elements at 0°. The computer-predicted pattern for this array and the switching techniques are shown in Figs. 6 and 7, respectively.

My 80-meter beam has been on the air since October 1977 using the new switching scheme, with excellent results. My 40-meter array still has only 90-degree switching capability but soon will be modified for 45-degree switching. WØLS has constructed a 45-degree, 40-meter version for $600 which works very well.

Q and A Session

Since the original articles generated many questions from interested amateurs, I'll take this opportunity to answer some of the more common questions publicly. The following may be some questions *you* have.

Q. What types of vertical elements do you recommend?

A. The writer uses quarter-wave vertical elements constructed from two-inch OD aluminum tubing made in 5-foot (1.5 m) sections which interlock. This type of construction requires guying, is very time consuming, and takes plenty of guy wire, anchors and insulators. Self-supporting, quarter-wave, 80-meter verticals with insulated bases and concrete-mounted pipe supports are appealing but may have problems with ice loading in the winter.

Most 40-meter systems can be done more easily; the writer uses slightly modified Dentron EX1 self-supporting quarter-wave elements. For dual 40- and 20-meter systems such as that at W8XM, it is suggested that the experimenter contact commercial firms for their recommendations in trap verticals.

Q. What are the trade-offs in using

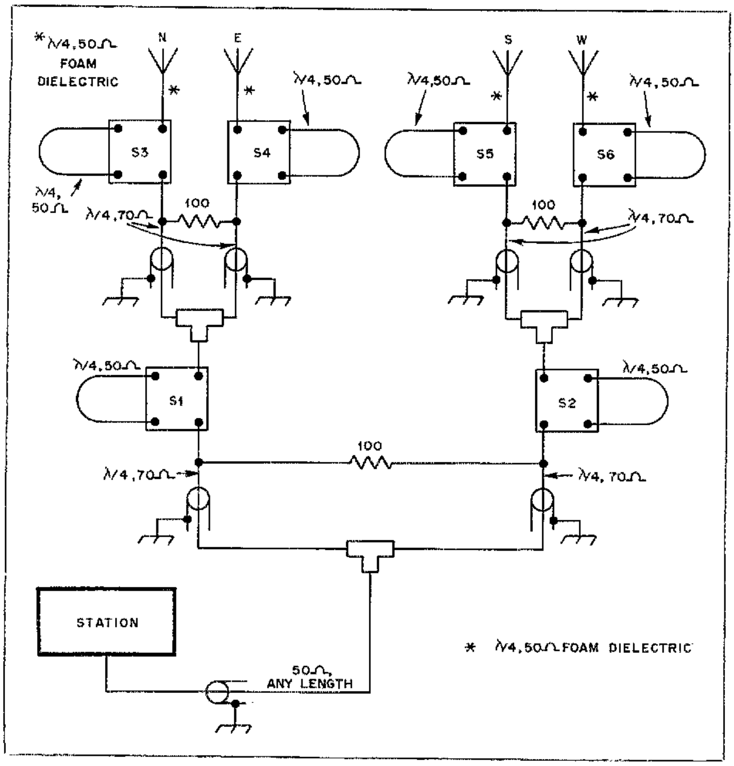


Fig. 7 — Switching diagram for a four-element square array with lobe selection every 45 degrees over a 360-degree range.

1/2-wave or 5/8-wave elements?

A. Obviously, longer elements will cost more and increase mutual coupling. It is my opinion that elements longer than 1/4 wavelength are not worth the trouble, except at frequencies higher than 14 MHz, where Ringo type half-wave construction is economical. Base-fed quarter-wave elements working against radials provide a noncritical match to 50-ohm coaxial line.

Q. What kind of problems should the builder of these arrays anticipate?

A. Many potential problems are addressed in the 1976 article. One which should be mentioned here is ensuring that all interconnections are satisfactory. Make a temporary short at the base of each element and check for dc continuity at the coaxial input during switching.

Next, with the shorts removed, check for short circuits or lossy cables. The input (at the transmitter end of the feed line) should read at least 100 kΩ. Quite often one finds sections of coaxial cable which have aged.

Finally, if you want a good pattern to result, construct your array as far as possible from other metallic objects. Trees do not seem to have any damaging effect on my vertical-array performance, but they would unquestionably deteriorate performance of arrays at 14 MHz and higher.

Q. How does your system compare on the air with other systems, such as the handful of 80-meter Yagis being used?

A. The 40- and 80-meter Yagis of W2HCW, located on Long Island, are louder on the long haul than the W1CF vertical array. Both antennas seem to be equal when receiving. Pluses for the vertical system include "instant rotation," greater bandwidth and less monetary outlay. Also, 80-meter Yagis tend to break under loads of ice and in high winds. [W2HCW's were lost in the fierce winter of 1977-78. — Ed.] Vertical arrays suffer virtually no "down time" due to weather damage. In addition, the W1CF array is hidden from view, being located in a forest. To perform adequately, an 80-meter Yagi must be very high (135-plus feet) and is more conspicuous.

Q. Just how does the bandwidth of the vertical arrays compare to other gain systems?

A. The writer's arrays operate over the entire 3.5-4.0 and 7.0-7.3 MHz ranges without noticeable degradation in front-to-back ratio. However, at the band edges the 100-Ω resistors may become warm, although none have blown out yet.

Q. How do your patterns compare with the ARRAY program computer-predicted patterns?

A. *Actual* patterns are always slightly worse but close enough so that the user won't be disappointed. For instance, with the computer predicting a 25-dB front-to-back ratio, most four-element vertical beams show 15 to 20 dB F/B. The F/B ratios will always be greater on the really long-haul paths, as with any other low-angle radiator.

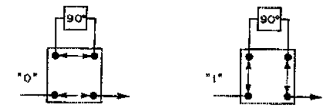
Q. Finally, what should I do first if I decide to put up a beam of your design?

A. Before spending all the time necessary to actually construct an array, you should check for latest developments in the area of vertical array design. Write the author for additional information and advice.

Table 1
Switch States for Various Element Phasings. (See Fig 7.) OM = omnidirectional.

	Element Phase, Degrees				*Switch States*					
Pos	*N*	*E*	*S*	*W*	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*
N	180	90	0	90	1	0	1	0	0	1
NW	90	0	0	90	0	0	1	0	0	1
W	90	0	90	180	0	1	1	0	0	1
SW	0	0	90	90	0	1	0	0	0	0
S	0	90	180	90	0	1	0	1	1	0
SE	0	90	90	0	0	0	0	1	1	0
E	90	180	90	0	1	0	0	1	1	0
NE	90	90	0	0	1	0	0	0	0	0
OM	0	0	0	0	0	0	0	0	0	0

STATES



Footnotes

[1]Atchley, "Switchable 4-Element 80-Meter Phased Array," *QST*, March, 1965.
[2]Atchley, Stinehelfer and White, "360°-Steerable Vertical Phased Arrays," *QST*, April, 1976.
[3]Wilkinson, "An N-Way Hybrid Power Divider," *IRE Transactions on Microwave Theory and Techniques*, January, 1960.
[4]American Design Components Division, B.L.B. Inc., 39 Lispenard St., New York, NY 10013.

Strays

NEW 10-METER BEACON

☐ A 10-meter beacon is operating in North Hollywood, CA, under FCC special temporary authorization. Until September 30, W6IRT will operate on 28.888 MHz using low-power cw emission. Monthly reception reports are solicited and should be sent to Norman Lefcourt, W6IRT, 7713 Wilkinson Ave., North Hollywood, CA 91605.

Antennas — Keeping Them Up

Basic Amateur Radio: Here is a potpourri of ideas designed to make the installation of your next antenna a little more permanent than the last.

By E. W. Ljongquist,* W4DWK/W1CQS

After 55 years of planning, constructing, and erecting antennas, and with the aid and information from many knowledgeable hams, I feel some of my experiences may be of use to the fraternity. The thoughts are not so much as to how the antennas went up, but why they fell down!

It may seem ridiculous to mention, but the antenna is the most important single item in an amateur's setup. Next comes a good receiver and a good operator who knows the tricks. Of course, an exotic call may be worth a few dB. (I have worked many a DX station who was using 5 watts or less, *and* a good antenna.) I will not overemphasize the importance of height. Instead I will point out that your antenna system — feed line, supports and the antenna itself — is the most exposed part of your real estate. Night and day, year in and year out, it is up there, being flexed, rained on, iced and contaminated with soot, maybe salt spray, gases and dust. Of course, there are physical and financial limits to construction, and to the strength of an antenna's supports and wire size, or an array's weight and wind-load limits. That, plus a few handy, easily affordable gadgets and adaptions, is what I wish to go into here.

Probably the most popular antennas in use are the half-wave dipole and its cousins, the inverted V and the sloper. All of these antennas require a center insulator. I have bought and used many types, from a completely sealed weather-tight assembly to a simple glass insulator. The simplest and best that I have used is made from an odd piece of Plexiglas, 3/16- or 1/4-inch (4- or 5-mm) thick, drilled as shown in Fig. 1. The rope and antenna wire holes should be smooth, but this is not necessary for the coax mounting holes. I have yet to have one fail. One has been holding up an 80-meter inverted V for eight years. A balun can be mounted on a larger piece, using epoxy to cement the balun network to the Plexiglas. Baluns, by the way, do not necessarily improve the operation of a dipole antenna. This type of insulator will also work well with open-wire feed line. It will hold a lot.

Wire

Have you tried to buy wire lately? After many years of changes and splicing, some of my wire looked more like solder than copper. That, and the failure of two guys on my "Four Bands on a Pole"[1] last March, sent me in search of some guying material. Four dollars today will buy you 50 feet of extremely fragile-looking stuff. On a long shot, I stopped at a wholesale electrical supply house. A meek request, plus mentioning that I was a ham, got me over 150 feet of electricians "pulling wire" for less than eight dollars. When installing it I did not strip it, but looped plastic and all through the insulators, stripping only enough to make the center connections.

Base for Verticals

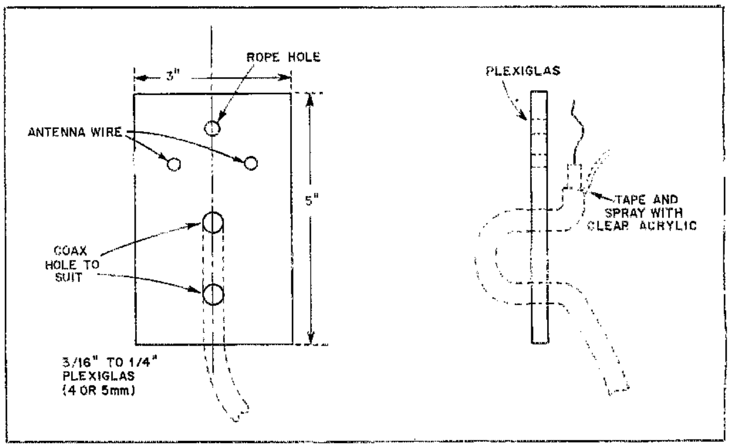
Putting something under a vertical or pipe mast to keep it from sinking into the ground or shifting has long been a problem for hams. A simple solution is to punch a hole in an old automobile hubcap, and drive an 18-inch (457-mm) piece of rod or pipe through it into the ground. Small hubcaps work best because they are easier to mow around. I went first class with a Cadillac hubcap, shown in the photograph. Radials can be fastened to the cap by drilling holes around the circumference and using short stove bolts to attach the wires. To insulate the base of a vertical, PVC pipe can be fastened to the base of the vertical and slipped over the ground mounting pipe.

Masts and Supports

Through the years I have used several methods to support my antennas,

[1]Ljongquist, "Four Bands on a Pole," *QST*, September, 1972.

Fig. 1 — An inexpensive, nearly indestructible center insulator for dipole antennas.



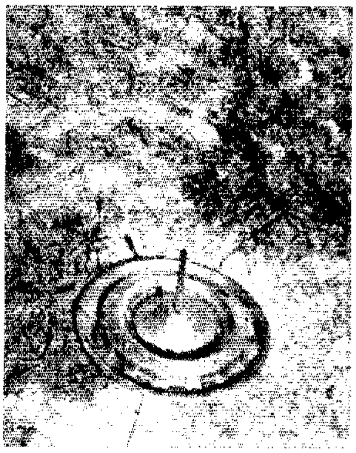
*1655 Meriden Rd., West Palm Beach, FL 33406

including the wooden masts described in past editions of *The Radio Amateur's Handbook*. Wooden masts work well, but require a few precautions to assure long life. Never surround wood with concrete. The wood will rot and you may not realize it until too late. It is better to mount upright angle or flat stock in the concrete and fasten the wooden mast to these supports with bolts.

Probably the most popular mast is the telescoping variety, commonly used as a television antenna support. Some amateurs use them to support a small beam and rotator but their performance in the presence of torque leaves much to be desired. A TV mast can be fastened to your house, but do not try to fasten the mast support to the cornice or siding with the lag screws furnished in the mounting kit. Try to find solid support in the framing of the house, and use a backing block of 2 × 4 or heavy plywood to pick up the solid fastening and bolt the mount to this.

Extend the mast after it is mounted. Have a helper hold the bottom section in place and, starting with the uppermost section, extend it section by section. It is possible to put up masts alone, but it is dangerous and takes far longer without help. Gloves and hard hats are a good safety precaution in any antenna work.

I have used nontelescoping TV mast for heights up to 50 feet but found that its flexibility and the maze of guy wires required can be a problem. After watching several sections of mast buckle, I had come to the conclusion that it is almost impossible to "walk up" a mast with antenna without disastrous results until the following technique was worked out. I use a section of iron pipe for the lowest two sections of the mast. Two guy wires are first anchored at the appropriate distance from the base (see Fig. 2) and the third guy wire is taped to the mast until it is needed. If you are using a second set of guy wires, tape them temporarily to the mast. It is more than annoying to find loops of guy wire dangling out of reach after the mast is vertical!



No, this is not the start of another strange encounter. It is a nifty way to keep a vertical antenna from sinking into soft soil and provides a junction point for ground radials.

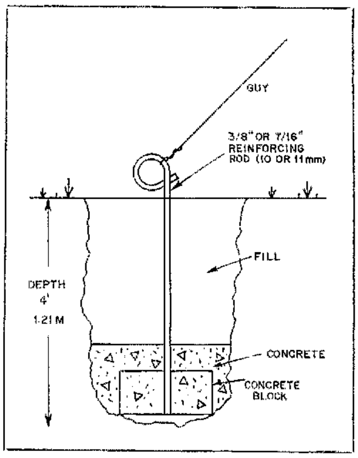


Fig. 2 — A method of making guy anchors from reinforcing rod obtained at a salvage yard. The concrete blocks can be obtained from the same source.

Trees

One thing can be said about trees; they are almost never where you want them. When my sons were younger, the problem of getting a pulley and line up into a stout tree was greatly simplified. They loved an excuse to climb. They did fine jobs wiring a pulley in place, and heaving the line with a suitable weight attached, out through the branches. They have since gone out on their own. Recently, I was raising a longwire antenna. I spotted a high, willowy locust tree the appropriate distance from the house. Through the help of the local ham underground, I located a very experienced "tree shooter." He appeared as arranged, with his bow, arrows and a long pole on the end of which was fixed a cone of grocers' twine. He tied the twine to an arrow. I held the pole as high as I could, and he shot the arrow through the topmost branches of the tree. I tied a length of plastic clothesline to the twine and pulled it up over the tree. The insulator and wire was attached to the plastic clothesline and pulled into place. The feed line was run into the shack, connected to a Transmatch, and some contacts were made. During the night a breeze sprung up, but seemingly nothing unusual. The next morning I turned on the rig and tried to tune up. Nothing doing; I looked out the window, and there was my new long wire on the ground! Going outside I found that the wire had parted. I hauled down the end attached to the tree, repaired it, and hauled it up again. Just then another gust of wind came along and down came my wire, again. I had never noticed how much a high, thin tree can toss about in the wind. So, sacrificing height for a stable anchorage, I finally ended up with a long wire not quite as high as the original, but one that worked almost as well.

Sheaves and Halyards

Never use "wire-reinforced" line, such as plastic-jacketed wire clothesline, as a halyard. Moisture enters the jacket and the result is hidden corrosion and weakness. A good substitute is plastic clothesline that has a core of stranded fiberglass. Braided nylon rope makes an excellent halyard though it does tend to stretch a bit. This can provide a shock-absorbing action though. Remember to leave enough slack line to allow complete lowering of the antenna.

Good, tight sheaves are hard to find. There is nothing more frustrating than to have a line run off a pulley and jam 50 feet in the air. Try to find a pulley that has the block close to the wheel so there will be less of a chance of the rope falling off and becoming jammed! QST

Strays

BOTHERED BY LATE *QSTS*?

☐ If you are moving or due for a renewal, you can help us get *QST* to you more quickly by letting us know your new address promptly and by renewing early. *QST* is mailed from our printer at Glasgow, KY, on or about the 20th of the month preceding the cover date. This can vary by one or two days depending on when the weekends fall. For example, the January, February, March and April issues were mailed on December 22, January 20, February 21 and March 21 respectively. Copies to persons whose renewals are received after the cutoff date printed on the first notice are mailed on the first available weekly mailing.

If you receive *QST* late every month, you may wish to file a complaint with the Postal Service. Ask for a Consumer Service Card (USPS form 4314). Just fill it out and drop it in the mailbox; Uncle Sam picks up the postage. — *W1GNC*

A Programmable Regulated Power Supply

Here is a supply to power those home construction projects. It will do your bidding and even take over when you goof.

By John Bipes,* KØYQX

Are you still using a string of batteries to power your homemade projects? Maybe the XYL is starting to object to the acid burns on the carpet from the Diehard that you bring in every evening to run your 2-meter fm rig. This versatile lab bench power supply provides many desirable features: programmable voltage and current limits; voltage adjustable to zero; voltage as a *linear* function of the control-knob rotation; positive overcurrent protection indicated by a pilot lamp, with resettability; rf immunity; and low ripple and noise output.

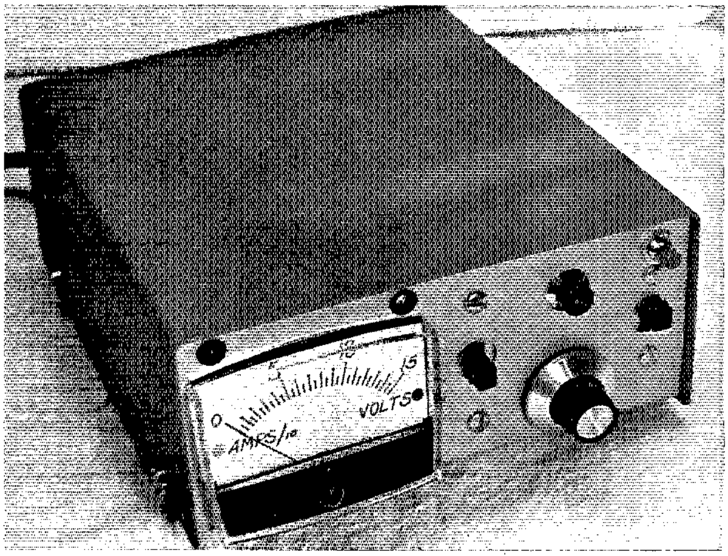
The output is adjustable from 0- to 15-V dc and is programmed with two internal resistors. It automatically shuts down after sensing a current overload of 1.5 amperes and displays a bright red overload indication until reset. In electronic service work this feature is especially handy as the supply does not continue to push the limiting value of current under faulty conditions. It simply notes the overload, then relaxes, awaiting your further instructions! The current threshold is programmable with one internal resistor.

The transformer, bridge rectifier, filter and three-terminal utility regulator portion of the instrument are taken from a CB power supply. Power for the adjustable regulator is taken prior to the fixed regulator. The fixed regulator is used only as a utility voltage source for powering the three indicator lamps in flicker-free fashion!

A large-wattage series pass transistor is the workhorse. It is controlled by two smaller devices which, in turn, are driven by a unique application[1] of a popular precision voltage regulator, the 723C integrated circuit. A silicon controlled rectifier is "tripped" to latch the adjustable regulator into the shutdown mode if too much current is drawn. A momentary switch can be depressed to reset the output to normal, or the ac switch may be switched off, then on again. Simply removing the excessive load from the supply will not cause reset. It is also fail-safe, as one cannot cause the power supply to exceed its current limit by any manipulation of controls.

Voltage and current metering is designed for economy. One meter is used and is switched using a dpdt slide switch. To reduce the possibility of "cockpit error" some "intelligence" lights are

The completed programmable power supply. Above the meter are the LED indicating current measurement (left) and voltage measurement (right). Dots of matching color are inked onto the meter face. The controls, from left to right, are the meter switch, voltage-adjust pot (large knob) and main power switch. The overload indicator is located above the voltage pot and the reset switch is above the main power switch.



*803 South Ave., North Mankato, MN 56001

[1]References appear on page 30.

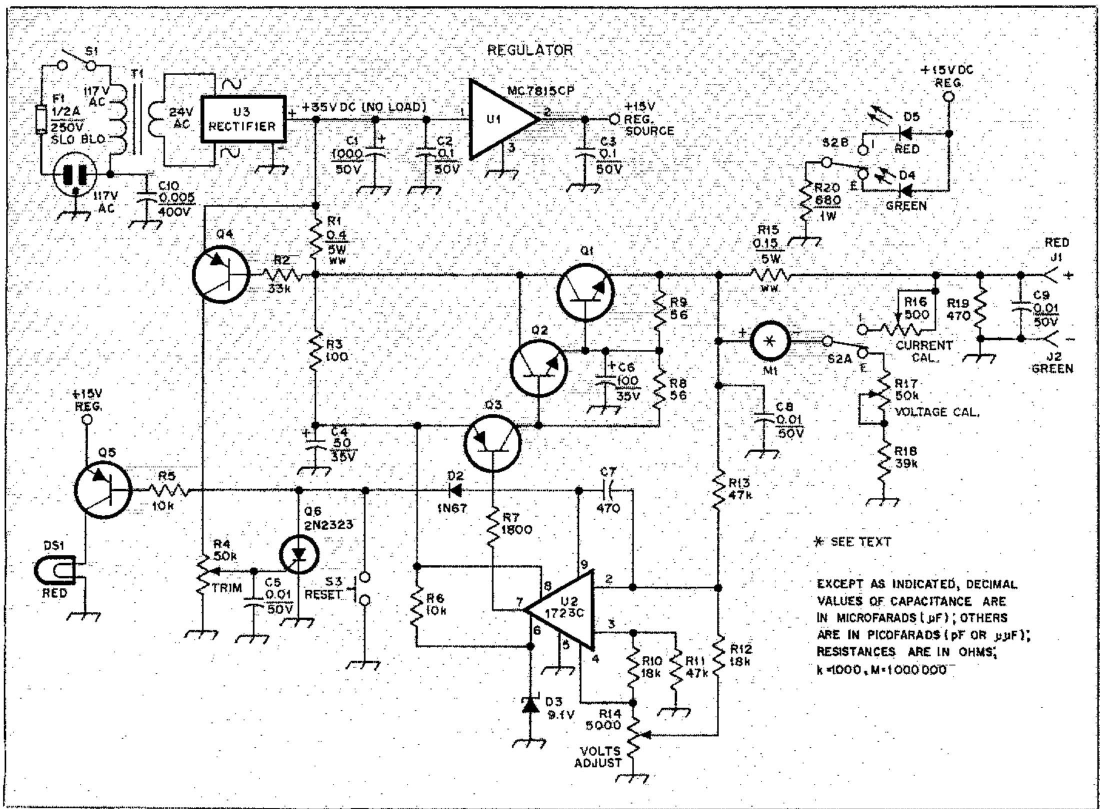


Fig. 1 — The regulated bench supply. Resistors are carbon-composition 1/2-watt types except as noted. R4 is adjusted by trial and error for best current-shutdown characteristics. No connection is made to pins not shown for U2.

D1 — Not used.
D2 — Small-signal germanium diode, 1N67 or equiv.
D3 — Silicon Zener diode, 9.1 (or 10) V, 1 W.
D4 — Green light-emitting diode, nominal 2-V, 20-mA variety.
D5 — Red light-emitting diode.
DS1 — Red incandescent lamp assembly, 14.5 V, 150 mA.
J1 — Red five-way binding post.
J2 — Green five-way binding post.
M1 — See text.
Q1 — Silicon npn power transistor, 2N3055.
Q2 — Silicon npn power transistor, 2N5296.
Q3, Q4, Q5 — Silicon pnp general-purpose transistor, 2N4126.
Q6 — Silicon controlled rectifier, 2N2323.
S3 — Spst momentary switch (normally open).
T1 — Power transformer; 117-V primary, 24-V, 2-A secondary.
U1 — Three-terminal 15-V, 1.5-A dc regulator, Motorola MC7815CP or equiv.
U2 — Voltage-regulator IC, Motorola MC1723CG or equiv.
U3 — Four-terminal bridge rectifier, 100 V, 2 A.

added, a green light-emitting diode for volts, and a red LED for amperes. Colored dots matching the respective ranges were inked onto the meter face.

Circuit Description

Operation of the heart of the adjustable regulator can best be understood by considering U2 first. Pin 4 of the 723C provides a precision, temperature-compensated reference voltage of 7.15 V. This terminal is the "WWV" of the entire instrument! The reference voltage is dropped across both the voltage-adjust potentiometer and the resistor string from pin 4 through pin 3 to ground. Therefore, the voltage selected by the setting of the potentiometer, and the voltage on pin 3, are constant. U2, being a differential amplifier, will try to keep the voltage on pin 2 the same as the reference voltage on pin 3. It follows that if potentiometer R14 is readjusted, the output voltage of the supply must move in the opposite direction to maintain this equality. Or if the load on the power supply attempts to "pull down," or "let up" the output voltage, the pass transistor will have to readjust its internal resistance to maintain equality. It follows also that if the potentiometer is set to the top (nearest pin 4), the output voltage of the supply will have to go to near zero. How close to zero depends on the leakage of the pass transistor, Q1. The minimum output voltage can be kept to an insignificant value of millivolts by using a good-quality transistor for Q1 and by the loading effect of R19 which shunts the leakage current to ground. Finally, if the slider is set to the bottom (nearest ground) the output voltage will rise to maximum. The maximum voltage may be described by the relation:

$$E_{max} = \frac{V_{ref} \times R11}{R10}$$

$$= \frac{(7.15)(47 \times 10^3)}{18 \times 10^3}$$

$$= 18.67 \text{ volts}$$

Note: Adjustment of the supply voltage slightly beyond the full-scale calibration of 15 volts is desirable.

If R10 is held constant, R11 may be said to be programmable, i.e., adjusted by the above formula for any desired output voltage. The limit would be a couple of volts below the input voltage. Note that R10 and R12 are always equal, as are R11 and R13. They are changed in pairs during programming.

The 723C operates by varying the effective resistance between pins 7 and 8. It raises the power supply output voltage by pulling down on the base of Q3 via R7. This action provides more base current for the quasi-Darlington connected pair, Q1 and Q2, and Q2 conducts more heavily. The reverse action follows in reverse order. U2 pin 8 provides operating input voltage for U2 via the RC filter, R3 and C4. Pin 7 receives regulated 9.1 volts from Zener diode, D3.

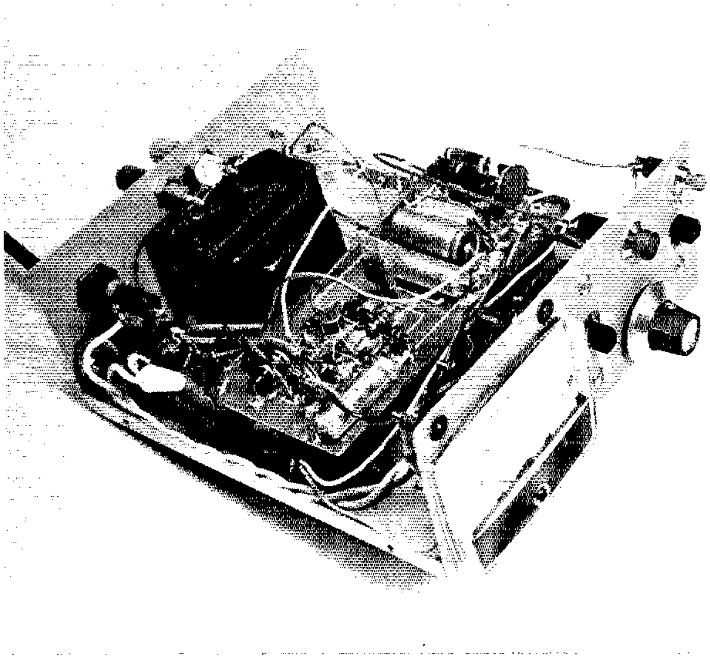
If the supplied current through J1/J2 is large enough to develop approximately 0.6 volt across R1, Q4 will conduct, raising the voltage on the gate of the SCR, Q6. The SCR then fires and its anode goes to ground potential. This action ties down pin 9 of U2, thereby prohibiting U2 pin 6, from providing any bias current for Q3, i.e., inhibiting the output of the power supply. Simultaneously, DS1 is lighted as Q6 drives Q5 into saturation, thereby applying the output of utility regulator U1 to the lamp. This is nominally 15V − $V_{CE\text{-}SAT}$, or about 14.5 volts. Incidentally, DS1 is an incandescent indicator as it is desirable to note its turn-on out of the corner of one's eye and it should therefore be quite bright. Reset occurs by either closing S3 or opening S1 momentarily; either operation eliminates the current through Q6. The threshold current is approximated by:

$$I_{max} = \frac{0.6\text{ V}}{R1} = \frac{0.6}{0.4} = 1.5\text{ amperes}$$

R1 may be selected by the above criteria to program the threshold to any value within the safe limits of the input circuitry, the pass transistor Q1, and heat sink.

If the output of the power supply should be externally pulled above the voltage for which it is set (during battery charging, for example) the emitter-base junction is merely reverse biased and the output voltage is allowed to float within reasonable limits. Although usually not destructive, this is not a good practice as some leakage current does flow. Component breakdown may occur if limits are exceeded, and U2 is "disappointed" with its lack of control.

The meter is a modified Radio Shack VU meter (internal rectifier removed and meter face changed). The ammeter shunt, R15, and the voltmeter multiplier, R16, were chosen for full-scale indications at 1.5 amperes and 15 volts respectively. A potentiometer was used for R16 to allow voltage calibration. The revised meter face was drawn with a fine-point pen on a piece of glossy cardboard salvaged from an end of the box in which the aluminum case was packaged! The plastic meter window was snapped off, the original face was removed (by removing two tiny screws) and it was used as a pattern for dimensions of the new face.



Interior view of the supply. Note the simple type of circuit-board construction and the use of bypassing directly at the output terminals (rear panel).

It is possible to construct a supply with other features, such as higher current capability. This is easily accomplished by the addition of paralleled and current-equalized pass devices. Additional steps of current-limit threshold may be added by switching in different values of current-sense resistance at R1 or R1 may be made infinitely adjustable through the use of a potentiometer. The supply shown is one of two units built to identical specifications. Three others, each of different capability, were built prior to these two. The first has a 5-ampere rating at 25 volts; the second was designed for commercial-service use with individual voltage and current metering and with a rating of 30 volts and 10 amperes. It has been in service for two years in a commercial two-way radio service shop. The third was designed with four pass transistors and driven by a ferroresonant computer power supply for maximum ratings of 15 volts and 15 amperes. It is excellent for powering older tube-type mobile radio equipment and does an excellent job of powering my new Ten-Tec Triton IV from the ac line.

If constructed with terminal bypassing and thorough shielding, good rf immunity can be obtained. Also, ripple and noise output has been measured by the author at approximately −70 dB during normal operation. Virtually all of the components for the supply were available through hobbyist retail stores such as Radio Shack. Although this unit was constructed of junk-box items, the parts if purchased new at Radio Shack would cost less than $60.

References

Miles, "Regulated Power Supply Is Adjustable from 0-38 VDC," *Electronics*, February 20, 1975, p. 93.
The Linear Integrated Circuits Data Catalog, Fairchild Semiconductor Corp., 1973, pp. 5-7.
The Radio Amateur's Handbook, ARRL, any recent edition.
Voltage Regulator Handbook, National Semiconductor Corp., 1975.

Strays

CANAD-X AWARDS

☐ For various combinations of contacts, the Canadian DX Association sponsors three different awards. Each requires a fee of $1 or 10 IRCs, and a list showing the date, time and specific location of each station worked. The list must be certified by a radio club official or two other licensed ratio amateurs. QSLs need not be sent, but should be available for inspection. Address the application to CANAD-X, c/o A. R. Leith, VE1AL/3, 11-311 Bunting Rd., St. Catharines, ON L2M 3Y4. The awards are the Trans-Canada Award, Seaway Award and Provincial Capitals Award.

Hints and Kinks

SQUEEZE-PADDLE OPERATION FOR THE HD-10

For just under $7, I have converted my Heath HD-10 keyer to squeeze-paddle operation similar to that of the HD-1410 keyer. I should point out that this modification produces only squeeze-paddle operation without straight-key functions produced from paddles treated as one.

Only four wires need to be disconnected and most of the work is mechanical. The procedure is to remove the cabinet bottom from the HD-10, extract the key-lever assembly, switch brackets, and to unsolder the four send and receive wires on the switches. Extend the four aluminum supporting posts from the circuit board 1-1/8 to 1-3/8 inches (29 to 35 mm) by adding two extra 6-32 nuts and two 6-32 × 1/2 inch machine screws at each post. Mask the front of the HD-10 keyer with masking tape. Lay out the area with a ball-point pen or a fine-line marker.

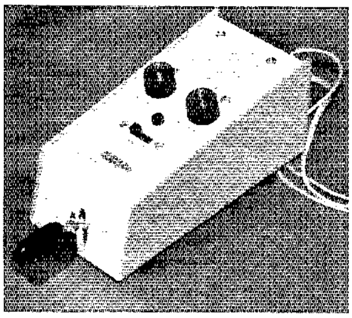
To prevent steel filings from settling on the boards, I placed the board in a box and taped it shut. Next, one should scribe a center line on the bottom of the HD-10 case. Lay a paddle mounting bracket on the scribed center line in such a manner that the line can be seen through all three drilled holes. This bracket should be in the center and parallel to the sides, but placed 1/32 to 1/16 inch (0.8 to 1.6 mm) from the front edge of the unit. Before drilling the case, refer to the HD-1410 manual for information about assembling the paddle levers and contacts. Make sure the three contact terminals are bent away from the foil. Check for clearance. With reference to the drawings, note that the white and black wires of the key assembly are connected to ground. A new ground lug should be installed near the front of the case at a hole originally used to hold the old bracket. For right-hand operation connect the green wire to S-1038 and the red wire to S-1048.

I hope anyone who tries this modification will be as pleased as I am. — *Dale R. Errington, WB8JKH*

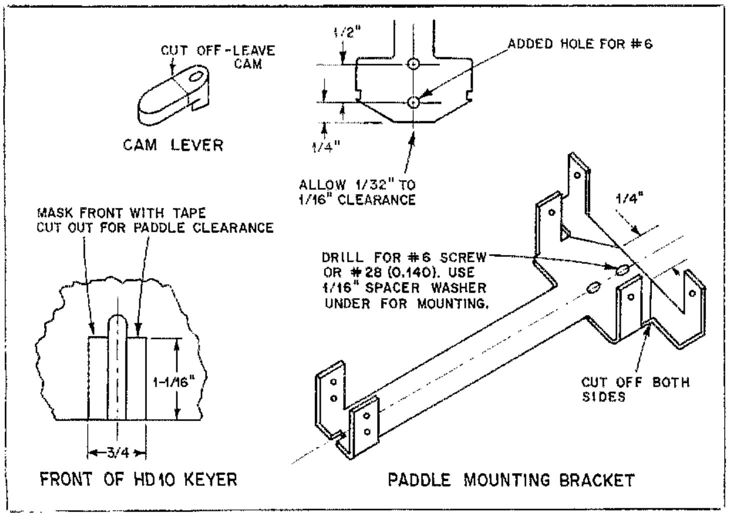
The following Heath items are needed to perform the WB8JKH modification of the HD-10 keyer for squeeze-paddle operation.

1 — HD-1410 assembly manual.
1 — 6-32 press nut, no. 252-109.
2 — 6-32 thumbnuts, no. 252-23.
4 — Rivets, no 256-15.
3 — Solder lugs, no. 259-9.
1 — Spring wire, no. 258-179.
2 — Paddle levers, no. 266-843.
1 — Paddle mounting bracket, no. 204-2019.
2 — Flat springs, no. 258-189.
1 — Cam lever, no. 266-844.
4 — Contact plates, no 469-21.
2 — Paddle knobs, no. 462-931.
1 — 1/2-inch spacer, no. 255-15.
1 — 1/16-inch spacer, no 255-74.
2 — 6-32 × 1-9/16-inch studs, no. 250-472.
4 — No. 6 shoulder washers, no. 253-2.
Other hardware:
2 — 4-40 × 5/16-inch machine screws.
10 — 4-40 × 1/4-inch machine screws.
4 — 6-32 × 1/2-inch machine screws.
10 — 6-32 nuts.
12 — 4-40 nuts.
12 — 4-40 nuts.
12 — 1/16-inch spacer washers.
2 — 6-32 × 3/4-inch machine screws.

The Heath HD-10 keyer modified for squeeze-paddle operation.



Mechanical information for converting HD-10 keyer to squeeze-paddle operation using HD-1410 parts. White and black wires are to be grounded. Inches × 25.4 = mm.

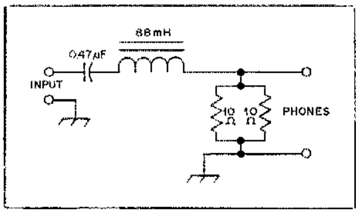


MODIFIED VERSION OF FRANK NOBLE'S FILTER

That cw filter designed by Frank Noble and described in November 1977 *QST* is a gem! Surely, many of the fellows I work can use it.

My version of the filter resulted from a lack of 0.5-µF, high-grade capacitors. I connected the inductor windings in series, providing a total inductance of 88 µH. The capacitors are Radio Shack noninductive units, part no. 272-1071. Although two no. 272-1070 (0.22-µF) capacitors can be employed, switching one out of the circuit to vary the tone, I find the 0.47-µF capacitor provides a more pleasant result.

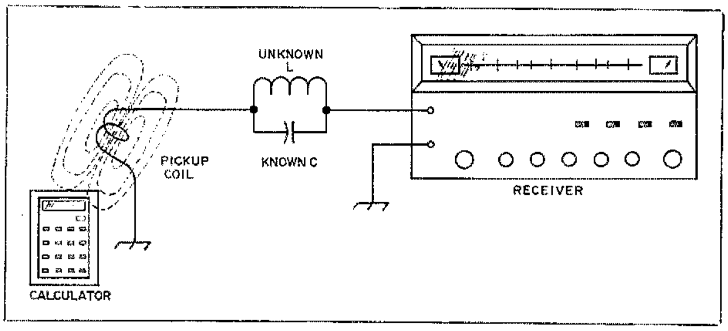
A 1-5/8 × 2-1/8 × 2-3/4 inch (41 × 54 × 70-mm) aluminum box, with a phono jack at each end, houses the components. Even though my SB-303 has a cw filter, the addition of the Noble-style circuit solves a lot of QRM problems! — *George Shuart, W4AMN*



This circuit, a modification of Frank Noble's audio filter, shows the method W4AMN compensates for a lack of high-grade, 0.5-µF capacitors.

THUMB INDEX FOR *CALLBOOK*

A thumb index for your *callbook* can be made by holding the pages of each call area together and feeding them slowly into a grinding wheel. Grind about 1/4 inch (6 mm) deep. — *Reggie Brown, WA4YKJ*



Rf noise generated by a calculator LED readout circuit may be used in this manner for determining unknown L or C values.

LONG-WAVE CONVERTER

The simple long-wave converter I have built provides surprisingly good results. At Hilton Head Island, SC, I receive bc signals on 164, 180 and 185 kHz plus the San Francisco SFI on 192 kHz. The converter tunes down to 10 kHz.

A random-length wire or vertical antenna will furnish adequate signal pickup. I do not recommend a loop antenna.

As the diagram indicates, the output of the converter is in the range of 7.0 to 7.5 MHz. This is fed to the input of my Tempo One receiver. The oscillator is an International Crystal OX-1 set for 7 MHz. I find that almost any diode type may be employed in the circuit as a substitute for the 1N34. In order to avoid stray rf pickup, the diode cathode should have a short lead connected to the output jack.

For the inductors, I suggest using Miller part nos. 9002, 9004 and 9006. A standard 2.5-mH inductor will provide resonance for a random length wire in the vicinity of 180 kHz. Some experimentation with capacitance and resistance values should result in peak performance. — *David Curry*

COLLINS OSCILLATOR DROPOUT

Because of hf-oscillator dropout in my Collins 75A-4 when operating on the 10-meter band, I presented the problem to the engineers at Collins Radio and also to Bob Cerrick of Telcom. They recommended that the following checks be made. The second of these mainly resolved the erratic situation in my receiver, for the B+ voltage was low. A lower value resistor, substituted for R21, restored the correct voltage to pin 6 of V4.

1) Check first-mixer tube V3 (6BA7) and crystal-oscillator tube V4 (12AT7).

2) Measure the B+ voltage at pin 6 of V4 (12AT7). It should be +175 V.

3) Test cathode bias resistors R17 and R18, which should be fairly well matched.

4) Locate the 12AT7 ground connection where R17, R18, R20 and the filament mate. Remove the ground lug and install a good-quality no. 4 internal- or external-tooth lockwasher between the chassis and ground lug. Zinc-plated types are best for this purpose, but other types will work as well. Carefully clean parts, assemble and tighten.

5) Find the ground connections for the 6BA7, R13, R14, C35, C36, R16 and filament ground. Repeat the lockwasher installations as with the 12AT7.

6) If oscillator alignment is necessary, follow the instructions in the Collins manual (page 5-3, item no. 9). — *Charles Preston, K4LJH*

CALCULATOR NOISE HELPS FIND LC VALUES

The value of an unknown microhenry inductor, including toroids, or of a picofarad-range capacitor can be found accurately using th broad spectrum of rf noise generated by the in terrupted LED readout of a pocket calculator As indicated by the drawing on this page, th noise is fed to the antenna input of an a-n radio through a parallel LC filter containin one known element. The receiver is tuned fo minimum noise with the calculator loosel coupled to a one- or two-turn pickup loop. Th audio gain is set high.

Alternatively, the needle of an S meter on th receiver can be observed, or the agc voltag level can be monitored to find the frequenc blocked by the LC filter resonance. The Q fac tor may be estimated from the sharpness of th null. There is no problem from broadcas transmitter interference at poor bc receptior locations such as inside steel-framed buildings — *James F. Wilkins*

[Editor's Note: Information in the above article wa presented in *Electronic Engineering* for mid-October 1977 and permission for publication in *QST* has beer granted by Morgan-Grampian Ltd. (publishers) o London. Full rights are reserved.]

The following formula may be used to determine unknown L and C values.

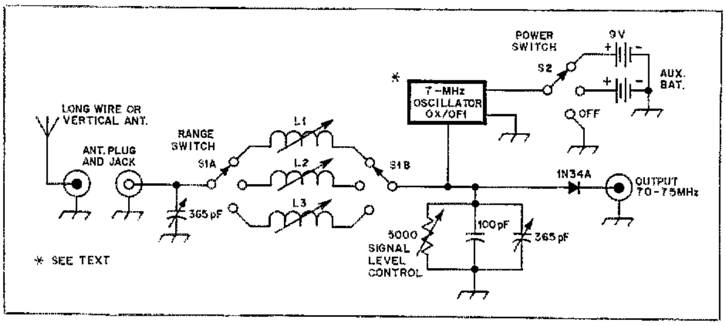
$$f_{MHz} = \frac{1000}{2\pi\sqrt{LC}} \quad \text{(Eq. 1}$$

where: f_{MHz} = MHz
L = µH
C = pF

Thus:

$$\text{Unknown L or C} = \frac{\left(\frac{1000}{2\pi f_{MHz}}\right)^2}{\text{known L or C}} \quad \text{(Eq. 2}$$

An easily built long-wave converter. The local oscillator is an International Crystal Manufacturing Company OX-LO or OF-1-LO. L1, L2 and L3, respectively, are J. W. Miller adjustable wide-range inductors nos. 9002 (0.180 to 0.800 mH), 9004 (2.10 to 8.00 mH) and 9006 (12.0 to 40.0 mH). A 2-pole, 3-position rotary switch is used for S1. S2 is a general-purpose, single-pole, three-position switch. The 7.0- to 7.5-MHz output of the converter is fed through coaxial cable to a shortwave receiver.



MORE FIRST AID FOR THE TA-33

I refer to repairing a TA-33 antenna, as suggested by Steve Jackson, WA3OHF/6, "Hint and Kinks" for November, 1977. I recommend, when a beam is down for repairs, that all traps and joints be cleaned thoroughly. Moisture, dirt, spiderwebs and other debris can collect in trap containers, leading to the possibility of serious coil damage. Cleaning the joints with a file or steel wool is part of the work. To properly finish the job the joints should be treated with Penetrox (made by Mosley) or an equivalent anti-corrosion solution. Lubrication, offered by the solution, not only frees the joints for easier element adjustment but also electrical contact is properly maintained. An alternative is to use an electrical contact paste such as that used by electricians. — *Charles M. Guschke, N5SW*

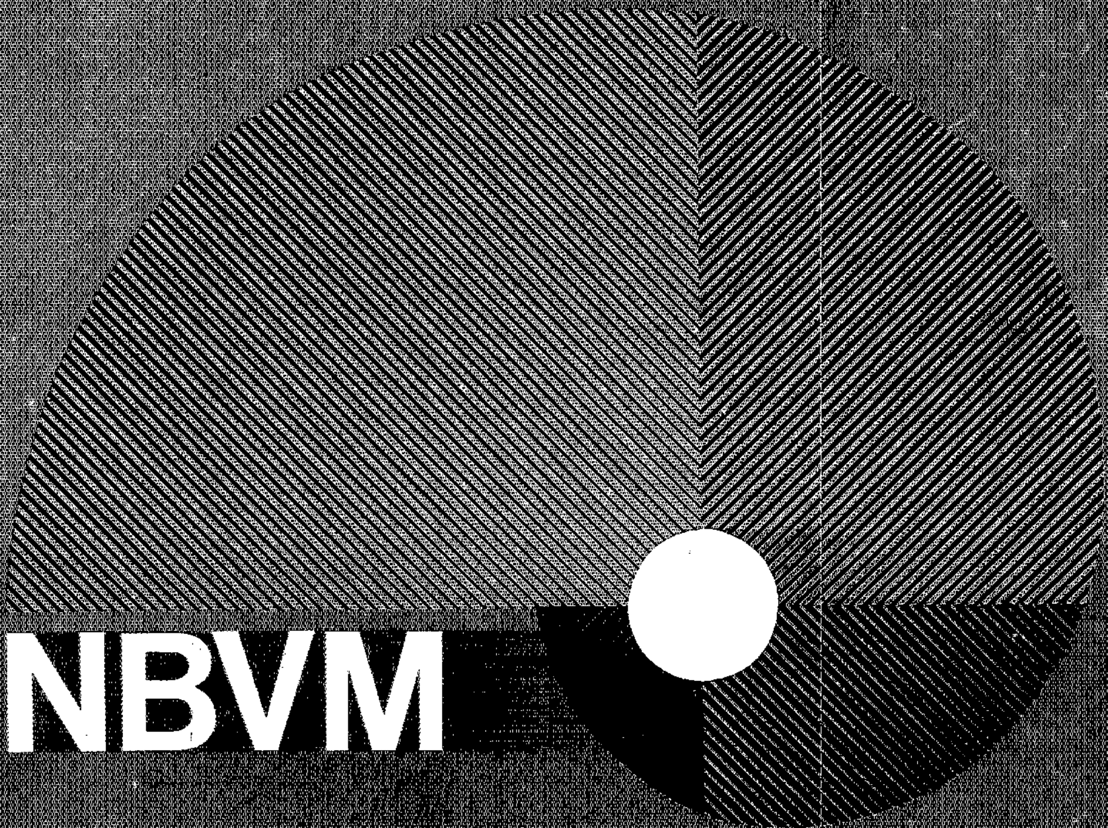
KINK

To strengthen the sidetone in the Swan 500CX or 700CX, insert a 0.01-µF to 0.05-µF capacitor in series with the 0.01-µF capacitor wired to pin no. 2 of V12, the 6GK6 audio amplifier. Increase the delay time for cw in the VX2 unit by changing the capacitor between the collector of Q3 and ground from 30 µF to 100 µF. — *Dr. Charles Schwartzbard, WB2IWH*

QST

devoted entirely to Amateur Radio

September 1978 $2.00



NBVM

Narrow Band Voice Modulation

Spiraling technology provides more QSOs per Megahertz. That means better communications for you. Get in on the historic tests of this amazing breakthrough.

Page 9

QST

September 1978
Volume LXII Number 9

QST (USPS 451-340) is published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

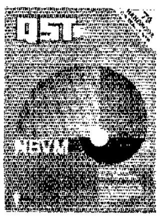
Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

Narrow-band voice modulation promises to be Amateur Radio's next contribution to the advancement of the radio art. See page 9.



Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

An Inexpensive Capacitance Meter

Basic Amateur Radio: Build this inexpensive capacitance meter using easily obtainable parts. It'll make a nice addition to your basic test equipment.

By Douglas A. Blakeslee,* N1RM

A beginner's first investment in test equipment is usually a volt-ohmmeter. Nicknamed the VOM, even a simple volt-ohmmeter measures voltage and current — both ac and dc — plus resistance. A VOM will take care of many routine maintenance tasks around the ham shack. Plus, it is an invaluable aid when building an electronic project.

Unfortunately, VOMs do not measure capacitance. The variability of capacitors (often called "caps") is notorious, some may be as much as plus or minus 200 percent from the marked value. Others, especially those sold by surplus houses and those found in old TV chassis and on computer boards, are not marked with a value at all. Thus, it is most useful to be able to measure capacitance. In this article we'll review the various types of capacitors and will describe a simple capacitance measurement unit. The circuit can be built as a stand-alone instrument or as an add-on for a VOM.

*4 Maple Lane, Brookfield, CT 06804

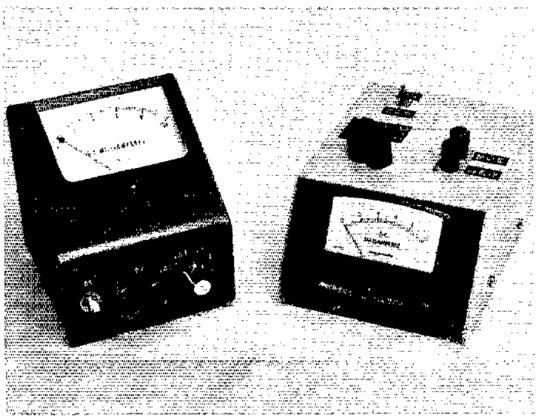
Capacitor Basics

Before we set about measuring a capacitor, let's review the basics of the device. A simple capacitor can be made from two metal plates separated by a small air gap. Connecting a battery to the two plates will cause a current to flow momentarily until the capacitor has charged to the potential of the battery. If the battery is removed, the capacitor will retain the charge, demonstrating an important property of capacitors — the ability to store energy. While the capacitor was being charged, current flowed, showing a second important property, the ability to block direct current while passing varying or alternating current.

Our capacitor uses air as an insulator between the two plates; the insulating medium is called the *dielectric*. Mica, paper, glass and ceramic are popular dielectric materials. The dielectric used will determine the voltage at which a given capacitor will break down. Capacitors should always be operated below their rated breakdown voltages.

If our two metal plates were one inch (25.4 mm) square and spaced 0.004 inch (0.1016 mm) apart, the capacitance value would be 56 pF. The *farad* (F) is the standard measure of capacitance, the ability of a capacitor to hold a charge. A one-farad capacitor would be large indeed. Practical capacitor values are measured in microfarads (μF), one millionth of a

Two versions of the capacitance meter are shown together here. At left is the author's prototype built using junk-box components in a commercial cabinet, and at right is another version built in the ARRL lab using Radio Shack parts exclusively in a home-built cabinet.



Mechanical layout of board, battery, meter and switch is shown in this photograph. In both units, the parts were mounted in such a way as to allow easy access to board for troubleshooting and IC replacement.

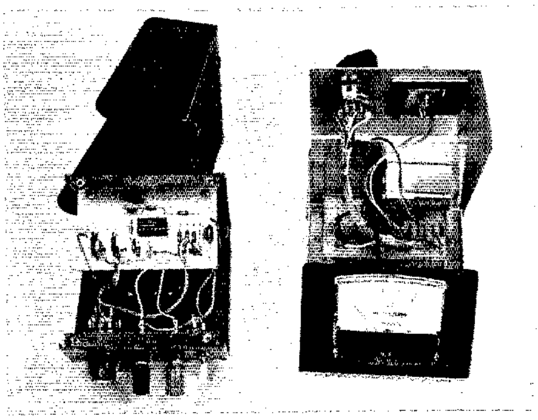


Table 1
Typical Capacitor Characteristics and Applications

Characteristic	*Aluminum Electrolytic*	*Tantalum*	*Mica*	*Ceramic*	*Paper*	*Air*	*Polycarbonate*	*Polystyrene*	*Polyester*
Max. frequency (Hz)	10^3	10^3	10^9	10^9	10^5	10^9	10^9	10^9	10^9
Max. capacitance (μF)	10,000,000	1500	0.01	1	100	5,000	10	10	1
Max. working voltage	500	300	800	10,000	5,000	10,000	500	1000	700
Size for given capacitance	very small	very small	small	small	large	large	small	large	small
Stability	poor	good	excellent	fair	fair	excellent	good	excellent	good
Application									
Blocking dc	no	sometimes	yes	yes	yes	yes	yes	yes	yes
Bypass	yes	yes	no	yes	yes	no	yes	yes	yes
Filter	yes	yes	yes	yes	yes	no	yes	yes	yes
Coupling	no	sometimes	yes	yes	yes	yes	yes	yes	yes
Frequency/timing	no	no	yes	no	no	yes	yes	yes	yes

farad, and in picofarads (pF), one million-millionth of a farad. Typical capacitance values used in radio equipment range from 1 pF to 10,000 μF.

Capacitor Types

Capacitors are denoted by their insulation or dielectric material, i.e., air, ceramic, paper and so on. Thus, a capacitor employing ceramic insulation is usually called simply a "ceramic." Each type of capacitor construction has advantages and disadvantages. A short discussion follows.

Air capacitors are usually made variable where one set of plates, the *stator*, is fixed and one set is variable, the *rotator* or *rotor*. Air is an excellent insulator, so air capacitors feature high working voltages and low leakage, plus the ability to handle high levels of radio-frequency (rf) current. Because they are variable, air-insulated capacitors are widely used in variable-frequency oscillators (VFO), transmitter output stages, and antenna-matching networks. For even higher voltage ratings, the capacitor plates can be placed in a vacuum. Such capacitors are often used in high-power transmitters, and they are commonly called "vacuum variables."

Ceramic capacitors are very popular for *bypass* (shunting rf energy to ground) and interstage coupling applications where the power level is low. The temperature stability of ceramic capacitors is usually poor so they are not used in precision tuned circuits. Ceramics are inexpensive and useable over a wide frequency range. Thus, they can be found in most ham gear.

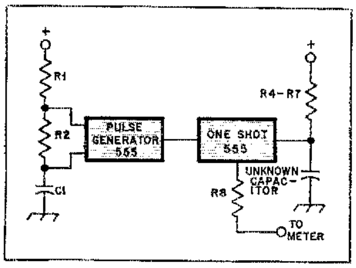
Mica capacitors overcome many of the shortcomings of ceramic capacitors in rf circuits. The mineral mica provides insulation, often with silver applied using a metalization technique. Mica capacitors are very reliable and stable. They can handle moderate rf power without excessive heating. Micas are widely used in VFO and transmitter circuits.

Paper capacitors use very thin, special paper impregnated with wax, an oil or, until recently, polychlorinated biphenyls (PCB). (Environmental problems have limited or eliminated PCB recently.) Paper capacitors tend to be rather large, so newer types have been developed where metal is deposited on the paper insulator. Metal foil is still used as the conductor in high-current and high-voltage types. Paper capacitors are generally used in audio and power circuits.

Aluminum electrolytic capacitors are widely employed as power supply filters and in bypass applications in low-frequency circuits. They feature very high capacitance for a given size. A very thin film of oxidation on the aluminum conductor provides insulation. Electrolytics must have dc voltage applied in only one direction; they have specified polarities which must be observed. The dc voltage aids in keeping the insulating layer active. Without voltage, the oxide film deteriorates, so the capacitors cannot be left unused for long periods. Electrolytic capacitors can vary widely from marked values and can be highly sensitive to temperature change. A special family of electrolytics which features better shelf life, better stability and higher capacitance is the *computer grade*. They are more expensive than standard aluminum electrolytics, but the wise shopper can find many available from surplus dealers.

Solid tantalum capacitors pack even more capacitance for a given size than aluminum electrolytics. They consist of sintered tantalum particles packed around a tantalum anode housed in a carbon case. Tantalums are available as either polarized or nonpolar units. The polarized types have dropped in price until they have become very popular in transistor circuits for audio and low-frequency radio applications.

Fig. 1 — Block diagram of the capacitance meter.



Plastic-film capacitors are the newest family. They employ polystyrene, polyester, Mylar, polypropylene or polycarbonate for insulation, and high stability is achieved. They are nonpolar and excellent for rf applications. The polycarbonate and polystyrene types are becoming popular in frequency-determining circuits.

In addition to the items listed above, the insulation material and construction technique used for a capacitor also effects the maximum voltage that can be applied. Table 1 summarizes typical characteristics of popular capacitor types and reviews typical applications.

All capacitors exhibit a resistance to the passage of ac current called reactance — *capacitive* reactance. As the value of capacitance is made smaller, reactance goes up for a given frequency, according to the relationship given in the appendix. The subject of reactance and performance of capacitors in ac circuits is complex and beyond the scope of our discussion. But remember, it exists!

Capacitors, as with all electronic components, are a combination of elements. In addition to capacitance, given units will show inductance, resistance and reactance. The resistance is usually small and can be ignored. In high-frequency applications the connecting leads have sufficient inductance to form a tuned circuit. This is why articles about building transmitter and receiver circuits invariably caution that capacitor leads should be kept short. Wise designers have long used the inductance of the capacitor lead to form a tuned circuit for low-impedance bypass applications. Above its resonant frequency the capacitor will appear inductive and will be unsuitable for most applications, so keep those leads short.

About the Circuit

A block diagram of the capacitance meter is shown in Fig. 1. Two 555-IC-type circuits are used; I employed a 556, which is two 555s in a single package. The inner workings of the 555 have been described in *QST*,[1] so we won't repeat them here.

[1]Footnotes appear on page 14.

One timer, U1A of Fig. 2, is connected as an oscillator that serves as a trigger for U1B. The ratio of R1 and R2 determines the length of the pulse generated during each oscillation cycle. We have chosen values for R1 and R2 such that the output pulse is of very short duration. R1, R2 and C1 set the frequency of oscillation, which is approximately 500 Hz. Thus, U1B receives a short pulse 500 times per second.

U1B, although it also uses the basic 555 IC, performs an entirely different function. It is connected as a *one shot*, a circuit that produces an output pulse of predetermined length (duration) for each start pulse, regardless of the start pulse length. In our circuit the pulse duration is set by a resistor connected from the positive supply to pins 12 and 13, and an external capacitor. The resistor is a fixed value and the capacitor values can vary over a 10:1 range. A smaller value capacitor will produce a short output pulse from the one shot while a larger value will produce a longer pulse. The pulse output is repeated each time a start pulse is received.

The longer a pulse, the more average power it contains. Or the longer the pulse, the higher the voltage will be as indicated on a dc voltmeter. The meter is much too slow to respond to pulse variations, so it shows the average value produced by repetitive pulses. If appropriate circuit values are chosen, the meter can be made to indicate capacitance values directly.

Our circuit uses a 1-milliampere full-scale meter (or VOM scale) with a large resistance in series, which forms a voltmeter. Capacitance ranges are obtained by switching in resistors. As long as the resistance/capacitance ratio remains the same, the pulse generated by the one shot is the same. Thus by switching resistors, which are decade values, we can read capacitance values over a wide range using a single meter scale. Ranges of 1000 pF, 0.01 μF, 0.1 μF, and 1 μF, full scale, are provided. Separate calibration resistors are provided for the low scale and the higher three scales, R9 and R10, respectively.

This circuit arrangement is by no means original. It has appeared in applications literature by Signetics — the originator of the 555 — and, for both frequency and capacitance measurement, in the *Electronics Casebook*. A somewhat more complicated circuit appeared in *ham radio* several years ago.[2]

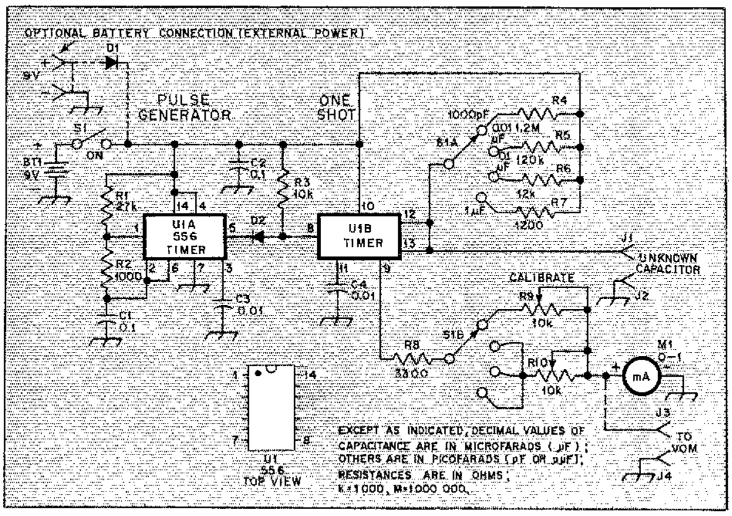


Fig. 2 — Schematic diagram of the capacitance meter. Alternative connections are shown with dotted lines. All part numbers in parentheses below are Radio Shack.

BT1 — 9 volt, transistor radio type (23-464).
C1-C4 — Ceramic capacitors (272-120 series).
D1 — Silicon power-type diode, 50 PIV or more (276-1101).
D2 — Switching-type diode, 1N914 or equiv. (276-1122).
J1-J4, incl. — 5-way binding post (274-661 or 274-662).
M1 — 0- to 1-mA meter (22-052).
R1-R8, incl. — Carbon resistors, 1/4 or 1/2 watt (271-1300 or 271-000 series).
R9, R10 — 10-kΩ potentiometers, linear taper, pc mount (271-218).
S1 — 2-pole, 4 or more position rotary switch (275-1386).
U1 — NE556 timer IC (276-1728).

Construction and Calibration

The circuit for the capacitance meter is constructed on a small etched circuit board. You can make your own board from the pattern published in this issue. Fig. 3 shows the parts placement. Before mounting parts, assure that the foil side of the board is clean and shiny. If not, rub the foil pattern with fine steel wool. Mount the parts a few at a time, following the layout, bending leads slightly to hold them in place. Although not absolutely necessary, it is a good practice to use a socket for U1 (and for most semiconductor devices where lead length is not critical). The socket greatly simplifies troubleshooting and replacement of a defective IC.

Solder the leads using a 20- to 50-watt iron and a small amount of rosin-core solder. Hold the iron in place until the solder melts and runs freely. Inspect each solder joint after it is made. It should be shiny and smooth. Lumped, matted or dull joints are an indication of trouble. Reheat bad joints and apply a small additional dab of solder, if necessary, to make a proper connection. Do not overheat, because prolonged heat can lift the foil from the board. When all components have been installed on the board, check to assure that all parts are in the correct places and those with polarity are oriented properly.

Next, prepare the cabinet. I used a Bud sloping-front enclosure and a Simpson meter from my "junkbox." If you are purchasing the parts, a Radio Shack cabinet (270-232) and "Shack" meter (22-052) are less costly. A Minibox-type enclosure will do if you are going to use your VOM as an indicator. Drill the appropriate holes.

Making a hole for the meter is a chore. A Greenlee chassis punch of the appropriate size is the best answer, although the large punches are far too expensive to be used just once or twice. Another technique is to scribe a circle slightly smaller than the desired meter hole. Then, mark a dotted pattern around the circle with a center or prick punch such that the outer circumference of holes after drilling will almost touch. Then drill the holes and knock out the center. Remove the burrs around the hole with a half-round file. The result might not please a purist, but it is more than adequate to mount a meter. Now spray paint the cabinet in your favorite color.

Next, mount the board in the cabinet and make all required interconnections. Mount the knob on the range selector switch, and mark the controls using Dymo or press-on labels. Install the battery, or connect the unit to an external 9-volt power source. A protection diode is provided to prevent accidental polarity reversal from damaging the meter components.

Calibration requires two capacitors, 0.001 and 0.01 μF. Ideally, they should be one-percent micas. Use the most accurate capacitors you can obtain. If no precision capacitors are available, try a batch marked with the same value and use the value that represents an average for the group. Place a 0.001-μF capacitor in the

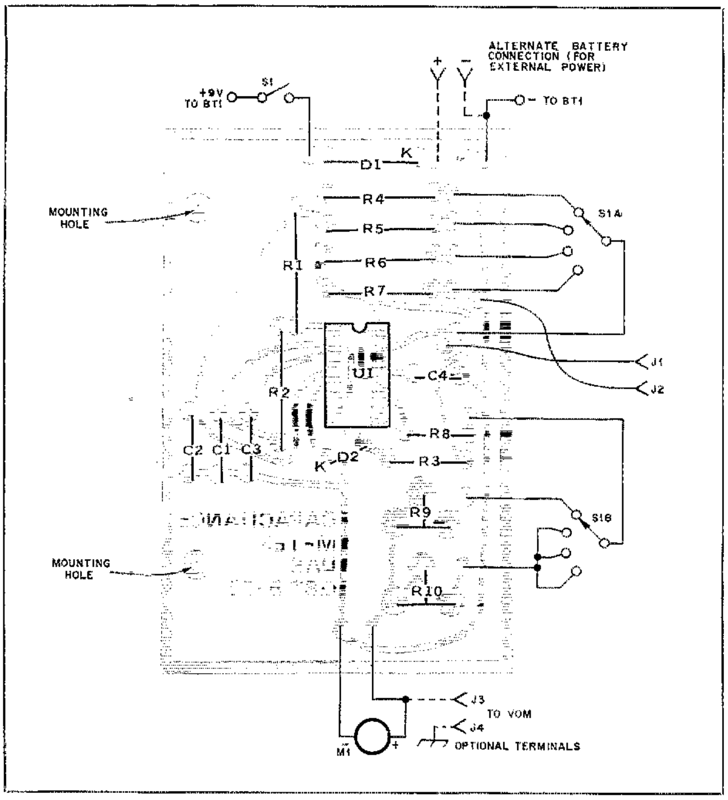


Fig. 3 — Parts placement guide for the capacitance meter. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (The etching pattern appears in the "Hints and Kinks" section of this issue.) K indicates the cathode of a diode.

test jacks, set S1 for the 0.001-μF scale, and adjust R9 until the meter indicates 1 mA. Use the 0.01-μF capacitor, select the 0.01-μF scale, and adjust R10 for 1 mA. Save the capacitors to check calibration from time to time. Note that the meter will not go to zero on the lowest range; this is so because the unit is reading stray circuit capacitance and the 556 input capacitance.

Using the Instrument

The cap meter applies a maximum of 6 volts to the capacitor under test. Therefore, any capacitor with a voltage rating of 6 volts or more can be checked. If the capacitor is polarized, assure that its negative lead is attached to the grounded terminal. This is easy to follow if you use color-coded terminals, red for positive and black for negative or ground.

The meter generally cannot be used to check the value of a capacitor soldered in a circuit. In most cases, if the power to the circuit is off, you can unsolder one lead of the capacitor under test. Connect both capacitor leads via short wires to the jacks on the cap meter. The connecting leads will introduce some error, but if the lengths are kept short reasonably good measurements can be made.

Of course you won't get laboratory accuracy with this inexpensive meter, but at least you will be able to sort out those "hamfest specials" you've been collecting. In most cases, the cap meter should read within ±10 percent of the actual value.

Appendix

The ac current through a capacitor is proportional to the voltage, capacitance and frequency. The net effect is called *reactance*, which is given by the formula:

$$X_c = \frac{1}{2 \pi f C} \qquad \text{(Eq. 1)}$$

where Xc = reactance in ohms
f = frequency in hertz
C = capacitance in farads
π = 3.1416

Footnotes

[1]"Time — IC Controlled," Technical Topics, *QST*, June, 1972, p. 36.
[2]Hall, "Direct-Reading Capacitance Meter," *ham radio*, Apr., 1975.

Strays

SELF-POLICING OF OSCAR FREQUENCIES

☐ With the advent of new OSCAR enthusiasm, an old problem has reappeared: use of the satellite during its scheduled off day, UTC Wednesday. It has been necessary to set aside a day specifically for recharge of the spacecraft battery, especially during the times of minimum sunlight. New operators are appearing daily on the satellite, and many do not know about Wednesday's operating schedule.

If the more experienced operator should advise you that Wednesdays are reserved for recharge or for special experiments, please adhere to the advice. It is very important to the life expectancy of the spacecraft battery.

Please be polite and use your call when self-policing, if the occasion should arise. Remember that the same regulations apply to space communications as they do for terrestrial. Enjoy your hobby. It may be the best one ever. It's up to you. — *W9KDR*

NO ONE OWNS A FREQUENCY, BUT . . .

☐ Often we at League hq. hear the complaint, "How can I listen to code practice from W1AW if someone insists on tuning up their kilowatt on 14080 kHz?" Luckily, most people adapt quickly, resorting to tapes as another means of code practice.

Consider, however, the case of Ron Peterson who lives in Clear Lake, MN. He is a stroke victim rehabilitating himself with assistance from Courage Handi-Hams in Golden Valley, MN. With plenty of free time, he quickly memorized his code tapes, and W1AW became Ron's only source of fresh code practice material. Moral: Before you tune on 3580 kHz or whatever, please remember that for some people, W1AW is all there is. — *WA1TZK*

QST congratulates . . .

☐ Don Meserve, WØHG, for receiving a Public Service Award from the main offices of the National Weather Service. He is director of the Office of Emergency Preparedness for Johnson County, KS. Don was advertising manager of *QST* from 1929 to 1932.

☐ Truett K. Smith, N4TK, of Nashville, TN, for winning an Emmy from the Academy of Television Arts and Sciences for outstanding achievement in sports programming. He was video tape editor of the 1976 Olympic Games.

Meet the Remarkable but Little-Known Vackar VFO!

Searching for a VFO with Rock of Gibraltar stability? End your band-edge worries with this self-contained unit. For the serious-minded cw operator, the chirp-free operation and undetectable frequency drift make this VFO a natural!

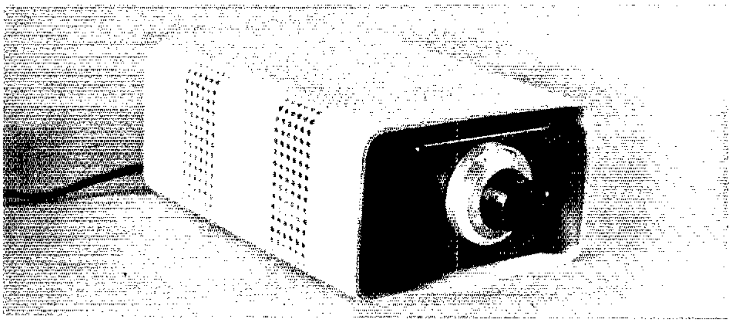
By Floyd E. Carter,* K6BSU

The dedicated cw operator must make severe demands of his station equipment. He knows that an elusive DX station amateur cannot be asked to tolerate a signal which drifts through the passband of his receiver or one which has keying chirp. For the cw man, his fist and the note of his transmitter form his "voice" to distant stations. Modern electronic keyers have made machine-like keying an inexpensive reality. Couple a keyer with a fine-quality VFO, and the DX station operator just cannot refuse to QSO.

In designing this heterodyne VFO, the goal was to produce a keyed oscillator with undetectable chirp or frequency drift. Keying of a conventional VFO invariably produces some instability because the starting and stopping of an oscillator upsets the fine balance of dc and ac conditions within the circuit, and with each key-down transition oscillation equilibrium must be reached. During this transient period, the oscillation frequency generally changes, resulting in chirp. Keying of a subsequent buffer stage following a free-running VFO generally allows a small portion of the VFO output to reach the receiver during key-up conditions if the station is set up for full-break-in cw. VFO shielding only reduces the feedthrough, but this may not be adequate for very sensitive station receivers.

Heterodyne-frequency generation eliminates all these problems because the VFO operates continuously on a non-harmonically related frequency which is converted to the operating frequency in a mixer or balanced modulator. Both the keyed crystal oscillator and the VFO operate far from the receiver frequency. Therefore, even though the VFO is not keyed, no harmonic of the oscillator will reach the receiver. Fig. 1 shows the block diagram of the heterodyne process, with frequency values applicable to this VFO.

*11232 Crist Dr., Los Altos, CA 94022



The Vackar oscillator VFO enclosed in an attractive, contemporary-styled cabinet. Below is an inside view showing rather high component density. The U3 output amplifier is on a separate board next to the transformer.

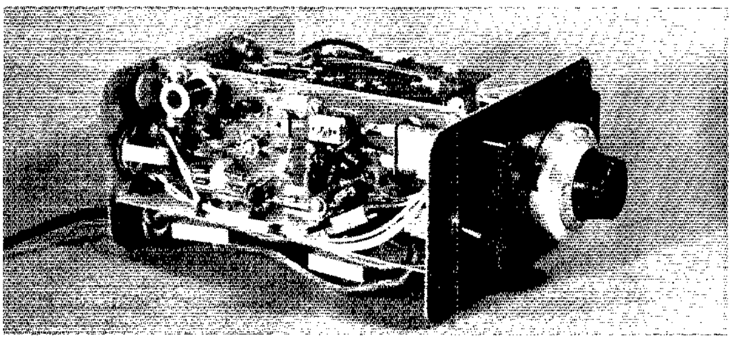
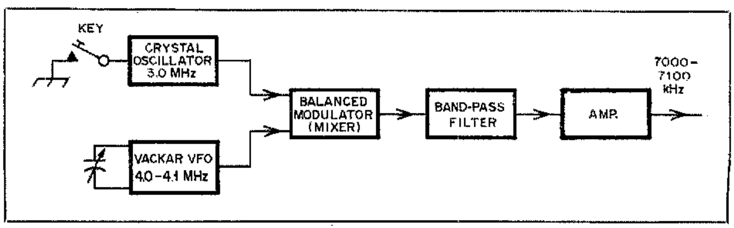


Fig. 1 — Simplified block diagram of the heterodyne VFO.



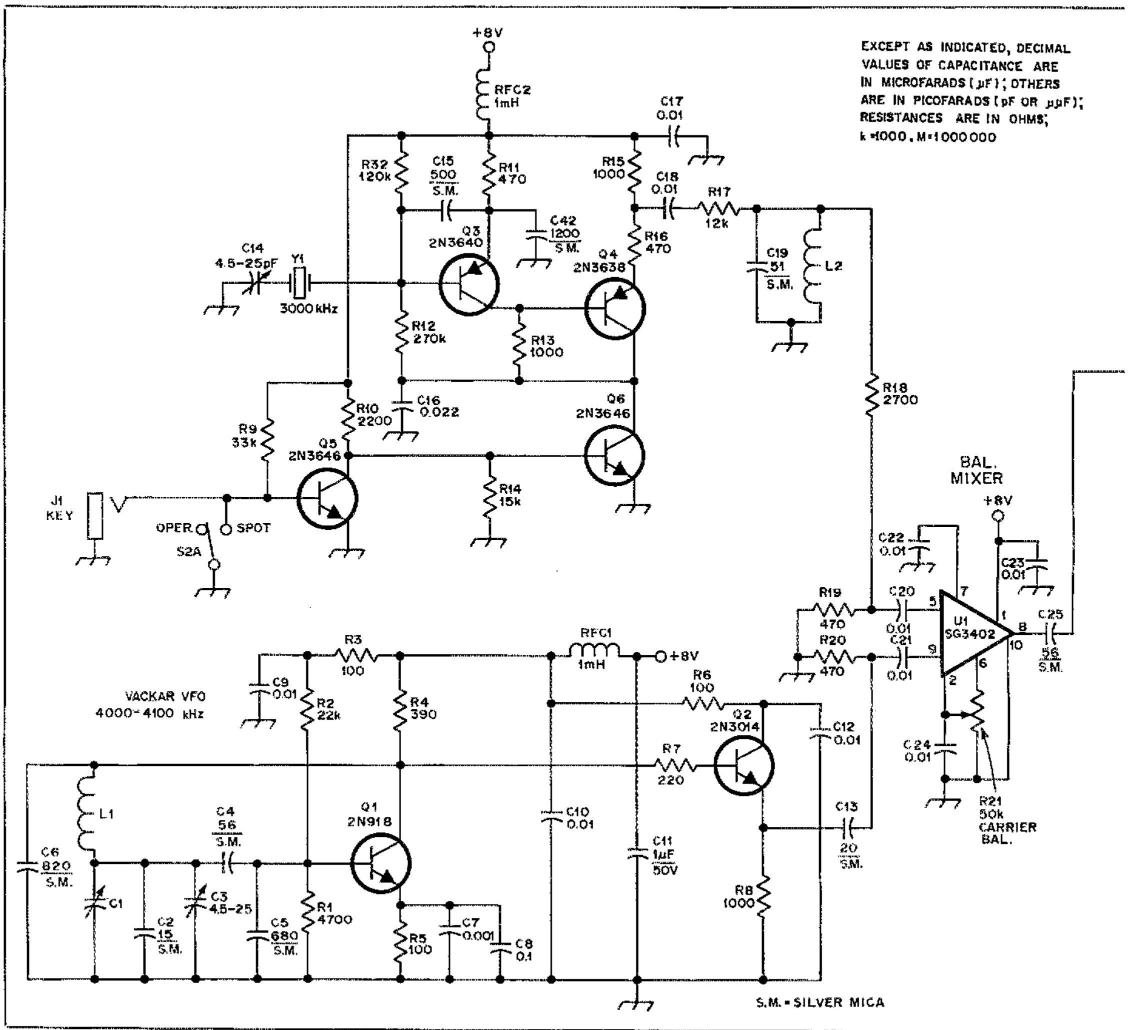


Fig. 2 — Schematic diagram of the heterodyne-oscillator VFO using the Vackar circuit. All resistors are 1/4-watt, five-percent tolerance. U1 is a proprietary product manufactured by Silicon General, Inc., 7382 Bolsa Ave., Westminster, CA 92683. The toroid core for L2, Ferroxcube no. 1041T060/4C4, is produced by the Ferroxcube Corp., Mt. Marion Rd., Saugerties, NY 12477. (For the convenience of builders who are unable to locate small toroids the author has available a limited supply.)

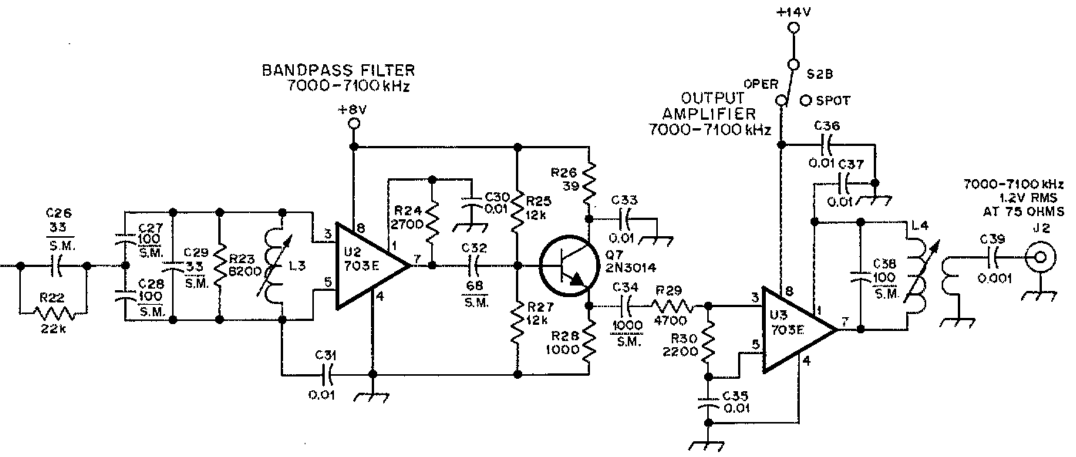
A normal mixer or unbalanced modulator output contains four prominent frequency components — the two input frequencies, their sum, and their difference. Either the sum or the difference may be used as an output by selecting the desired frequency in a band-pass filter. The balanced mixer is a more sophisticated refinement of the basic mixer circuit, because the two input frequencies are eliminated in the mixing process so that the output contains only the sum and difference frequencies. Consequently, subsequent filtering is made easier.

The VFO circuit used in the heterodyne VFO was first described by Vackar[1] in 1949. This circuit formed the basis for further research by Clapp, resulting in his classic article published in 1954.[2] The Vackar circuit closely resembles the Clapp circuit except for the method of feedback. The Vackar is series tuned like the Clapp, but the tank circuit as well as the transistor are shunted by unusually low reactances which reduce the effects of the transistor reactances. Further refinements of the Vackar circuit were described in 1968 by Jordan,[3] who provides design criteria for use at any frequency.

Construction

The photographs suggest one possible layout. For ease of modification and experimentation, the prototype was built in separate modular form equipped with connectors. Only a few precautions must be kept in mind when designing a layout. First, as with any VFO, mechanical stability is essential. An aluminum extrusion was used as a base for the oscillator. The tank components were bolted to this extrusion and the remainder of the circuit is contained on a glass-epoxy-board bolted to one lip of the extrusion. Heavy solid wire is used to interconnect the tank circuit components to prevent changes in stray circuit capacitance from shock or vibration. The integrated circuits have much higher bandwidths than required, and are capable of oscillations at vhf.

[1]Footnotes appear on page 18.



C1 — Variable capacitor, approximately 2 pF (1 rotor and 1 stator).
C3, C14 — 4.5-25 pF variable capacitor, CRL no. 825-AZ.
C7, C39 — Fixed capacitor, 0.001 µF, CRL no. CE102.
C8 — Fixed capacitor, 0.1 µF, CRL no. DDA104.
C9, C10, C12, C17, C18, C20-C24, incl., C30, C31, C33, C35, C36, C37 — Fixed capacitor, 0.01 µF, CRL no. CK103.
C16 — Mylar fixed capacitor, 0.022 µF, CDE no. 1S22.
C40 — Fixed capacitor, 1000 µF 25 V dc, CDE no. HWM 1000-25. (Fig. 3)
C41 — Fixed capacitor, 500 µF, 15 V dc, CDE no. HWM 500-15. (Fig. 3)
D1 — Silicon voltage regulator diode, 8.2 V, 400 mW, Texas Instrument no. 1N756A or equiv. (Fig. 3)
J1 — 1/4-inch phone jack, Switchcraft no. 11.
J2 — Chassis rf jack, Switchcraft no. 3505F.
L1 — 19 µH, 31 turns No. 22, enameled copper wire, 7/8 inch long, 1 inch diameter. Ceramic form, National no. XR-50.
L2 — Toroid core, Ferroxcube no. 1041T060/4C4, approximately 50 turns no. 28 enameled copper wire.
L3 — Miller no. 42A000CB1-2, 26 turns no. 24 enameled copper wire.
L4 — Miller no. 40A000CB1-2, primary 26 turns no. 28 enameled copper wire, 3/8 inch long; secondary 12 turns no. 28 enameled copper wire.
Q1 — Npn silicon annular transistor, type 2N918 or equiv.
Q2, Q7 — Npn silicon annular transistor, type 2N3014 or equiv.
Q3 — Pnp silicon low-power transistor, type 2N3640 or equiv.
Q4 — Pnp silicon high-current switching transistor, type 2N3638 or equiv.
Q5, Q6 — Npn silicon low-power transistor, National Semiconductor type 2N3646 or equiv.
Q8 — Npn silicon annular transistor, type 2N697. (Fig. 3)
S1 — Spdt toggle switch, Alco no. MST-105D.
S2 — Dpdt toggle switch, Alco MST-205N.
U1 — Variable gain, wideband amplifier/multiplier, Silicon General no. SG3402.
U2, U3— Linear IC, monolithic rf i-f amplifier, Fairchild no. 703E.
U4 — Silicon miniature diode assembly, Motorola MDA 950-2 or equiv. (Fig. 3)
Y1 — Oscillator crystal, 3000 kHz. Sources listed in *QST* advertisements.

Therefore the bypass capacitors should be mounted close to the IC with short leads. The planetary ball reduction gear couples the tuning capacitor to the tuning knob. This is not an ideal setup for it is not possible to calibrate the dial because the ball drive slips at the end of travel. However, accurate calibration of a VFO is not a great advantage, inasmuch as crystal band-edge markers are required if one is going to operate within striking distance of a pink slip.

Test and Adjustment

The only tuned circuit which is not adjustable is the 3-MHz band-pass filter consisting of L2 and C19. This should be resonated with a grid-dip meter after first overwinding the toroid core and removing turns one at a time until the circuit resonates. This circuit removes harmonics from the crystal oscillator and helps to reduce spurious inputs to the balanced modulator.

With the VFO operating and keyed, the output of U1 should be monitored while adjusting R21, the carrier-balance potentiometer, for a null at both 3 MHz and 4 MHz. The null should occur simultaneously. Next, monitor the output of J2 through a length of coaxial cable terminated in the transmitter. The cable is necessary because the cable capacitance is reflected back into the circuit for L4 and C38 and forms part of the total tuning capacitance. Adjust L3 and L4 for maximum drive to the transmitter. While rapidly keying the crystal oscillator, adjust C14 for the best starting characteristics. Finally, C1 is adjusted to cover the spread of 4.0 to 4.1 MHz. Adjustment is made with C3 and by bending the plates of C1 for the desired delta C for full rotation.

If a spectrum analyzer is available, the optimum tuning may be quickly reached for maximum rejection of unwanted frequency components. The prototype circuit had all unwanted components down by at least 40 dB. With key up, the VFO feedthrough at 4 MHz was down 30 dB. This level is not detectable with the station receiver and tuned circuits in the driven transmitter will reject these components.

With S2 in the SPOT position, power is removed from the output buffer amplifier and the crystal oscillator is keyed. This

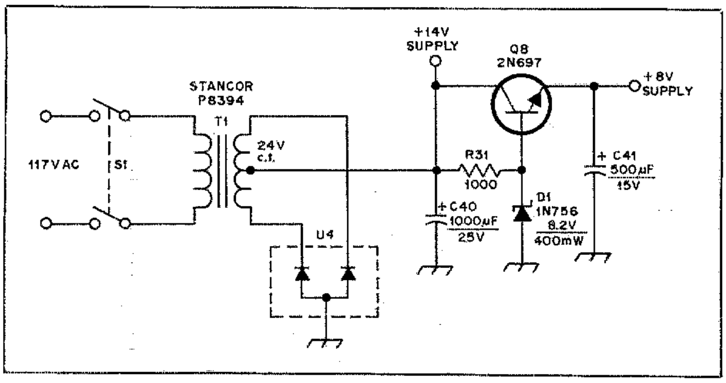
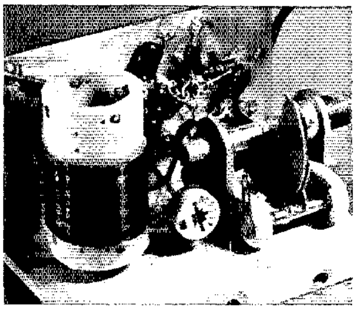
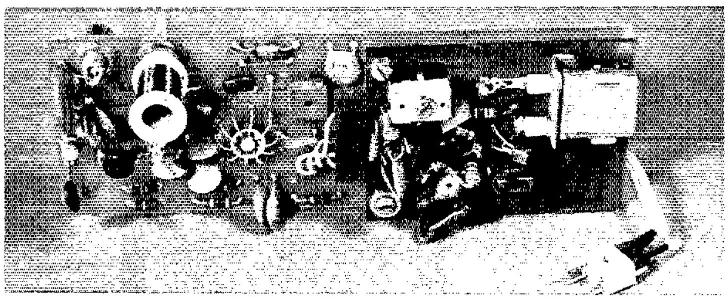


Fig. 3 — Power supply for the heterodyne VFO. Miniature diode assembly U4 is Motorola part no. MDA-950-2 or equiv.



The Vackar oscillator circuit is constructed on a heavy extrusion. Large bus wire interconnects tuned circuit components. L1 is wound on a ceramic form and coated with epoxy resin. C1 is a heavy-duty two-bearing capacitor reduced to one rotor and one stator plate.



Crystal oscillator and balanced mixer board. The oscillator is a highly modified International AO1 assembly. The small toroid coil on the oscillator board is L2. The balanced mixer (10-lead IC) is on the main board. U2 and Q6 are at far left. As is typical with developmental circuits, the board shows evidence of modifications.

generates a weak signal which can be monitored in the station receiver for frequency spotting. In the OPERATE position, control is transferred to the keyer. Any commercial keyer with an open-collector, current-sinking output will work with this VFO. If there is doubt in one's mind about this feature of a particular keyer, the schematic diagram of the keyer should be examined, or the manufacturer should be consulted. Of course, a relay output will also work with the VFO

The normal output of the heterodyne VFO is about 20 mW into a load of 75 ohms. The driven transmitter operates straight through on 40 meters for outputs of 7.0-7.1 MHz. Using the driven transmitter as a multiplier, 20-meter output from 14.0-14.2 or 10-meter output from 28.0-28.4 MHz is available. The driven transmitter must also be provided with fixed bias to prevent excessive dissipation in the final amplifier under key-up conditions. For transmitters with cathode or emitter keying, fixed bias should be added to cut off the final amplifier during key-up conditions.

The heterodyne VFO has been in use with a Viking-II transmitter with the station set up for full break-in cw operation. It is the only VFO I have ever used where operation very close to the band edges in the Extra Class portion is possible without constant nervous strain from wondering just where the transmitted frequency will end up after a long QSO.

References

[1]Vackar, "LC Oscillators and Their Frequency Stability," *Tesla Technical Reports* (Czechoslovakia) Dec., 1949.
[2]Clapp, "Frequency Stable LC Oscillators," *Proc. IRE.*, Aug., 1954, pp. 1295-1300.
[3]Jordan, "The Vackar VFO: A Design To Try," *Electronic Engineer*, Feb., 1968.

Strays

THE RAEM AWARD

☐ Basic rules require the applicant to submit a minimum of 68 points accumulated by contacting Soviet amateur radio stations above the Arctic Circle. Repeat contacts with the same stations do not count, and a specific city or inhabited area may be counted just once (i.e., only one QSL from Cape Chelyuskin). The exact location is required on each QSL card. *Cw contacts only* count after December 24, 1972.

1) An RAEM contact is 15 points.

2) A contact with a Soviet drifting Arctic station is worth 10 points (i.e., UPOL-21).

3) A contact with a fixed Soviet Antarctic station (usually 4K prefix) is worth 10 points.

4) A contact with Cape Chelyuskin, Cape Schmidt, Vankarem, Dickson, Pevek, Ambarchik or Ustx-Olenex is worth 5 points.

5) A contact with Soviet Arctic Islands is worth 5 points (Wrangel, Ayon, Severnaya Zemlya, Ostrov Dickson, Ostrov Kildin).

6) Other stations or locations above the Arctic Circle are worth 2 points.

7) For South American stations, all points value double.

To apply for this or any other Russian award, send your QSL cards, a cover sheet with your name, call, mailing address, the name of the award you are applying for, plus a list of confirmations (date, call, emission, frequency, reports) to Box 88, Moscow, USSR. Each application must be accompanied by 14 IRCs (the equivalent of one ruble) for return of the cards by registered mail. — *W1YL*

KM1CC QSL CARDS

☐ Anyone who worked special event station KM1CC should send a QSL with an s.a.s.e. to W1GAY, P. O. Box 637, Vineyard Haven, MA 02568. After January 1, 1979, all KM1CC cards will be destroyed.

Designing a Vertical Antenna

Graphs cut through the mathematical headaches of antenna design. Put them to work and build a vertical that will shake the air with energy.

By Walter Schulz,* K3OQF

Here is a vertical designed and built from graphs contained in *The ARRL Antenna Book* and *ARRL electronics data book.* In my case the antenna was completely made from discarded Yagi beam elements — a junk box vertical!

By combining information found on transmission lines and antennas in *The ARRL Antenna Book* a design concept may be realized. Explaining further, antennas go through impedance variations in a manner similar to transmission lines. An open-ended transmission line exhibits inductive and capacitive reactances above and below "resonance," respectively. However, at resonance inductive reactance cancels capacitive reactance, leaving only a resistive component. The characteristics of a vertical are similar to those of an open ended transmission line.[1] Engineers use this concept to calculate conjugate impedance at an antenna feed point.

By using graphs of the universal reactance curves[2] and radiation resistance curves,[3] knowledge of mathematics other than simple arithmetic is not necessary. These charts make the solution to feed-point conjugate impedance and top loading problems simple.

Let's Design a Vertical

The antenna selected for illustration in this article is a top-loaded vertical for the 40-meter band, operating at one quarter wavelength or 90 electrical degrees.

Electrical degrees are often employed as units of measure when working with antennas. Their use not only helps one to mentally visualize antenna length, regardless of wavelength, but they are essential when working with the graphs mentioned above.

*3617 Nanton Terrace, Philadelphia, PA 19154

[1]Footnotes appear on page 21.

In the broadcast industry the practical physical limit for top loading is considered as approximately 30 electrical degrees[4] when applied to a disk. To find the actual physical length of a vertical antenna having this full limit of top loading, subtract 30° from 90°. The resulting 60° may then be converted to feet (or meters) by this equation:[5]

$$\text{Length in ft} = \frac{2.73 \times \ell}{f_{MHz}} \qquad \text{(Eq. 1a)}$$

$$\text{Length in m} = \frac{0.83 \times \ell}{f_{MHz}}$$

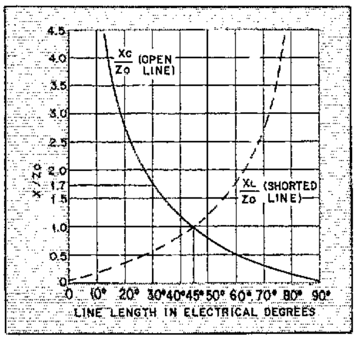
where ℓ = length in degrees

Thus,

$$\text{length} = \frac{2.73 \times 60}{7} = 23.4 \text{ ft} \qquad \text{(Eq. 1b)}$$

In order to proceed to the next step in the calculations, one should survey the aluminum stock on hand, and select masting having the desired outside diameter (OD). The tubing selected as an example for this article had an outside diameter of one inch. To obtain dimensions in meters (millimeters) multiply feet by 0.3048 (304.8) inches by 0.0254 (25.4).

Fig. 1 — Universal reactance curves for open and shorted transmission lines.



Let's now consider the vertical mast as an open-ended transmission line, so that the conjugate impedance and 30° top-loading dimensions can be determined. This equation is for computing the characteristic impedance:[6]

$$Zo = 60 \left[\ln \left(\frac{2h}{a} \right) - 1 \right] \qquad \text{(Eq. 2)}$$

where
ln = natural log (2.3 times the common log),
h = length or height of vertical mast in inches
a = *radius* of mast in inches

Thus,

$$Zo = 60 \left[\ln \left(\frac{2 \times 280.8}{0.5} \right) - 1 \right] = 361 \text{ ohms}$$

By referring to the universal reactance curves in Fig. 1 the 30° of top-loading reactance can be found. Look across on the abscissa (line length in electrical degrees) finding 30°, and run along the projection vertically to a point on the Xc/Zo (open line) curve. At that point proceed horizontally toward the ordinate reading X/Zo = 1.7. By transposing X/Zo = 1.7 we observe that X = 1.7 × Zo, with the result X = 1.7 × 361 = 614 ohms reactance for 30° top loading.

How to Find Your Hat Size

Refer to Fig. 2 for the nomograph for LC constants, taken from the *ARRL data book.*[7] Place a ruler across 7 MHz and 614 ohms Xc reactance. The ruler crosses the capacitance line at 37 pF. For 30° of top loading, 37 pF of capacitance is required.

Turn next to Fig. 3, the graph of capacitance vs. diameter,[8] where the proper diameter for 37 pF can be found. Note

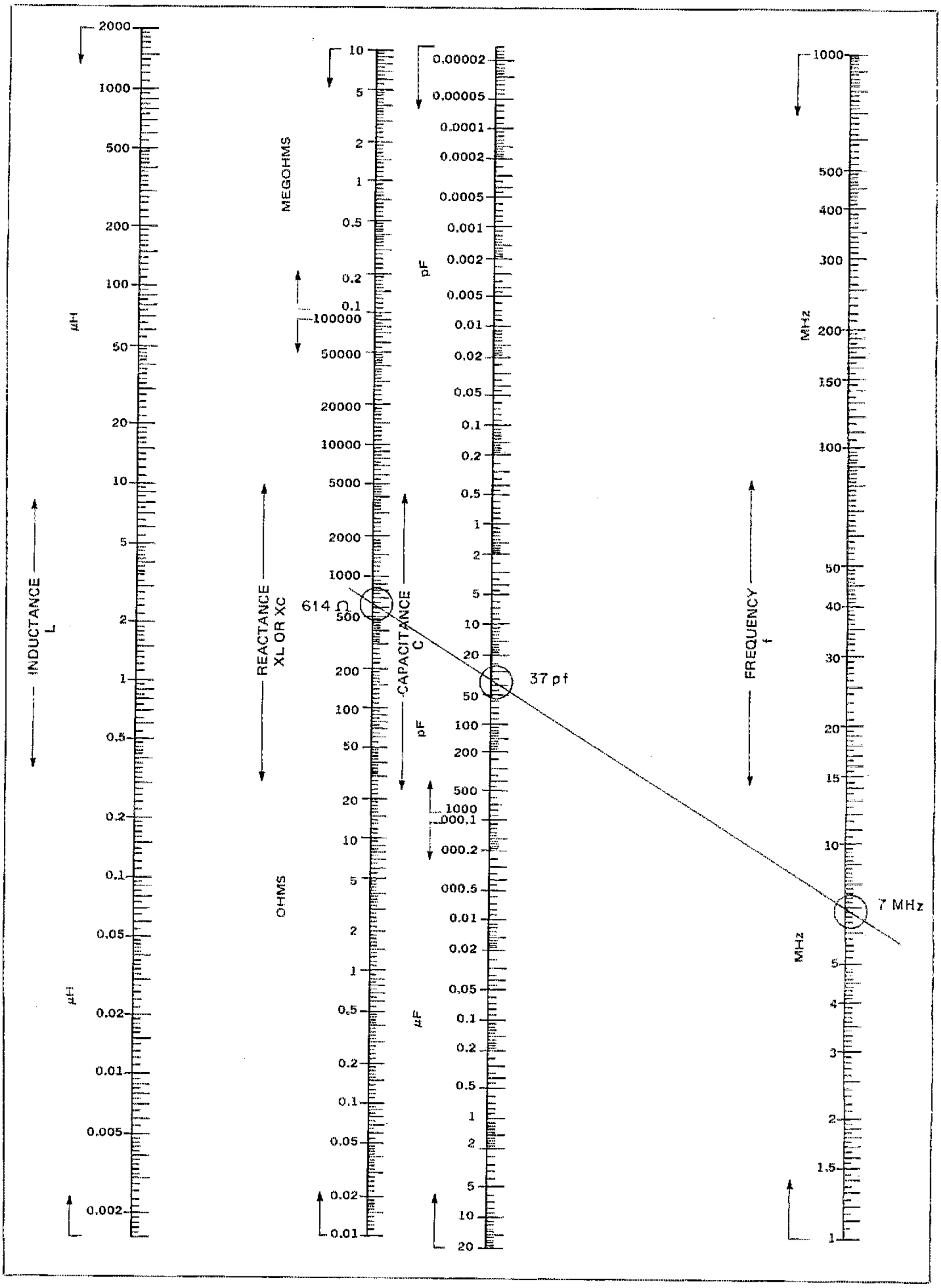


Fig. 2 — Nomograph for LC constants showing how values for the antenna described in the text are plotted.

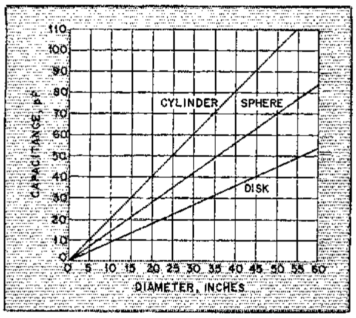


Fig. 3 — Capacitance of sphere, disk and cylinder as a function of diameter. The cylinder length is assumed equal to its diameter.

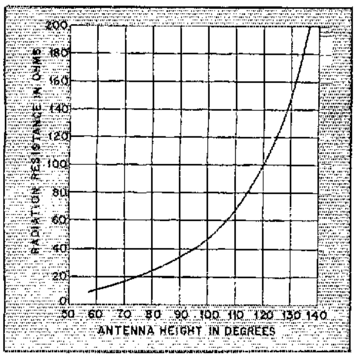


Fig. 4 — Radiation resistance vs. antenna height in degrees, for a vertical antenna over perfectly conducting ground or a highly conducting groundplane.

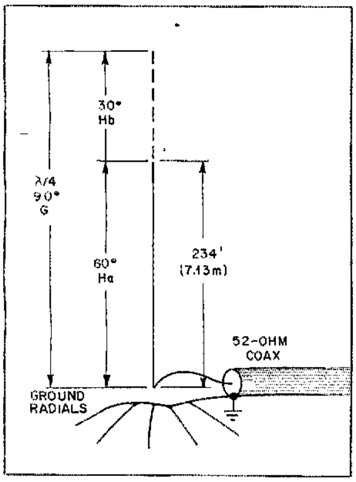


Fig. 5 — Dimensions for a quarter-wave vertical antenna with 30° of top loading. The dimensions in electrical degrees are provided. H_a represents the vertical portion and H_b is the capacitance hat. The antenna is series fed by the coaxial transmission line. There are 60 radials, each 0.2 wavelength long, in the ground system.

the position of 37 pF on the ordinate and the position of the point marked "disk" on horizontal projection. At this point follow the projection down to the abscissa (diameter, inches). The value, 40 inches, is the required diameter of the top-hat disk.

The skeleton disk shown in the photograph is fashioned into a wagon-wheel configuration. Six 20-inch lengths of 1/2-inch wide OD aluminum tubing are used as spokes, each emanating from the hub at equidistant intervals. The spokes terminate at a loop made of no. 14 copper wire. Note that the loop will increase the capacitance slightly.

To find conjugate impedance refer to the radiation-resistance-vs.-antenna-height graph, Fig. 4. Looking at the curve we see that for 90° (on the abscissa) we will have 36-ohms radiation resistance (on the ordinate). An estimated radial ground system loss resistance of 4 ohms for 60 radials, each 0.2 wavelength long,[9] may be added to the 36-ohms radiation-resistance value. This results in a total resistive value of 40 ohms. (Note: 60 radials were used with the antenna selected for the example).

Again referring to the universal reactance curves, Fig. 1, we see that 90° on the abscissa yields a reactance value of zero. Therefore, the conjugate impedance at the feedpoint is $Z = 40 \pm j0\,\Omega$. The electrical design for the completed antenna is shown in Fig. 5.

A further word about the universal reactance curves; these curves in reality are trigonometric functions. The two functions of interest here are $X/Zo = \cot \theta°$ for open transmission lines and $X/Zo = \tan \theta°$ for shorted lines. Knowing this information one could make his own graph using trigonometric tables.

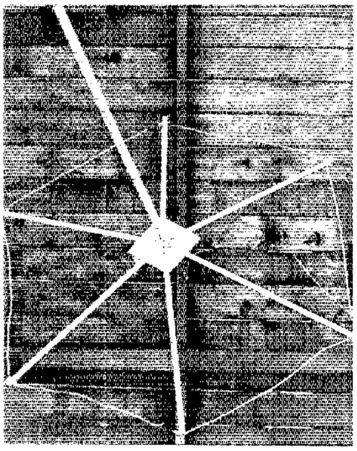
For beginning radio amateurs without knowledge of the Smith Chart, use of the graphs facilitates vertical antenna design. They offer numerous possibilities in planning with a simple and direct approach.

When the 40-meter antenna was finally constructed, stations in Europe could be worked on a daily basis barefoot from the Philadelphia area. On several occasions stations as far away as the Indian Ocean have been worked. QST

Footnotes

[1]Jordan, *Electromagnetic Waves and Radiating Systems*, Prentice-Hall, Inc., 1968. pp. 388-396.
[2]*The ARRL Antenna Book*, 1968, p. 80.
[3]Fig. 2-74, *The ARRL Antenna Book*, 1974, p. 60.
[4]Laport, *Radio Antenna Engineering*, McGraw-Hill, Inc., 1952, p. 80.
[5]Department of Navy, *Naval Shore Electronics Criteria: HF Radio Antenna Systems*, Naval Electronic Systems Command, Washington, DC, 1970, p. A-6.
[6]Jasik, *Antenna Engineering Handbook*, McGraw-Hill, Inc., 1961, p. 19-3.
[7]*ARRL electronics data book*, 1976, p. 27.
[8]Fig. 2-80, *The ARRL Antenna Book*, 1974, p. 62.
[9]Stanley, "Optimum Ground Systems for Vertical Antennas," *QST*, December, 1976, pp. 13-15.

Joseph Blair, W2UI, stands beside a top-loaded 40-meter vertical antenna that is the key to regular contacts with stations in Europe.



A close view of the capacity hat for a 40-meter vertical antenna. The radial arms terminate in a loop of copper wire.

Prescaler Updates the DVM/Frequency Counter

Let your *QST*-course digital counter reach new highs of up to 250 MHz. This vhf prescaler does the trick!

By Robert D. Shriner,* WAØUZO

As part of a series of articles concerning work with integrated circuits published in *QST* in 1976,[1] the circuit of the digital voltmeter/frequency counter generated widespread interest among radio amateurs. The era of digital electronics for amateur communications had arrived, and here was a device deserving a place in every ham station. It offered a means of measuring voltages with reliable accuracy and also provided a highly dependable method of measuring frequency.

More than two years have slipped by since the prototype DVM/FC appeared as a finished product in the ARRL laboratory. Now the time has arrived to consider the addition of a prescaler that will enable the counter to have a substantial increase in frequency range. Incorporating this extra feature in the basic unit does not demand a forbidding amount of space nor does it require more than a few hours work. Because of the tenfold increase, a 25-MHz counter can be modified to read up to 250 MHz. Indeed, that should be right down the pike for the vhf enthusiast.

With such a goal in mind, I designed and built the prescaler which I am about to describe. The configuration is an adaptation of a popular circuit published several years ago by the Semiconductor Group of the Fairchild Camera and Instrument Corporation.

Anatomy of the Circuit

The vital organ of the vhf prescaler is Fairchild's popular IC, the 95H90 decade counter. At the front door of the frequency expander is preamplifier Q1 with associated components selected for a frequency range from 25 to 250 MHz. D1 and D2 are the stalwart guards ready to chop down any Rocky Mountain-size signals that otherwise would overload the circuit.

A 95H90 decade counter was chosen for use as U1 because of the very high speed with which it can divide by 10. You can see, by referring to Fig. 1, that Q1 feeds the signal to U1 through C3. The prescaler output is fed to the input circuit of the DVM/FC. Attention is called to the fact that the prescaler should not directly drive the 82S90 or the 74196 ICs. Because U1 requires about 150 mA, a separate 5-V regulator, U2, is included in the prescaler circuit. The purpose of this regulator is to prevent an overload of the existing 5-V supply. Also, as a preventive measure, R5, a 100-ohm resistor, has been inserted to hold down the work that U2 has to do. This reduces the input voltage to approximately 15 volts. However, if this circuit is to be used with another counter that has a good 12-V supply, R5 may be eliminated.

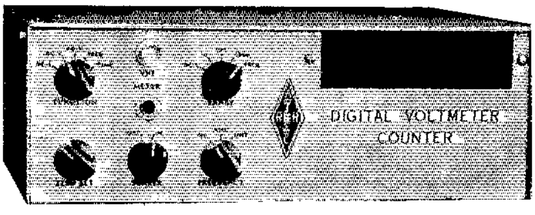
Putting It Together

Physically, the prescaler is compact and should fit easily within the DVM/FC structure. For builders who wish to avoid making their own circuit board, the board and a parts kit (less the input connector and switches) are available.[2] With a prefabricated board, construction of the prescaler becomes a comfortable one-evening project.

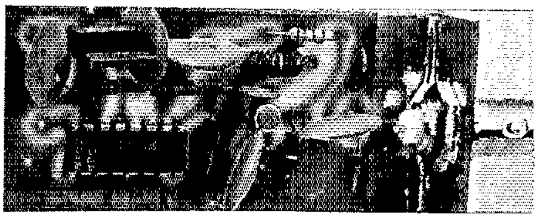
For those industrious individuals who want to make their own circuit boards, the etching pattern is given in the "Hints and Kinks" section of this issue. Fig. 2 is a parts-placement guide and Fig. 3 shows the mechanical assembly of the board.

*1740 E. 15th St., Pueblo, CO 81001

[1]Footnotes appear on page 24.



The Circuit Board Specialists version of the digital voltmeter/counter described in the popular *QST* article series, "Learning to Work with Integrated Circuits."[1]



A compact prescaler designed for use with the *QST* digital voltmeter/frequency counter. The LM340T-5 regulator is in the upper left. The Fairchild 95H90 prescaler IC is visible at the lower left.

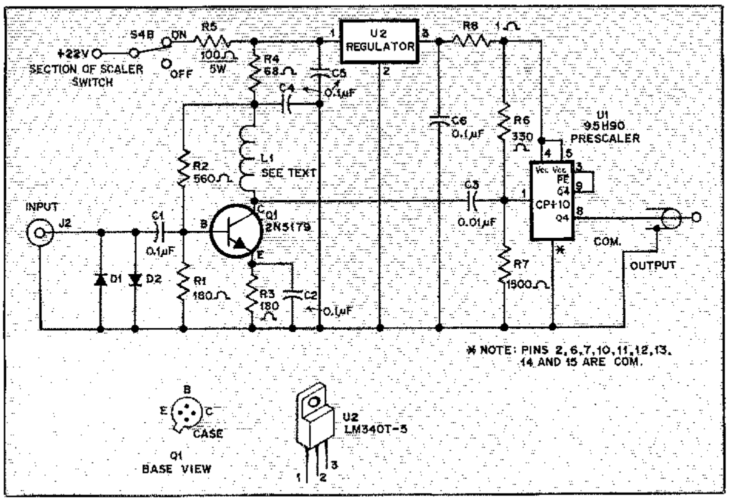


Fig. 1 — The vhf divide-by-10 prescaler circuit. See Fig. 4 for DVM switching modification. No connection is made to pin 16 of U1.

C1, C2, C4-C6 incl. — 0.1-μF disk.
C3 — 0.01-μF disk.
D1, D2 — Switching type 1N914N.
J2 — BNC, type UG-1094.
Q1 — Npn silicon hf, type 2N5179 or 2N3600.
R1, R3 — 180-ohm, 1/4-watt.
R2 — 560-ohm, 1/4-watt.
R4 — 68-ohm, 1/4-watt.
R5 — 100-ohm, 5-watt.
R6 — 330-ohm, 1/4-watt.
R7 — 1500-ohm, 5-watt.
R8 — 1-ohm, 1/4-watt.
U1 — Decade counter, Fairchild type 95H90.
U2 — Positive voltage regulator, type LM340T-5.
See Fig. 3 for L1.

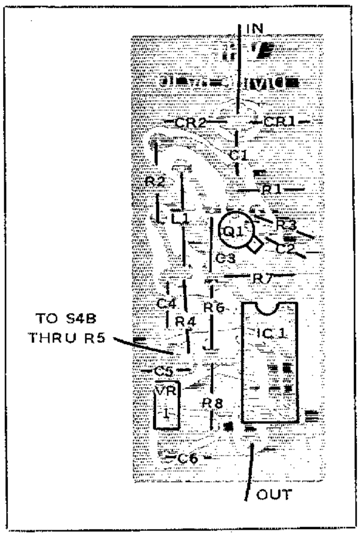


Fig. 2 — Parts placement guide for the vhf prescaler. The shaded area represents an X-ray view of the copper pattern. The etching pattern appears in the "Hints and Kinks" section of this issue. The board is double-sided copper clad, with all but a small strip etched away from the component side (see the photo and Fig. 3).

Fig. 4 shows the modifications needed for the switching circuits of the DVM/FC.

Construction should begin with preparation of the prescaler board and the small BNC connector mounting panel (also made from pc material). Dimensions are given in Fig. 3. A well-centered hole should be made in the small panel to accommodate the BNC connector. A copper strip, shown in the drawing, is placed at the front end of the circuit board to provide a means of soldering the small BNC panel to the circuit board. The foil side of the board is also soldered to the small panel. The dual soldering is done for the sake of rigidity.

As indicated by Fig. 3, the BNC connector nut is to be located properly over the hole and then soldered in place. A good idea is to rub the nut with a piece of emery cloth, or file it lightly before soldering. At this point I should mention that the BNC outer conductor is grounded to the printed circuit board but this part of the connector *must be insulated* from the DVM/FC chassis ground. Also for this same reason, the front side of the little circuit-board upright for the BNC connector should be beveled around the connector hole to prevent contact between the BNC connector and chassis ground. An insulating washer should also be used to isolate the BNC connector from the chassis ground.

Examination of the DVM/FC should disclose a convenient location for mounting the prescaler and providing a front panel hole for the BNC connector. Builders who obtain the ready-made housing[2] may find a convenient mounting location between S1 and S2. The hole to be made in the panel of the DVM/FC should have a diameter of 7/16 inch (11.1 mm), particularly if a metal chassis is used for the DVM/FC.

Two construction guidelines apply to this project. Use a low-wattage soldering iron and keep the leads short. Do not use a socket for U1; it just plain won't work.

After preparatory work has been done, assemble the electronic components, making sure that the correct items are on hand. Then mount all components *except* the 95H90 integrated circuit.

Checking the Voltage

As a precaution before the 95H90 is installed, you should make a voltage check. Temporarily connect the prescaler to the voltage source in the DVM/FC. If all is well within the prescaler and the DVM/FC, just 5 volts (and no more!) should appear at the output of the voltage regulator. Damage to U1 will occur if more than 5 volts are allowed to reach the 95H90.

If the voltage is correct, disconnect the temporary power connections and solder the 95H90 in place. Use care to be sure that the IC is inserted in the proper direction and that none of the pins are bent out of position.

At this point the prescaler is ready to be installed in the DVM/FC, and the one-inch (25-mm) input lead connected from the pc board to the center conductor of the BNC connector. RG-174/U cable should be used between the output switches and the DVM/FC front end. In order to maintain continuity, be certain that the coaxial cable shields are bonded together when completing the circuits to the switch assembly.

Using the Prescaler

The Q1 preamplifier components have been selected for an input impedance of approximately 50 ohms. Therefore, a 1/4-wave whip antenna may be used for rf pickup from nearby equipment. A 1-watt handheld transceiver operating at 146 MHz will key the prescaler/counter from a distance of six to 10 feet. Do not, however, feed a transmitted signal directly into the prescaler, for you will probably put your newly built unit into orbit with OSCAR 8!

Suppose, now, that we want to count a popular 2-meter frequency — 146,940,000 Hz. Remember that we have divided by 10 so our display frequency will be 14,694,000. Adjust the counter for the HZ position and we read 4000. In the KHZ position the reading will be 694.0. In the MHZ position 14.69 is the reading.

"So, we've checked operation in the 2-meter range," you say. "What about 450 MHz? How do we go about that?"

Well, "podner," there's no need to prospect around here for a solution to that. We can solve that nice and easy like. Just make yourself a two-turn loop, one-inch diameter, using no. 12 insulated wire. Connect the loop to a length of coaxial

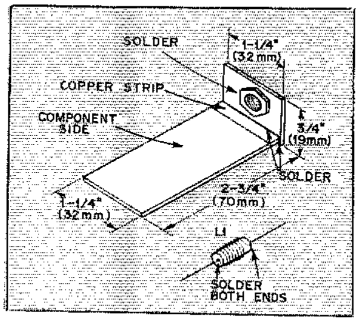


Fig. 3 — The dimensions and construction of the pc board and BNC-connector upright. At the right is L1, an eight-turn coil of no. 28 wire wound on the body of a 1000-ohm (or higher), 1/2-watt resistor.

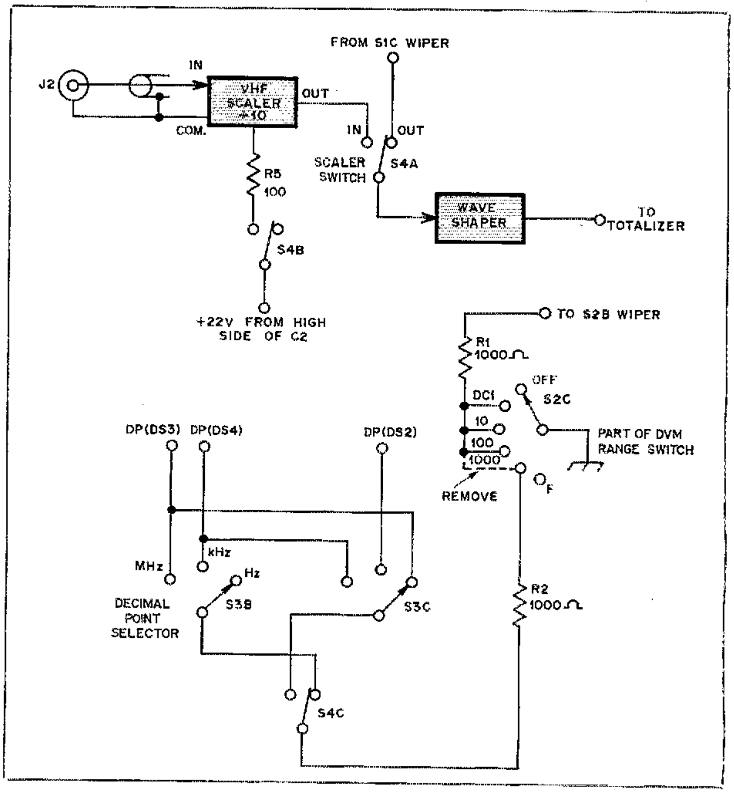


Fig. 4 — Modification of the original *QST*-course DVM/Frequency Counter circuit to accommodate the vhf prescaler. Reference should be made to the course diagrams, Fig. 26 and Fig. 30.

cable plugged into the prescaler. If you poke the loop around the last multiplier stage of your transmitter and the DVM/counter displays 225 MHz, just multiply that by two. That's it! So, my friend, if you want your digital voltmeter/frequency counter to grow, then this is the way to go!

Footnotes

[1] A complete collection of the popular *QST* series, "Learning to Work with Integrated Circuits," is contained in the new solid-state anthology, "Solid State Basics," available for $5 (in the USA) from ARRL Headquarters, 225 Main St., Newington, CT 06111.

[2] At the time of this printing the prefabricated circuit board is available for $4 and the parts kit (less input connector and switches) for $21 from Circuit Board Specialists, P. O. Box 969, Pueblo, CO 81002.

Strays

ARRL ESTABLISHES HALL OF FAME

□ At its July 1977 Meeting, the League's Board of Directors authorized the creation of an ARRL Hall of Fame to honor those members and others who have made important, substantial or outstanding contributions in the field of amateur radio. Nominations are solicited in accordance with the guidelines listed below. Nominations received by December 29, 1978, will be considered by the board at its Second Meeting in 1979.

A number of amateur radio pioneers, living or deceased, deserve the honor of being charter nominees. If you are personally familiar with the contributions one of them has made, don't wait for someone else to do it; begin the nominating process yourself!

Hall of Fame Guidelines

1) Purpose: The American Radio Relay League has established its hall of fame to honor those members and others who have made important, substantial, or outstanding contributions in the field of amateur radio; to ensure that these contributions will not be forgotten by future generations of amateurs; and to motivate today's amateurs to establish high levels of achievement and dedication as their personal goals.

2) Eligibility: Nominees for the ARRL Hall of Fame should be those radio amateurs and others whose achievements or personal dedication have earned for them the lasting respect and admiration of the amateur community. Nominations should be based upon achievements or activities which occurred at least six years prior to submission of the nomination. Nominations may be based upon outstanding technical or operating achievements, important personal contributions to the League or to amateur radio, or substantial contributions over an extended period of time.

3) Nominating procedure: (a) Nominations may be submitted at any time to the Secretary, ARRL. Nominations received in any calendar year will be considered at the Second Meeting of the Board of Directors in the following year. (b) Election to the ARRL Hall of Fame is a high honor which is not bestowed lightly; therefore, nominations should fully and clearly document the qualifications of the nominee. The nomination must be signed by at least five Full Members of the League. (c) The nominations received during a calendar year will be reported to the membership via the League's journal, *QST*, no later than April of the following year. The membership will be asked to submit comments or additional information on the nominations. All relevant information on nominations will be made available to each director no later than 30 days prior to the Second Meeting of the Board.

4) Elections: Each director shall cast a single, secret ballot for not more than three nominees. A nominee shall be declared elected to the hall of fame upon receiving the votes of not less than 12 directors during a single balloting.

5) Award: A suitable award shall be devised and presented at an appropriate time and place, and with all due ceremony. A list of members of the ARRL Hall of Fame shall be displayed in the lobby or museum at ARRL headquarters.

An Auditory Dip Oscillator

Need to check that antenna, track down parasitics or neutralize an amplifier? Let this novel dipper do the work. Its advantage? You can literally play it by ear!

By W. Earl Quay,* W4MKC

Over the years numerous articles have been written about the ways in which sightless radio amateurs carry on routine activities at their stations, including the construction and maintenance of their equipment. The alternative methods employed by these amateurs are based on the use of touch and sound. A principal reason for my article is not that I'm departing from the alternatives, but because I wish to emphasize that possession of sight or all sensory capacities is not wholly necessary for being a full-fledged radio amateur. Of course there are difficulties for the sightless, but with a bit of effort most problems can be solved and a few evaded.

My lack of sight may be of little consequence to readers of this magazine but it should evoke a measure of interest in the device described and the form of schematic diagram (or rather the substitute for it) which can be used without sight, or on the air.

Dip oscillators have been used by blind radio amateurs for many years. These devices have been produced in various forms. Some have been cumbersome. Others were complicated.

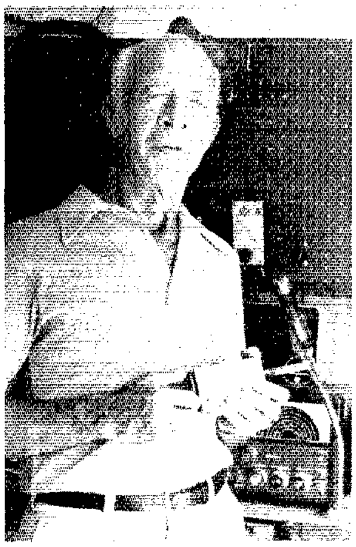
When I decided to provide myself with a dipper, my plans called for simplicity of design, easy construction, good audible readout and a healthy degree of sensitivity. While I built my device for personal use, it was designed to be shared with others. In particular, I felt that the audible readout feature offered a real advantage to all users of dip oscillators. For those amateurs blessed with sight, the auditory dip oscillator permits full attention to be given to work at hand.

The ADO Design

The beginning or rf portion of the auditory dip oscillator is a modification of the Heath HD-1250 dip-meter circuit. Following the initial dipper section is the readout circuitry consisting of a detector amplifier and a commonly used audio oscillator/amplifier that drives a small speaker. Provision is made for a headset to monitor modulated signals. The transistors are available at Radio Shack stores.

Except for the Heath dip-oscillator plug-in coils which I used, all the components are assembled inside a 5-1/4 × 3-1/16 × 2-1/8-inch (133 × 78 × 54 mm) enclosure. I've mounted the power switch, miniature speaker, phone jack, pitch control and tuning knob on the case, while the circuit board is placed inside, adjacent to the tuning capacitor. For the sake of easy removal, the battery is mounted outside.

Author W. Earl Quay, W4MKC, stands beside his station equipment. In his hand is the auditory dip oscillator described in this article.



The Verbal Diagram

My method of handling a schematic diagram is verbal. It bears a resemblance to the instructions found in Heathkit manuals. I've arranged the information about the auditory dip oscillator (Fig. 1) in this manner.

"B-plus (9 volts) goes through S1 to the top of a 50-kΩ potentiometer with the bottom terminal grounded. The arm or slider of this potentiometer goes through a 1500-ohm resistor to the collector of Q1 and through a 0.01 μF bypass capacitor to ground. The collector of Q1 goes through a 47-pF silver-mica capacitor to tank connection no. 1. The collector of Q1 also goes through a 10-kΩ resistance, thence through a 27-kΩ resistor to ground. The junction of the 10-kΩ and the 27-kΩ resistors is connected through a 100-kΩ resistor to the base of Q1. The base of Q1 is connected through a 4700-ohm resistor and a 5-pF silver-mica capacitor in parallel on through a 47-pF silver-mica capacitor to tank connection terminal no. 2.

"The emitter of Q1 goes through a 27-ohm resistance to ground and through a 0.001-μF capacitor to ground. The junction of tank connection no. 1 and the 47-pF capacitor goes through 100-kΩ resistance paralleled by a miniature 25-pF trimmer capacitor to the base of Q2. Tank connection no. 1 is wired to the shell of the phono jack for the plug-in coil and to variable-capacitor stator no. 1. Tank connection no. 2 goes to the tip of the phono connection for the plug-in coil and to the stator of variable capacitor no. 2. The common rotors of capacitors 1 and 2 are both grounded. This completes the dipper portion.

"The base of Q2 goes through 10-kΩ

*4128 S.E. 10th Ave., Cape Coral, FL 33904

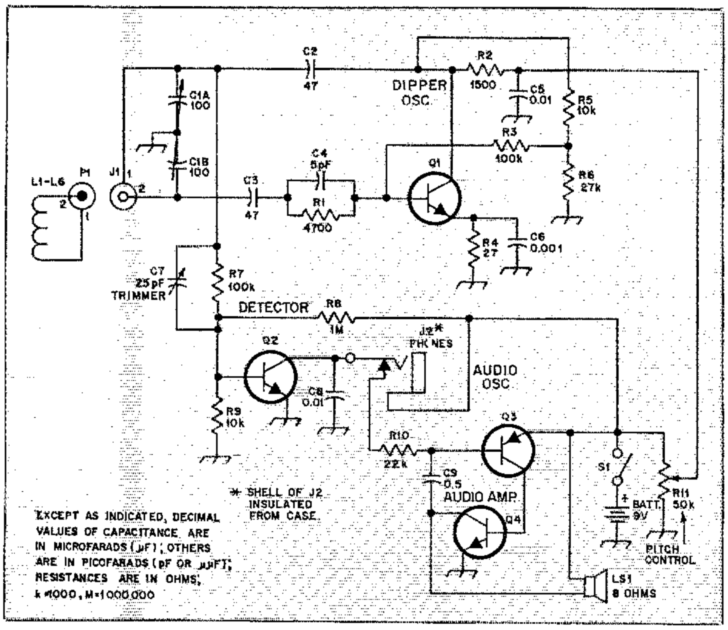


Fig. 1 — The W4MKC auditory dip-oscillator circuit. An audio tone circuit takes the place of a visual meter, an arrangement that is useful to the visually handicapped amateur. L1 through L6 are Heathkit part nos. 40-1689 through 40-1695. All fixed resistors are 1/4 watt.

C1 — Split-stator capacitor, 100 pF per sec.
C2, C3 — 47-pF silver mica.
C4 — 5-pF silver mica.
C5, C8 — 0.01-μF disk ceramic.
C6 — 0.001-μF disk ceramic.
C7 — Trimmer capacitor, 25 pF max.
C9 — 0.5-μF polyester dielectric tubular.
J1 — RCA-type phono jack.
J2 — Phone jack.
LS1 — Miniature replacement loudspeaker, 8 ohm.
P1 — RCA-type phono plug.
Q1, Q2, Q4 — Npn rf oscillator/amplifier transistor, Radio Shack RS-2011 or equiv.
Q3 — Pnp, general-purpose transistor, Radio Shack type RS-2021 or equiv.
R1 — 4700 ohm.
R2 — 1500 ohm.
R3, R7 — 100 kΩ.
R4 — 27 ohm.
R5, R9 — 10 kΩ.
R6 — 27 kΩ.
R8 — 1 MΩ.
R10 — 22 kΩ.
R11 — Linear-taper potentiometer, 50 kΩ, Radio Shack no. 271-1716.

resistance to ground. The base of Q2 also goes through 1 MΩ of resistance to B+ at the bottom of S1. The emitter of Q2 goes to ground. The collector of Q2 is wired through a 0.01-μF capacitor to ground. The collector of Q2 also goes to the tip connection of a phone jack. The shell of the phone jack (insulated from the case) goes to the plus connection under S1. The idler connection on the phone jack goes through a 22-kΩ resistor to the base of Q3. (Note: The 1-MΩ resistor may be changed to a higher or lower value in order that the dipper presents a very low pitch or clicking sound whenever the unit is turned on. Also, when magnetic phones are plugged into the phone jack the audio oscillator is disconnected. A modulated rf signal then may be monitored. Alternatively, a visual meter may be plugged into the jack.) This completes the detector amplifier.

"The base of Q3 goes through a 0.5-μF capacitor to the collector of Q4. The emitter of Q3 is wired to the plus connection under S1. The collector of Q3 goes directly to the base of Q4. The emitter of Q4 is grounded. The collector of Q4 is wired through the speaker to the plus connection under S1. B-minus, incidentally, is grounded. This completes the audio oscillator and all circuit wiring.

Except for those capacitors otherwise indicated in the diagram and on the parts list, all are disk ceramic. Q1, Q2 and Q4 are Radio Shack no. 276-2011 or equivalent. Q3 is Radio Shack no. 276-2021 or equivalent. The split-stator tuning capacitor consists of two 100-pF sections on a single shaft with a common rotor. Builders may have to shop around for the capacitor. Some suggested sources are other amateurs, flea markets or suppliers of surplus radio equipment. G. R. Whitehouse & Co., 11 Newbury Dr., Amherst, NH 03031, stock a variety of variable capacitors.

Technically minded amateurs may find that developing an actual schematic diagram from given circuit information is an interesting experience. The wording may appear difficult only at the beginning.

Using the Dipper

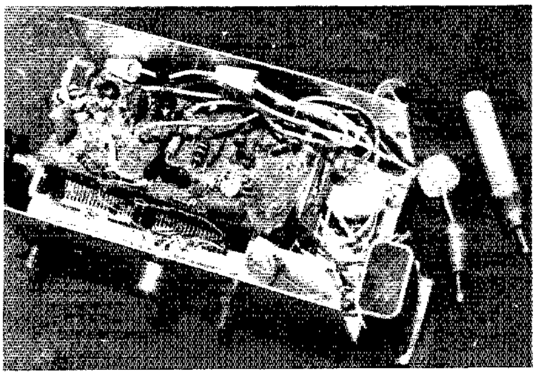
The moment the dip oscillator is turned on a low-pitched tone or clicking sound should be heard. Advancing the pitch control produces a rise in the audio frequency of the tone heard through the speaker. As the tuned circuit of the dipper becomes loaded by an external source, the pitch will drop sharply. Even touching the dipper coil will have a similar effect. Because of the good sensitivity of the dipper, the slightest changes of the circuit under test or a change in the physical conditions surrounding the dipper will be noted by a change in tone.

I have made comparisons of sensitivity with that of dip oscillators belonging to other amateurs. Mine seems to be the equal of any comparison units that were tried. I've observed that even wind blowing on an antenna will result in an excursion of the tone while performing a check of the antenna characteristics.

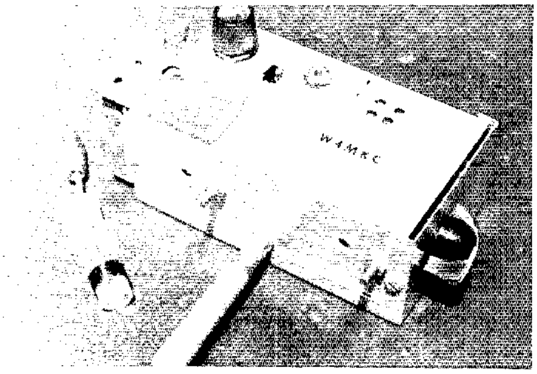
To determine the resonant frequency of a tank circuit, the dipper coil is brought close to the tank inductor. The dipper is then tuned until the audio tone drops. The pointer on the dipper dial, supplemented by a calibrated receiver, indicates the frequency of the tuned circuit under test. The "rightness" or the "wrongness" indicates if adjustment is needed and in what direction the inductor or capacitor must be changed to produce the resonant frequency being sought. Since the rf output of the dipper is somewhat modulated by the audio oscillator, there is no difficulty in locating the dipper signal on a nearby receiver.

The procedure for establishing the value of an unknown capacitor is essentially the same as that used to determine the value of an unknown inductor. If the value of a capacitor is unknown, connect the capacitor in parallel with an inductor of known value. If the value of a coil is to be ascertained, place the coil in parallel with a capacitor of known value. In either case after the dipper coil is brought close to the circuit under test, the dipper is tuned until a pronounced change in the audio pitch is heard. The dial reading of the dipper indicates the resonant frequency of the test circuit. One then has the necessary information to calculate the unknown value from the equation "f equals 1 over 2 pi times the square root of LC," where f is the frequency in hertz, L is the inductor value in henrys, and C is the capacitance in farads. Incidentally, do be careful with those decimal points!

A dip oscillator is a practical, simple instrument for making antenna or transmission-line measurements. For use in obtaining a ball-park indication of the characteristics of an amateur's antenna,



This close-up photograph of the inside of the auditory dip oscillator shows the circuit board above the split-stator capacitor. At the right is the 9-V battery and two of the coils.



An external view of the W4MKC dip oscillator. The 9-V battery is mounted at the left. At the right side of the enclosure is the tuning knob. Mounted atop the case are the phone jack, power switch and the pitch control.

the limited accuracy can prove quite satisfactory. One of the easiest measurements that may be made with a dip oscillator is checking the resonant frequency of a center-fed half-wave dipole. The antenna feed line is disconnected and replaced by a one-turn loop. The dipper is placed close to the coil and adjusted until a dip is noted. The lowest frequency at which the dip occurs is the resonant frequency of the antenna. Because the dip measurement is taken at a low-impedance point, the dip should be quite pronounced. Checking the resonant frequency of a grounded quarter-wave antenna is also easily accomplished. The transmission line is disconnected at the antenna feed point, being replaced by a one-turn loop. The dip oscillator is applied as above. One may find that attempting to determine the resonant frequency of a half-wave dipole at a high-impedance end may not be too satisfactory. The dip is often less pronounced. Capacitive coupling is also required.

As a general practice, antenna measurements should be made with the feed line disconnected. A reason for this precaution is that if the line is not perfectly matched to the antenna a false indication may be given. Furthermore, the dip oscillator should not be coupled to the shack end of a transmission line in order to check the resonant frequency of an antenna. Keep in mind, also, that an antenna will not show the same point of resonance when suspended in the air as it will when measured in a lower position near the ground.

After the dip oscillator has been used to determine the approximate resonant frequency, final trimming becomes a matter of cut and try while SWR checks are made and perhaps a field-strength meter is employed to determine when maximum radiation has been achieved.

Whether one wishes to find the Q of a circuit, ascertain the bandwidth of an antenna, check crystals or filters, track down parasitics or neutralize an amplifier, a dip oscillator is a device for these tasks. There should be room for one at every amateur station, including one with an auditory readout.

Consultative assistance in preparing this article and the photography were provided by David W. Bowman, W4OUU.

Feedback

☐ In "Transmitter Design — Emphasis on Anatomy," Part 3, in July 1978 *QST*, two errors appeared in the parts placement diagram. In Fig. 8, page 24, the component shown between the base of Q11 and the ground foil should be a 0.01 µF, *not* "10." The unmarked component shown between the base of Q10 and the other side of T2 secondary should be "10," for a 10-ohm resistor.

☐ In "Results, 1978 Simulated Emergency Test" (July 1978 *QST*, page 63), Ball County should have been Bay County, and listed under N. Florida rather than S. Florida. This raised N. Florida's point total to 5991, and reduced S. Florida's total to 4196.

Also, S. New Jersey's reports were included under N. New Jersey. The correct listing is

N. New Jersey	(1246)	620
Bayonne	W2KB	142
Chatham	W2UH	187
Englewood	W2CC	63
Union Co.	N2NS	228
S. New Jersey	(607)	1329
Atlantic Co.	WA2YQV	107
Burlington Co.	K2QIJ	1020
Cumberland Co.	WA2EMY	48
Gloucester Co.	WA2SEA	154

☐ The postage required for WØSL's HP-67 and -97 az-el programs for OSCARs 7 and 8 and Phase III ("OSCAR 8 Has a Message for You," July 1978 *QST*, page 42) is *Domestic,* one program (O7, O8 and RS or Phase III), 30 cents with s.a.s.e. Two programs, 45 cents with s.a.s.e. *Foreign,* one program, an IRC for 2 oz. and s.a.s.e. Two programs, an IRC for 3 oz. and s.a.s.e. Send to Roy Welch, WØSL, 908 Dutch Mill Dr., Manchester, MO 63011.

☐ In "RF Heating in the Ham Bands" (June 1978 *QST*, page 13), the following source reference was omitted: Rogers, S. J. and King, R. S., "Radio Hazards in the m.f./h.f. Band," *Nonionizing Radiation,* December, 1970, pages 178-189.

Strays

The Connecticut Amateur Radio Society was organized largely for the purpose of putting on New England Division Conventions in the Hartford area. It runs great conventions, and it operates in the black. Here, at the Rochester (NY) Hamfest and New York State Convention on May 20, 1978, Lew McCoy, W1ICP, representing CTARS, presents ARRL President Harry Dannals, W2HD, with a check from CTARS to ARRL for $3000. No wonder W2HD was smiling!

A Solid-State Transverter for 70 Cm

Put those tubes away and move up to the state of the art. Use this device to get on 432 MHz; even work OSCAR Mode B.

By Robert R. Eide,* WØENC

This unit was designed as a replacement for my vacuum-tube type exciter. It provides 1 watt output, enough to drive a solid-state linear amplifier to the 10- to 15-watt power range. It is driven from a low-level output supplied by a transmitter or transceiver operating in the cw or ssb modes on 28 MHz. The transverter has been duplicated by several other builders with no major difficulties encountered.

Circuit Description

The components called out in this description are located in Fig. 1. The oscillator circuit is similar to one described by WØMJS in the *AMSAT Newsletter.*[1] Provisions have been made on the circuit board for a second oscillator stage so that the transverter may be used over two frequency ranges such as 432-434 or 435-437 MHz by switching the Zener-regulated supply voltage to either of the two oscillators. Crystals used are in the 67-MHz region. The oscillator output is diode switched by D2 and D4 to Q2 which triples it to 202 MHz. A potentiometer in the emitter circuit of Q2 provides adjustment for the proper output level from the oscillator chain. Q3 doubles to 404 MHz, while Q4 amplifies the signal and provides a separate output connection which may be used to provide LO injection for a receive converter.

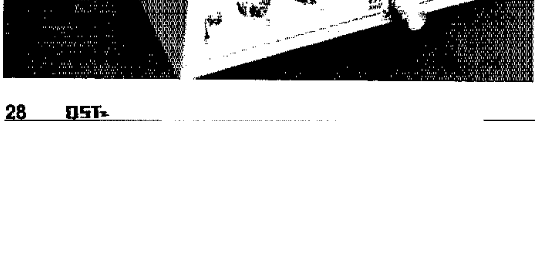
Q5 and Q6 operate as a balanced mixer with the output tuned by means of variable-coupling loop L6. A potentiometer in the source circuits provides dc balancing. Balance of the output circuit is obtained by adjustment of capacitors C44 and C45. The linear-amplifier stages, Q7, Q8 and Q9 operate in class AB. Trimmer potentiometers are provided for bias adjustment on transistors Q8 and Q9. The bias voltage is regulated by a Zener diode. The tuned circuits for these stages utilize striplines etched on the circuit board.

Construction and Adjustment

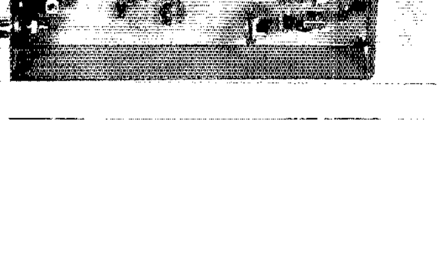
The circuit is constructed on G-10 glass-epoxy single-sided circuit board 1/16-inch (1.6-mm) thick and 6-inches (152-mm) square. After etching and drilling, the board was plated with Kepro immersion tin-plating solution. Capacitors specified as disk ceramic should be small enough to fit on the circuit board. C2, C54, C3 and C55 should be temperature-stable types to assure oscillator stability. Fixed resistors are 1/4 watt except R1, R30 and R19, which are 1/2-watt types. All resistors may be 10-percent tolerance. All components are seated against the circuit board to avoid long lead lengths. The transistors should be spaced not more than 3/16 inch (4.8 mm) above the circuit

*53 St. Andrew, Rapid City, SD 57701

[1]Footnotes appear on page 30.



A front view of the 432-MHz transverter showing the feedthrough capacitors for power and control functions and the output connector. The nameplate is made from a Kepro Black Anodized Nameplate Kit, cat. no. NP-404, available from Kepro Circuit Systems, Inc.



Interior view of the WØENC transverter. The oscillator and mixer stages are along the top of the box with the driver and final amplifier at the bottom. A photocopy of the designer's layout for the circuit board is available from ARRL for 50 cents handling charge and an s.a.s.e. This layout may be helpful to those builders who are experienced in the preparation of etched circuit boards.[2]

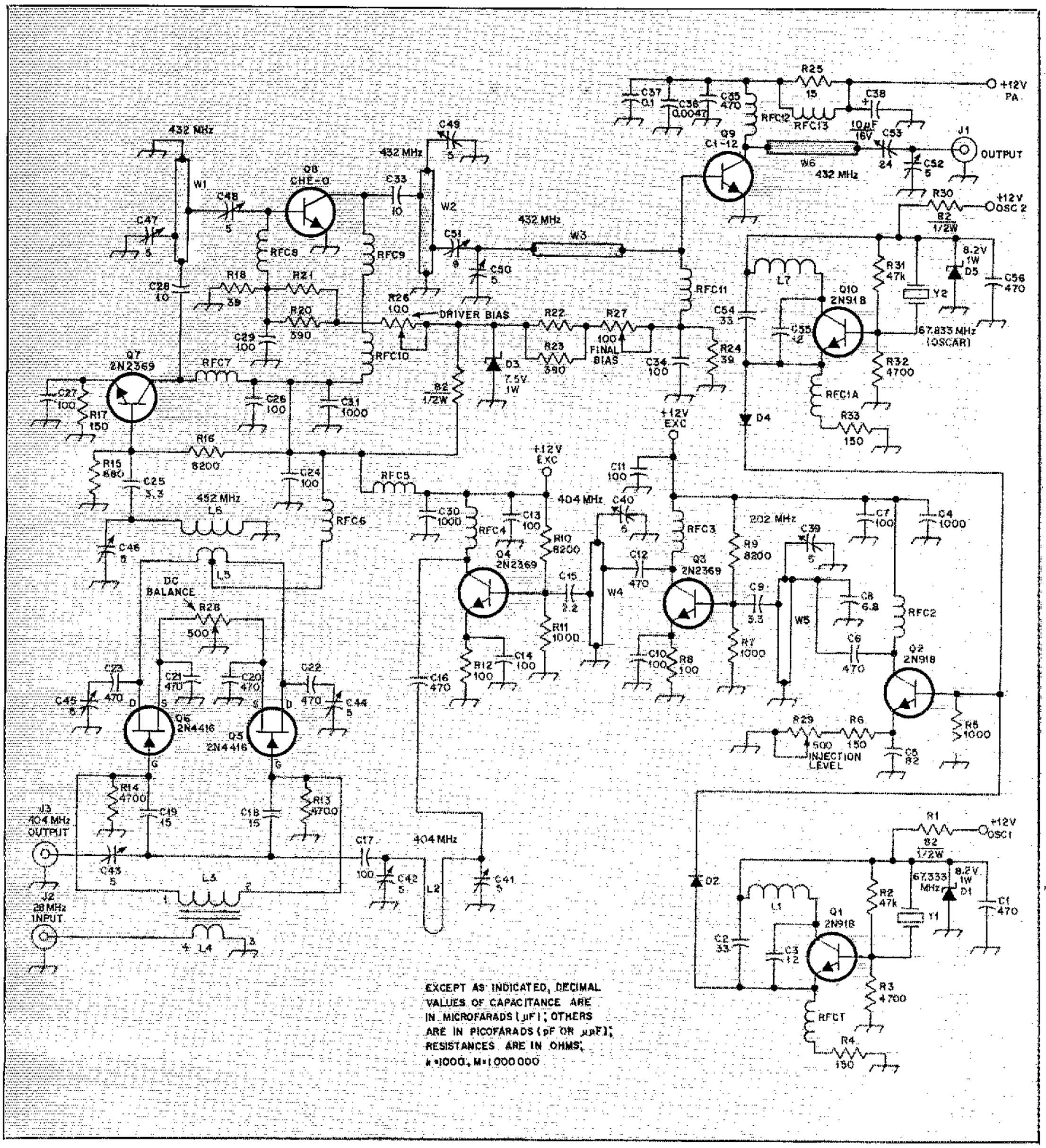


Fig. 1 — Schematic diagram of the transverter. L2, L5 and stripline inductors are on the designer's layout.

C40-C50, C52 — 5-pF variable capacitor, Johnson 187-0103-005 or equiv.
C51 — 9-pF variable capacitor, Johnson 189-0503-005 or equiv.
C53 — 24-pF variable capacitor, Johnson 189-0509-005 or equiv.
D1, D5 — 8.2-V 1-W Zener diode, 1N4738.
D2, D4 — Silicon switching diode, 1N914.
D3 — 7.5-V 1-W Zener diode, 1N4737.
L1, L7 — 7-1/2 turns no. 28 enam. wire on Miller 25A014 form (white core).
L3 — 19-3/4 turns no. 26 enam. wire on Miller 25A014 form (green core).
L4 — 2-3/4 turns no. 26 enam. wire wound over L3.
L6 — See Fig. 3.
Q1, Q2, Q10 — Npn silicon amplifier transistor, 2N918.
Q3, Q4, Q7 — Npn silicon switching transistor, 2N2369.
Q5, Q6 — N-channel JFET, 2N4416.
Q8 — CTC CHE-0, driver transistor, Communications Transistor Corp.
Q9 — CTC C1-12, power transistor, Communications Transistor Corp.
R21, R22 — See text.
R26, R27 — 100-ohm potentiometer, linear taper, pc mount, TRW X201R101B.
R28, R29 — 500-ohm potentiometer, linear taper, pc mount, TRW X201R501B.
RFC1 — Rf choke, 20 turns no. 28 enam. wire wound on 1000-ohm 1/4-watt resistor.
RFC2 — Rf choke, 12 turns no. 24 enam. wire, close wound, 1/8-inch diameter.
RFC3 — Rf choke, 6 turns no. 24 enam. wire, close wound, 1/8-inch diameter.
RFC4, RFC7, RFC9 — Rf choke, 7 turns no. 24 enam. wire, close wound, 1/8-inch diameter. RFC4 has Amidon 43-101 ferrite bead on cold end.
RFC5, RFC8, RFC10, RFC11 — Rf choke, 2-1/2 turns no. 24 enam. wire wound on large ferrite bead (Amidon 43-801).
RFC6, RFC12 — Rf choke, 9 turns no. 24 enam. wire, close wound, 1/8-inch diameter.
RFC13 — Rf choke, 2-1/2 turns no. 28 enam. wire wound on ferrite bead (Amidon 43-5111).
Y1 — 67.333-MHz crystal, 0.001-percent tolerance, HC-25/U holder.
Y2 — OSCAR crystal 67.833-MHz, 0.001-percent HC-25/U holder.

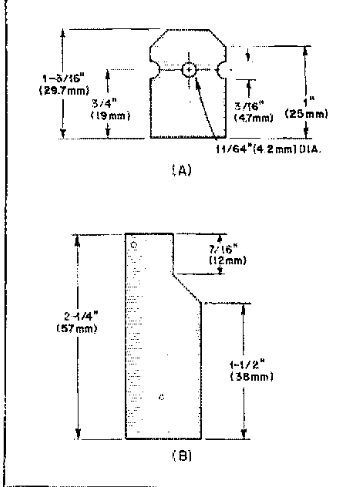


Fig. 2 — Templates for making the heat sinks for Q8 (at A) and Q9 (at B). The material is 3/32-inch (2 mm) thick aluminum. The heat sinks are attached to the circuit board with no. 2-56 fasteners.

board. Transistors Q8 and Q9 require heat sinks. Construction details for the heat sinks are given in Fig. 2. Connect only one lead of RFC10 until the bias voltage for Q9 has been set. Cleaning the circuit board of excessive rosin with a rosin removing solvent such as Kester AP20 will lend a professional appearance to the finished project.

Set potentiometers R26 and R27 to midrange. Before applying drive, remove the dc power from the oscillator terminal. Ground the base connections of Q8 and Q9 with short jumper leads. The supply voltage can be between 12 and 13.8 volts, however it should be the same voltage that will be used in future operation. Connect +12 volts to the exciter terminal and through a milliammeter to the loose end of RFC10. The potential measured across D3 should be approximately 7.5 volts. If it is, remove the jumper leads from the base connections. Adjust R26 for a Q8 collector current of 2 to 3 milliamperes. If this cannot be done, the combined resistance of R20 and R21 must be changed. Increasing the combined resistance will decrease collector current and decreasing the combined resistance will increase the collector current.

Once the proper operating point (2 to 3 milliamperes) is set, install R21 (if used) and permanently install RFC10. The same procedure is followed for setting the bias for Q9. The milliammeter is connected in series with the PA terminal and resistors R22, R23 and R27 are adjusted for a collector idling current of 5 milliamperes.

Connect +12 to +13.8 volts to the OSC, EXC and PA terminals, a 50-ohm load to the 432-MHz output connector and an hf exciter capable of delivering 1-V pk-pk at 28 MHz to the i-f input. Too much drive signal will decrease the output, cause nonlinear operation, and if the level is much above 1 volt will destroy the mixer FETs. The proper drive level can be verified by measuring the 28-MHz exciter output into a 50-ohm load with an rf probe and setting it for 0.6 volt before connecting it to the transverter.

All tuning adjustments in the transverter are made for maximum output at 432 MHz. If an rf wattmeter is not available use an rf probe and electronic voltmeter as an indicator. Final amplifier collector current should not be allowed to exceed 200 milliamperes. A counter or 432-MHz receiver can be used to determine that the transverter is operating on the proper frequency. Mixer-output link

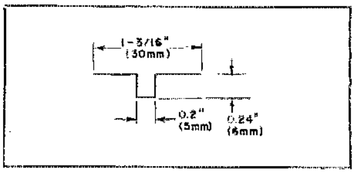


Fig. 3 — Dimensions for L6. The material is no. 24 copper wire. If possible it should be silver plated.

L6 should be adjusted for minimum oscillator-chain feedthrough to the output. This should be checked with the i-f excitation removed. The best setting for L6 is usually in the vertical position. The finished transverter may be mounted in a box made from pc-board material. Recheck all tuning adjustments after mounting the unit in the box.

Performance

Although the transistors used are not linear types, the ssb quality is good. Two-tone tests performed by the author showed the distortion products to be down a minimum of 36 dB. Tests were made from a distance of one mile with the transverter driving a 35-watt amplifier. No spurious signals were detected in the output over a frequency range of 200 to 500 MHz.

A word of thanks is due WAØQLP for his help and encouragement with this project. Also to the many who have built this transverter and to those who are using ready-to-operate units, a big thanks.

Footnotes

[1]"A 432/435-MHz Converter For OSCAR 7," *AMSAT Newsletter*, June, 1974, p. 18.
[2]Complete or basic parts kits are available from the author.

Strays

ROUGH WEATHER FOR THE CLIPPERTON DXPEDITION

☐ The sailing vessel *Felipe* was en route from San Diego to Clipperton Island for a DXpedition when high winds and heavy seas put her in distress. Weather information was unobtainable through normal channels, so ham radio came to the rescue.

Hugh Vandegrift, WA4WME, aboard ship, contacted Bill Christian, K4IKR, of Huntsville, AL. Bill immediately informed the Weather Service Office. Eventually, the San Francisco office relayed to K4IKR where weather conditions were best, and Bill was able to help the *Felipe* steer out of the rough weather. All arrived safely at Clipperton. — *W5VOW*

Burt Simpson, WA6GBQ (right), president of the Santa Clara County (CA) Amateur Radio Association presents a check for $50 to ARRL Pacific Division Director Bill Stevens, W6ZM.

HELPING HAM RADIO GROW

☐ ARRL-affiliated clubs throughout the United States are showing increasing interest in the new League program to aid the growth of amateur radio in developing countries. This money will enable Headquarters to send one complete, simple, 20-meter station in kit form to a needy student of amateur radio in one of the developing countries of Africa or Asia. Is your club interested? Complete details are available from the International Services Officer, ARRL Hq., Newington, CT 06111. — *WA6IDN*

SMILE FOR YOUR LICENSE

☐ Much the same as passports, FCC radiotelegraph licenses must now bear the licensee's photograph. Full details are available from FCC, Regional Services Division, 1919 M St., N.W., Washington, DC 20554.

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

HOW DANGEROUS IS RF RADIATION?

❑ Workers at Motorola have recently conducted experiments of great interest to most amateurs. Their results have been published in several IEEE publications.[1-3] I'm grateful to Mr. Ronald Brecher, WA2EUN, who supplied a copy of the March, 1977, document.

The experimenters constructed a simulated human head and torso and exposed it to the radiated fields from 150- and 450-MHz 6-watt, handheld transceivers. Both radios were equipped with helical or "rubber duck" antennas. In addition, tests were performed with a 1/4-wavelength antenna installed on the 450-MHz unit. A thermal probe was used to measure temperature rise due to exposure. These experiments were performed because of concern that the newer, high-power units might pose a health hazard. Previous measurements of the field strength surrounding these radios had indicated that an incident field intensity exceeding 10 mW/cm^2 might exist. This is a safety standard for human exposure to rf energy at higher frequencies.

Because the field would be concentrated by a probe causing nontypical localized heating, the probe was removed while the transmitter was operating. The "dummy" was exposed for from 15 to 60 seconds. After power was removed, the probe was again inserted and the temperature change determined. Steps were taken to prevent thermal transients caused by insertion and removal of the probe. It would have been possible for heating to occur in small areas not being monitored by a probe. To look for "hot spots," an IR (infrared) scanner was used to take thermograms of the dummy.

Assuming the transceiver was positioned as it would be during normal operation, no significant heating effects were noticed on either band. Even at 450 MHz, the temperature rise was slight. At a shallow probe depth (0.2 inch or 5 mm), the greatest temperature rise was less than 1°C. At deeper probe penetrations the temperature rise was less. Attempting to determine possible hazards from a measurement of radiated field intensity may cause misleading results. The low total energy and high field impedance which exist when such radios are brought in close proximity to the body will result in lower energy transfer than field-strength measurements alone would seem to infer. For example, at a point two inches (50 mm) from the helical antenna of the 150-MHz transmitter (Fig. 1), a Narda field probe measured a maximum field intensity of 168 mW/cm^2. This value greatly exceeds the 10 mW/cm^2 exposure standard. Measurements based on the penetrating effects at the same point indicate a maximum power flow density in tissue of 2.8 mW/cm^2. On 450 MHz, with the same spacing from the 1/4-wavelength *whip* antenna (Fig. 3), a maximum radiated intensity of 16 mW/cm^2 was found. Power-flow density was only 2.5 mW/cm^2. The radiation meter indicates a hazardous condition, while actual measurement of the effects shows this is not the case. Power *absorption* in all cases was less than 1 mW/cm^2.

IR thermograms did not detect any unusual hot spots. A health hazard exists when the tip of the antenna is close to the eye (within 0.2 inch or 5 mm) and the transmitter is operated. In this case, an rf burn will result on the cornea. The thick plastic cap on the tip of the antenna makes this unlikely to occur. When the radios are held in the normal position for use, no eye hazard exists.

While these tests were performed at 150 and 450 MHz, I think it is safe to assume we need not fear our portable 220-MHz rigs either. These tests point out the fallacy of using radiated field intensity as a criterion of safety. Some consumer publications have begun to measure the field strength radiated from CB radios. Consumers have been warned not to stand close to the mobile whip while a 5-watt CB transmitter is operating, due to the high field strength! These papers have shown that radiated power may greatly exceed that which is absorbed and converted into heat. Amateurs should continue to exercise prudence when using uhf and microwave equipment, of course. It does seem that our portable transceivers pose no threat to our health. — *J. E. Kearman, W1XZ, RFD, Collinsville, CT 06022*

[1] Balzano, Garay and Steele, "Energy Deposition In Biological Tissue Near Radio Transmitters At Vhf And Uhf," *IEEE 1977 Conference Record of Vehicular Technology Group*, March, 1977. Experiments at 150 and 450 MHz.

[2] Balzano, et al, "A Comparison Of The Energy Deposition Between Portable Radio Transmitters At 900 And 450 MHz," *IEEE 1978 Conference Record of Vehicular Technology Group*, March, 1978.

[3] Balzano, et al, "Heating of Biological Tissue in the Induction Field of VHF Portable Radio Transmitters," *IEEE Transactions On Vehicular Technology*, May, 1978. Results of experiments at 150 MHz.

Fig. 1 — This drawing shows the position of the 6-watt 150-MHz radio in relation to the head of the dummy. In this configuration, with the transmitter operated for 60 seconds, the temperature increases noted were observed.

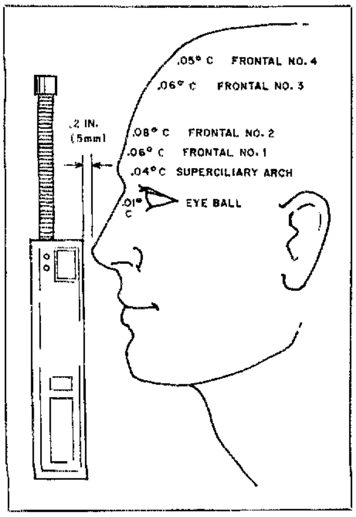


Fig. 2 — Position and thermal effects of a 6-watt, 450-MHz radio equipped with a helical or "rubber duck" antenna. A "hot spot" exists near the tip of this antenna. The eyeball is shadowed in its recess and receives very little exposure.

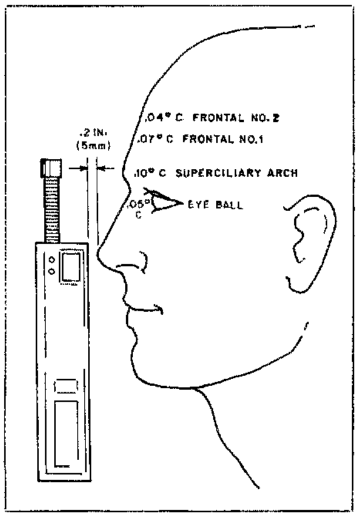
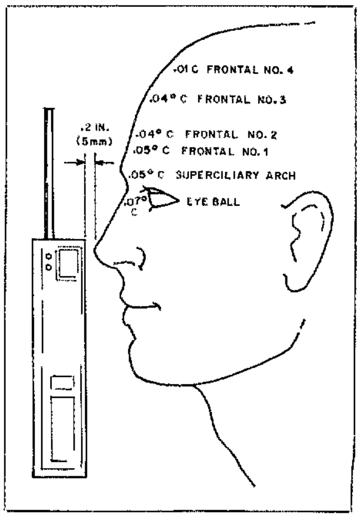


Fig. 3 — The same 450-MHz rig, this time with a 1/4-wavelength whip installed. Power density in the eye is greater, but still very low.



☐ The article, "RF Heating in the Ham Bands," which appeared in *QST* for June, 1978, includes some statements which, in light of extensive experiments performed in our research laboratories, are not correct. Although Dr. Ruderman properly warns amateurs to use caution to avoid unnecessary exposures, the power-density levels he quotes are too high to be realistic. At a distance of 10 meters from a half-wavelength 10-meter dipole connected to a one-kilowatt output source, the power density in the horizontal direction is about 0.08 mW/cm², not 0.8 mW/cm² as stated by the author. This last value would be found at a distance of 10 meters in the bore sight direction of a 10-dB-gain beam antenna.

Turning to the vhf bands, Dr. Ruderman states that a mobile installation transmitting 10 watts effective radiated power (erp) from an antenna mounted on the left fender, less than one meter from the driver (how much less isn't specified), could expose him to a power density of 10 mW/cm². This value is not corroborated by experimentation. Some research departments at Motorola, Inc., have conducted careful measurements of power density inside the cabins of cars equipped with mobile transmitters. The Narda model 8310 radiation monitor, calibrated for vhf operation, was used. In the situation described by Dr. Ruderman, at a distance of 1.1 m between driver and antenna, the maximum power density measured was 0.05 mW/cm², substantially lower (23 dB) than the 10 mW/cm² level quoted by Ruderman. The 0.05 mW/cm² level is slightly less than the power density one would find in free space (in the direction of maximum gain) at about one meter from a vhf dipole connected to a 10-watt output source.

In the matter of portable transmitters, Dr. Ruderman states that 30-40 mW/cm² power densities exist in the immediate vicinity of a 144-MHz antenna connected to a 1-watt-output transmitter. These values are not supported by experimental evidence either. First of all, it is difficult to define, let alone measure, power density so close to an rf source. At a point near the radiator, different parts of an antenna contribute fields propagating in completely different directions, precluding any obvious definition of power flow. In these conditions, one can measure only energy density (mJ/cm³), by separately evaluating the E and H fields with appropriate instrumentation. In the near field, however, the electromagnetic energy density does not have a simple relationship to power flow. Unlike the far-field case, part of the energy is stationary (static type) and part is propagated. To avoid these difficulties, we measured power deposited in simulated humans, by operating 6-watt-output 150-MHz portable radios equipped with helical antennas. Helices were selected because they caused much higher energy density readings in field probes than did quarter-wavelength telescopic antennas. The results of these measurements were presented in a recent paper.[4] The experiments have shown that, at vhf, electromagnetic energy in the immediate proximity of a portable radio antenna does not penetrate into muscle or brain tissue of the human body. There is energy deposition only in the very surface fatty layers. In addition, it was found that if a user operates a 1-watt portable radio with the case 0.2 inch (5 mm) from his mouth, the maximum absorbed power density (which can be measured from heating effects) is less than 0.2 mW/cm². This value is much lower than the deposition levels (8-10 mW/cm²), due to an incident power level of 30-40 mW/cm² which, Dr. Ruderman states, exist near a portable transceiver.

I would like to reassure radio amateurs of the absence of any detected thermal radiation hazard from commercially available mobile and portable radio transmitters, if such equipment is properly installed and operated in accordance with simple common sense. — *Quirino Balzano, Ph.D., Manager, Antenna Systems Research Laboratory, Communications Division, Motorola, Inc., 8000 West Sunrise Blvd., Ft. Lauderdale, FL 33322*

[4]Balzano, et al, "Heating of Biological Tissue in the Induction Field of Vhf Portable Radio Transmitters," *IEEE Transactions on Vehicular Technology*, Vol. VT-27, No. 2, May, 1978.

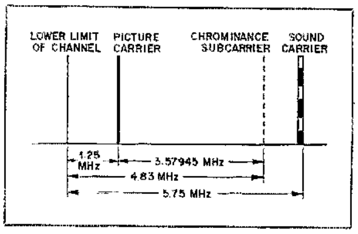
COLOR TVI

☐ I would like to call your attention to a TVI phenomenon that has been in existence for years, yet which has never received much publicity. It is a "color TVI" problem since it results in colored hash marks on color TV programs only. There are absolutely no signs of interference on black-and-white pictures.

For the past few years, a number of amateurs in the Detroit area have been experiencing color TVI on channel 4. While I have been successful in pinpointing the cause, I have had no success in trying to cure it. Color TVI occurs when a harmonic from an amateur transmitter beats against, or heterodynes with, the chrominance subcarrier frequency transmitted by the TV station. The color subcarrier is a comparatively weak signal which rides piggy-back on the main picture carrier. It is 4.83 MHz above the lower frequency limit of the TV channel (see Fig. 4).

Because of the low level of this signal, it is extremely susceptible to interference. The interference increases as the color brilliance level is increased. The number, width and angle of the stripes vary in relation to the difference between the heterodyne and the 15,734.264-Hz horizontal oscillator frequency. On 20 meters, the stripes appear to make a 360-degree rotation about every 3.15 kHz (fifth harmonic of 3.147 kHz ≈ 15,734) across the interfering range. The following TV channels will be susceptible to interference from amateur transmitters:

Fig. 4 — Diagram showing the relative positions of the video carrier, chrominance subcarrier, and audio carrier in a broadcast TV signal. In practice, the actual position of the video carrier may be offset by ± 10 kHz. The frequency of the chrominance subcarrier, which is a modulation of the video carrier, is considered to be 3.57945 MHz. When the harmonic of a transmitted signal falls near the position of this subcarrier in the signal, a heterodyne is generated. This beat frequency generates bars which appear on the screen of a color TV set.



Channel 2: Interference range 29.3-29.5 MHz. The second harmonic of 29.415 MHz = 58.83 MHz, the color subcarrier frequency.

Channel 4: Interference range 14.1-14.25 MHz. The fifth harmonic of 14.17 MHz = 70.83 MHz, the color subcarrier frequency.

Channel 6: Interference range 28.8-29.0 MHz. The color subcarrier frequency is 86.83 MHz, the third harmonic of 28.94 MHz.

A number of tests have been made from seven amateur stations located as close as two miles (3.2 km) to the channel 4 transmitter. All stations produced color TVI on channel 4 when operating on 20-meter sideband between 14.2 and 14.25 MHz. Several makes of amateur and television equipment were used. Various types of low-pass filters were tried without improvement. All TV receivers had outdoor antennas and were equipped with high-pass filters. I'd appreciate hearing from anyone who has solved this problem. — *Ralph A. Dage, W8PHZ, 8078 Lochdale, Dearborn Heights, MI 48127*

ON "PREDICTING RADIO HORIZONS AT VHF"

☐ I read Walker's article (*QST*, June, 1978, page 28) with interest. However, I noticed two errors related to the 33-percent additional distance factor mentioned by the author.

This adjustment factor serves to account for atmospheric *refraction,* as Walker correctly states on page 28. It is *not* related to *diffraction,* as discussed on page 29. The 33-percent factor is incorrectly used. In the equations used to calculate distance to the horizon, the radius of the earth should be increased by one-third. The amount of atmospheric refraction, or bending, depends upon the rate of change of the *index of refraction* with respect to height. At vhf and uhf, the index is a function of atmospheric pressure, temperature and water vapor content of the air. For average conditions the curvature is on the order of $3.9 \times 10^{-5}\ \text{km}^{-1}$, although it may vary greatly from this figure with time. Curvature of the earth is about $15.7 \times 10^{-5}\ \text{km}^{-1}$. This represents a radius of curvature of

$$\frac{1}{13.8 \times 10^{-5}}$$

or 7246 km, a value *33 percent larger* than that of earth. Solving for the distance to the horizon (x), we find it is related to the radius of the earth (R) and antenna height (h), as $x = \sqrt{2Rh}$, for h << R. For the optical horizon, R is approximately equal to the radius of the earth, 6370 km. For the vhf radio horizon, R should be increased by 33 percent, so that

$$x = \sqrt{(2)(1.33)(6.37 \times 10^{-6})(h)}$$
$$\approx 4120\sqrt{h}$$, where distances are in meters.

Note that this increases the distance to the radio horizon by a factor of $\sqrt{1.33}$, or 1.15 times the distance to the optical horizon. This equation is essentially the same as one appearing on page 11 of the *Antenna Book* (13th ed.), which was, in part, the basis for Fig. 1-6 on page 12 of that edition. The radio horizon is about 15 percent farther from the observer than the optical distance. Fig. 2 of Walker's article gives distances which are about 15 percent too high. — *Russ Lee, WA4VLE, 933 Bluestone Rd., Durham, NC 27713*

[Editor's Note: *We* goofed, not Mr. Walker, the author. His original information presented data based on the optical horizon only, and we supplemented it during editing to provide data on the radio horizon.]

Product Review

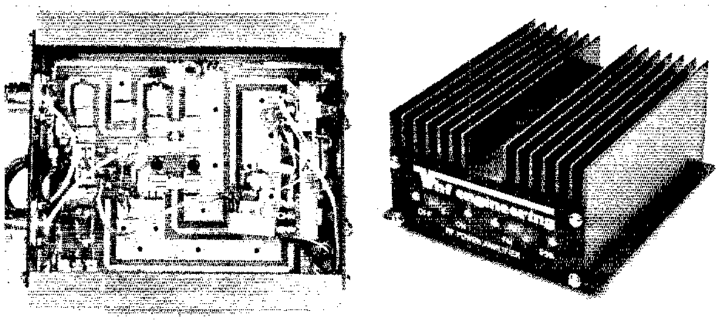
VHF Engineering "Blue Line" RF Power Amplifier

Most vhf/uhf transceivers and transverters now on the market generate about 10 watts output. This is especially true of the multimode rigs which are seeing increasing use on cw and ssb, particularly on OSCAR. Now, you can have a lot of fun at that power level; in fact, if you're using an efficient, high-gain antenna for satellite work you're well advised not to run any more, or you'll show up on the list of "bad guys" who are overloading the satellites. But there are hordes of hams who need a bit more power, at least occasionally, and a half-dozen companies whose products are designed to fill that need.

One of the most interesting of these companies is VHF Engineering. Started literally as a basement operation by Bob Brown, W2EDN, just a few years ago, VHF Engineering now employs about 60 people in ever-expanding facilities in Binghamton, NY. Best known for its line of repeaters, the firm got its start supplying inexpensive kits for vhf fm, and now enjoys a booming export business and a growing list of government and commercial customers.

The "Blue Line" was introduced last year as a full line of vhf/uhf amplifiers in factory-wired form. Pete Rau, WA2EYN, is responsible for the design. The various models use common components and circuitry wherever possible, including circuit boards (see photo). The model chosen for testing is the BLE 10/40, which produces 40 watts of clean output when driven with 10 watts in the 420-450 MHz band. The BLE 10/40 would be of particular interest to OSCAR 7 Mode B operators and to users of 10-watt-output fm, cw and ssb rigs who are looking for an easy way to boost their power by 6 dB.

As with most similar amplifiers, the "Blue Line" units are simply installed in the feed line between the transceiver and the antenna. Connectors on the BLE models are type N. The only other connection is to a hefty 12-volt (nominal) supply. Internal circuitry switches the amplifier into the line when rf drive is applied to the input, and out again when the drive is removed. An illuminated front-panel switch selects Class C or linear operation, and in the latter position also provides a half-second delay in the relay dropout to eliminate relay chatter during cw and ssb operation. Another switch disables the amplifier for straight-through operation. There are no internal tuning adjustments; the only reason you might have for opening the attractive blue-and-black box would be to admire the component layout.



Internal and external views of the VHF Engineering BLE 10/40 amplifier. The circuit board is double-sided G-10 glass-epoxy board with plated-through holes. The same board is used for all of the 40-watt amplifiers in the "Blue Line" series; not all of the stripline inductor is utilized in this model.

Because of the ease with which such an amplifier can be installed and operated, a word of caution is in order. Forty watts of uhf energy deserves to be treated with a certain amount of respect. Most roof-mounted antennas will place the radiated power far enough away from people to stay well within the permissible levels of exposure. However, indoor antennas and those mounted close to the ground, including mobile antennas, should be used with care, especially if there is a chance of exposure for a long period of time.

In operation, the amplifier has proved to be at least as free of spurious emissions as any 432-MHz exciter we have been able to find to drive it. The FCC does not have specific limitations on spurious emissions for equipment operating above 235 MHz, but the more stringent test is whether you can operate without affecting your neighbors, ham or otherwise! In this regard, the BLE 10/40 passes muster nicely. The second harmonic was measured in the ARRL lab as being 58 dB down. — *K1ZZ*

VHF Engineering BLE 10/40 RF Power Amplifier
Frequency range: 420-450 MHz.
Power output: 40 watts, nominal, with 10 watts drive.
Dimensions (HWD): 2-3/4 × 5-5/8 × 7 inches (70 × 143 × 178 mm), including switches, connectors and mounting flanges.
Weight: 2 pounds, 7 ounces (1.1 kg).
Power requirements: 13.5 V dc, approx. 6 A on ssb, 5 A on fm, for rated output.
Price class: $180.
Manufacturer: VHF Engineering, Box Q, 320 Water St., Binghamton, NY 13901.

FLUKE 8020A MULTIMETER

Digital. The mere mention of the word in promotional literature for a piece of gear suggests state of the art and associated high sales. Unfortunately, digital readout offers only greater *precision* as opposed to analog readout systems. The *accuracy* of a readout is determined by the scheme used for the measurement and the quality of the measurement equipment, not by the medium (digital or analog) itself. What good are five digits of readout if the accuracy is low enough that the last two digits don't mean anything?

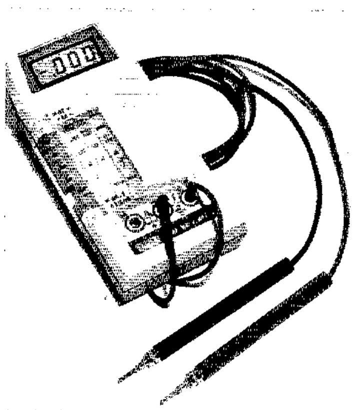
If a highly accurate means of measurement is employed in a digital readout system, a totally different situation exists. Full advantage of the greater readout precision can be taken, and readings "down to a gnat's eyebrow" are possible, with far greater ease than with an analog system. The Fluke 8020A is just such a piece of test gear.

The John Fluke Manufacturing Company has been in the test-instrument business for years. Only now are they entering the consumer market with the 8020A. The quality associated with their other equipment is retained with the 8020A.

The 8020A is a 3-1/2-digit portable multimeter. All the standard VOM functions are included as well as a conductance function. The table shows all the functions as well as their associated ranges. Any of the functions or ranges can be selected from a row of interlocking push buttons on the side of the unit.

There are two conductance ranges on the 8020A; 0.1 nanosiemens (nS) to 200 nS and 0.001 millisiemens to 2 mS. (A siemens is the new international unit for conductance. One siemens is equal to 1/Ω, replacing the mho.) This translates to effective resistance ranges of 5 MΩ to 10,000 MΩ and 500 Ω to 1 MΩ. High values of resistance such as capacitor leakage can be measured, as well as dc current gain (beta) of transistors.

The resistance ranges also offer an interesting feature. Some of the ranges (200 Ω, 20 kΩ, and 200 kΩ) allow in-circuit resistance measurements. The open-circuit voltages produced on these ranges will not forward bias semiconductor junctions, which would cause invalid measurements. Thus semiconductors need not be removed from circuits under test. Thoughtfully Fluke has provided for testing of semiconductors. The remaining resistance


The Fluke 8020A multimeter with test leads. The large, easy-to-read liquid-crystal display keeps current consumption down, making battery life long.

Fluke Multimeter

Functions: Dc volts, ac volts, dc current, ac current, resistance, conductance.
Dc voltage ranges: 200 mV, 2 V, 20 V, 200 V, 1000 V.
Dc voltage accuracy: ±0.25% of reading +1/−0 digit.
Dc voltage input impedance: 10 MΩ.
Ac voltage ranges: 200 mV, 2 V, 20 V, 200 V, 750 V rms.
Ac voltage accuracy: Depends on frequency, but is better than 5% of reading +5/−0 digits through 5 kHz.
Ac voltage input impedance: 10 MΩ, capacitance 100 pF.
Resistance ranges: 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2000 kΩ, 20 MΩ.
Conductance ranges: 2 mS, 200 nS.
Dc current ranges: 2 mA, 20 mA, 200 mA, 2000 mA.
Dc current accuracy: ±0.75% of reading +1/−0 digit.
Ac current ranges: 2 mA, 20 mA, 200 mA, 2000 mA.
Ac current accuracy: Depends on frequency and range, but is better than 2% of reading +2/−0 digits.
Power: 9-volt alkaline battery recommended or Fluke Model A-81 battery eliminator.
Battery life: 200 hours typical.
Battery indicator: Display reads BT when battery life of 20% remains.
Size (HWD): 1-1/2 × 3-3/8 × 7-1/8 inches (38 × 86 × 181 mm).
Weight: 13 ounces (370 grams) with battery.
Price class: $170.
Manufacturer: John Fluke Mfg. Co. Inc., P. O. Box 43210, Mountlake Terrace, WA 98043.

ranges provide a measurement voltage large enough to forward bias a p-n junction, allowing checks to be made.

The unit is based on a custom LSI chip. Analog-to-digital conversion as well as readout functions are performed by this one chip. A sturdy plastic case houses the electronics. The case is durable enough to withstand falls from a workbench without a scratch. Large liquid-crystal displays provide the readout. Overload protection is provided on all ranges, protecting both the instrument and the user.

By virtue of the liquid-crystal display, battery life is quite sustained. Fluke claims up to 200 hours of use from a single 9-volt alkaline transistor radio battery (which they supply). A battery eliminator is available as an option, as is a carrying case and specialized probes. Test leads are supplied with the 8020A.

Documentation of the unit is well provided in the manual. Measurement techniques as well as theory of operation are described in detail. A certificate of calibration, tracing the measurement standards used for calibrating that particular instrument, is among the documents which come with the 8020A. Fluke claims long-term calibration adherence in the 8020A (1 year). Fluke service centers throughout the world can refurbish and recalibrate any 8020A out of warranty (the warranty is valid for 1 year) for a fee of $40, ensuring continued reliability of measurements made by the owner. — *K1JX*

WILSON ELECTRONICS SYSTEM ONE 4-ELEMENT TRI-BAND ANTENNA SYSTEM

The antenna arrived during a mid-winter New England snowstorm; it was well below freezing outside and the prospects, just before Christmas 1977, of getting the antenna up for a quick preview were just about nil. However, making a few concessions to family convenience, I unpacked all the tubing and hardware in the family room and assembly began. Taking it in easy stages, a few evenings later I completed the assembly of the *five* elements, as well as the five sections which comprise the boom. Then the entire antenna was removed to the garage where it hung out of the way awaiting the end of the holidays. Needless to say, Christmas was barely over before the urge to get the antenna on top of the 60-foot tower became overpowering.

The cold (+15°F or −9°C), the slippery and precarious conditions on the hill in the vicinity of the tower, and the icy brook that had to be crossed countless times are not really part of this review. The actual raising of the antenna on New Year's Day, however, will stand out in this reviewer's mind for a long time. Winter is definitely not the recommended time for erecting antennas in the Northeast.

System One instructions are detailed drawings that do an excellent job of explaining how all the parts fit together; and there are *many* parts to be assembled. However, in attempting to follow the diagrams or exploded views, several times I made the mistake of installing a piece of hardware that subsequently had to be removed to allow another piece to be slid onto the boom. A suggestion has been made to the manufacturer that, at least as far as the boom is concerned, detailed sequential instructions be supplied. But then, perhaps you will be luckier — or smarter. A few minor errors had crept into the instructions. Wilson has prepared new instructions which correct the errors found. These new instructions are now being shipped.

Basically, the System One antenna functions as four elements on 10, 15 and 20 meters. The *fifth* element mentioned above does duty as the reflector on 10, where the spacing would otherwise be unsatisfactory using the element that functions as the reflector on 15 and 20 meters. While there are five elements on the boom, it defies convention and common sense to call it a five-element beam. Only four elements work at any time. These antennas are a definite improvement over the previous types of triband antennas, but let's not get carried away.

The Wilson System One employs dual-band traps. That is, each trap includes the circuitry to function on 10 and 15 meters. Two sets of adjustments are provided, one for cw and one for phone. At resonance, and for a reasonable distance either side, the VSWR is below 1.5:1. However, if you frequently work both modes (as this reviewer does), a third set of adjustments, straddling the two that are provided, would be most welcome. This has been suggested to Wilson. For example, if the resonant points for phone operation were 28.50 instead of 28.65 MHz, 21.25 instead of 21.325 MHz, and 14.2 instead of 14.275 MHz, the setting would more nearly serve the needs of those who prefer the low end of each of the phone bands while enhancing cw operation as well. As is, when the antenna is set for phone operation, the VSWR at the low end of the cw segment will be well over 2:1.

A 1:1 balun is recommended by Wilson for use with the System One, however it is not provided. Imagine the disappointment of a new purchaser in a remote area who finds, as he is about to hoist the antenna to the top of his tower, that he still needs something else before he can put the antenna on the air. Wilson Electronics makes the balun, and it has been suggested that the balun be made part of the antenna package with the price adjusted to include the cost of the balun.

All hardware and fittings are first class, and every last nut and bolt was present. Wilson has done a fine job of providing an antenna that goes together in a straightforward manner, and that also will give the operator the convenience of working three bands with one antenna while offering performance nearly equal to monoband antennas.

The boom is approximately 25 feet 6 inches (7.8 m) in length, while the longest element is approximately 26 feet 6 inches (8.1 m).

Since the first of the year, hundreds of contacts have been made in perhaps a hundred countries while running 500 watts PEP during casual operation. The antenna seems to perform equally well on all bands. — *W1SE*

Wilson System One Tri-Band Antenna

Weight: 55 lb (25 kg).
Input impedance: 50 ohms.
Form of matching: Beta.
Surface area: 8.6 ft² (0.8 m²).
Maximum power input: Legal amateur limit.
Price class: $250.
Manufacturer: Wilson Electronics Corp., 4288 S. Polaris Ave., Las Vegas, NV 89119.

COMMUNICATIONS POWER WM-7000 WATTMETER

Are you looking for a portable rf wattmeter that can serve your shack at home, mobile or perhaps at that vacation QTH? The Communications Power WM-7000 should do the job. This unit boasts a large (3-1/2-inch or 89-mm wide) easy-to-read meter and displays a number of necessary station measurements: forward watts in 20-, 200- or 1000-watt scales, VSWR calibrated from 1.2:1 to 3:1, and peak or average power. A common 9-volt transistor-radio battery supplies power to the unit so that no ac is necessary. This reviewer operates quite a bit of hf mobile, so the portability of the WM-7000 has been found particularly convenient. The VSWR scale has been very helpful in getting some mobile-antenna loading coils adjusted to resonance.

There is no means for checking to see that power to the unit is turned on, except for the position of the on-off switch; therefore, two batteries were prematurely run down by my accidentally leaving the WM-7000 turned on for a couple of days at a stretch. How about an LED for an on/off indicator? There *is* a handy switch for checking the condition of the battery, and it appears that under normal use, there should be long battery life, especially if an alkaline cell is used.

A look inside the unit shows neat and tidy construction. The WM-7000 is made in the USA by Communications Power, Inc., 2407 Charleston Road, Mountain View, CA 94043. — *WA1EEA*

Communications Power WM-7000 Wattmeter

Description: Peak-reading wattmeter/SWR indicator.
Size: 6 × 5 × 3-1/2 inches (152 × 127 × 89 mm) HWD.
Weight: 1 lb (0.5 kg).
Color: White cabinet with black panel; white lettering.
Cabinet: Aluminum.
Ranges: 20, 200, 1000 watts; 1.2 to 3:1 SWR.
Price class: $65.

PARTS PROCUREMENT CORNER

Already the letters are rolling in. At the time of this writing (late June) we've received a dozen or so letters concerning this column. If this is any indication of what's in store, there shouldn't be any problem filling this column with useful material each month. Most of the letters we've received thus far read something like this. "Hey, have you heard about Joe's Discount Parts Emporium? Send them a quarter and they'll mail out a catalog. Here's the address." Guess it's not too surprising that we've never heard of many of the suppliers.

Last month we listed a few of the well-known, large-scale distributors across the country. It's only fair that this month we highlight some of the smaller, perhaps not so well-known distributors. If you would like to have the name of your outfit included in a subsequent listing drop us a line and a copy of your catalog.

All of the outfits carry a varied line of products too numerous to mention. A self-addressed stamped envelope (business size) will most likely assure a return of one of their catalogs or flyers.

Jameco Electronics
1021 Howard Ave.
San Carlos, CA 94070

Delta Electronics
P. O. Box 1
Lynn, MA 01903

D & V Radio Parts
12805 W. Sarle
Freeland, MI 48623

Electronic Instrument & Specialty Corp.
MC Division
5 Lowell Ave.
Winchester, MA 01890

Adva Electronics
Box 4181
Woodside, CA 94062

Alpha Electronic Laboratories
2302 Oakland Gravel Rd.
Columbia, MO 65201

Amateur Radio Center
11 S. Morris
Mesa, AZ 85202

Poly Paks
P. O. Box 942
Lynnfield, MA 01940

Circuit Specialists Co.
P. O. Box 3047
Scottsdale, AZ 85257

Fair Radio Sales
Box 1105
Lima, OH 45902

G. R. Whitehouse & Co.
11 Newbury Drive
Amherst, NH 03031

Key Electronics
P. O. Box 3506
Schenectady, NY 12303

John Meshna Jr.
P. O. Box 62
E. Lynn, MA 01904

Caddell Coil Corp.
Poultney, VT 05764

Modern Radio Laboratories
P. O. Box 1477
Garden Grove, CA 92642

If you are looking for ready-made circuit boards for amateur projects, there are at least two names that come to mind. Contact them directly to find out what boards they have available.

Circuit Board Specialists
P. O. Box 969
Pueblo, CO 81002

RTC Electronics
P. O. Box 2514
Lincoln, NE 68502

Circuit Board Specialists also provides complete parts kits for some of the projects featured in *QST* and other League publications. Again, contact them directly for information on what is available.

For the serious vhf-er a special deal is available on GaAs FETs (gallium-arsenide FET — extremely low noise), courtesy of Microwave Semiconductor Corporation. See June 1978 *QST* for particulars. These devices, designated MSC H001, are available only to licensed amateurs in quantities of from one to 10 units. The special amateur price is $40 per unit. To order, send a certified check or money order (no cash) payable to Ham Trans, P. O. Box 383, South Bound Brook, NJ 08880.

Be sure to include your call sign with your order. Please do not call about these devices since this special offer is made possible by elimination of normal administrative costs. No phone orders will be accepted. — *W1VD*

NEW BOOKS

Handbook of Linear Integrated Electronics for Research, by T. D. S. Hamilton. Published by McGraw-Hill, cloth-bound edition 416 pages, 8 × 10 inches. Price: $24.50.

If you're interested in the theory behind linear integrated circuits (ICs) — how the devices work, and their functions in circuits — you should be interested in this new publication from McGraw-Hill. Although this book is intended for use mainly by research scientists and engineers who use electronics in their work, the emphasis is on theory rather than specific applications, thus making it useful to those advanced amateurs interested in this area. Also included is up-to-date info on recent developments and available products.

The first chapter is a "Review of Basic Circuit Theory," which goes from Ohm's law through Laplace transforms. The next seven chapters cover op amps, feedback systems, various amplifiers, oscillators, circuit functions, power supplies and circuit devices. The last two chapters discuss optoelectronics and signal detection.

Handbook of Linear Integrated Electronics for Research contains over 300 illustrations, author and subject indexes, and an extensive set of references. — *K1TX*

110 Electronic Alarm Projects, by R. M. Marston, published by Hayden Book Co., Inc., 50 Essex St., Rochelle Park, NJ 07662. Paperback edition 5-1/2 × 8-1/4 inches, 112 pages. Price: $4.95.

The last listing of the ARRL stolen equipment registry contained over 60 ham rigs which were "lost" to the criminal element. Surprised? Don't be. This isn't really such an alarming figure, however, many other items are swiped from hams every day! And usually because they weren't properly protected.

Not that most of us don't *think* about protecting ourselves from theft, it's just a long way between *thinking* and *doing*! Maybe the reasons are legitimate, but it usually boils down to "I can't find the kind of alarm I need."

One solution to the above dilemma is to build an alarm circuit to fit your needs and specifications. *110 Electronic Alarm Projects,* by R. M. Marston, is a prime source of information on home, auto and equipment alarms. No matter how unusual your alarm needs, in this book you can find a circuit or combination of circuits which should perform the task satisfactorily. Divided into seven chapters, the volume devotes the first five to industrial and home type alarms, including burglar, temperature, light-sensitive, proximity, power-failure, sound and contact-operated varieties.

Chapter 6 gives an in-depth analysis of automobile protection. Details of immobilizers, antitheft alarms, ice-hazard alarms, overheat alarms, and low-fuel alarms are included.

In his final chapter, Mr. Marston discusses instrumentation alarms. These circuits should interest anyone who wishes to protect expensive equipment from damage due to over-voltage or similar conditions. If you have ever destroyed a valuable circuit because the regulation in your power supply went haywire, you can appreciate the many applications of these protective circuits. Chapter 7 displays alarms which can be activated by ac or dc current or voltage, or by resistance.

All alarm circuits contained in *110 Electronic Alarm Projects* are complete with easy-to-read schematics and part values. According to the author, all circuits described have been built and evaluated. They utilize readily available semiconductor devices, with most circuits being designed around standard bipolar transistors, 741-type operational amplifiers, CD4001 quad two-input MOS NOR gates and SCRs.

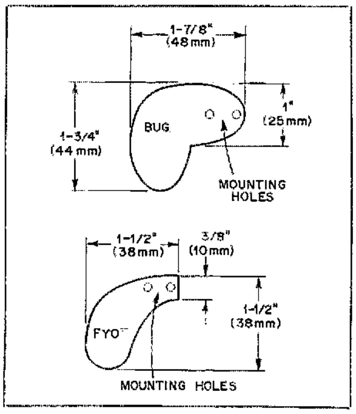
As an aid to readers, Mr. Marston provides in an appendix the outlines and pin connections of all semiconductors used. — *K1TX*

Hints and Kinks

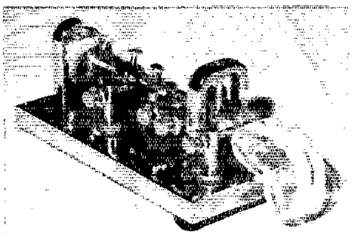
PADDLES REDUCE FATIGUE

In using my bug keyer, I found that the arrangement of the paddles was conducive to muscle tiring. After a little head scratching and a hint from W9DU, I produced a new set of paddles that reduced the fatigue. As may be seen in the photograph a set of L-shaped thumb and finger pieces have been applied to the bug.

The new paddles are made of 3/8-inch (10-mm) thick Plexiglas. Dimensions may be varied to suit the individual operator. To accommodate a pair of bevel-head machine screws for mounting the paddles, I drilled the thumb (dit) piece and both drilled and tapped the finger (dah) piece. For keyers requiring less operating force, such as the FYO, 1/8-inch (3-mm) plastic may be used and shaped as drawn. — *James J. Di Spirito, Jr., WB9TCT*



Patterns for making fatigue-reducing paddles for a bug (top) or a W8FYO keyer (bottom).



These Plexiglas paddles make sending with a bug easier.

STABILIZING THE R-392/URR RECEIVER

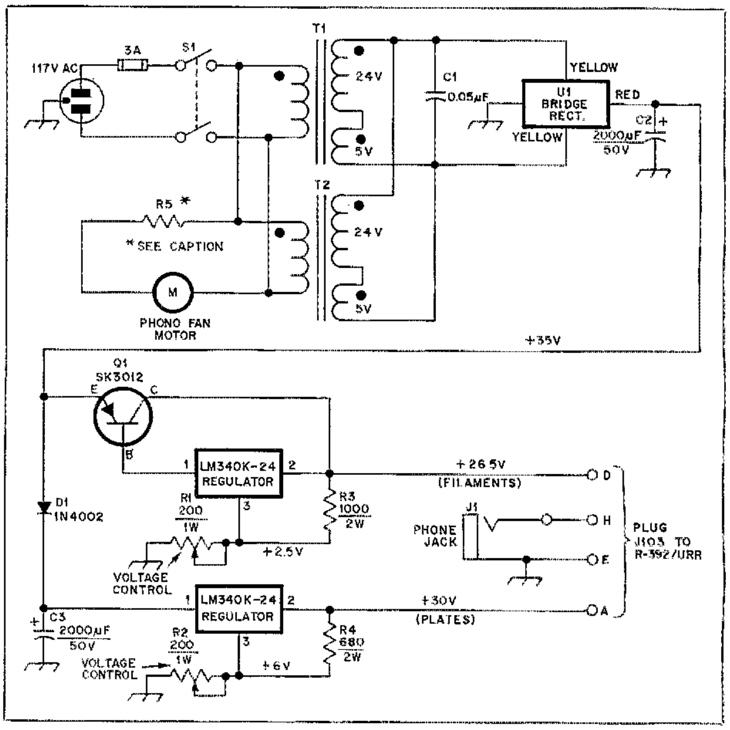
Restoration of a military surplus R-392/URR receiver has rewarded me with a set that has high performance, is compact yet rugged, and offers such features as the reception of cw, voice and single-channel frequency-shift radioteletype. With the improved power supply shown on these pages, the set provides fine results on ssb in addition to successful reception of weather map information which is fed into my RJ-4 military-type facsimile recorder.

Like much of the surplus gear that's available, this set suffered from years of neglect and lack of operation. Thorough cleaning and lubrication plus alignment were required for restoration. Switches and contacts were treated with TV contact cleaner, while high-quality lubricating oil was carefully applied to shaft bearings and moveable parts. Access to the bandswitch required removing the audio chassis along with disconnecting the associated cables and bandswitch shaft. Holes in the bottom of the panel provide access to some of the areas that required cleaning.

A troublesome 100-hertz BFO shift was resolved by employing the dual-voltage regulated power supply shown in the drawing. Action of the crystal-oven thermostat caused the voltage change responsible for the difficulty. The new power supply not only made ssb tuning a pleasure, but also reduced the frequency-measuring error to less than 100 hertz. By applying 30 V dc to the plates while maintaining 26.5 V dc on the filaments, performance was further enhanced.

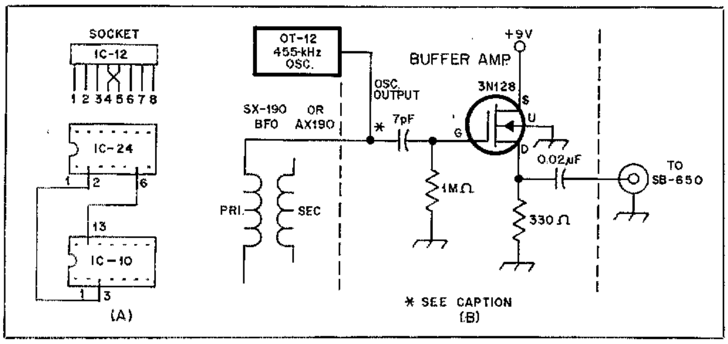
An alternative for the 25-A bridge (which may no longer be available), I suggest that the builder get the no. MDA 980-3, 12-A bridge from James Electronics, 1021 Howard Ave., San Carlos, CA 94070. Power transformers T1 and T2, no. FA-6705, are from Fair Radio Sales, Box 1105, Lima, OH 45803. Substitute transformers are no. 18A1743-4 from Burstein-Applebee, 3199 Mercier, Kansas City, MO 64111, or Radio Shack no. 273-1514.

I do recommend that cooling air be directed between the transformers, over the transistors and over the chassis beneath the bridge. Regulators should not be mounted near the transformers. — *Joseph F. Stephany, N2XS, ex-K2KSJ*



The military surplus R-392/URR receiver may be stabilized by the use of this dual-voltage regulated power supply.

J1 — 1/4-inch phone jack.
Q1 — Pnp germanium transistor, RCA SK3012 or equiv.
R1, R2 — Bourns Trimpot, 200 ohm, 1 watt, wire wound, model 3345.
R5 — Fan voltage dropping resistor, 10 W. Value determined according to motor specifications and speed (250 ohms suggested).
S1 — Dpst switch.
T1, T2 — See text.
U1 — Bridge rectifier, 12 A, Motorola MDA-980-3 or equiv.
U2, U3 — Voltage regulator, National Semiconductor LM340K-24 or equiv.



The Heath SB-650 frequency display may be used with the Allied AX-190 receiver by employing this buffer amplifier. Except for the addition of an International Crystal OT-12 oscillator at point X, the circuit is identical to the original which appeared on page 43 of *ham radio magazine* for June, 1973. The 3N128 is a depletion type FET. A crossover of the connections to pins 4 and 5 of IC-12 in the SB-650 permits the counter to count up for two periods and down for one.

USING THE SB-650 WITH THE ALLIED AX-190

Ham radio magazine in June, 1973, presented a modification of the Heath SB-650 frequency display for use with receivers and transceivers of brands other than Heathkit, for which it was designed. The circuit arrangement I am providing applies to the use of this device with the Allied AX-190 receiver. The modification corrects an error of ± 1.5 kHz that would always be present in the readout and compensates for an a-m readout error of 455 kHz. It appears because the AX-190 BFO oscillator is switched off in this mode. The AX-190 is the amateur version of the SX-190.

As the original article stated, three oscillator signals are used from the receiver to actuate the frequency counter. These are from the HFO, LMO or VFO, and the BFO. The AX-190 uses two crystals in the BFO (456.5 kHz for lsb and 453.5 kHz for usb).

For some time I tolerated this condition, but finally I came up with a simple solution. A separate 455-kHz crystal oscillator could be installed inside the counter and connected directly to the BFO input. In my case an International Crystal OT-12 board was purchased as well as a surplus 455-kHz crystal. I used a buffer amplifier similar to the one described in *ham radio magazine.* To operate the crystal oscillator and buffer amplifier, 12 V dc was taken from Zener diode D6 in the counter. An explanation of the counter operation is too lengthy to be presented here, but I do suggest that the original article be obtained from *ham radio magazine* or through a library. The drawing I have shown for IC-12 (SN74192N) in the SB-650 correctly indicates that this is a 16-pin device, and not 14-pin as referred to in the article mentioned above. With the error problem solved, the readout is now as accurate as the capability of the counter. — *C. A. Chamberlain, W5RSH*

USEFUL SEMICONDUCTOR REFERENCE BOOK

The 1978 edition of the *Archer Semiconductor Reference and Application Handbook,* available at Radio Shack stores, contains cross reference listings of more than 46,000 transistors, diodes and other interchangeable devices. The computerized information is based on a careful analysis of important parameters of listed devices. The 144-page handbook also provides application information, including actual circuit diagrams for most listed ICs, clock chips and modules. Detailed information will also be found on the 8080A CPU chip. — *Dave Klemp, WB1AND*

CHARGING BATTERIES WITH SOLAR ENERGY

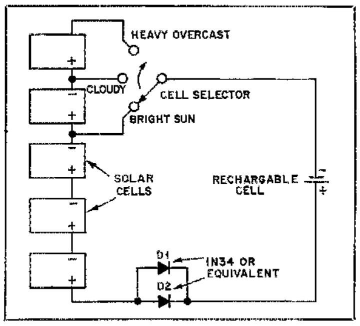
Putting sunlight to work charging batteries is a project my 11-year-old granddaughter developed for a school science project. With a bit of guidance from me, she constructed a charger using the circuit shown in the accompanying diagram. A selector switch allows a choice of the number of cells to be engaged when charging. Overcast skies require the use of more solar cells than on sunny days.

Solar devices of the type employed in the charger are available as single cells or as two cells in series. A single cell, on a bright day, can deliver 0.5 V with a full current capacity of 50 mA.

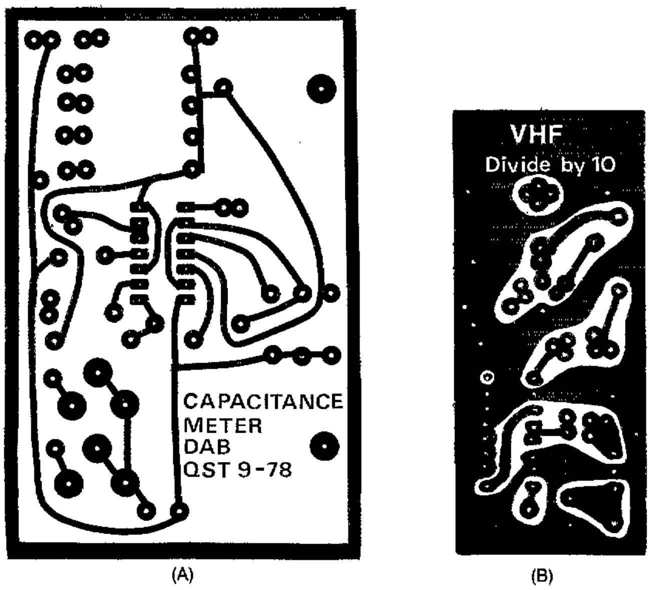
Two diodes are incorporated in the circuit to prevent battery discharge during darkness. Because of the voltage drop through the diodes (0.2 to 0.4 V) another solar cell may be included to compensate for the drop.

Some cells do not have leads. Leads made of fine wire (such as no. 26 or smaller) may be very carefully soldered to the bare metal on the negative (purple) side as well as on the positive section. Dropping or bending a solar cell will break the glass base. Mounting them on a piece of wood or plastic offers suitable protection. — *Joe Rice, W4RHZ*

A solar-operated battery charging circuit. The solar units are Radio Shack parts no. 276-128. Similar devices, sold under the Calectro label, are available from many parts distributors.



Circuit-board etching patterns. At A is the pattern for the inexpensive capacitance meter (see the parts layout in Fig. 3, page 14 of this issue). At B is the pattern for the vhf prescaler (parts layout in Fig. 2, page 13). In each pattern, shading represents copper. The patterns are shown at actual size from the foil side of the circuit board. The board for the vhf prescaler is double sided (see article).



(A) (B)


QST
devoted entirely to Amateur Radio
October 1978 $2.00
The Sardine Sender —
have fun with this 3/4-watt
80-meter weekend project.
Page 15
ARRL

QST

October 1978
Volume LXII Number 10

QST (ISSN: 0033-4812) is published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

If you've been hungry for an 80-meter companion to the Tuna Tin 2, see page 15.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A Newly Discovered Mode of VHF Propagation

Shattering the 2-meter DX record has become commonplace lately. Equatorial FAI is one theory on what's behind these super band openings.

By Joseph H. Reisert,* W1JR, ex-W6FZJ, W1JAA and Gene Pfeffer,** KØJHH

On October 29, 1977, at 0200 UTC, LU1DAU, La Plata, Argentina, worked YV5ZZ/6, Bocha de Uchire, Venezuela, on 145.9-MHz cw! By 0310 UTC, the signals had improved greatly, and a two-way ssb contact was made. Both stations were running less than 100 watts and used 10- to 12-dB gain antennas. When the signals faded at 0400 UTC, a new terrestrial-only 2-meter record of 3135 miles (5045 km) had been set.

For many years, vhf operators have known of transequatorial (TE) radio propagation on 6 through 15 meters. [1-4] While it was speculated that this mode could support the propagation of 2-meter signals under the right circumstances, such conditions had never been reported. It now appeared that TE had made it to 2 meters. Again and again, YV5ZZ worked into Argentina. By the end of November, such contacts became almost commonplace. With reports of bigger and better openings coming each day, we began trying to correlate contemporary solar-terrestrial conditions with those present during prior TE-mode QSOs. We noticed many discrepancies, leading us to conclude that this fantastic propagation was not TE, but possibly a result of magnetic-*field-aligned irregularities* (FAI) in the equatorial ionosphere.

Some Background Information

The push for a new 2-meter record had been spurred on by the observations of YV5ZZ. On November 8, 1976, Edgar heard OSCAR 7 Mode A uplink (145.9-MHz) signals from LU7DJZ. He was not listening to the downlink signal on 10 meters — what he heard was really on 2 meters! This prompted weekend schedules at first, eventually leading to nightly attempts at a QSO. Contact was made on either 21.4 or 50.1 MHz. If conditions looked good, attempts were made on 145.9 MHz. To prevent OSCAR QRM, the frequency was later changed to 145.1 MHz.

After nearly a year of trying, they made it. Since the first contact, there have been over 40 days when known openings have occurred, and they have been observed on all continents. The more noteworthy events are listed in Table 1. Also shown are the times during which the openings were observed. Fig. 1 is a map showing the location of stations active in these openings. The bulk of the favorable conditions seem to occur within the period from sunset to midnight. Signal strength was not the same for each opening and varied considerably during the course of a contact. Stations sometimes reported that received signals "sounded like moonbounce," but more often they were well above the noise. Even low-power (100 watts effective radiated power) ssb and fm stations participated. Stations over 500 miles (800 km) apart often participated in an opening.

TE-Mode Propagation

By reviewing some prior work and findings in the field of TE propagation, we hope to point out comparisons that indicate another mode is responsible for the more recent contacts.

A TE path is generally considered to be between stations located 1500-2500 miles (2400-4000 km) either side of the magnetic equator.[5] No east-west paths have been reported. Backscatter sounding studies have identified the paths as being the result of two or more successive reflections in the F-layer region of the ionosphere. The ray path for such a signal is shown in Fig. 2. Because no intermediate ground reflections are involved, signal strength is greater than might be expected. TE depends on a phenomenon called "ionospheric tilt." Instead of an ionosphere which is concentric with Earth, a tilt may occur, especially after sunset or sunrise at the ionosphere. An ionosphere having opposite tilts over a large area is required to support successive reflections. In the equatorial region, tilts occur daily near sunset, when the height of the ionosphere begins to increase, rising higher than that to the north and south. Later in the evening the ionized layer settles and the tilts disappear. Waves striking this tilted layer have a lower angle of incidence then would normally be the case. This allows higher frequencies to be propagated, typically 1.5 times the daytime maximum usable frequency

Table 1
Propagation "Firsts" via FAI

Date	*UTC*	*From/To*	*Comments*
November 8, 1976	0037	YV5ZZ/LU7DJZ	LU7DJZ OSCAR Mode A uplink signal heard
July 1, 1977	unknown	PY2OD/TU2EF	TU2EF OSCAR Mode A uplink signal heard
October 29, 1977	0200-0400	YV5ZZ/LU1DAU	First reported QSO via this mode
February 12, 1978	0005-0020	LU/KP4-YV	No 6-meter path but good 2-meter signals
February 13, 1978	0004-0110	LU/KP4-YV	YV5ZZ heard LU3AAT on 432 MHz but no QSO
February 20, 1978	0400-0405	YV6ASU/LU3AAT	LU3AAT only station heard in north. Note relatively late time
February 24, 1978	1200	VK8GB/JH6TEW	First VK-JA QSO on 2 meters
April 10, 1978	1800	ZE2JV/5B4WR	First Asia-Africa QSO via this mode
April 12, 1978	1800	SV1AB/ZE2JV	First Africa-Europe QSO via this mode

*17 Mansfield Dr., Chelmsford, MA 01824
**49 Burham Rd., North Billerica, MA 01862
[1]Footnotes appear on page 14.

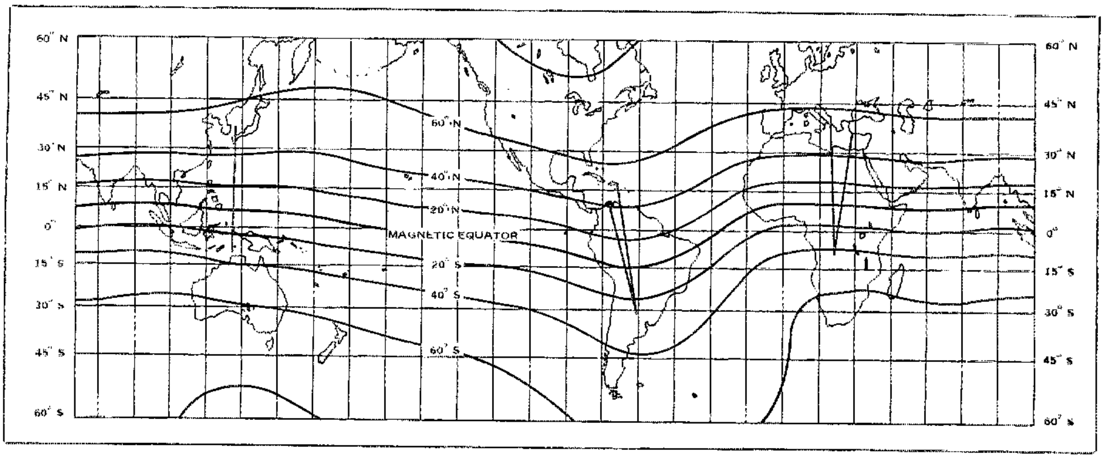


Fig. 1 — Approximate location of stations which successfully made use of FAI can be seen on this map. The contour lines indicate geomagnetic latitudes.

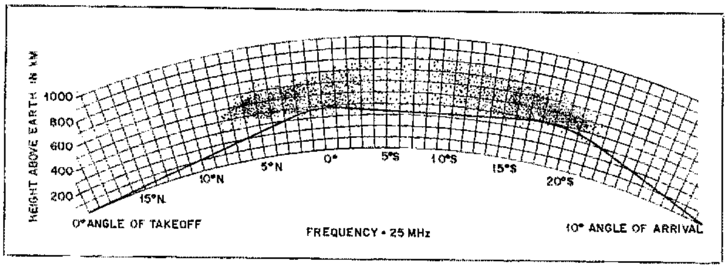


Fig. 2 — Cross section of a transequatorial ray path, showing the effect of ionospheric tilt on a 25-MHz signal. This drawing shows a typical example of TE propagation. (From Davies, "Ionospheric Radio Propagation," U.S. Government Printing Office, Washington, DC, 1965.)

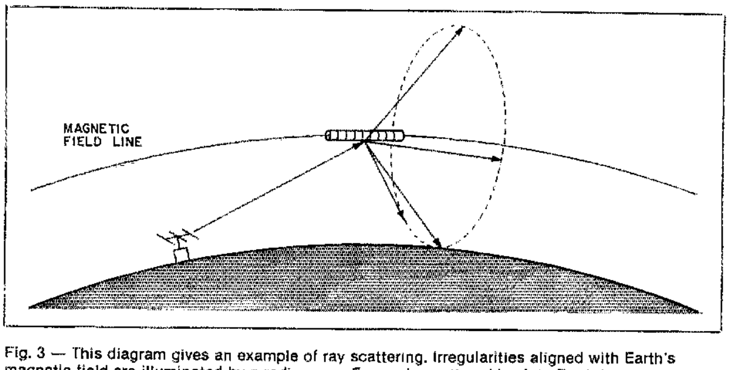


Fig. 3 — This diagram gives an example of ray scattering. Irregularities aligned with Earth's magnetic field are illuminated by a radio wave. Energy is scattered back to Earth in a cone-shaped pattern. Stations within the area intersected by the cone can receive the signal.

(muf). Attenuation of frequencies above 80-100 MHz is severe.[6] Six-meter openings are usually coincident with enhanced 10-and 15-meter propagation, and signals are usually distorted with a characteristic flutter fading. TE propagation is most often noted between 1700 and 2100 local time at the path midpoint, moving from east to west as the earth rotates, but some afternoon openings have been observed as well.[1,7] TE occurs most often during the equinoctial periods (around March 21 and September 23). It is least common during solstitial periods (around June 22 and December 22).[1,5] The best TE conditions seem to occur at or near a sunspot-cycle peak.

Comparison with Recent Openings

The 2-meter contacts between Australia and Japan and in South America have been between stations located approximately 1500-2000 miles (2400-3200 km) from the geomagnetic equator. One exception was the reception of OSCAR 7 Mode A uplink signals (145.9 MHz) from TU2EF, Ivory Coast, by PY2OD, Santos, Brazil. This path lies along the geomagnetic equator and represents the only known east-to-west propagation of this type. Because this observation was made prior to the first confirmed 2-meter contact, it was met with no small amount of skepticism! Classical notions of TE do not account for this path. Since the effect was noticed, on July 1, 1977, TU2EF has moved to Brazil. It is hoped that other African stations will be found who are willing to experiment with South American amateurs on this path.

The 2-meter openings to date have shown little correlation with equinoctial periods. In fact, 10 openings have occurred within 30 days of a solstice. It remains to be seen whether the frequency of openings increases as an equinox approaches. Two meters is 2 to 3 times higher in frequency than the greatest mufs observed during the 1957-58 peak of sunspot cycle 19. This period was an all-time high for solar activity. In fact, 2 meters is not the highest frequency at which this phenomenon has been observed. On February 13, 1978, YV5ZZ heard weak but identifiable signals from LU3AAT, on 432.1 MHz. Two-meter and 432-MHz propagation far exceeds the capability of the TE mode. YV5ZZ was using his satellite antenna system, which is steerable in azimuth and elevation. In the direction of LU3AAT, his horizon is obstructed by a range of mountains. The lowest elevation angle which allows for clearance of the mountain range is 8 degrees. On February 16, 1978, YV6ASU heard LU3AAT on 432 MHz, with his antenna at about the same angle of elevation. On yet another occasion, KV4FZ heard LU3AAT on 145.1 MHz. He reported that a peak in signal strength occurred when the antenna elevation angle was 8-10 degrees. This geometry suggests that single-hop F-layer reflection isn't involved. The angle also seems high for the tilt associated with TE.

At first, 2-meter tests were conducted only when strong 50-MHz TE signals were noted. However, on February 12, 1978, KP4EOR contacted two Argentine stations at a time when no 50-MHz path existed. This effect, which was also noted by YV5ZZ on occasion, would not normally be expected for TE.

When the occasions of openings were compared with solar flux and geomagnetic indices for the dates involved, no correlation was seen. The first contact did take place on a day when auroras were reported in the Northern Hemisphere. This appears to have been coincidental as the condition did not repeat. TE is most prominent at a solar cycle peak. We are presently ascending from a solar minimum.

Because these observations indicated the recent contacts did not result from fantastic TE propagation, we began to look for another propagation mode to account for them. Our attention was immediately drawn to the possibility that they were somehow related to irregularities in the equatorial ionosphere.

Scattering Mode

One phenomenon related to the ionosphere is called *scintillation*.[8] This is seen as amplitude and phase variations of signals which transit a nonuniform ionized region. Scintillation causes the signal to fade by breaking it up into several ray paths which may or may not arrive in phase at the receiver. The ionospheric irregularities which cause the scattering may be thought of as bubbles of electron density different from that of the surrounding medium. These bubbles can become directional reflectors of radio signals. They behave roughly as thin elongated rods aligned with Earth's magnetic field.[9] A representation of one rod is shown in Fig. 3. The angle of reflection of a wave is equal to the angle of incidence, but both paths need not lie in the same plane. A wave incident on a cylinder excites conically shaped reflections. If the transmitter properly illuminates irregularities aligned with the magnetic field, the cone will intersect Earth. Signals may then be received within the area covered by the cone. Scattering tends to add still more paths, allowing reception throughout a belt-shaped area, rather than a circular or elliptical one.

Vhf signal-scattering irregularities can occur daily in the equatorial region. In fact, the occurrence of scattering irregularities is greatest near the magnetic equator and in the polar regions. The phenomenon is least seen in the middle latitudes. Polar-region aberrations are associated with the auroras. In the equatorial region they commence abruptly about 1900 local time, become more patchy and sporadic through the night. Disruption in the equatorial F region has been linked with an increase in the height of this layer, the same phenomenon responsible for TE. The optimum time for scatter propagation via these field alignment irregularities (FAI) is about one hour later. FAI show seasonal variations. The precise pattern also depends on the longitude and period of the solar cycle. FAI tend to be more common during equinoctial periods, the winter months and years of high solar activity.[10] In the Americas, FAI seem to be concentrated in the period from October through March, all but disappearing during June, July and August. In the Africa-Mediterranean region, occurrences also are frequent from October to May. There are many openings in the period June through August. For the Asia-Australia region, present data indicate the maximum may even be in June and July.

FAI tend to occur within 10 degrees of the geomagnetic equator. Satellite studies have indicated that irregularities large enough to scatter 144-MHz signals exist at heights of up to 620 miles (1000 km) just at and shortly after sunset. Recently, studies have been made with the 50-MHz scatter radar in Jicamarca, Peru. They indicate that the irregularities may last as late as midnight, local time. It was found that plumes of electrons in the otherwise depleted regions form ducts which can trap vhf signals. They are then scattered

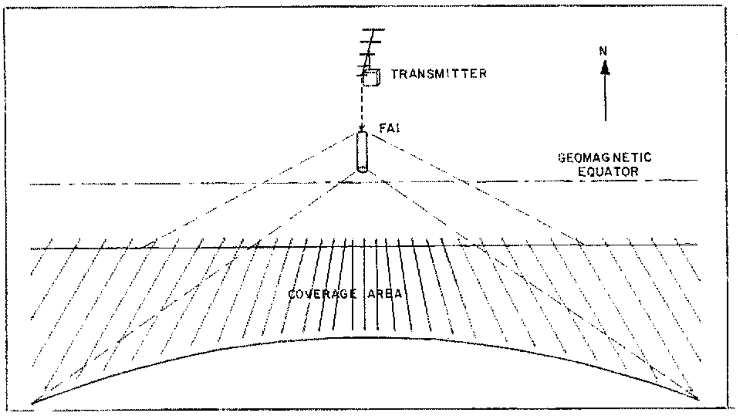


Fig. 4 — When a station north of the equator is transmitting in a southerly direction, the southern coverage area will be similar to that shown in this drawing, shown as if looking down from a great height. Size of this area is dependent upon the length and horizontal extent of the scattering medium, and its position relative to the transmitter and receiver. The coverage pattern for a southern station beaming north would be a mirror image of that shown here.

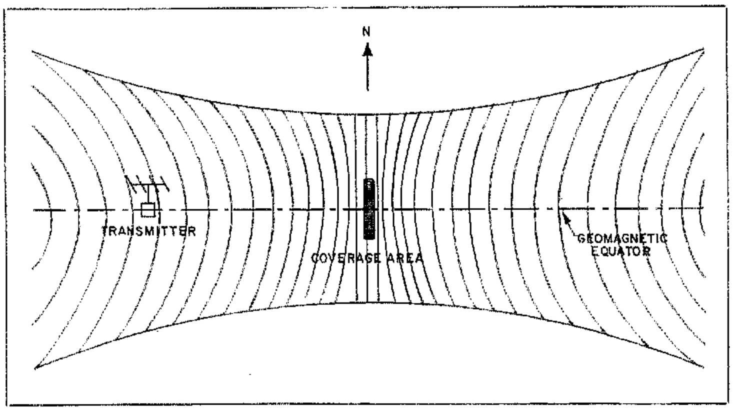


Fig. 5 — Scatter-mode coverage in an east-west direction along the magnetic equator. As in the case shown in Fig. 4, coverage area is dependent upon the horizontal extent of the scattering medium. A relatively wide coverage area may be possible if north-south alignment of the irregularities is not an important aspect of the phenomenon.

back to Earth at the point they exit the duct. Strong scintillations noted on satellite signals received near the geomagnetic equator have been tied to these features. FAI ranging in height from 375 to 500 miles (600 to 800 km) could account for propagation on even the longest of the observed paths.[11]

In the early 1970s, several government agencies participated in an experiment to study the effects of artificial irregularities in the ionosphere.[12] Since naturally occurring auroras were known to scatter vhf signals, man-made irregularities were tested for the same properties. Reflection of frequencies up to 430 MHz was found at times when normal transmission was possible only through 10 MHz. So strong were the reflections that cw and ssb communication at frequencies of 20-50 MHz was possible using 100-watt-output transmitters and 10-dB-gain antennas. Above 50 MHz the reflection coefficient fell off steadily, so that 430-MHz receiver-noise figures on the order of 1 dB were needed to produce usable signals over long paths. Fading rates increased with frequency. Naturally occurring irregularities in the nighttime equatorial ionosphere can produce similar effects and the geometry is correct for long-distance north-south propagation. If there is a coherence (adding effect), from the banded structures which occur naturally in the equatorial FAI, the observed signal strengths could be supported with modest amateur equipment.

It is interesting to note that, since the geomagnetic field lines in the ionosphere above the magnetic equator are nearly parallel to the Earth's surface, communications in both north-south and east-west directions should be possible, given adequate power levels.[13] In the case of north-south propagation across the geomagnetic equator, the propagation mode is as depicted in Fig. 4. East-west propagation via FAI is theoretically possible near the geomagnetic equator. Possible coverage is diagrammed in Fig. 5. This could account for the reception of OSCAR uplink signals from TU2EF in Brazil, an east-west path along the geomagnetic equator.

Another interesting property of propagation via FAI is that long-range transmission from within or above the ionosphere to the ground is possible. The cone of signals generated by satellite transmissions incident on equatorial FAI can intersect the ground when the geometry is correct. Such a mode could explain the reception of OSCAR downlink signals when the satellite is well below the listener's horizon.

Scatter propagation causes the signal to flutter. Either or both increased frequency and fewer reflections will enhance the severity of flutter. KP4EOR noted that received signals sounded like a buzz saw! Tests conducted after midnight, local time, have uncovered no recurring openings. Radar data from Jicamarca indicate that such openings, if possible at all, should be rare, because of the absence of suitably sized scattering surfaces after local midnight. Prediction of FAI presence may be possible with the aid of amateur satellites. Ionospheric scattering results in an observed Doppler frequency shift which differs from the expected value. An accurate Doppler plot may reveal shifts in a patchy ionosphere. Amplitude flutter on the beacon and downlink signals might also reveal the existence of an opening via FAI.

Conclusions

The recent record-breaking 2-meter openings exhibited many characteristics which were previously unobserved and unexplained. In an effort to explain to ourselves what was happening, we noted many characteristics directly related to the occurrence of irregularities in the alignment of Earth's magnetic field. It seems likely that these contacts resulted from propagation by the fine-scale structure of the equatorial ionosphere, rather than broad tilts related to normal ionospheric conditions. Confirmation awaits further testing by amateurs. If we are correct, the implications are exciting for vhf operators worldwide. Contacts between South America and Africa, and Africa and Asia on frequencies up to 432 MHz may be possible. We congratulate the avid vhf operators who have participated in this work so far, and urge them to continue trying for new DX records.

Our sincere appreciation goes to Mr. Edgar Mueller, YV5ZZ, for the excellent data he provided. Also our thanks to Mr. Jack Klobuchar, W1BZT; Mr. Richard Allen and Mr. W. E. Brown, ex-W1ZIG, for their assistance in providing technical comments and propagation information.

References

[1]Cracknell, "Transequatorial Propagation of V.H.F. Signals," *QST*, December, 1959.
[2]Southworth, "A Look Back and Ahead at PRP," *QST*, June, 1959.
[3]Tilton, "TE Propagation — V.H.F. Discovery Extraordinary," *QST*, April, 1963.
[4]Whiting, "How Does TE Work?" *QST*, April, 1963.
[5]Bowen, "Vhf Characteristics of the Transequatorial Ionosphere," *Space Physics*, Journal of Geophysical Research, April, 1968.
[6]Ibid.
[7]Villard, et al, "Studies of Transequatorial Ionospheric Propagation by the Scatter-Sounding Method," *Journal of Geophysical Research*, Vol. 69, (1957), p. 399.
[8]Aarons, "Equatorial Scintillations: A Review," *IEEE Transactions on Antennas and Propagation*, September, 1977.
[9]Frank, Fenwich and Villard, "Communicating at Vhf via Artificial Radio Aurora," *QST*, November, 1974.
[10]McSherry, "Ionospheric Scintillations at Shf," *Microwave Journal*, June, 1977.
[11]Basu, "Preliminary Comparison of Vhf Radar Maps of F Region Irregularities with Scintillations in the Equatorial Region," *Journal of Atmospheric and Terrestrial Physics*, Vol. 39, 1977, p. 1251.
[12]Frank, et al.
[13]Cracknell.

Additional References

Burke, Dimatelli, Sagalyn and Kelly, "Large Amplitude Irregularities at Low Latitudes in the Topside Ionosphere," *Air Force Geophysics Laboratory Environmental Research Paper No. 616*, November 28, 1977.
Melty and Perkins, "Ionospheric Modification Theory: Past, Present and Future," *Radio Science*, November, 1974.

Feedback

☐ There was a pricing error in the footnote about *QST* binders in "What's So Rare as a *QST* from 1915?" (August 1978 *QST*, page 43). Small-size (pre-1976) binders are $5 postpaid, and large-size ones (1976 and on) sell for $6 postpaid. Also, the World War I publication hiatus began after the September 1917 issue, not the December issue.

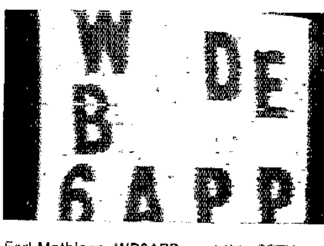
☐ There were two errors in the Contest Advisory Committee list in September 1978 *QST*, page 52: W2FVS is now K2SX and K9UIY lives at 1258-1/2 S. Galena, Freeport, IL 61032.

☐ In "CQ Ham Radio" (August 1978 *QST*), the Westchester Emergency Communications Association Field Day station should have been identified as W2IT.

☐ The list of improvements for the SB-100 referred to in the June "Hints and Kinks" item, "Better S/N and Gain for SB Series," can be found in May 1968 *QST*, page 53.

☐ On page 57 of "How's DX?" (August 1978 *QST*), the photo on the left is A9XBJ. A9XBC is the operator on the right.

Strays



Earl Mathison, WB6APP, sent this SSTV picture to Jed Jenson, WA6WTN. Their shacks are eight miles apart in Antelope Valley. However, their SSTV pictures travel about 1100 miles via OSCAR.

Build This "Sardine Sender"

Basic Amateur Radio: Weekend projects are fun! This 80-meter cw QRP rig will provide entertainment in the home workshop and on the air. A good antenna and 3/4 watt of power will net a lot of solid QSOs.

By Doug DeMaw,** W1FB

Did you have fun and excitement with the Tuna-Tin 2 from May 1976 *QST*? Chances are that you did if you're a QRP-rig operator. Many requests followed publication of the little 40-meter rig, asking for an 80-meter version of the circuit. Well, here it is, and all of the parts except for the chassis are stocked by Radio Shack. Of course you'll need your own crystals, power supply and key, but those are pretty standard items in most ham shacks today.

**Senior Technical Editor, ARRL.

There's no mandate that says you need to use a sardine can. Any metal foundation will be suitable, so take your pick from what's available to you. The important thing is that you follow the circuit given and keep the leads neat and short.[1]

A Simple Circuit

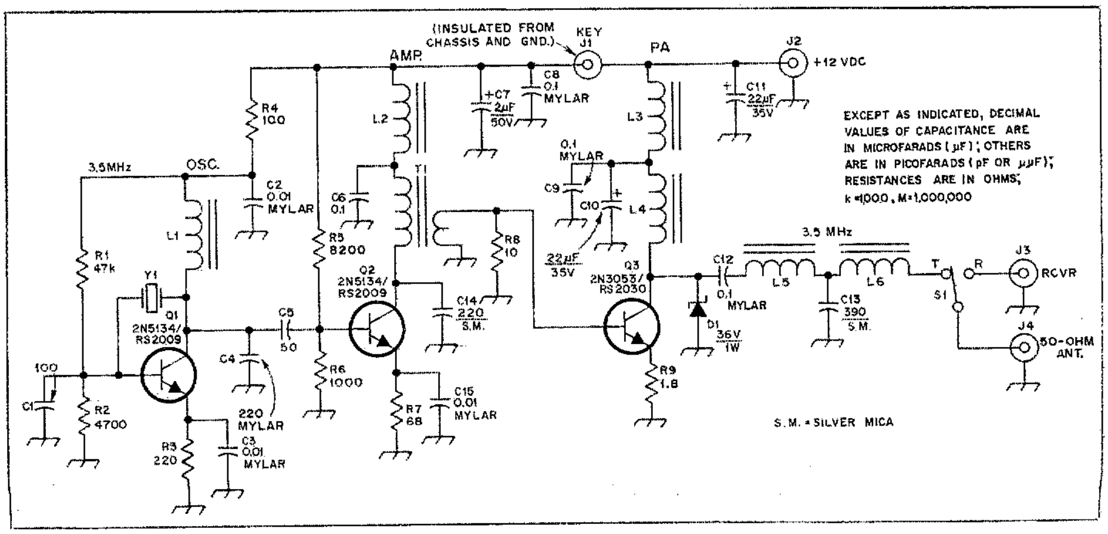
Three bipolar transistors are specified in the circuit of Fig. 1. Transistors with characteristics similar to those listed should work satisfactorily. The important matters to consider when making substitutions are the maximum collector-emitter voltage (24 or greater), maximum dissipation (2 watts or more) and the f_T rating (20 MHz or higher). For example, 2N2222A transistors can be used at Q1 and Q2, and a 2N2102 will work at Q3. There's no harm in experimenting: It helps you learn more about semiconductors.

Q1 performs as a Pierce oscillator. The crystal is placed in the feedback path from collector to base. An untuned collector circuit is used. Q2 functions as a Class A

[1] Pc negatives, pc boards and parts kits for this project are available from Circuit Board Specialists, Box 969, Pueblo, CO 81002.

Fig. 1 — Schematic diagram of the Sardine Sender. Capacitors are disk ceramic unless otherwise noted. Resistors are 1/2-watt composition. Numbered components not appearing in the parts list are identified numerically for parts-placement information only. Polarized capacitors are electrolytic.

D1 — 36-V, 1-W Zener diode.
J1-J4, incl. — Single-hole mount phono jack.
L1 — 100-µH choke (Radio Shack 273-102).
L2-L4, incl. — 10-µH choke (Radio Shack 273-101).
L5 — 12-µH inductor (Radio Shack 273-101 with 4 turns no. 26 enam. wire added).
L6 — 8.9-µH inductor (Radio Shack 273-101 with 3 turns removed).
S1 — Miniature spdt toggle or slide switch.
T1 — Broadband transformer (Radio Shack 273-101 for primary, with 5-turn secondary of no. 26 enam. wire over C6 end of primary).
Y1 — 80-meter fundamental type of crystal (crystal socket optional).



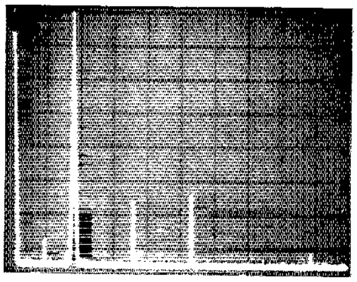


Fig. 2 — Spectrum-analyzer display of the transmitter output. The full-scale vertical line near the left is the carrier. The vertical scale is 10 dB per division, and the horizontal scale is 2 MHz per division. All spurious responses are at least 54 dB below peak carrier value, more than conforming to the FCC requirement of 40 dB or greater reduction.

broadband driver which has a broadband solenoidal transformer in the collector (T1). Q3 operates Class C and is supplied with operating voltage all of the time. It conducts when the 12-volt line to Q1 and Q2 is keyed at J1. Conduction is brought about by the application of driving power from Q2. R9 is used in the emitter of Q3 to prevent burnout and to improve stability through the introduction of degenerative feedback.

Additional protection is offered to Q3 by the inclusion of a Zener diode, D1. This diode clamps on rf voltage peaks in excess of 36 volts. The collector level could exceed that amount if Q3 broke into self-oscillation, or if no load was attached at J4 during key-down conditions.

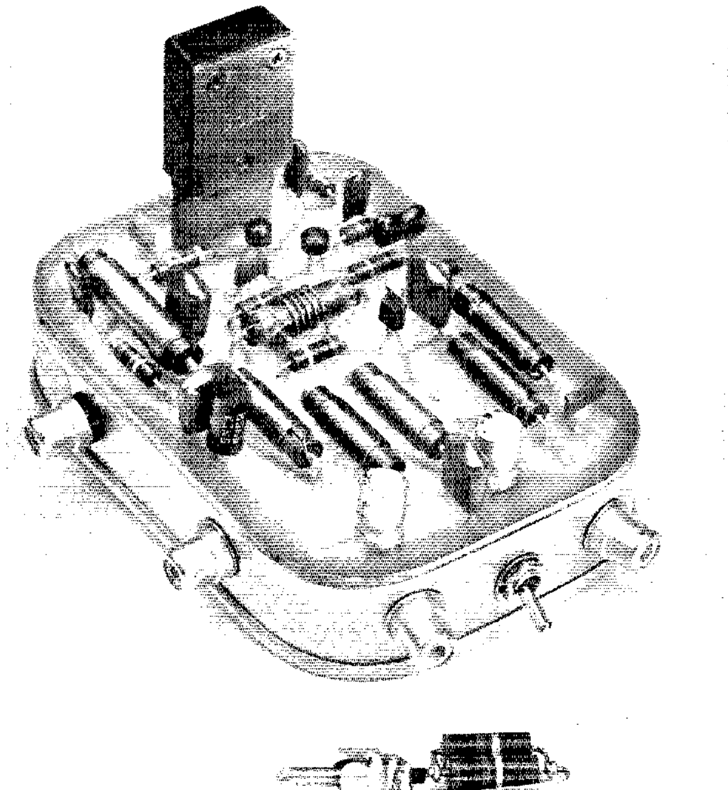
L2 and L3 are decoupling rf chokes which help prevent rf energy from one stage reaching another — a condition which could cause transmitter instability and spurious output. The associated bypass capacitors are part of the decoupling networks.

R8 is bridged across the secondary of T1 to help prevent self-oscillation of Q3, by lowering the Q in that part of the circuit. S1 is used as a simple T-R switch to change from transmit to receive.

A fixed-tuned low-pass T network is used as the Q3 output tank. It requires no tuning. Operation will be satisfactory from 3.5 to 3.75 MHz with this circuit. An oscillograph is given in Fig. 2 to show the spectral purity of the transmitter. Harmonics are 54 dB or greater below the peak carrier value indicated.

Testing and Operation

After the components are mounted as shown in the layout of Fig. 3, a 47- or 56-ohm 2-watt resistor can be connected across J4 to serve as a dummy load. Plug in a key at J1 (note that both contacts of J1 are *above* ground, thereby placing the key in series with the 12-volt line to Q1 and Q2).



The Sardine Sender, sequel to the Tuna-Tin 2 40-meter transmitter from May 1976 *QST*. The sardine-can chassis is optional. Note that the key jack is insulated from the chassis by a piece of phenolic or plastic on each side of the metal chassis.

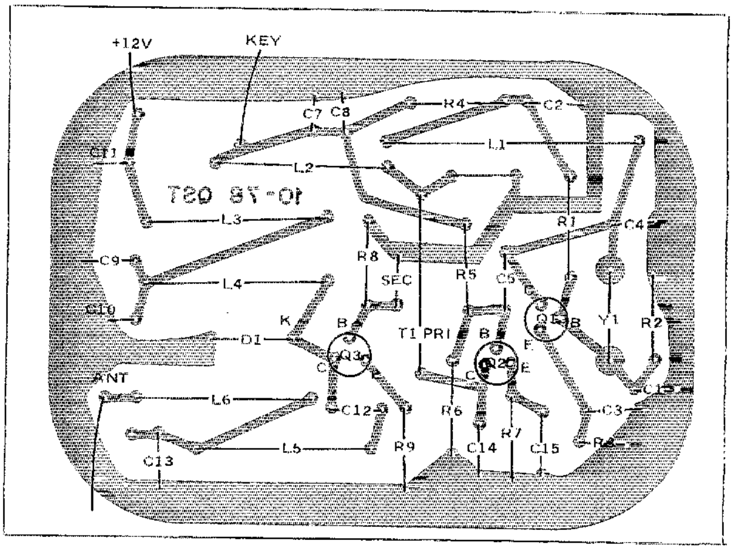


Fig. 3 — Parts placement diagram for the Sardine Sender. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (The etching pattern appears in the "Hints and Kinks" section of this issue.) The K indicates the cathode of D1.

Next, a dc power supply which furnishes 11 to 14 volts (not critical) is connected to J2. If an rf probe and VTVM are available, connect the probe from J4 to ground and key the transmitter. A power output of 3/4 watt should provide an rms voltage of 6.5 across a 56-ohm dummy-load resistor.

Monitor the signal in a receiver and make sure that there is no chirp. The principal cause of chirp with this circuit would be a sluggish crystal at Y1. Should a chirpy note result when a *good* crystal is used, experiment with the value of capacitance at C4, the feedback capacitor. Try values between 100 and 680 pF, selecting a value that provides a good cw note.

Table 1
Voltages at Key Points in the Circuit

	DCV (key up)	*DCV (key down)*	*RMS Volts (key down)*
Q1-E	0	+ 3.2	0
Q1-B	0	+ 1.1	2.2
Q1-C	0	+ 10.6	0.8
Q2-E	0	+ 2.0	0
Q2-B	0	+ 1.3	1.3
Q2-C	0	+ 12.0	7.7
Q3-E	– 0.05	+ 1.8	0
Q3-B	– 0.05	– 0.04	0.9
Q3-C	+ 12.0	+ 12.0	8.2

Dc and rms voltage readings at the terminals of Q1, Q2 and Q3 as measured with a Heath VTVM and diode rf probe. Departures of 10 percent from the above readings are not indicative of problems.

Table 1 provides dc and rms voltage readings at check points in the circuit. This table will be helpful if difficulties with performance are encountered. Measurements should be made with a VTVM and rf probe.

When this transmitter is used with an effective 80-meter antenna it will be possible to have QSOs with stations 1000 or more miles distant. The important thing to remember is to pick a clear frequency on which to call CQ. When answering CQs, respond to the loud signals for best results. If you hold a General or higher license class, look for other QRP denizens around 3540 kHz — on the spot on 80 meters where your brethren congregate.

Strays

HAMS' EARS HELP COAST GUARD SIEZE SMUGGLERS

□ One night in St. Thomas, VI, an Amateur Radio operator tuning across the band heard some unusual traffic on 7218 kHz. Three vessels were discussing a rendezvous for that night off French Cay in the Turks and Caicos Islands. He immediately reported this to the U.S. Coast Guard.

Earlier, the U.S. Customs Service had reported that a vessel laden with marijuana had been seized east of Puerto Rico. It had been in communication with two other vessels on 7268 kHz. Coast Guard personnel noted that the call signs and names used were identical.

The El Paso Intelligence Center was contacted for additional information. A vessel of the same name and description had been suspected of smuggling in the fall of 1975 and the summer of 1976. Thanks to the alert ears of an Amateur Radio operator another link was forged in the chain that will eventually remove this vessel from the narcotics trade.

This case, and a similar case on the West Coast, leads the Coast Guard to believe that some narcotics smugglers are taking advantage of the amateur bands for long-range communications on frequencies that are not usually monitored by law-enforcement agencies.

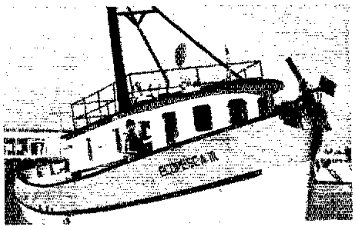
Fortunately, over the years, the Coast Guard and Amateur Radio have developed a good working relationship. There are many examples of search and rescue such as the sailing vessel *Kluanne*, a 31-foot sloop that was rescued thanks to the alert ears of the ARRL. This same public-spirited assistance can also aid the Coast Guard in law enforcement.

If an Amateur Radio operator overhears a vessel or vessels using the ham bands to carry out criminal activities, this information should be conveyed to the Coast Guard for the purpose of enforcement of applicable federal laws (Table). The Coast Guard welcomes any information amateurs may provide to help them protect those who use the sea for pleasure and trade, and prevent the use of oceans by smugglers, hijackers, thieves and other criminals. — *Ensign Paul Breckenridge, USCG*

U.S. Coast Guard Districts

The following telephone numbers reach United States Coast Guard District Operations Centers and are manned 24 hours a day.

First District
Boston, MA 617-223-3644
Second District
St. Louis, MO 314-425-4614
Third District
New York, NY 212-264-4800
Fifth District
Portsmouth, VA 804-398-6231
Seventh District
Miami, FL 305-350-5611
Eighth District
New Orleans, LA 504-589-6225
Ninth District
Cleveland, OH 216-522-3984
Eleventh District
Long Beach, CA 213-590-2225
Twelfth District
San Francisco, CA 415-556-5500
Thirteenth District
Seattle, WA 206-442-5886
Fourteenth District
Honolulu, HI 808-546-7340
Seventeenth District
Juneau, AK 907-586-7340
U.S. Coast Guard Headquarters
Washington, DC 202-426-1830



Smuggler *Ecopesca III* is boarded by Coast Guard. Another potential ham-band intruder is captured. *(U.S. Coast Guard photo)*

A ship's contraband is unloaded under Coast Guard supervision. Hams provide valuable clues to illegal operations. *(U.S. Coast Guard photo)*

The *Yosuru* in tow. Amateur Radio operators help Coast Guard by monitoring ham bands. *(U.S. Coast Guard photo)*

The Canadian Wonder

Some tall trees, wire and a bit of Canadian ingenuity provide a 20-meter wire beam that's just the ticket for working into your favorite part of the world.

By R. J. Barrett,* VE7AUZ

As a former holder of a G call recently emigrated to British Columbia, I was anxious to keep in touch with my ham friends back in the United Kingdom. Being blessed with several tall trees to be used as supports, I made my first antenna a dipole. It ran east-west, providing a good shot over the North Pole into Europe. Soon I discovered a rather sad fact of life; big beams and high power are popular in North America and contacts on 14-MHz phone for a QRPer with a dipole are marginal at best.

My first attempts to improve the situation found me reading antenna books for information on wire arrays. These books showed that a simple two-element beam for 14 MHz could be made using wire elements and wooden spreaders about 11 feet long. The radiation pattern of this antenna is bidirectional. The W8JK array is a good example of this type of beam. The 11-foot spreaders were made from wood, and the whole thing hung from the trees. On the ground, 11-foot spreaders look a lot smaller than they are.

Problems arose when it was finally erected. First, the antenna snaked about and became tangled in the tree branches. Worst of all, there was no rejection to signals coming from the U.S. A unidirectional antenna was a must, preferably one without 11-foot wooden spreaders. It was back to the books for a few evenings.

And then I saw it. In Fig. 1 is a graph reproduced from *The ARRL Antenna Book*. It shows that the theoretical gain of a two-element parasitic array with 0.05-wavelength spacing is approximately 3 dB. The front-to-back ratio for this spacing is approximately 20 dB. The radiation resistance is 12 ohms. This graph also implies that both driven element and director are self-resonant. However, at 0.05-wavelength spacing the director must be tuned to a *lower* frequency than the driven element. To realize maximum performance, trimming may have to be carried out and SWR checked at the height at which the antenna will be used. By careful tuning, both the gain and front-to-back ratio can be improved.

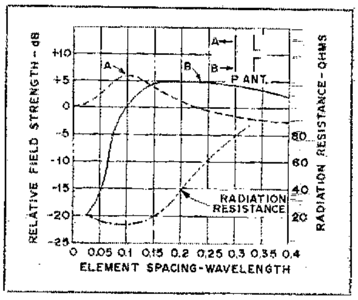
The main difficulty with narrow spacing occurs if the beam is constructed of aluminum tubing using the plumber's delight technique of construction. The input impedance will change as the elements wave about in the wind. By constructing the antenna from wire and using spreaders at the ends and center, this effect can be minimized.

Armed with all this information, I decided to build a scale-model beam for the 2-meter band using no. 26 wire, and 3-1/2-inch wood spreaders. The antenna could then be scaled for 20-meter operation after the 2-meter design was optimized (Fig. 2). This approach worked very well indeed!

The feed-point impedance was converted from approximately 12 ohms to 50 ohms by using a folded dipole for the driven element. A folded dipole looks like a thick dipole and broadens the frequency response and this type of driven element is recommended for all frequencies. Also 50-ohm coax can be used as feed line.

The 2-meter model was adjusted by carefully changing the spacing between the elements, while observing an SWR indicator for a minimum reflected reading. The parasitic director was pruned by snipping off 1/8-inch pieces and checking the signal strength of a known signal on a 2-meter receiver. Antenna adjustments are tedious, but careful and repeated measurements soon indicated a forward gain just a little over 4 dB and a front-to-back ratio of 18 dB. The final dimensions of the 2-meter model are shown in Fig. 2. You may want to make one to gain experience with close-spaced beams. The finished product is not suitable for normal amateur use as it is rather fragile and a bit too small to be practical.

Fig. 1 — Theoretical gain of a two-element parasitic array over a half-wave dipole as a function of element spacing when the parasitic element is self-resonant.



Construction and Adjustment

On 14 MHz, the spacing of 0.05 wavelength comes out to only 3.5 feet. The antenna is light and easy to handle. The antenna may be cut to the dimensions given in Fig. 2 and used as is, but time spent pruning and improving the front-to-back ratio by slightly adjusting the spacing between the elements and director length will be repaid by optimum performance. You may use a balun in the center of the driven element to convert the balanced antenna to unbalanced coaxial feed line. I did not, and results were still excellent.

The feed-point impedance, and therefore the SWR, is affected by the height of the antenna above ground and by the element spacing. If your rig is SWR-protected, you may adjust the SWR by slightly altering the element spacing. Adjustments should be made for the

*12040 — 98th Ave., Surrey, BC V3V 6P7

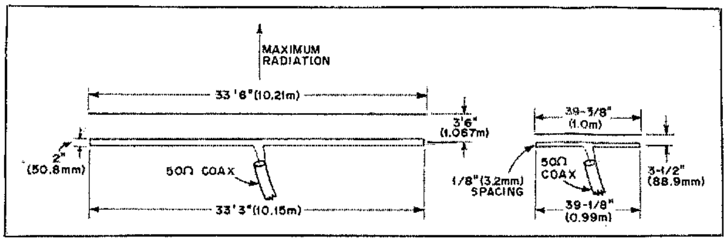


Fig. 2 — Dimensions for the Canadian Wonder close-spaced beam for both 2- and 20-meter versions. The 2-meter version is used only as an experimental model.

operating height of the antenna. Lower the antenna, make an adjustment, and haul it up again to check the SWR. This is a long procedure, but may be necessary if the SWR is initially high.[1]

Here are a few things to bear in mind when pruning antennas for the hf bands. Antennas will show high front-to-back ratios and expected gain only on *low angle* signals. Practically all vhf signals are received at low angles, but a great many hf signals arrive at rather high angles. Very few beams display optimum performance on such signals. Don't expect that S9+ 40-dB signal coming in from 500 miles away to just disappear off the back. You will get much better results on a signal emanating from a local station about five miles down the road.

Twenty meters has been providing good propagation so perhaps results on DX worked means little. However, the Canadian Wonder at 70 feet seems to hold its own very well. Many more European stations are worked now than previously.

I would recommend this antenna to any amateur, stuck with a simple dipole, who would like to try something better with a minimal outlay of cash.

[1][Editor's Note: As Fig. 1 shows, the front-to-back ratio changes more quickly with spacing than does the radiation resistance, so it may be necessary to adjust both the director length and element spacing for a compromise between low SWR and high front-to-back ratio.]

Strays

PENNSYLVANIA HAMS PROVIDE MARATHON ASSISTANCE

□ With only one week's notice, Judy Manola, WB3GRT, enlisted 13 fellow hams to provide communications checkpoints for the Carlisle, PA, 10,000-meter marathon. She set up a portable station at work and asked for assistance through the local repeater, WR3ABR, 146.28/88 MHz.

Volunteers came from three clubs in the 35-mile area: The South Mountain Repeater Association, the Cumberland Amateur Radio Club and the Central Pennsylvania Repeater Association. Pete Cooper, WB3BTU, acted as net control.

Fortunately, the only injury sustained during the race was a runner who broke some blood vessels in his knees. Joe Keller, WB3IDC, got him to the police, who in turn took him to the hospital for treatment.

Patients accompanied by Amateur Radio operators with handhelds are loaded into waiting ambulances at the old St. Mary's Hospital.

HOW FAST ARE YOU SENDING?

□ Bill Fisher, W2OC, suggests this formula for determining code sending speed. First count the number of seconds it takes to send the word PARIS. Then divide that number into 51.6. The result is words per minute. For example, if takes you four seconds to send PARIS, the speed is approximately 13 wpm.

HAMS FOLLOW THE BEDS AS HOSPITAL MOVES PATIENTS

□ How do you move 69 patients, some in critical condition, across town to a newly constructed hospital? The answer is — very carefully! Communications provided by Racine and Kenosha (WI) hams helped make such a move come off without a hitch.

It was necessary for St. Mary's Hospital to coordinate this move to the point of following each patient from his hospital room in the old hospital to his room in the new hospital. Three of the patients were rolled, while still in their beds, into a very large truck and transported. Aside from the movement of the patients, other critical hospital equipment and supplies had to be moved simultaneously. — *W9HAG*

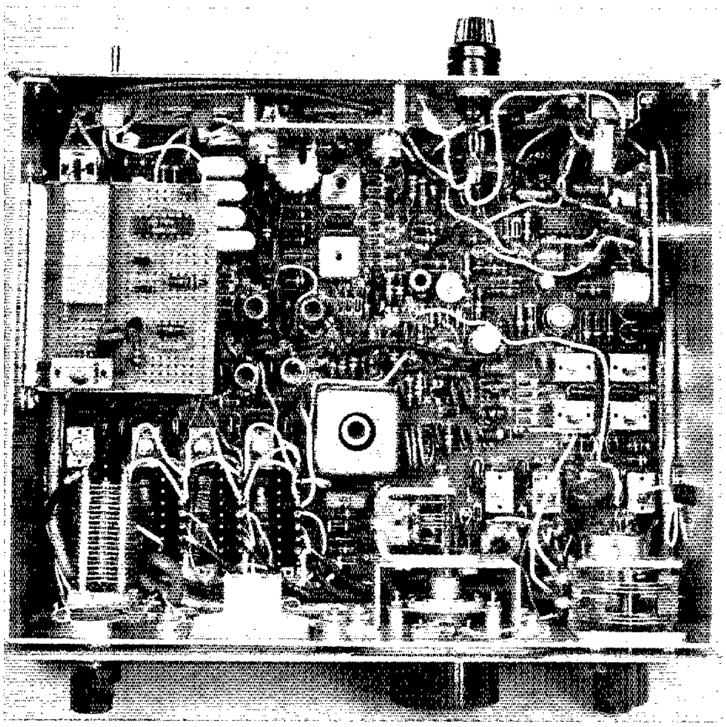
Patient on stretcher completes trip to the new St. Mary's Hospital. Ham in foreground with 2-meter handheld rig keeps in constant contact with the net control center.

A 25-kHz Calibrator for the HW-8

Ever get a pink slip or OO report for out-of-band operation? Now even the operator of low-cost QRP equipment can have the luxury of a 25-kHz calibrator. The added circuitry won't cost you more than your whole station either.

By Dave Karpiej,* K1THP

The calibrator is mounted on the upper left wall of the HW-8 and is controlled by the subminiature toggle switch on the rear apron. The small board mounted vertically on the rear apron is an added-on SWR indicator.



In just a few short years the Heathkit HW-8 has become one of the most popular QRP rigs on the air. For a modest price it covers several bands and offers many operating conveniences. One drawback, however, is in the dial calibration. The dial is calibrated in 5-kHz increments, adequate for most operations but a little hard to read if you are one of those operators who must stay in a specific subband. Most of these subbands are in increments of 25 kHz from the bottom of a band. More than one Novice, General or Advanced class amateur has probably felt a little shaky while operating within 5 kHz of a subband edge.

The solution is quite simple and can be found at your local Radio Shack store. Of course it may be used with receivers other than the HW-8, too. A 100-kHz calibrator kit (Radio Shack 28-140) is available for less than $10. All that is needed to turn it into a 25-kHz calibrator is one 7473 dual J-K flip-flop integrated circuit. The output from the 100-kHz calibrator is fed into one half of the 7473 and is divided by two. This 50-kHz signal is fed to the other half of the 7473 where it undergoes a further division by two. The output is a 25-kHz square wave, five-volts peak-to-peak, that is rich in harmonic content. The calibrator is powered from the HW-8 12-volt bus. A five-volt Zener diode

*Editorial Assistant, *QST*

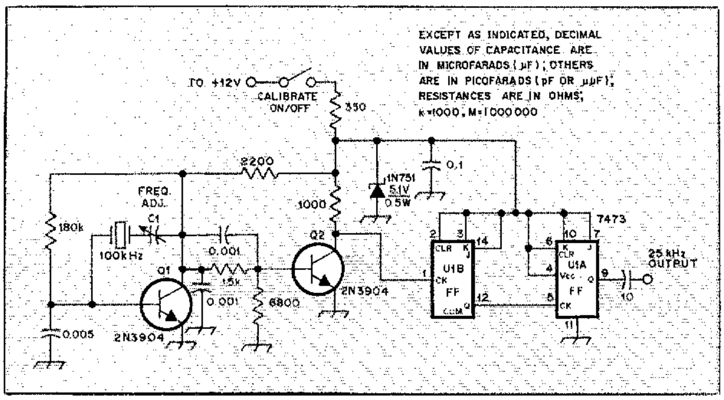


Fig. 1 — The complete schematic of the 25-kHz calibrator. Application is not limited to the HW-8. For use with older vacuum-tube types of receivers the circuit board can be installed in a small box and powered by a 9-volt battery. Most parts shown are available in kit form from Radio Shack (see text). The integrated circuit and Zener diode must be purchased separately.
C1 — 4- to 40-pF trimmer.
U1 — TTL dual J-K flip-flop, type 7473.

supplies regulated voltage for the oscillator and the divider chip. The schematic is shown in Fig. 1.

Construction

The calibrator, as it comes from Radio Shack, is meant to be built on a plastic "P-Box." I rejected this method of construction because the end result does not readily fit into the HW-8 cabinet. The preferred method is to mount the components on a small printed-circuit board that can be attached to the upper left-hand portion of the inner cabinet with no. 6-32 spade bolts. Other acceptable methods are Vectorbord and flea clips, or a piece of "kluge card" that has DIP patterns on it and point-to-point wiring with small-gauge hookup wire. A subminiature toggle switch is mounted on the back panel of the HW-8, just above the antenna connector. This is used to turn the calibrator on and off. The output from the calibrator is coupled to the receive side of the antenna relay through a 10-pF capacitor. Power for the calibrator can be picked up from the power switch on the HW-8.

Operation

After the circuit is wired and installed in the HW-8, the only step left is calibration. The easiest way to do this is to enlist the aid of a receiver capable of tuning WWV. Tune in WWV and connect a piece of hookup wire from the output of the calibrator to the antenna terminal of the receiver. Apply power to the HW-8 and turn on the calibrator switch. Adjust C1 on the calibrator board until the calibrator is zero beat with WWV. Remove the piece of hookup wire and the calibration job is complete. It should now be possible to hear the calibrator output at the lower edge of an amateur band on the HW-8 and every 25 kHz up the band. This little calibrator should find much use in keeping your HW-8 receiver tuned up and those pink slips out of your mailbox. QST

Strays

Great Lakes Division Director Richard A. Egbert, W8ETU (left), awards a certificate of appreciation to Maurice E. Hope, W8EMD, at the Great Lakes Division Convention. Maurice has been an ARRL official observer, ARRL emergency coordinator and Michigan RACES radio officer. Looking on is Michigan SCM Stanley J. Briggs, W8MPD.

A TIP FOR HAMS TRAVELING ABROAD

□ A large number of amateurs are planning trips abroad, and many will take their rigs with them. My recent experience in Holland shows there is one universal thing you can do to help pass a technical examination — be friendly! Remember, you are a guest and are being granted a privilege.

The Dutch equivalent of the FCC, Radio Controle Dienst, informed me by letter that my station was to be inspected in two weeks. However, the time was inconvenient, so I immediately called to ask for a later hour. By establishing this early contact, I helped set up a friendly atmosphere. I also let the inspector know the extent of my language capabilities, with an eye to avoiding any possible misunderstanding.

On the "big day" the inspector arrived with his arms full of sophisticated test equipment. He took measurements of drift, bandwidth and the field strength of my signal. He also checked my logbook and antenna. All in all, it was a very thorough examination.

If you are faced with a similar test, here are a few helpful hints. (1) If the time of the test is inconvenient, try to set a new time at their convenience. (2) If you do not speak the language, try to have someone there who does, preferably another ham who knows the technical terms. (3) If your QTH is difficult to find, send them a simple map.

Above all, remember you are a guest. Remain friendly and help make it easier for your fellow amateurs to be granted the same privileges you are enjoying. — *Maury A. Swartz, WA4LYL*

ANTIQUE WIRELESS CLUB FORMS

□ An antique wireless club has formed in Schenectady, NY, named the Antique Radio Collectors of Schenectady. So far, it has 68 members. Anyone wishing to join should contact Jack Nelson, W2FW, 915 Sherman St., Rotterdam, NY 12303.

Hello there! My name is O. Q. Buro. That's short for Overseas QSL Bureau. I'm the star of the new audio-visual production, "The Official ARRL Overseas QSL Bureau" (SC-18). The premiere netted rave reviews, and I'm now available to local slide projectors around the country for your viewing pleasure. In a style all my own, I take you step by step through *your* outgoing QSL Bureau and show you how to get the most out of it. To arrange for a showing in your local ham community write to the Club and Training Department for a CT-20 order form. I'll be happy to ham it up for your club meeting.

Build This High-Performance Top-Band Converter

You need a good converter if you're contemplating regular operation on 160 meters. A strong front end is essential if bc stations are operating nearby. This converter will let you live next door to commercial a-m stations without overloading problems.

By Max Arnold,* W4WHN and Doug DeMaw,** W1FB

What's that you said? You've been an amateur for many years and have never closed a key or push-to-talk switch on the "top band"? If your curiosity has finally driven you to investigate this fascinating band, you're probably wishing you had some good receiving capabilities — a setup that has a "crunch-proof" receiver and plenty of bandspread to stretch out the 1800- to 2000-kHz slice of spectrum on 160.

This smooth-performing converter is designed for use with an existing receiver which covers 20 meters. In other words, the *up-converting* technique is used to get from 1.8 to 14 MHz, the latter being the tunable i-f. The converter front end contains a Butterworth band-pass filter (fixed tuned) which will cover 1800 to 1900 kHz. Those wishing to operate in the upper part of 160 meters can peak the filter for 1900 to 2000 kHz.

*612 Hogan Rd., Nashville, TN 37220
**Senior Technical Editor, ARRL

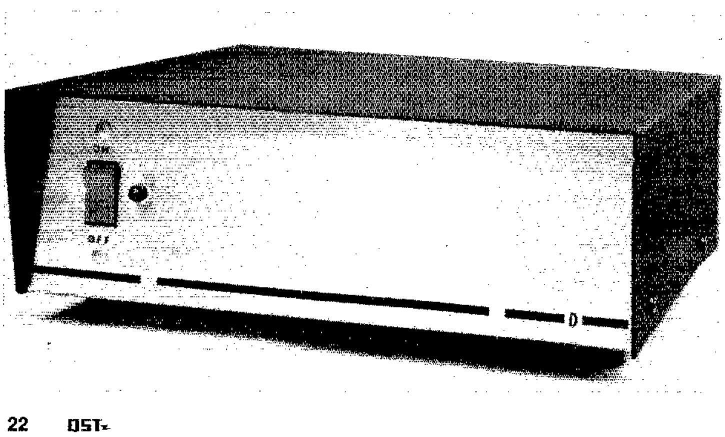
Circuit Highlights

A schematic diagram of the solid-state converter is provided in Fig. 1. FL1 is a two-pole Butterworth filter with a 3-dB bandwidth of 100 kHz. The design was developed by means of a computer during some work done by W7ZOI. Specific design information for this type of filter is given in *Solid State Design for the Radio Amateur* (ARRL) and in the *ARRL electronics data book.*

Q1 serves as an rf amplifier to compensate for the conversion loss of the diode-ring mixer, U1. The mixer is followed by a diplexer (L4, L5 and the related capacitors). This provides a proper 50-ohm termination for the mixer to enhance the IMD characteristics. The L5 pi network also functions as a low-pass i-f output filter. L4 and the two 82-pF capacitors form a high-pass network at three times the i-f (42 MHz). Conversion loss for U1 is approximately 8 dB. The LO injection level is +7 dBm.

The local-oscillator section operates at 12.2 MHz to establish a converter i-f of 14.0 to 14.2 MHz. C4 is used for netting the crystal to 12.2 MHz. This causes 1800 kHz to fall at 14.0 MHz and 2000 kHz to coincide with 14.2 MHz. Q3 functions as an amplifier/buffer to boost the oscillator output to the required +7-dBm LO injection level. A pi network matches the collector impedance of Q3 to the 50-ohm LO port of U1. It serves also as a low-pass filter.

The front-panel controls required for the converter are conspicuous by their absence. A power switch and an LED indicator — that's it. Input and output jacks are located on the rear panel.



Assembly

Double-sided, copper-clad pc board is used. The copper on the component side of the board functions as a groundplane. The ground foils on each side of the board should be joined at several points. This aids electrical stability by reducing unwanted rf ground loops on the board. Circuit boards, negatives and complete parts kits for this project are available from WAØUZO.[1]

Fig. 2 shows an interior view of the first model that was built by W4WHN. An Apollo utility cabinet contains the converter and a 12-volt, regulated dc power supply. Ample room remains for one or

[1]Circuit Board Specialists, P. O. Box 969, Pueblo, CO 81002.

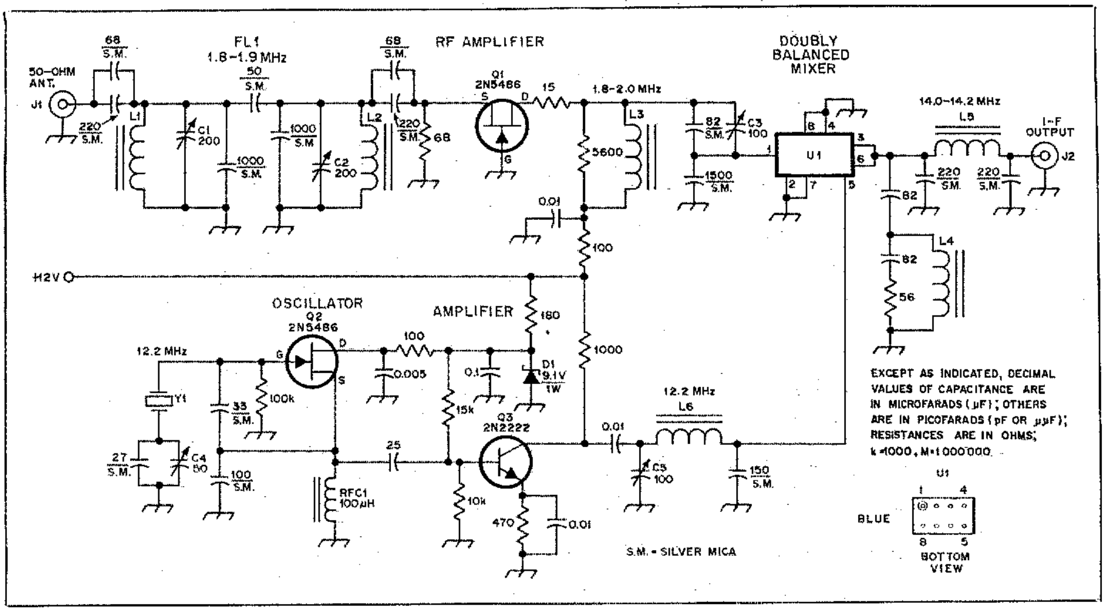


Fig. 1 — Schematic diagram of the high-performance converter. Fixed-value capacitors are disk ceramic unless otherwise noted. Fixed-value resistors are 1/2-watt composition.

C1, C2, C3, C5 — Mica compression trimmer.
C4 — Miniature ceramic trimmer.
D1 — 9.1-volt, 400-mW, or 1-W Zener diode.
J1, J2 — SO-239 style coaxial connector.
L1, L2 — 31 turns no. 22 enam. wire on T68-6 toroid core (5.1 µH).
L3 — 66 turns no. 28 enam. wire on T68-1 toroid core (50 µH)
L4 — 7 turns no. 24 enam. wire on T50-6 toroid core (0.2 µH).
L5 — 11 turns no. 24 enam. wire on T50-6 toroid core (0.55 µH).
L6 — 26 turns no. 28 enam. wire on T50-6 toroid core (2.8 µH).
RFC1 — Small 100-µH choke.
U1 — Diode-quad, doubly balanced mixer module ML-1; SRA-1 or CM-1 suitable. Base connections are the same for each brand, (ML-1 from Mini-Circuits Laboratory, Brooklyn, NY 11203. CM-1 from Cimarron, Denver, CO 80207).
Y1 — 12.2-MHz fundamental crystal, 32-pF load capacitance, type GP, (International Crystal Mfg. Co., Oklahoma City, OK).

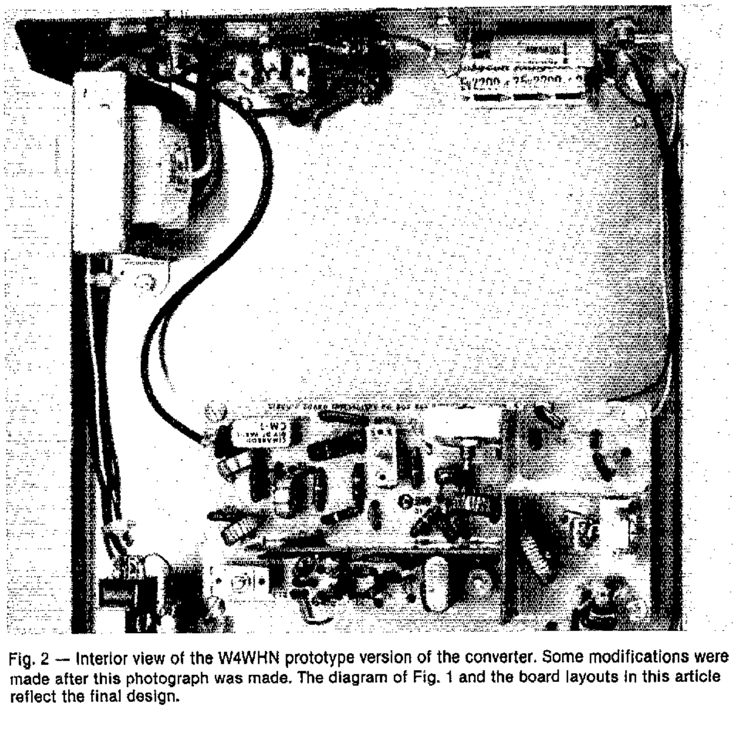


Fig. 2 — Interior view of the W4WHN prototype version of the converter. Some modifications were made after this photograph was made. The diagram of Fig. 1 and the board layouts in this article reflect the final design.

two small converters for other bands. The components seen on the pc board in Fig. 2 do not correspond entirely with the circuit of Fig. 1 and the layout given in Fig. 3. This is so because some circuit changes were made after the prototype model was completed. The pc-board shield dividers shown in the photograph are optional. There is room on the pc board to include them, if desired.

The turns of wire on all of the toroidal inductors should be spaced uniformly. Also, they should occupy all of the core area rather than being bunched together over one section of the core. A coating or two of Q dope can be applied to the toroids after they have been wound. That will keep the turns firmly in place.

Alignment

Connect the converter to a 14-MHz receiver by means of 50-ohm coaxial cable. Supply a weak signal at J1, setting the signal source at 1850 kHz (or 1950 kHz for high-end operation). Observe the receiver S meter and adjust C1 and C2 for maximum signal response. Repeat this adjustment again. Next, tweak C3 for maximum signal output from the converter. C5 is adjusted in a like manner. If a VTVM and rf probe are available, set C5 for approximately 1.6 volts rms. Finally, adjust

C4 so that Y1 is exactly on 12.2 MHz.

Using the Converter

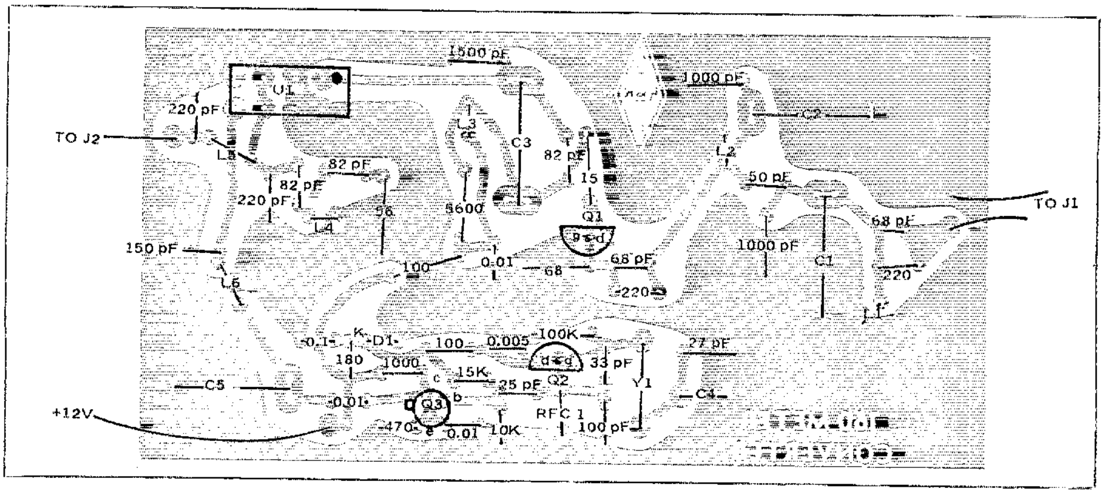
Depending upon the area in which the converter is used, LORAN signals (loud buzz of considerable bandwidth) may be heard even during the daylight hours. Chances are that not much phone or cw activity will be found during the day, but once the sun sets there should be a lot of activity between 1800 and 1850 kHz. Likewise from 1950 to 2000 kHz for the West Coast area. The cw operators are found most often in the 1800 to 1810 part of the band, with ssb and limited a-m operation taking place between 1810 and 1850 kHz. The "DX window" is between 1825 and 1830 kHz. Courteous U.S. and Canadian amateurs stay out of the window to permit foreign amateurs to call CQ and work U.S. and Canadian stations as they transmit elsewhere in the band — usually between 1800 and 1805 kHz.

The greatest period of activity on 160 meters is from September through April when QRN is at its lowest level. The band is quite noisy during the warm months of the year, and propagation is generally inferior during that period.

The Butterworth filter used at the input of this converter is designed for a 50-ohm impedance. It will not perform properly if the antenna is not matched for 50 ohms. If random lengths of wire or dipoles for other bands must be used, a Transmatch should be placed in the line to establish a 50-ohm termination for the filter.

The overall gain of the converter has been purposely set near unity. This will help prevent front-end "bashing" of the tunable i-f receiver when strong signals are present. Too much converter gain will severely degrade the dynamic range of the i-f receiver, leading to cross modulation, desensing and IMD responses. QST

Fig. 3 — Parts placement guide for the converter. The circuit board has foil on both sides. The etching pattern for the non-groundplane side appears in the "Hints and Kinks" section of this issue, and is shown in X-ray view here as the shaded area. Whole-number values with no units represent resistances in ohms; k = 1000. Decimal-value numbers alone represent capacitance in microfarads. K indicates the cathode of a diode.



Strays

ANTENNAS, NOT TOWERS

☐ The new rule said, "no towers," and the Oakland County, MI, Amateur Radio Emergency Service (ARES) was put off the air for five years until a bit of detective work unraveled the mystery. We discovered the phrase originated with the architect who designed the new sheriff's building. He had asked the radio man in charge, "What do you require for all the present and future needs of the County Radio Services?" After much study and figuring, the architect proposed a tower 200 to 300 feet high. Then in good faith, he ruled, "No towers on the building." At great expense, the antennas were located some two miles away and phone lines were leased to take care of the radio needs.

In our letter to the county, we pointed out we did not need towers, only antennas. The antennas were described in simple fashion: "They look like fish poles." We even suggested an antenna that was not too long and did not require radials. Our letter was simple and to the point: We could not provide emergency backup for the county if we had to use phone lines and complex rigs. We wanted things simple, low cost and mobile to serve the needs of the county residents.

We were pleased when we received word to "go." We immediately put up the antenna, ran the cable, and put the rig on the air. K8NKB was the first to reactivate from the County Building Complex.

Could the simple phrase, "no towers," affect your civil defense, ARES or Skywarn program? Is there a vacuum somewhere in the system that keeps you from taking part in some public service program? Could an innocent phrase such as "no towers" cause your well-running emergency program to come to a grinding halt? Yes, there is a lot of public relations work needed to keep an Amateur Radio Emergency Service fully utilized. — *W8HS*

These distinguished visitors dropped by ARRL headquarters recently. Meredith and Pete Hoover, W6ZH, were in the Newington area while attending the 1978 National Red Cross Convention in Hartford where Pete was elected to the National Red Cross Board of Governors. Congratulations, Pete!

SSTV Pictures from Your Microcomputer

Everyone asks, "How can microprocessors be used in Amateur Radio?" If slow-scan TV is your thing, here is a startling answer.

By Barry Sanderson*

Many amateurs have had a desire to get into slow-scan TV reception and transmission. More are interested in microprocessors and their role in Amateur Radio. This article puts the two together. Using the technique described here, you can generate simple graphic and alphanumeric characters without a camera! First, let's review the slow-scan signal, its makeup, and characteristics.

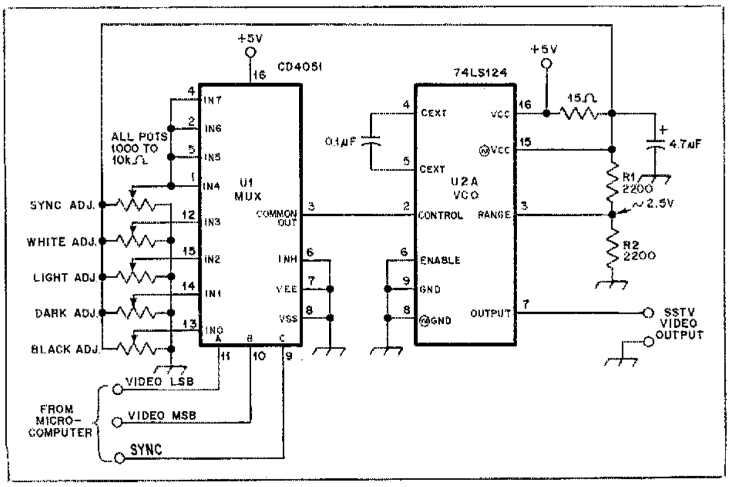
Slow-scan TV signals consist of two parts, the picture information and the synchronization information. The picture information is represented by a signal in the frequency range of 1500 Hz to 2300 Hz (1500 Hz corresponds to black and 2300 Hz corresponds to white). The frequencies in between correspond to shades of gray between black and white.

The synchronization information is represented by a frequency of 1200 Hz. The duration of the 1200-Hz signal distinguishes horizontal and vertical synchronization signals. The horizontal sync signal lasts for five ms and the vertical sync signal for 30 ms. The horizontal sync signal marks the boundary between the end of the picture information for one line and the start of the picture information for the next line. The vertical sync signal marks the boundary between the last or bottom line of one picture and the first or top line of the next picture.

At 15 lines per second, the time required by one line is 66.7 ms. Of this, five ms are required for the horizontal sync signal. The remaining 61.7 ms are filled with the picture information for that line. One entire picture is composed of 30 ms of sync signal (the vertical sync signal takes approximately one-half a line time) followed by 128 lines containing picture information and horizontal sync.[1]

*402 N. LaSalle, Indianapolis, IN 46201

Fig. 1 — A digital-to-analog-to-frequency converter for slow-scan television. No connections are made to IC pins not shown.
U1 — CMOS analog multiplexer, type CD4051.
U2 — TTL dual voltage-controlled oscillator, type 74LS124; one section unused.

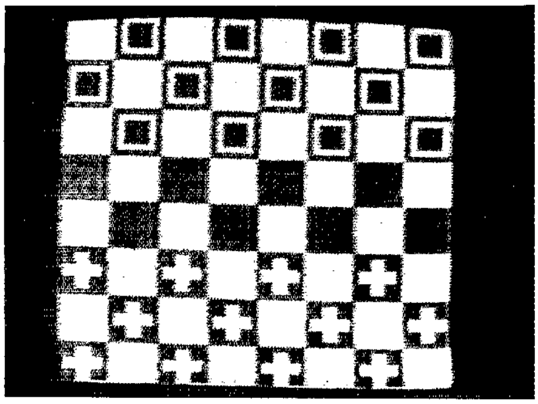


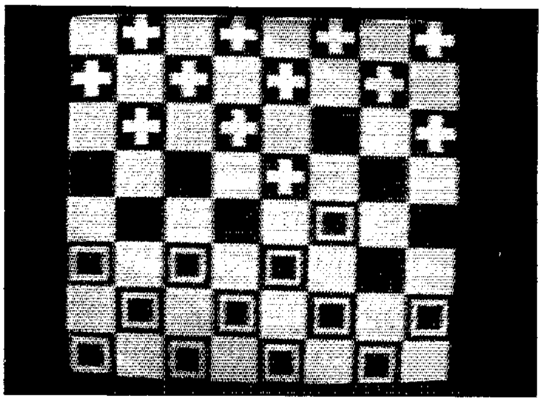
Picture Format

I made some changes in the picture format to simplify the signal-generation process. Rather than allowing 128 different lines in each picture, I allowed only 64 different lines in each picture. In order to make 128 total lines I repeated each line once so that the vertical dimension of each of my picture elements (pixels) is two of the 128 total lines or 1/64 of the total picture.

Also, I decided to make only 64 different pixels possible horizontally. Thus my pictures are an array of 64 by 64 squares or pixels. Each of these pixels is one of four shades of gray. In order of increasing brightness, these shades of gray are named: black, dark, light and white.

[1][Editor's Note: The amateur standard, adopted by gentlemen's agreement in 1968 when SSTV was first authorized for general use in the U.S. and Canada, calls for 120 lines per frame, requiring eight seconds to transmit a complete picture. In recent years the trend has been toward 128 lines per frame, especially when digital-logic circuitry is used to develop the sync signals, requiring 8.53 seconds to send a picture. With proper adjustment of the vertical sweep circuitry in a receiving monitor, either rate may be received satisfactorily.]





In the photo on the left is shown the screen at the starting point for a game of checkers. The white crosses and the light squares represent opposing sides in a game. At right, the board is shown as it might look after a couple of moves have been made.

I lumped the pixels together in groups of eight both vertically and horizontally. Each of these groups is called a character. Each character is a square of 64 pixels (eight pixels on a side). Thus the entire picture consists of a square of 64 characters. There are eight rows of characters with eight characters in each row.

There are no further limitations on what the characters look like. Besides the letters, numbers and punctuation marks that the word "character" connotes, characters can be made to symbolize anything you want. Some examples of things that characters could symbolize are chessmen, battleships, submarines, torpedoes, mines, tanks, artillery, shells, missiles, space ships, planets, stars, photon torpedoes and so on.

The hardware added to make the conversion from microcomputer logic output to the audio signal required for slow-scan is shown in Fig. 1. The conversion is done in two steps. First the logic levels are converted to an analog voltage by a multiplexer. Next, this analog voltage is converted to an audio frequency by a voltage-controlled oscillator (VCO).

The three microcomputer output bits (two bits representing one of four shades of gray, and one sync bit) are applied to the address inputs of an eight-channel CD4051 analog multiplexer. A separate pot is provided to set each of the five different levels (sync, black, dark, light and white). The selected signal is applied to the control input of half of a 74LS124 VCO. The slow-scan video signal is taken from the output of the 74LS124.

For this circuit to yield desirable results each pot must be adjusted so that the proper frequency is output by the VCO when that pot is selected to provide the control voltage to the VCO. The adjustment procedure consists of selecting each pot in turn and adjusting that pot until the VCO oscillates at the proper frequency for that pot. The proper frequencies are Sync — 1200 Hz; Black — 1500 Hz; Dark — 1767 Hz; Light — 2033 Hz and White — 2300 Hz.

The Program

My program is based on two things. First, a hardware timer that generates an interrupt at a regular interval, and second, a routine that is executed in response to the interrupt that is under program control and changes as the program executes.

The hardware timer is set to generate interrupts at the pixel-output rate. The interval is calculated from the slow-scan specification by dividing the time allotted for the picture portion of a line (approximately 61.7 ms) by the number of pixels per line (64). The result is 963.5 microseconds.

One of three interrupt service routines is executed in response to each interrupt from the interval timer. The three routines are named VSYNC, PICT and HSYNC. VSYNC is executed during vertical sync time. It inserts the vertical sync signal and changes the interrupt response to PICT at the end of the vertical sync signal. This means that the next interrupt will result in PICT being executed instead of VSYNC.

PICT fetches the picture information stored in a portion of memory and outputs it to the proper port. After 64 pixels have been output, it changes the interrupt response to HSYNC. Thus HSYNC will be executed in response to the next interrupt.

HSYNC activates the sync signal for five pixel times and then changes the interrupt response to either PICT or VSYNC. If 128 lines have been output, VSYNC is executed in response to the next interrupt; otherwise PICT is executed in response to the next interrupt.

Since the generation of a slow-scan TV signal corresponding to the stored picture is done by interrupt service routines, the leftover time is available to the main-line program to perform other functions.

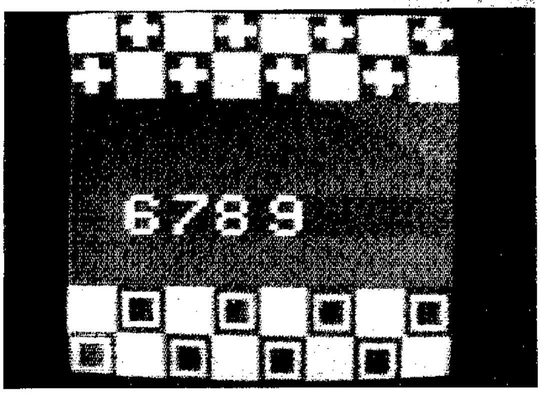
Picture Updating

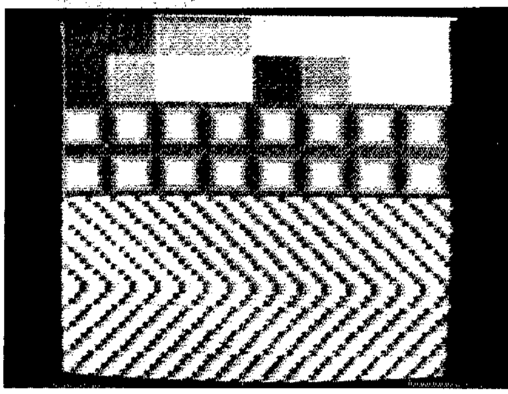
One thing that should be included in the main-line program is a way to change the contents of the memory locations that hold the picture. One approach is to allow a new character to be written into any of the 64 character positions on command from an input device (typically a keyboard). Both the new character and its position in the picture are required each time this command is executed. This type of picture updating is useful in game-playing situations, such as checkers or chess.

Another way to update the picture is to have the position in the picture of the new character incorporated into the program. Thus the input device just supplies a string of new characters and the program places them in the picture. This type of picture updating is useful for alphanumeric pictures or fixed pictures (CQ, QSL, etc.).

Still another way to update the picture is to have both the new characters and their positions in the picture incorporated into the program. This allows a predetermined sequence of pictures to be output.

Since the method of picture updating depends on the situation and the hardware available, I have not included a discussion of my main-line program. However, the three interrupt service routines and a fourth subroutine will actually do all of the work, generating the slow-scan TV signals from stored picture information. With a thorough understanding of the functions performed by these subroutines, you should be able to incorporate them into a program of your own that generates a slow-scan TV signal of pictures of your





At left is an example of 5 × 7 dot matrix numbers fit into characters and displayed on the screen. In the right photo, the top two rows of characters are gray scales. The next two rows consist of a square character that is black around the perimeter, white in the center, and light and dark in between. The bottom half of the picture consists of a sequence of gray scales where the shade of gray changes with every pixel. Each line of pixels is jogged one space to the right for the first 16 lines, then the direction of sliding of gray scales is reversed.

own choosing. This article will provide you with that necessary understanding.

The rest of the article discusses some counters which are used to control program execution, the way the picture is stored in memory, the GET C subroutine which fetches the next pixels to be output, and the three interrupt service routines.

Three eight-bit counters are used to control program execution. These are the X counter, the Y counter, and the PIXEL counter. The X counter is incremented each time a new pixel is output, and is reset to zero at the end of each horizontal sync period. The Y counter is incremented each time the X counter is reset to zero. The Y counter counts the number of picture lines that have been output. It is reset to zero during each vertical sync period. When taken together, the X and Y counters define the position of the pixel on the TV screen at any given moment. The PIXEL counter is used differently by the three interrupt service routines. These uses will be explained separately as the three routines are discussed.

Character Storage

Each pixel requires two bits to specify one of the four shades of gray. An 8-bit word can hold four consecutive pixels. Two consecutive 8-bit words hold eight consecutive pixels, or one line of a character. Thus for each character, 16 consecutive 8-bit memory locations are required to store the two-bit codes specifying the shade of gray for each of the 64 pixels.

In my model, the two video bits required by my interface circuit are connected to the highest order bits of an output port (bit 7 to the video most significant bit, MSB, and bit 6 to the video least significant bit, LSB). Therefore, bits 7 and 6 of the first word of memory for a particular character indicate the shade of gray for the first pixel (upper left corner) of that character. Bits 5 and 4 of that same word correspond to the second pixel of that character. The next two bits correspond to the next pixel, and so on.

Bits 1 and 0 of the second word correspond to the upper right-hand pixel. Bits 7 and 6 of the third word of memory for a particular character correspond to the first (left-most) pixel in the second line of the character. Bits 7 and 6 of the 15th word correspond to the first pixel in the eighth line of the character, and so on. Finally, the lower right-corner pixel is stored in bits 1 and 0 of the 16th word for that particular character.

As a specific example, consider the character diagrammed in Fig. 2A. The cross-hair lines indicate pixel boundaries. This character is a white cross on a black background. Fig. 2B lists the 2-bit codes required for this character according to the following convention: 00 = black, 01 = dark, 10 = light, 11 = white. The solid lines represent microcomputer word boundaries. The table in Fig. 2C shows a hex listing of the contents of the 16 consecutive memory locations required to store this character. A starting address of N is assumed.

Picture Storage

Since a picture is composed of 64 characters, I decided to store a 7-bit value in the first 64 locations on page one of memory to represent each character of the picture. (A page is 256 8-bit words.)

I made these the upper 7 bits of the 8-bit word and forced the LSB to be a zero. The resulting 8-bit word is used to fetch the low order half of a 16-bit address from page two of memory. The high-order half of the address is fetched from the location just above the one containing the low order half of the address. The upper seven bits of the location on page two where the low and high order halves of the address are stored are the same. The LSB is a zero for the low-order half and the LSB is a one for the high-order half. This 16-bit address specifies where the word containing the first four pixels of the character is stored. The remaining pixels are stored in the 15 words following the word in which the first four pixels are stored.

Bits in the X and Y counters specify which of the 16 memory locations associated with each character contains the pixels to be output next. These bits are used to calculate the offset from the word containing the first four pixels to the word containing the pixels to be output next.

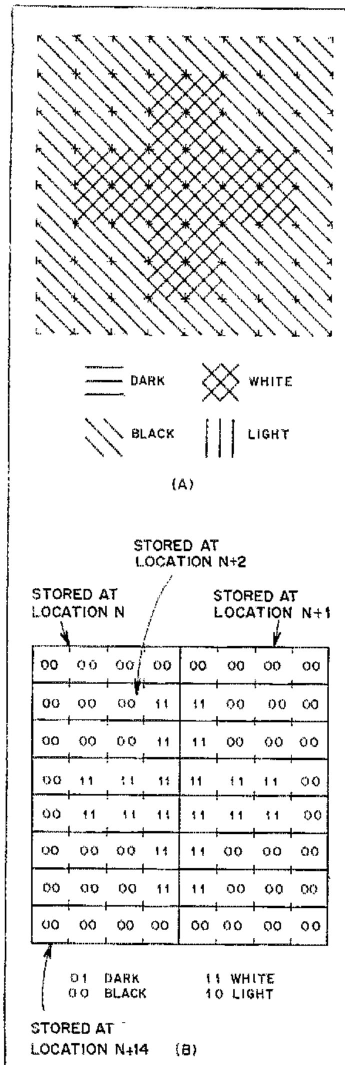
The GET C Subroutine

In order to understand the GET C routine, you should first realize what each bit in the X and Y counters corresponds to with respect to the TV picture. The individual bits are referred to by a letter and a number, the letter being X for the X counter and Y for the Y counter. X7 is the MSB of the X counter, XØ is the LSB of the X counter, Y6 is the next to the MSB of the Y counter, and so on.

X2, X1 and XØ specify which of the eight pixels on a given line of a given character is to be output next. The next three bits (X5, X4 and X3) specify which of the eight characters on a given line is to be output next. X6 goes from a 0 to a 1 when all 64 pixels on a line have been output.

Y3, Y2 and Y1 specify which of the eight lines of a character are currently being output. Y6, Y5 and Y4 specify which of the eight rows of characters is currently being output. Y7 goes from a 0 to a 1 after all 64 lines have been output twice (each line is repeated to make 128 lines). YØ indicates whether a particular line is being output for the first or second time.

As you can see in Fig. 3, the GET C



Address	*Data (Hex)*
N	00
N + 1	00
N + 2	03
N + 3	C0
N + 4	03
N + 5	C0
N + 6	3F
N + 7	FC
N + 8	3F
N + 9	FC
N + 10	03
N + 11	C0
N + 12	03
N + 13	C0
N + 14	00
N + 15	00

(C)

Fig. 2 — Example of data to represent a character. The cross-hair lines at A indicate pixel boundaries; a complete SSTV frame is 64 × 64 pixels. The 8 × 8-pixel character is stored in 16 bytes of computer memory.

subroutine first assembles the bits from the X and Y counters, specifying one of the 64 character positions, into an 8-bit number. This number is in the range of 0-63 inclusive. Next the number of the character currently in that position is fetched from that memory location in page one. This character number is multiplied by two and the result used to fetch a 16-bit address from two consecutive memory locations on page two.

This 16-bit address gives the location of the word containing the first four pixels of the character. An offset of $0000Y_3Y_2Y_1X_2$ is added to this 16-bit address. The result is an address of the memory location containing the next four pixels to be output. These four pixels are placed in the temporary video storage location. The GET C subroutine then returns control to the routine that called it.

Subroutines

The PICT subroutine (Fig. 4) uses the pixel counter to determine which of the four pixels in an 8-bit word have not been output yet. Each time this subroutine is executed a pixel is transferred from the temporary video storage location to the proper output port. The data in the temporary video storage location are rotated two bits to the left so that the next pixel is in the two highest order bit positions.

After every four pixels have been output, the GET C subroutine is called to update the temporary video storage location with the next four pixels to be output. After 64 pixels have been output, the interrupt response is changed to HSYNC and the pixel counter is loaded with 5. Therefore, the HSYNC subroutine will be executed in response to the next interrupt instead of the PICT subroutine.

The HSYNC subroutine (Fig. 5) uses the pixel counter to make the horizontal sync signal five pixel times long. This results in a horizontal sync signal about four percent shorter than the SSTV specification requires; however, it is close enough. After the pixel counter has been decremented to zero, the X counter is reset to zero and the Y counter is incremented. If all 128 lines have not yet been output, GET C is called (to update the contents of the temporary video storage location). The pixel counter is then set to 4 and the interrupt response is changed to PICT. If, however, all 128 lines have been output, the pixel counter is set to 31 and the interrupt response is changed to VSYNC.

The VSYNC subroutine (Fig. 5) uses the pixel counter to make the vertical sync signal 31 pixel times long. After the pixel counter has been decremented to zero, the Y counter is reset to zero. Then GET C is called (to update the contents of the temporary video storage location), the pixel counter is set to four and the interrupt response is changed to PICT.

Since a slow-scan TV signal is an audio

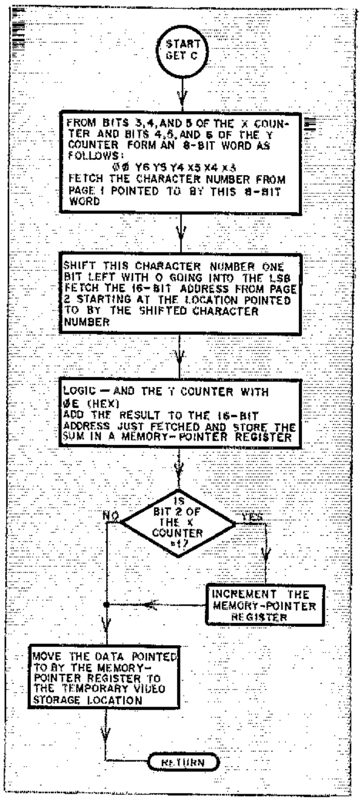


Fig. 3 — Flow diagram of the GET C subroutine.

waveform, it can be transcribed on any tape recorder with low noise, flutter and distortion characteristics. I made up some characters, and then some pictures from those characters. I used my program to generate the slow-scan TV signal corresponding to those pictures and recorded it. I then took this tape to someone who has a commercially available scan converter. This scan converter accepts a slow-scan video signal as an input and outputs a "normal" or fast-scan video signal which can be displayed on a TV monitor. The pictures in this article are ones I took of the TV monitor while it was hooked to the output of a scan converter receiving my taped slow-scan signals.

This particular scan converter did something to pictures with sharp high-contrast edges, causing a decrease in picture quality. The converter superimposed a checkerboard pattern of black dots on the picture. Instead of each pixel being the proper width, each pixel is only half as wide as it should be with the other half being a black dot. The black dot appears either to the left or right of the half-size

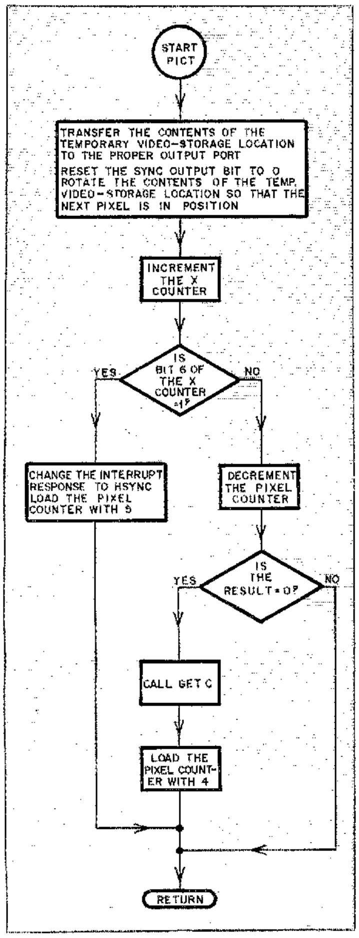


Fig. 4 — Flow diagram of the PICT subroutine.

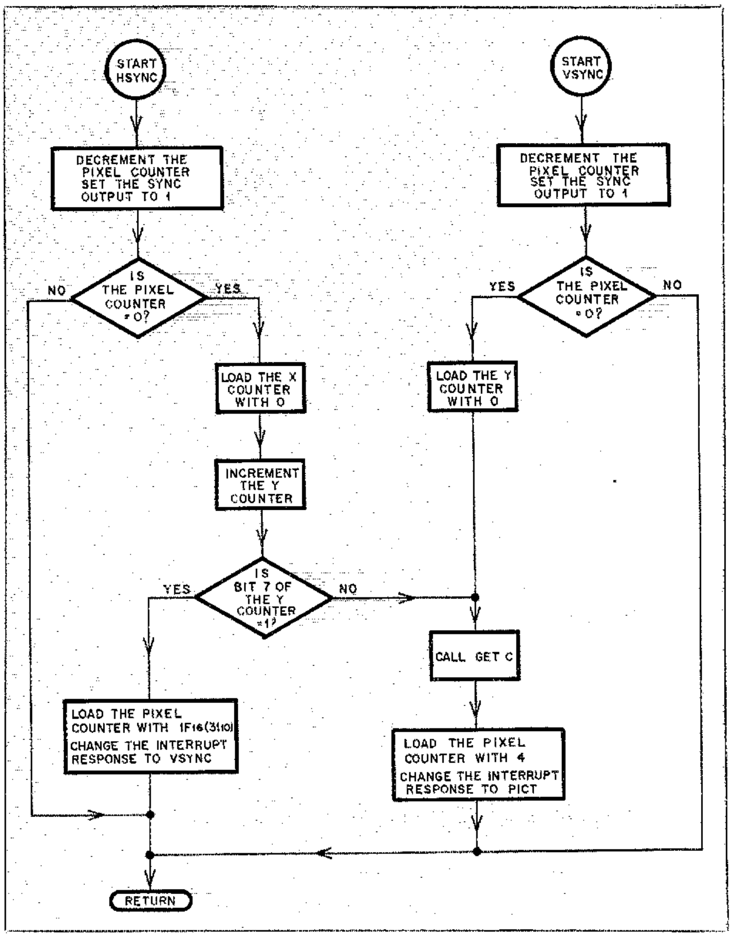


Fig. 5 — Flow diagram of the HSYNC, VSYNC subroutine.

pixel alternating from one line to the next. This accounts for the fuzzy vertical edges in these pictures.

I have purposely not included a listing of my program, because it is written in assembly level language and I attempted to use as many special Z-80 instructions (which are not a part of the 8080 instruction set) as practical. I also freely used special hardware features which I designed into my microcomputer. Thus, a significant number of the instructions in my program involve some special feature of my microcomputer. Rather than "sidetrack" to explain these, I have discussed the algorithm I used and hope you can adapt this algorithm to your microcomputer and application.

Strays

"ROADEO" HAMS

□ Backing through obstacles, steering around tennis balls and negotiating a serpentine course that would raise the hair of a Grand Prix driver were just some of the difficulties that 279 school bus drivers faced during the recent fifth annual Wisconsin School Bus Safety "Roadeo" in Madison, WI. Devoted to safety for the school-age rider, the event was made possible by the 21 hams who assisted. It was surely a communication and organizational challenge not seen since Field Day!

The Madison Area Repeater Association, Four Lakes Amateur Radio Club and Yellow Thunder Amateur Radio Club undertook the task of providing mobile, portable and fixed 2-meter equipment and personnel to keep track of the drivers, their scores and equipment.

Headquarters for the event was the Madison-Sheraton Hotel, where K9VAL acted as net control. Twenty other hams sporting an assortment of gear and antennas were scattered throughout the road course and elsewhere at the Dane County Exposition Center. K9BIL acted as field coordinator for these locations.

A bus equipped with 2-meter gear was used to shuttle entrants and spectators to and from various events. WR9ABT, the MARA repeater, provided clear, concise communications. — K9ZZ

Medium-Scan Television — A New Amateur Frontier

Just what is MSTV? It's about to happen, on 10 meters!

By Dr. Don C. Miller,* W9NTP

As the radio spectrum becomes more and more crowded, what better way is there to promote Amateur Radio worldwide than to be the first to transmit moving television pictures to Europe, *without* the aid of a repeater satellite? This very task has been undertaken recently by an energetic group of experimental SSTV hams who, with the help of the ARRL, have received a Special Temporary Authorization (STA) from the Federal Communications Commission.

This STA was granted on June 16 to W9NTP, W3EFG, WB9LVI, W6MXV and WØLMD. It permits the testing of a 36-kHz-bandwidth television system on the 10-meter band on a frequency segment of 29.0-29.3 MHz. The task of transmitting moving television pictures in such a bandwidth will not be easy. It rivals much of the work being done in commercial and military fields where systems are being developed for low bandwidth and long-distance transmission.

Why should this group succeed when many other investigators have not had success? Let us look back in history. Twenty years ago SSTV was an infant and there was very little interest in low-bandwidth, still-picture transmission. While SSTV started out with a few technically oriented hams, it has resulted in pictures from Mars and become one of the main tools in commercial and military systems today. This would probably not have happened if amateurs hadn't persisted in promoting SSTV through magazines, STAs and the Military Affiliated Radio System (MARS).

The hams listed on the MSTV STA will need the help of hundreds of others. This is where the reader can help. Cooperation is needed in Europe, too.

Squeezing the Bandwidth

The only possibility of transmitting moving television images over international distances is to reduce the rf bandwidth to near 36 kHz. The problem therefore becomes one of reducing a standard TV video image of 3-MHz bandwidth to one of 15-20 kHz. No magic breakthrough is going to occur in video processing. The designer will be forced to leave "something" out of the regular TV image in order to bring the bandwidth down to the acceptable width. The choices are (1) reduce the number of pixels (resolution cells), (2) reduce the number of lines in the image, (3) reduce the number of fields in the frame, or (4) intermix some of the above deletions of data in some acceptable manner.

Many years ago television was standardized to a field rate of 50/60 Hz in order to reduce viewer flicker. This transmission rate is not necessary today because data-storage systems (digital scan converters with semiconductor memories or possibly P7 phosphor screens) can reduce the necessary data rate and bandwidth to present acceptable moving pictures which have no flicker. Experimenters have demonstrated that field rates as slow as 7.5 fields per second are adequate for many applications of television.

Table 1
Suggested Interim MSTV Standards

Field rate: 5 fields/second
Fields: Interlaced
Frame rate: 2.5 frames/second
Lines per field: 64
Lines per frame: 128

The STA experimenters are suggesting the specifications given in Table 1 in order to get as many hams involved as possible. The final system will be much more exotic, but these standards will permit modification of all existing analog SSTV gear. Later the progress will require the use of a digital scan converter (such as a converted Robot 400) or a microprocessor system such as that produced by one of the STA investigators (Digital Group, WØLMD), to take full advantage of the more complicated system with greater degrees of motion.

The video bandwidth can be calculated from the following formula: Base video bandwidth = (number of field/s) = (number of lines/field) × (number of pixels/line)/2. The video bandwidth based on the above specifications of Table 1 therefore is (5 fields/s) × (64 lines/field) × (128 pixels/line)/2 = 20,480 Hz. These standards can be made synchronous with both 50- and 60-Hz power countries. This video bandwidth will possibly fit the 36-kHz STA segment.

Let's list the work that needs to be done by those who want to help. We would like to enlist each interested amateur in participating in this two-year experiment. The immediate plans are given in the following paragraphs.

1) Develop an fm transmitter (36-kHz bandwidth) on 29.150 MHz. This transmitter will transmit a gray-scale television image when accessed. This will be the test beacon to catch band openings.

2) Develop a 36-kHz fm receiver for MSTV. Perhaps some of the rf modules produced today can be used.

3) Convert the driven-sweep P7 SSTV monitors such as the W6MXV and WØLMD circuits to the new MSTV standards.

4) Convert digital fast-scan converters (like W6MXV's circuit) to the new standards.

5) Convert analog Robot gear to the new MSTV standards.

I would like to hear from any readers who desire to take the responsibility for any of the above conversions. All of the above suggestions should be completed during the first year of the STA (June 1978 to June 1979). During the second year, concentration will be on the development of a digital scan converter or microprocessor software for the finalized standards. The STA investigators would like to send out progress reports individually, even though we hope to publish reports in the amateur magazines. If you would like to be a part of this electronic adventure into experimental ham radio, send a self-addressed envelope to W9NTP. If you are seriously interested in having your name added to the list of the STA investigators (this would permit transmission of MSTV) it will be necessary to show that you have developed receiving equipment before you can apply to the FCC. Recently, personnel on the FCC were heard to say, "Hams should be building their own equipment." I certainly agree. QST

*RR 1, Box 95, Waldron, IN 46182

Product Review

KDK FM-2015R Two-Meter Transceiver

In today's auto market you can find just about anything you want, from a stripped-down subcompact to the most luxuriously appointed limousine. For radio amateurs, the 2-meter fm market presents a similarly wide choice. The KDK FM-2015R fits somewhere in the luxury class of 2-meter fm rigs.

For the past year I have owned and operated a KDK FM-144, the predecessor of the FM-2015R. Since I have been very pleased with the performance of the FM-144, I thought I knew what to expect from the FM-2015R. As the FM-144, the FM-2015R covers more than the 2-meter amateur band (144-148.995) in 5-kHz steps. The extended frequency range and the 5-kHz-step provisions make the FM-2015R attractive in view of the new repeater subband with proposed inputs and outputs that will not necessarily fall every 15 kHz.

That much was expected. I had seen some ads for the FM-2015R indicating that its appearance was not much different from the FM-144, except that it had more knobs and switches. The FM-144 fits what I call the generic description of a 2-meter fm rig, "a small rectangular black box having three knobs and two switches; the overall effect suggesting that it came from the cockpit of a DC-9 or from an army jeep." The FM-2015R does not begin to fit that description, nor do the pictures in the ads do it justice. That was pleasant surprise number one. It is a singularly attractive piece of equipment.

That is all well and good, but not of as much significance as what's *inside* the rig. The transmitter produces true fm by using a Varicap as a reactance modulator. Several operators have commented on the fine audio quality of the transmitted signal. A three-position toggle switch on the front panel selects either high power (15 watts) or low (1 watt), with the center position being off.

The receiver uses double-tuned rf circuits (Varicap) peaked automatically at the operating frequency and dual-gate MOSFETS to achieve very low levels of cross modulation and intermodulation while at the same time providing good sensitivity over the entire 5-MHz range. My personal use indicates that Kyokuto Denshi has achieved excellent results by designing the receiver this way. I have used the FM-144 in downtown Hartford and midtown Manhattan with no evidence of intermodulation distortion. I have used the FM-2015R in downtown Hartford and Boston with no sign of "intermods." Suffice it to say that these areas are "polluted" with rf. Sensitivity of the FM-2015R is as good as that of any other rig I have used, being better than 0.25 μV for 20 dB of quieting.

A five-position rotary switch is used to choose the MHz portion of the operating frequency. The hundreds-of-kHz and tens-of-kHz portions of the operating frequency are selected by two concentric knobs. The operator can add 5 kHz to the operating frequency by throwing a toggle switch. The receive frequency is read on four *large LEDs* (the first two digits, "14," do not change and are painted on the dial). The hundreds-of-kHz switch and the tens-of-kHz switch both have built-in stops so they will rotate only from zero to nine; thus, the frequency can be set totally "by feel," which is important to blind operators or to is otherwise busy watching something else, e.g., the road!

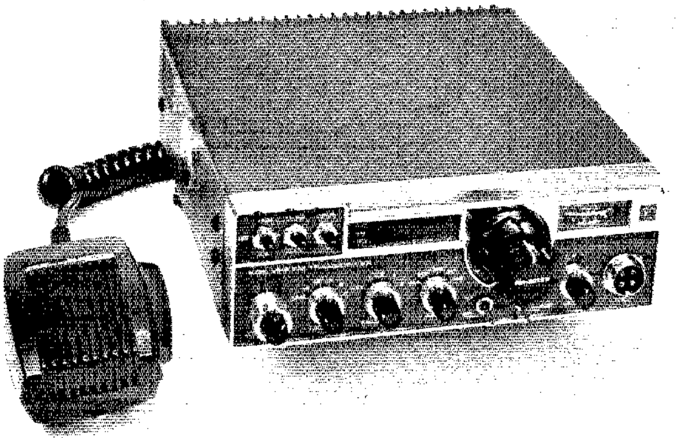
A six-position rotary switch is used to select the mode of the transmitter. For simplex operation the transmitter is operated on the receive frequency. The standard plus- and minus-600-kHz offsets are also built in. Three additional positions are available for nonstandard offsets. The operator merely plugs in the proper crystal to get a particular nonstandard offset — the owner's manual gives explicit directions for determining the frequency of the crystal. So far, this is pretty much similar to the FM-144, so there were no surprises.

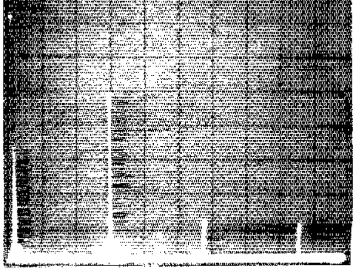
Do You Remember Me?

Suppose you have two favorite repeaters with outputs on frequencies such as 147.06 and 146.91 MHz. With a synthesized rig you could be at a slight disadvantage over someone using a "rock-bound" rig. To go from one to the other you have three switches to throw, while your friend has only to twist one knob. The FM-144 gets around this problem partially by including an extra position on the MEGAHERTZ switch that gives you a "priority" frequency regardless of how the other knobs are set. To change the frequency of the priority channel, the operator must remove the case and "reprogram" a diode matrix board. Although this certainly beats buying more crystals, it could be easier.

And it is, with the FM-2015R. The concept of priority or favorite frequencies has been carried much further. The diode matrix board has been replaced by high-speed CMOS RAMs which provide not one but *four* memorized

The KDK FM-2015R cabinet is finished in dark gray, providing a very modern appearance. The density of knobs and switches gives some indication of the number of features and "luxury options" that have been incorporated into the basic design.





Transmitter output of the FM-2015R as displayed on a spectrum analyzer. Vertical divisions are 10 dB per division; horizontal divisions are 50 MHz each. This shot was taken with the '2015R running at rated output on 146.52 MHz. The top reticle line represents the full amplitude of the fundamental, which was partially notched out here to prevent overload distortion in the analyzer. The second harmonic at 293 MHz and the third at 439 MHz are both more than 67 dB below the fundamental. All other spurs are at least 73 dB down. These measurements were taken in the ARRL lab.

frequencies. Furthermore, the operator can reprogram them at will without taking the rig apart. A five-position rotary switch selects among OFF and the four frequencies — in the OFF position the normal switches control the operating frequency. To program a particular frequency, the operator simply sets the regular frequency controls for that frequency, turns the memory switch to the chosen "channel" and throws the toggle switch. To program a different frequency, the operator repeats the steps with the new frequency. It may sound complicated, but it isn't. The first time this reviewer tried it, it took two minutes, 12 seconds (including one mistake) to program all four memories.

When the memory channels are programmed, and the memory switch is moved from OFF to one of the other positions, the normal frequency controls are overridden. Whatever frequency is programmed into the memory becomes the operating frequency (and is read out on the display). A built-in NiCad battery keeps the memory from being erased when power is turned off. Thus, for the mobile operator (or anyone else in a hurry) the FM-2015R provides easy and speedy operation comparable to a crystal-controlled rig.

Hide and Seek

The memory channels also have a versatile scanner built in. As with most scanners, the operator simply throws a switch and the scanner starts looking for a "busy" channel. The unique function here is that, instead, the scanner can hunt for a "quiet" channel and will lock on that frequency when it is found. In an area such as Connecticut, where the repeaters are in almost constant use during certain portions of the day, this feature can save lots of dial twisting. The scanner overrides all other frequency controls. If the scanner is activated, it immediately begins to scan the four memory frequencies regardless of the setting of the other switches. Since the scan-lockup functions are controlled by the presence of a squelch signal, the scanner can't be used for transmitting.

A New Era for Discrimination

When I read the manual and found out that the S meter also doubles as a discriminator meter, I was indifferent. In this day and age of frequency counters could there possibly be a repeater that was not "exactly" on frequency? Oh well, it would be a nice toy and it might help in tuning up one of my crystal rigs when I change crystals — or so I thought at the time. To my surprise I have found about 30 percent of the repeaters I have worked to be significantly off frequency! The FM-2015R also has a receiver incremental-tuning (RIT) feature built in. With the use of the discriminator meter and the RIT, I suddenly discovered that the repeaters I had previously accused of having "lousy audio" were, in fact, off frequency. The RIT certainly makes copy much more pleasant under such circumstances.

Other Features and Options

The FM-2015R also has a built-in tone-access system which can be turned on from the front panel. The operator can choose between a continuous subaudible tone (67 to 207 Hz) and a tone burst (1750 Hz). An *internal* switch selects one of these two modes. The frequency of the tone can be adjusted by changing the value of capacitors. Provisions are also made for connecting a Touch-Tone pad to the unit.

KDK FM-2015R 2-Meter Transceiver

Dimensions (HWD) and weight: 2-1/2 × 7 × 7-1/2 inches (65 × 180 × 190 mm), 5 lbs (2.3 kg).
Power requirements: 12-15 V dc at 3 A (high power transmit).
Frequency range: 144.0 — 148.995 MHz in 5-kHz steps.
Power output: 15 watts (high) or 1 watt (low).
Receiver i-f bandwidth: 6 kHz at − 6 dB, 12 kHz at − 70 dB.
Transmitter deviation: 5 kHz.
Price class: $420.
Supplier: Amateur Wholesale Electronics, 8817 S.W. 129 Terrace, Miami, FL 33156.

Options available for the FM-2015R include a MARS/CAP kit which permits operation below the regular amateur band. This modification requires the "dedication" of two of the memory channels. It *does* provide the operator with direct readout of both transmit and receive frequencies. At a recent hamfest an amateur who had made the modification said that it took him about an hour.

Amateur Wholesale Electronics also has a "super scanner" option available which will enable the operator to scan any frequency between 144 and 148.995 MHz, any segment of this band, or the entire band.

The FM-2015R has one disadvantage: The knobs on the mode switch, memory switch and MEGAHERTZ switch are a bit small for someone as "ham-fisted" as this writer. But given the number of functions that have been built into this small package, this inconvenience is small.

A Word About Service

During the course of this review the ARRL lab crew routinely subjected the KDK FM-2015R to a spectrum analysis. Although spurious output suppression on the simplex and plus-600-kHz offsets exceeded FCC requirements by a comfortable margin, it was found that on the minus-600-kHz offset, the review unit did not quite meet FCC specifications. Amateur Wholesale Electronics was contacted and informed of the problem. It was their opinion that the unit was slightly out of alignment.

The review unit was returned to Amateur Wholesale Electronics where they verified the findings of our spectrum analysis. The unit was realigned and returned to ARRL. The unit was then resubjected to spectrum analysis, and this time easily surpassed all government requirements on all frequencies in all offsets.

A lesson to be learned from this is elementary: "Things *ain't* as simple as they used to be!" The FM-2015R (or any other synthesized rig) is a complicated piece of equipment. Proper servicing requires some pretty sophisticated test equipment, including a spectrum analyzer. Although saying this may go against the grain of tradition, lacking the expertise or the test equipment, the average amateur is advised to return a defective synthesized rig to the factory for service.

Price class of the KDK FM-2015R is $420. Detailed information can be obtained from Amateur Wholesale Electronics. — *Pete O'Dell, N1UM*

HY-GAIN MODEL 214 TWO-METER YAGI

This is a review that almost wasn't written. For awhile it looked as if Hy-Gain Electronics was going out of business, a bankruptcy victim of the deflated CB market. It was good news indeed when Telex Communications, Inc., a name familiar to hams from their audio products, announced that it was buying Hy-Gain's non-CB business and that Hy-Gain's well-known line of amateur antennas would return to production. In fact, there's a certain poetic justice to it. The CB business and the old management, which pushed Class-E CB, are gone, but the ham business lives on, with many of the same fine people who have staffed it for years.

The Hy-Gain model 214 is a 14-element Yagi for 2 meters. Hy-Gain Yagis have long been in use by serious 2-meter operators, especially the wide-spaced 8- and 15-element versions. The 214 is a significant departure from the old designs; the feed system is the same (a split dipole, insulated from the boom, with beta match), but the elements are close-spaced (boom length is 15-1/2 feet or 4.72 m) and the parasitic elements are made of solid rod mounted *through* the boom. Hy-Gain uses a clever method of mounting these elements, the details being shown in Fig. 1. The antenna is very light in weight (about 5-1/2 pounds or 2.5 kg) and is relatively inexpensive. Therefore it is realistic, both physically and economically, to think in terms of stacking two or more Yagis for improved gain and directivity. The array we tested was a set of four 214s, horizontally polarized and cut for the lower half of the band (144-146 MHz).

Construction of the individual Yagis is an easy two-hour job with the aid of the illustrated instructions supplied by Hy-Gain. The only problem encountered, and a very minor one at that, was that the driven element did not line up exactly in the same plane as the parasitic elements. The mounting hole for the driven-element insulator was not exactly perpendicular to the holes for the parasitic elements. This was easily remedied by bending the tubing used in the driven element slightly, and may not be characteristic of all production runs of the antenna.

Ample warnings against letting the antenna come into contact with power lines are supplied, in recognition of the number of accidental electrocutions of inexperienced antenna installers which have occurred recently.

The model 204 stacking kit provides for a stacking distance of approximately 12 feet (3.7 m) between antennas. In our case, the entire array was assembled on the ground and then hoisted into place atop a 70-foot (21-m) tower. This was a bit tricky, though only two people were needed to do the job. Some of the elements were bent in the process, but it was no problem to straighten them with a long pole once the array was safely bolted to the mast. Light weight does not equate with flimsy construction, and there is no reason to believe the antennas would not survive a New England winter. The serious operator probably would want to replace the RG-59/U coax phasing lines supplied by Hy-Gain with RG-11/U to reduce losses. Also, the RG-58/U used for the balun could be replaced with RG-8/U or similar coax. Taking these steps would raise the power-handling capability of the antenna above its rating of 250 watts, continuous duty.

Performance of an antenna is difficult to evaluate objectively without an antenna test range, and the League does not have one available. However, Hy-Gain does, and its engineers supplied us with a radiation pattern for the array which seems to agree closely with

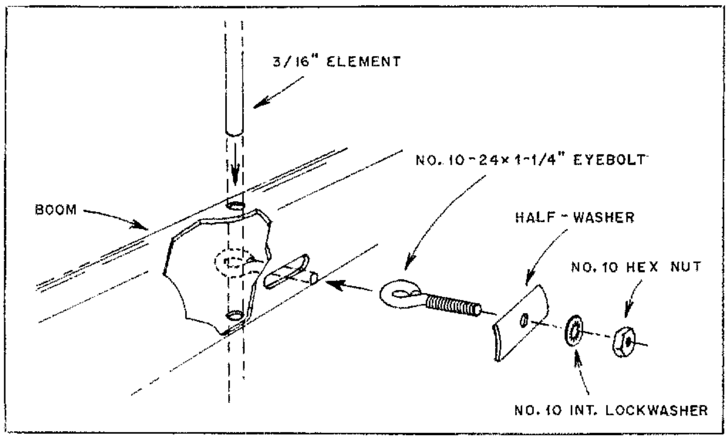
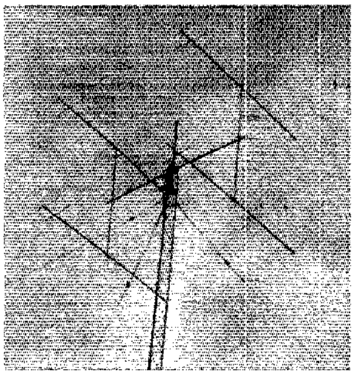


Fig. 1 — Details of the method used to mount and secure the elements *through* the boom.



The array of four 14-element Hy-Gain Yagis as installed at K1ZZ.

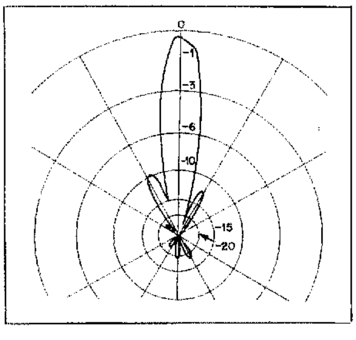


Fig. 2 — Horizontal-plane radiation pattern of the pictured 56-element array at 145 MHz, as measured on the Hy-Gain antenna test range and verified in operation at K1ZZ. The plotted points show the radius calibration in decibels.

findings from our on-the-air tests. The magnitude of the side lobes may surprise you if you have not used stacked antennas before. However, they are typical of an array of this type, and can be reduced by changing the spacing (at some expense in gain). Some comparisons were made with a single Yagi of different design atop the other tower at K1ZZ, about 115 feet (35 m) above the ground. While the single Yagi gave comparable performance over some relatively short paths, in no case was it better than the 56-element array, and on longer paths the array had a definite edge in spite of its lower height. As one might expect, fading is less of a problem on the large array.

What can you expect to work with this sort of antenna? K1ZZ, in the middle of the Connecticut River valley, is not exactly in a classic vhf location. Shortly after the antenna went up, we caught a minor aurora and traded S7 signal reports on cw with K8III near Cleveland, almost 500 miles (800 km) away. Paul suggested we try working on the direct path, and sure enough, signals were about S6 without any assistance from the auroral curtain! Since then, we've confirmed that we can work reliably. It's not unusual to work 10-watters out to 250 miles (400 km) or so, and in the June contest seven hours of operation yielded 166 QSOs in 23 sections. The station transmitter supplies about 300 watts to the antenna, which certainly helps.

In summary, the Hy-Gain 214 is worth considering if you're looking for a lightweight, reasonably priced antenna for 2 meters. (We haven't spoken about performance at the high end of the band, but dimensions are given for cutting the elements for operation there, and mounting the antenna for vertical polarization is no problem.) It lends itself well to stacking; an array of 214s should be practical in many cases where an array of heavier, longer boom Yagis would not. And, if you think it would be fun to tell your contacts, "The antenna here is 56 elements," you're absolutely right!

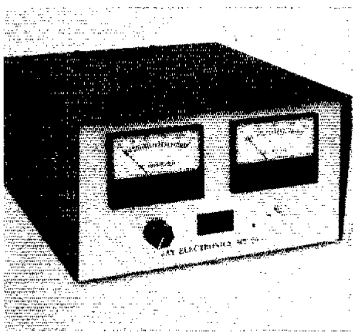
The individual Yagis retail in the $27 class. The model 204 stacking kit, as reviewed, is in the $115 class; model 202, for stacking two Yagis vertically polarized, is $40. — *Dave Sumner, K1ZZ*

SAY SPS-20M POWER SUPPLY

Vhf fm power amplifiers and the new wave of 12-volt-powered hf transceivers have generated an unprecedented demand for high-quality, low-voltage power supplies. Manufacturers have been responding by producing new power supplies every week. But how can you tell a

SPS-20M Specifications

Power input: 105-125 V ac at 60 Hz.
Output voltage: Adjustable from 3 to 14 V dc.
Ripple voltage: 0.2 mV RMS.
Current limit: 25 A.
Overvoltage: +17 V dc nominal.
Continuous current: 20 A.
Meters: Individual volt and current meters.
Dimensions (HWD): 5-1/4 × 9-1/4 × 12-1/4 inches (135 × 235 × 310 mm).
Weight: 18 lbs (8 kg).
Price class: $180.



The brushed-aluminum front panel on the SPS-20M contains meters, power switch, voltage-control potentiometer, and circuit-breaker reset button.

good power supply from one which might be inadequate, or even damage your equipment? You look for good regulation (voltage remains constant with and without load), no ripple (no hum in the signal), equipment protection (overvoltage and overcurrent protection for both rig *and* power supply), and quality construction for long life. The Say Electronics Inc. SPS series sports these features and more.

QST tested the top-of-the-line SPS-20M model, which features a rating of 20 amperes continuous, 25 peak, fully adjustable output between 3 and 14 V dc, and both voltage and current meters. Most of the hefty 18-lb (8-kg) box is concentrated in the transformer, 50,000-μF capacitor and large heat sinks. The circuit diagram reveals additional protection in the form of a fuse in the transformer primary (protecting the single most expensive component) in addition to automatic current limiting, overvoltage and short-circuit protection. A Darlington regulator with four 2N3771 transistors in parallel is controlled by the 723 IC, with near-perfect regulation. Rapid switching between no load and a 5-A load varied the voltage less than 0.5 percent! Ripple was nearly undetectable, thanks to a full-wave bridge rectifier and extensive filtering ahead of the regulator. The output is fully bypassed, and no af or rf feedback was observed.

The handsome, brushed-aluminum front panel contains the illuminated power switch, 20-A circuit breaker, meters and voltage control. The output terminals are under the large heat sink on the back of the unit.

Say Electronics (750 N.W. 57th Court, Fort Lauderdale, FL) makes a complete line of power supplies, the SPS-2, -4, -8 and -20. The last three are also available in adjustable, metered versions, such as the SPS-20M. — *Chod Harris, WB2CHO*

Technical Correspondence

The publishers of QST assume no responsibility for statements made herein by correspondents.

ON SOLID-STATE PA MATCHING NETWORKS

□ I would like to pass along some observations I've made which are of interest to builders of solid-state Class C hf transmitters.[1] I have found that the use of such matching networks as the commonly recommended L and T,[2] as well as any other network with an inductor or series LC as the input element,[3] will inevitably result in improper circuit operation. The circuit will exhibit poor collector efficiency, spurious output, or a high transistor failure rate, unless one of these conditions is met: (1) the output transistor is very rugged (in which case it won't fail, but the other conditions will remain); (2) the transistor output capacitance is 100 pF or higher; (3) a Zener diode is connected across the transistor (more about this later); or (4) the network is modified in a manner I will describe.

Let's see what causes the problem. Although there is an optimum resistive impedance for a transistor to "see" (approximately $V_{CC}^2/2P_O$),[4] the transistor does not present this or any other impedance. Rather, it acts much as a simple on-off switch. At the instant the transistor is turned off, current flowing through the rf choke is dumped into the circuit elements. The dominant circuit presented to this current is parallel resonant, with L being the network input inductor and C the transistor output capacitance, C_O. C_O is in parallel with stray circuit capacitance. This circuit "rings" at its resonant frequency, which is not necessarily related to the operating frequency.

Fig. 1 shows the schematic of a typical 40-meter, 2-watt-output amplifier. Fig. 2A is a photo of the oscilloscope waveform at the collector of Q1. The presence of 70-volt, 50-MHz ringing at the collector may be readily seen. I was able to obtain this picture only because the particular transistor was exceptionally rugged — several devices were destroyed in the attempt. Although this condition could be detected with a wavemeter coupled loosely to the collector circuit, it can only be observed with the aid of a wide-bandwidth scope. The instrument used to obtain these photos has a 250-MHz bandwidth.

A photo of the waveform at the load is shown in Fig. 2B. Distortion may be reduced by filtering, but — assuming the transistor is not destroyed — collector efficiency will be less than optimum. Typical efficiency will be on the order of 40 to 60 percent, rather than the 70 to 80 percent obtained from a well-designed amplifier stage.

An advanced circuit-analysis computer program was used to investigate the circuit of Fig. 1, assuming perfect inductors, capacitors, source, load and a good model of the 2N3866 transistor. The graphical results of this analysis are shown in Fig. 3. Because of the use of perfect components, frequency and amplitude of the simulated waveform vary slightly from the real waveforms shown in Fig. 2. The striking similarity to Fig. 2 and the presence of ringing in the simulation verify that the phenomenon is *not* a spurious oscillation in the usual sense, nor is it due to stray capacitance or inductance or poor circuit layout. *It is inherent in the use of this type of network!*

A capacitor connected from the collector to ground or, preferably, from collector to emitter, will solve the problem if it approximately resonates with the input inductor at the operating frequency. The capacitor will reduce collector-voltage swing to less than 30 volts with a 12-volt supply. The effect on the Q of common networks will be negligible and only slight readjustment of the variable capacitor(s) will restore the correct match.

A Zener diode connected across the collector will sometimes solve the problem, but not because of Zener action! A typical 33-volt, 1-watt Zener diode has a capacitance of 200 to 800 pF, depending on the amount of reverse bias. This is generally sufficient to prevent the ring in the first place.

This letter has been necessarily brief but I hope it will enable the reader to take advantage of these matching networks without wondering — as I did for a long time — why sometimes they work and sometimes they don't. — *Roy W. Lewallen, W7EL, 5470 S.W. 152 Ave., Beaverton, OR 97005*

Fig. 1 — Schematic diagram of the 7-MHz Class C amplifier used to examine the oscillation problem.

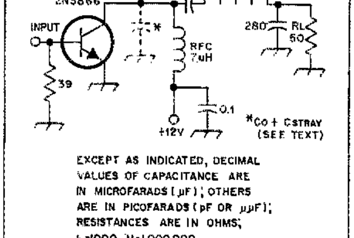
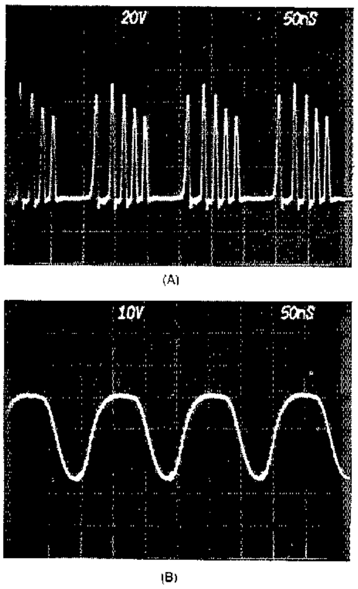


Fig. 2 — Photos of the actual waveforms obtained with the amplifier. Operation was observed with a high-speed oscilloscope. At A, collector waveform; at B, waveform at the output.



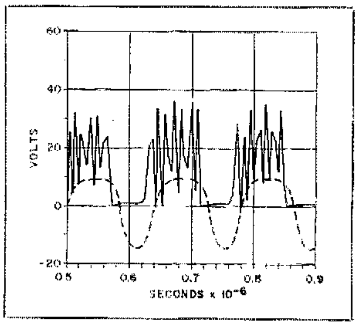


Fig. 3 — When the circuit of Fig. 1 was analyzed on a computer, the waveforms shown were predicted. The solid line indicates how the computer expected the waveform at the collector to look. Expected output waveform is shown by the dotted line.

Footnotes

[1]Strictly speaking, the Class C amplifiers used by amateurs may be better described as Class D, as they are typically driven to saturation. In fact, this is the reason for the problem described here. However, such operation does allow high collector efficiency. For a more detailed discussion of this topic, see Sokal and Sokal, "Class E — A New Class of High-Efficiency Tuned Single-Ended Switching Power Amplifiers," *IEEE Journal of Solid-State Circuits*, Vol. SC-10, No. 3, June, 1975.

[2]Hayward and DeMaw, *Solid State Design for the Radio Amateur*, ARRL, 1977, pp. 52-53.

[3]*The Radio Amateur's Handbook*, 54th Edition, 1977, ARRL, p. 161.

[4]Hayward and DeMaw, p. 24.

CORRECTION TO "SIMPLIFIED ANALYSIS OF RF CIRCUITS"

☐ Regarding my remarks in "Technical Correspondence," February 1978 *QST*, the equation should be

$$(10 + j\omega L) \text{ in parallel with } \frac{1}{j\omega c} = 50 \qquad \text{(Eq. 1)}$$

This translates to

$$\frac{(10 + j\omega L) \times \frac{1}{j\omega c}}{(10 + j\omega L) + \frac{1}{j\omega c}} \qquad \text{(Eq. 2)}$$

$$\text{i.e., R1 in parallel with R2} = \frac{R1 \times R2}{R1 + R2} \qquad \text{(Eq. 3)}$$

— *Louis C. Graue, K8IT, 624 Campbell Hill Rd., Bowling Green, OH 43402*

SOLAR WIND A CAUSE OF LDES?

☐ Earth's magnetic field is greatly distorted, being highly compressed on the side of the planet which faces the sun, and stretched out on the opposite face. Ions comprising the solar wind might follow a path roughly as shown in Fig. 4, forming a turbulent area at some distance from Earth. Signals reflected from this area would have little Doppler shift, and may account for the long-delayed echoes reported by Rasmussen.[5] — *Henry C. Wolking, W4BNF, 1723 Wavecrest Ave., Merritt Island, FL 32952*

ON "BUILD THIS NOVICE FOUR-BAND VERTICAL"

☐ Regarding Anderson's article in June 1978 *QST*, good signal reports from stateside stations should not necessarily be taken to mean that an antenna is an exceptional performer. In the case of this antenna, I suspect the reports merely illustrate the fact that with reasonable propagation conditions and 250 watts transmitter input, almost any antenna will get out. While I applaud Anderson's efforts to produce an effective low-cost antenna, only slightly more work will result in a vertical that works really well.

I question operating the antenna in the 3/4-wavelength mode on 10 and 15 meters. To realize the full DX potential of these bands, radiation at a low angle is needed. The lowest angle of radiation from a single vertical element occurs when the element is 5/8 wavelength long. Anderson states that unity VSWR on 80 and 40 meters could be obtained by adjusting the taps on the loading coil. Theoretically, a 1/4-wavelength antenna has a radiation resistance of about 35 ohms. A shortened version such as the one described should present a lower resistive impedance when the capacitive reactance is tuned out by the loading inductor. This makes the claimed 1:1 match to 50-ohm transmission line suspect. If this figure is accurate, then a loss resistance is probably in series with the antenna element. The band-switching arrangement may be the cause of this loss. Notice that in Fig. 1 of the article, the loading inductance is varied by shorting part of the coil. The shorted section is tightly coupled to the "working" section. The loading coil is acting as an autotransformer, with the low impedance of the shorted section transformed to a load across the portion of the coil used to resonate the antenna. The effect is similar to that of a brass slug in a coil — the inductance is reduced to less than that of the same coil with an air core. We now need more turns (higher rf resistance) to obtain a desired inductance, thereby lowering Q and increasing losses. In the antenna described, this loss presents a good impedance match, but dissipates considerable rf power.

I suggest the following modifications to the system:

1) Shorten the radiator to 20 feet, 9.75 inches (6.34 m), 5/8 wavelength at 28.1 MHz.

2) Use a two-pole band switch and separate resonating circuits for each band (Fig. 5).

3) A radiator of this length will function as a shortened half wavelength on 15 meters. Two matching circuits are shown (Fig. 6 and 7). The inductively tapped system is simpler, but the capacitive divider provides better harmonic rejection. Operation on 15 meters is practically independent of the ground system.

4) This type of antenna is entirely suitable for use by General class licensees; therefore 20-meter capability should be included. The vertical element functions as a lengthened quarter wavelength. Its inductive reactance may be resonated with a series capacitor. The radiation resistance of a lengthened quarter wavelength element is greater than the nominal 35 ohms of the resonant length, so a VSWR approaching unity would not be unreasonable here. One setting of the tuning capacitor should allow coverage of the entire band.

5) Use individual loading coils for 80 and 40 meters. Tune the system to resonance and accept whatever VSWR exists (within reason). If the transmitter doesn't like the load, change the length of the feed line.

6) Bring the connection to the antenna out the *top* of the box and make it short and fat. — *George H. Woodward, W1RN, 17 E. Cedar St., Newington, CT 06111*

[5] Rasmussen, "Ghost Echoes on 1296 MHz," June 1976 *QST*, page 36.

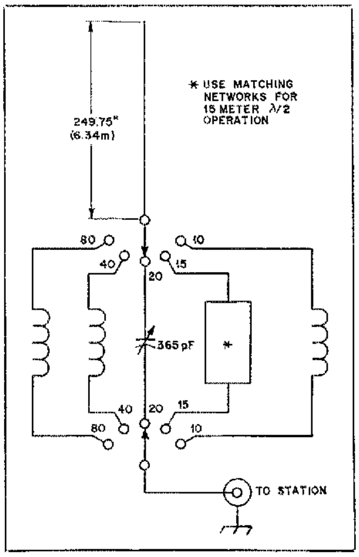


Fig. 5 — A two-pole bandswitch may be used to select the optimum matching network for each band. Coils should be cut to the correct inductance. Shorting turns results in losses, as explained in the text.

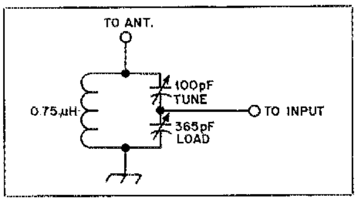


Fig. 6 — A matching network which may be used for half-wavelength operation on 15 meters. This tapped-capacitor arrangement provides better harmonic rejection than a tapped coil but is more complicated.

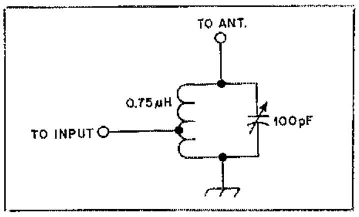
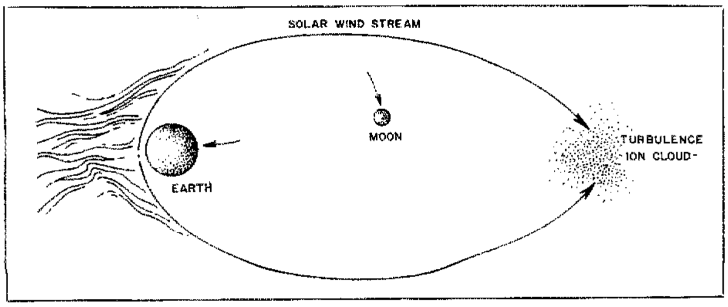


Fig. 7 — Tapped-coil method of resonating the antenna on 15 meters. While not as effective at reducing harmonic radiation as that shown in Fig. 6, this arrangement is easier to construct and adjust.

Fig. 4 — As radiation from the sun known as the "solar wind" approaches Earth, it deforms the geomagnetic field, as shown here. A turbulent cloud of ions may be responsible for one form of long-delayed echoes.



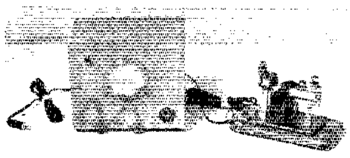
Hints and Kinks

THE MUSIC BOX CW-TO-TELEGRAPH CONVERTER

Fifty years ago, when barely tall enough to reach the ticket window at the railroad depot, I was permanently impressed by the mysterious clicking of the telegraph sounder. Today, similar music may be heard at my radio shack. The instrument, however, is not activated from a telegraph circuit to a distant operator. It responds instead to a modern transceiver tuned to the amateur cw bands. This article is written for the benefit of others who may wish to enjoy the pleasure of hearing a sounder faultlessly reproducing cw transmissions.

At the heart of the Music Box is a sensitive relay driven by the rectified audio from a transceiver and capable of handling 35 wpm. The relay controls a 12-V dc circuit to my 400-ohm sounder. Adjustment of the dc voltage to the sounder from 5 to 18 volts permits the use of a variety of sounders.

This cw-to-telegraph converter may be built on an open chassis or even in breadboard form. Normal workmanship should be applied to wiring. A template supplied with the relay provides drilling information for mounting the relay on a thin piece of Formica that may be placed over a hole cut in the chassis. The converter, pictured in the photograph, has the speaker and components mounted in the 4-1/4 × 4-1/2 × 5-3/4-inch (108 × 114 × 146-mm) cabinet. The ring trimming the speaker opening was cut from the frame of an old 2-inch speaker and the grill came from an old transistor radio.



The nostalgic sound of the railroad telegraph set is brought to the ham shack by this converter. It is activated by cw signals from a receiver.

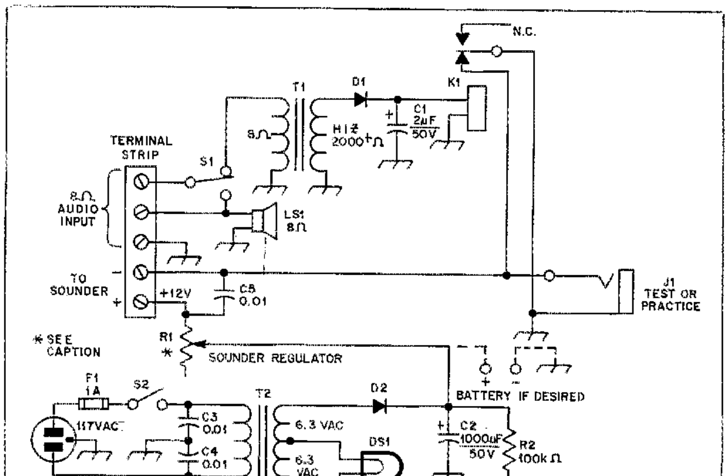
There are no particular restrictions on the lengths of the connecting leads between the 8-ohm output of the receiver or transceiver and the input to the Music Box. After these connections are made, the receiver is tuned to a chosen cw signal and adjusted for best readability while listening to the monitor speaker. The sounder should then clatter away to one's heart's content.

By adjusting the potentiometer for the proper dc voltage, the unit may be used to power and key a code-practice oscillator. The converter acts as a scrubber which eliminates any interference, leaving just the copy that's tuned in. A prerecorded message from a tape recorder will actuate a sounder by means of this device. That could interest amateurs at a museum or an exhibit.

The signal-to-noise ratio must be good enough to prevent tripping the relay by noise. The cw filter of a modern receiver usually compensates for much of the noise. — *D. S. Getchell, W9KSR, ex-W1GKA*

Schematic diagram of the Music Box cw-to-telegraph converter.

C1 — 2 µF, 50 V.
C2 — 1000 µF, 50 V.
C3, C4 — 0.01 µF, 400 V.
C5 — 0.01-µF disk ceramic.
D1, D2 — Diode, type 1N4000, 1 A, 50 V, Radio Shack no. 276-1101 or equiv.
DS1 — 6.3-V pilot lamp.
F1 — Fuse, 1 A, 250 V.
J1 — Phone jack.
LS1 — 2-inch speaker, 8 ohm.
R1 — 1000 or 1500-ohm, 2-W potentiometer.
R2 — 100,000 ohm, 1 W.
S1 — Spdt rotary switch.
S2 — Spst rotary or toggle switch.
T1 — 8-ohm audio output transformer (installed in reverse).
T2 — Heavy-duty filament transformer, 117 V ac primary, 12.6 V ac secondary, 3 A, Radio Shack no. 273-1511 or equiv.



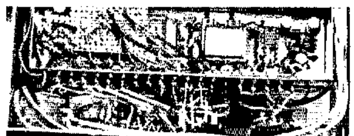
A SCANNER FOR THE KDK

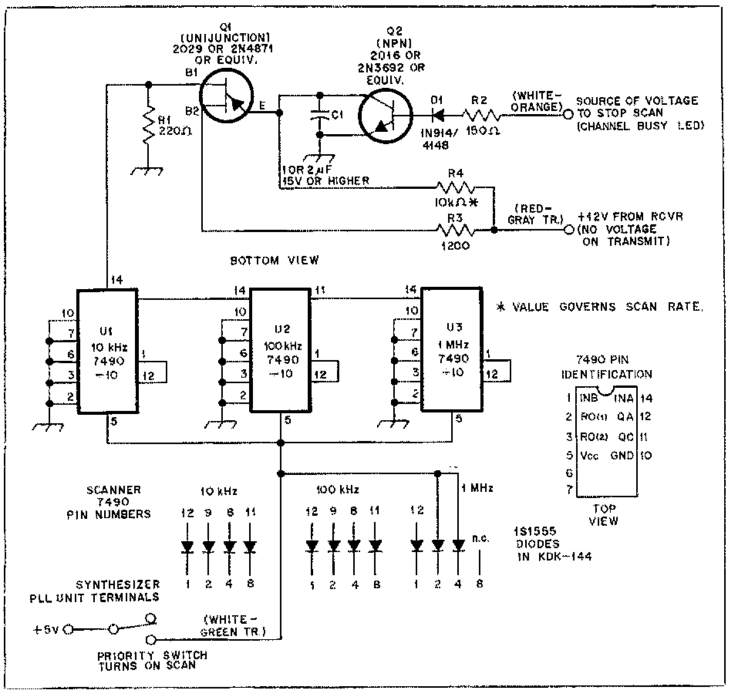
Phil Deem, K9PD, designed an excellent scanner for use with the KDK-144 2-meter transceiver. The circuit, strikingly simple, may be assembled on Micro-Vectorbord. I placed one within the PLL unit of my FM-144-10SXR-II without the need for external switches. Only two leads must extend from the PLL chamber. One is connected to the +12-V supply at the receiver side of the T-R relay. The other is wired to the Channel Busy LED which provides the voltage to stop the scan on frequency. Scanning range is from 146 to 147.99 MHz.

Placing the MHz switch of the transceiver in the priority position activates the scanner supplying +5 V dc to the three 7490 decade counters. The scanner clock (unijunction oscillator) receives power from the receive B+, insuring that the unit will stop scanning if the microphone button is pressed. Driving the Channel Busy LED is the squelch circuit which also controls the clock. Scanning will stop when a signal strong enough to open the squelch turns on the Darlington-connected transistors Q1 and Q2, shorting out the unijunction timing capacitor. A light squelch-control setting works best.

In my opinion, the use of the Channel Busy LED to provide a source voltage to stop the scan is not as precise as using a discriminator voltage. I find, however, that it rarely stops other than on the correct frequency. If it should stop 10 kHz too soon, correction is made by momentarily depressing the PTT

The small circuit board mounted in the PLL chamber of the KDK-144 contains the K9PD-designed 2-meter scanner. Installation requires only two leads and no external switches.





The K9PD scanner circuit designed for use with the KDK-144 transceiver. It scans from 146 to 147.990 MHz. Outputs of the 7490s are connected to the loop programmable counters in the KDK by way of the diodes formerly used to program the priority channel. IC connections not shown are not used.

C1 — 1 to 2 μF, 150 V or higher.
D1 — 1N914 or 1N4148.
Q1 — Unijunction transistor, type 2029 or 2N4871.
Q2 — Npn transistor, type 2016 or 2N3692.
R1 — 220 ohm, 1/4 watt.
R2 — 150 ohm, 1/4 watt. (May be needed.)
R3 — 1200 ohm, 1/4 watt.
R4 — 10,000 ohm, 1/4 watt. (Resistance value determines scanning rate.)

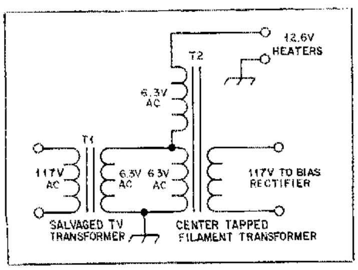
switch. Whenever a signal drops out, scanning is resumed. In that case, and if so desired, scanning may be halted by opening the squelch.

I'm excited about Phil's idea. Surely, other amateurs should give it a try. The cost, by the way, is just under $5. — *Robert W. Shoemaker, Jr., W9MTU*

PINCH HITTING WITH TV TRANSFORMERS

Stuck for a source of bias and filament voltages? I was recently, when a project required 12.6 V ac for the heaters in addition to −100 V for bias. Lacking the appropriate transformers, I rigged up two, salvaged from old TV sets. One may see from the accompanying diagram that T1 is wired in the normal manner, but T2 is installed in reverse and is used partially as an autotransformer. The customary primary winding of T2 furnishes 115-V ac for the bias circuit, while the secondary handles both the input and filament voltages. This transformer should have a small current rating margin over operating current requirements. — *Peter Gilson, WA2TSF*

WA2TSF used this circuit configuration with two salvaged TV transformers to obtain bias and filament voltage when he lacked more appropriate ones.



A USEFUL CLAMPING TOOL

For that third hand, obtain a surgical hemostat. It resembles a pair of scissors but is designed for clamping. Because this device has a snap lock, it is ideal for holding parts to be soldered or for retrieving nuts, bolts and washers. — *Carl Nebelsky, WB1BPZ*

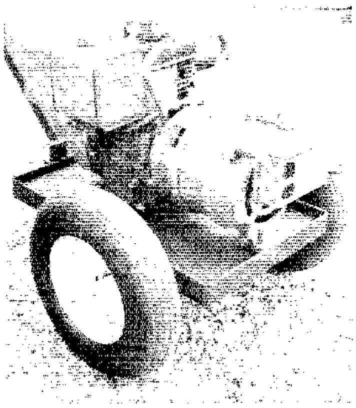
IMPROVING THE HEATH HD-1250 CARRYING CASE

To prevent the foam in the Heath HD-1250 dip-meter carrying case from activating the on-off button, cut a one-inch-square piece from the pad in two places. This will protect the button regardless of the position of the meter. — *Tom Lauderdale, WA6QQY*

READY POWER WHEN YOU NEED IT

I've had a 3-kW generator for several years. It was always parked in an awkward spot in the garage. Putting the generator to use or moving it to another location was short of being an impossibility. With help from a welding shop, the generator is now mounted on a frame with 8-inch heavy-duty pneumatic tires on ball-bearing wheels as shown in the accompanying photograph. With an added tote handle this emergency power source may be moved around easily or put on our utility trailer for use anywhere. — *Bud Norwood, WA4QGV*

This 3-kW generator is moved about easily at WA4QGV now that it is mounted on a professional-appearing moveable frame.



NOISE REDUCTION FOR THE MOBILE YAESU FT-227R

The Yaesu FT-227R, when powered from the cigarette lighter circuit, may or may not be well endowed with noise, depending upon the make of car it is used in. My solution for the car with the noise problem is to install a physically small axial-lead 1000-μF, 25-V capacitor from the 12-V input to the flange of the rf coaxial connector (PL-259) inside the Yaesu. This capacitor will flatten out most transients and transistorized ignition noise on both transmission and reception. Some of our good old American cars have a load of ignition noise appearing on the lighter circuit. — *Jacques Beauchemin, VE2YC*

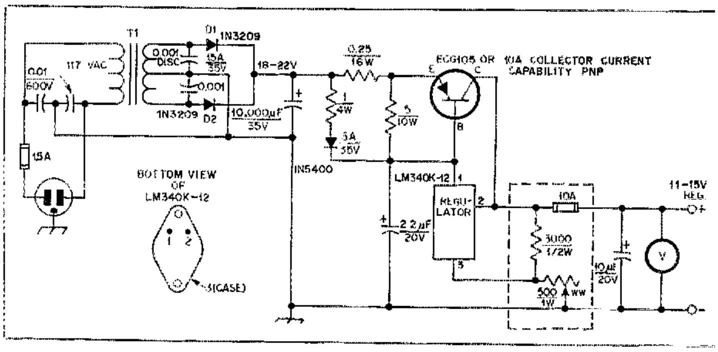
MODIFICATION OF THE UGLY DUCKLING

When I built the Ugly Duckling power supply described in *QST* for November, 1976, the regulated output delivered only 11.4 volts dc. That was lower than the 13.6 volts I had wanted to operate my fm transceiver. With the few changes I have described here, I was able to get from 11 to 15 volts output at 10 amperes with no heating.

Circuit modifications included increasing the filter capacitor to 10,000 μF and placing the no. 3 terminal of the regulator above ground potential by means of a 500-ohm, wire-wound, 1-watt potentiometer. A 3000-ohm, 1/2-watt resistor was connected from the no. 3 to the no. 2 terminal of the regulator in order to place a positive voltage on the no. 3 (case) terminal. In order to eliminate all hum in the supply output, I used a common one-point ground.

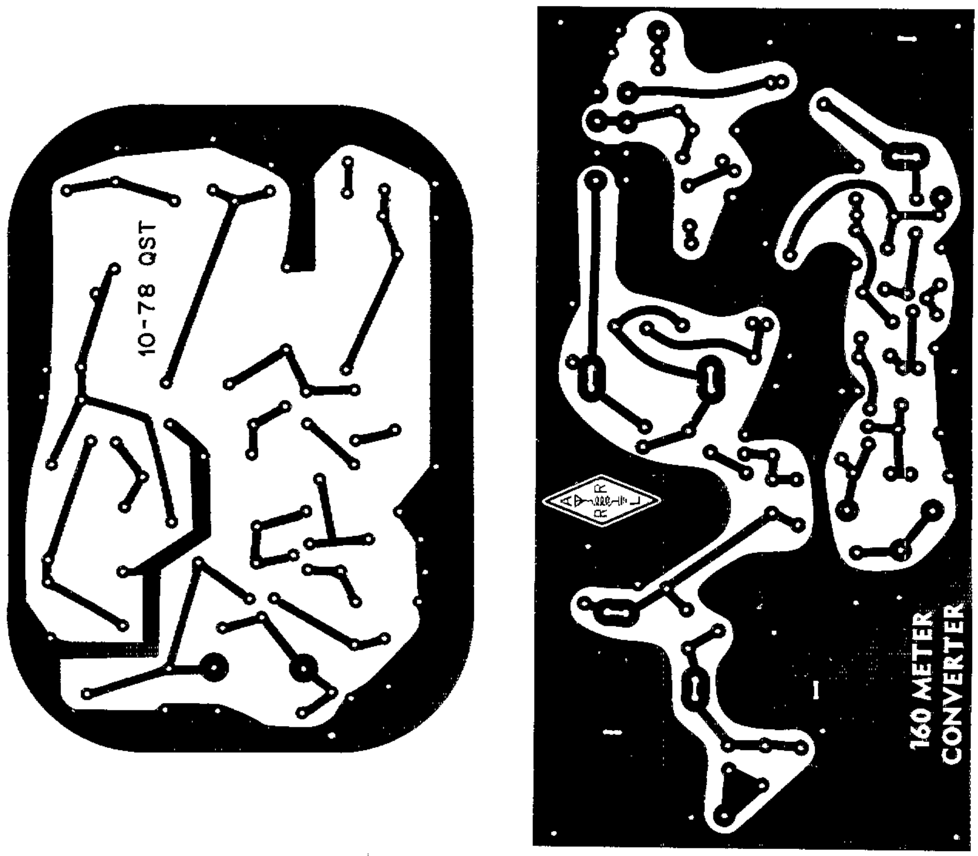
The pass transistor may be any pnp with a collector-current capability of 10 amperes or more. Regulators may be obtained from James Electronics, 1021 Howard Ave., San Carlos, CA 94070.

My 50-watt fm marine-radio transceiver has been working well with the modified Duckling. With the regulated supply providing 13.3 volts, the transceiver can draw 9.2 amperes with the key down and at less than 1/10-volt fluctuation. — *H. R. "Pappy" Conley, W5UY*



This modification by W5UY improves the voltage output of the Ugly Duckling power supply that was described in November 1976 *QST*. Details of rewinding an old TV transformer to furnish 18 volts across the secondary were presented in that article.

Circuit-board etching pattern for the Sardine Sender, left (see the parts layout in Fig. 3, page 16 of this issue). Black represents copper. The pattern is shown at actual size from the foil side of the circuit board. Right, pattern for the 160-meter converter (see Fig. 3, page 24 of this issue). The board is double sided, with one side etched to the pattern shown here (shown at actual size, black representing copper). The opposite side of the board may be unetched, with clearance holes drilled in the foil for component leads.



How Safe Is Your Ham Shack?

Part 3: Lightning, running amok, can ruin a whole day. Here's how to protect your shack, your gear and yourself by directing strokes into the ground.

By Bill Wilson,* VE3NR and James M. Morris,** K1UJ

Lightning is a problem faced by nearly every amateur operator. From time to time, QST *publishes material describing how to protect your station, home and family from a disastrous lightning stroke. There is no absolute protective procedure which will prevent lightning damage, however. The amateur is encouraged to take every possible measure to assure proper grounding of antennas, masts and radio equipment.*

Disconnecting antenna feed lines and rotor cables from equipment before *a storm develops is a safety requirement. In fact, during the storm season, it is best to connect antennas only when the station is in actual operation. Probably one of the best ways to afford some lightning protection to equipment from a direct or secondary stroke is to disconnect the coaxial and control cables coming into the radio room and place them outside of the building.* — W1XT

Nature's strike force, awesome as it is, normally doesn't worry most amateurs as they put up antennas. The reality hits when thunder rumbles and the sky darkens, only to be pierced by blazing flashes of lightning. Their power is immense. A typical discharge can be anywhere from 10 to 100 million volts at 1000 to 300,000 amperes, peaking in two microseconds and decaying to a 50-percent value in 40 μs. Amateur antennas present a tempting target for lightning strokes, as they often soar above the highest trees and rooftops in an area.

Station Protection[1]

Equipment is often connected to antennas by coaxial cable which, unfortunately, represents a good solid conductor. Any protection, in effect, is a *filtering* process. Every ampere taken to earth through a *shunt* path is one less reaching the vulnerable equipment. The policy should be "shunt, then isolate." Virtually all antenna elements can be grounded by plumber's delight techniques or stubs. Remember that high broadcast antennas and professional communications stations are designed to survive direct strokes. Solidly bond the grounded portion of the antenna to the grounded support structure. Optimize the tower-to-ground link until you run out of ideas or money. The rods should be copper-clad, at least 1/2-inch (13-mm) diameter and 10 feet (3 m) long. Bond the coaxial cable shield to the tower at the takeoff point.

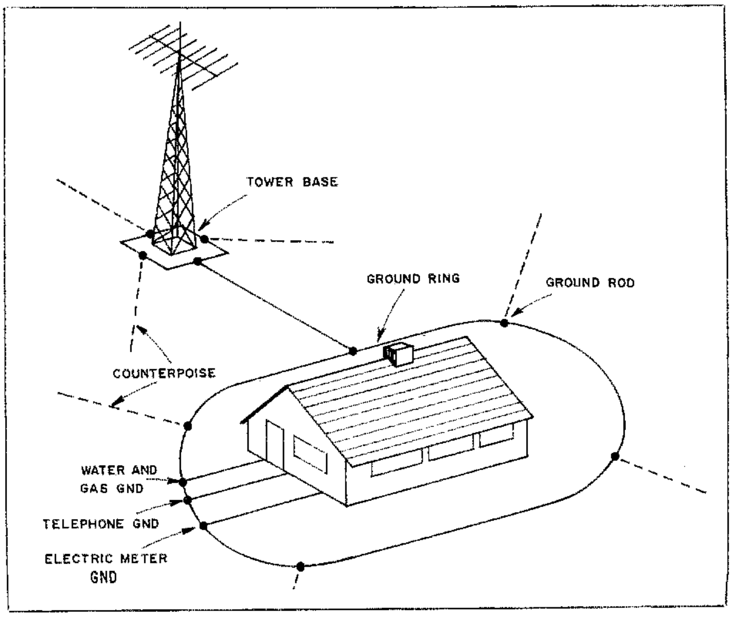
To *isolate* currents coming off the coax, bring it off the tower with the minimum permissible bending radius, introduce as many right-angle bends as possible, and wind it into a coil of several turns near the equipment cabinet entry. To deal with the surge that does reach the equipment, the cabinets should be effectively grounded with heavy-gauge leads such as no. 6 AWG. For a good path these earth leads should be short, fat and as straight as possible, in the clear, and not in conduits. Bring the coax alongside this earth lead, and bind them together.

Lightning Rods and Primary Conductors

Unfortunately, a grounded antenna system by itself will not sufficiently protect nearby structures. Rather it may become a lightning attractor that can induce *sideflashes* and *step voltages* into unprotected structures and persons.

In any lightning-protection system there are three unique features which distinguish it from the usual radio aerial configuration. Taking them from the top, literally, they are (1) the lightning rods (called "air terminals") and the primary conductors, (2) the grounds, and (3) the common linking by secondary conductors of all metallic objects in, on and around the dwelling.

Fig. 1 — A typical grounding arrangement for a ham shack and a free-standing metal tower. The dotted-line counterpoise conductors should be used where the driving of rods is impractical or for supplemental grounding where conditions indicate the need. The buried peripheral ground rings are uninsulated no. 2 AWG tinned, solid copper conductors.



*1427 Cavendish Rd., Ottawa, ON K1H 6C1
**Copy Editor, *QST*

[1]This section is based on A. K. Guthrie, "Lessening Lightning's Effects," *IEEE Newsletter of the Vehicular Technology Group*, July, 1975.

At least two paths should go to ground from all lightning rods, except those atop narrow structures such as the antenna support. For hams the most essential item to check is the primary or "down" conductor, which interlinks the lightning rods and feeds those circuits to ground. It should be braided out of no. 17 or larger wire, with a total cross-section area of about 59,500 circular mils (c.m.), equivalent to a cable between no. 2 and no. 3 AWG. If aluminum wire is used the strands should be no. 14 or larger and the cable should have 98,000 c.m. (no. 0 AWG). Other main-conductor material includes one-inch wide aluminum or copper tape, no. 12 or no. 14 AWG, respectively. Form gradual bends in at least an eight-inch (203-mm) radius, being careful not to make any "U" or "V" pockets. Remember that these are for hefty currents.

Suitable Grounds

All efforts should be undertaken to supply generous contact between earth and the antenna system. Rather than just have a low-resistance ground junction, one must first have a sufficient metal distribution in the earth (or on the surface if you are dealing with rock). Should the soil under the house be moist and a good conductor to a considerable depth, then simply extend each primary down conductor to one or two ground rods. They should be located about two to eight feet (0.6 to 2.4 m) from the building corner and driven to a 10-foot (3-m) depth.

Should the top soil be shallow, terminate each conductor into a tree-trunklike ground system. For clay, the system trunk should extend at least 12 feet (3.7 m), with several branches at least 10 feet long, all buried one or two feet down. If the shallow soil is sandy or gravelly, four or more of those branches should run out to at least 24 feet (7.3 m). Where possible use ground rods, though this may not be feasible in shallow soils.

On rock or very shallow soil (less than a foot) it is advised that the building be surrounded by a counterpoise ring of a main-size conductor laid in crevices or a shallow trench. Connect the down conductors to the ring. From that, extend radial conductors out at least 12 feet and connect them to copper plates of at least nine square feet (0.83 square meters) or to corrosion metal such as a car radiator, an old copper wash boiler, or similar materials buried in hollows or landfill. Very good ground connections can be made from metallic water supply pipes and well casings.

Do not solder connections. Clamps for at least 1-1/2 inches axially along the conductors, pipes, lightning rods, ground rods, and other metal objects are mandatory. See that all of the ground system is well buried, with the soil carefully tamped in place around the conductors and ground rods. Where the installation is on rock it is particularly important to have the crevices, hollows, ground plates and scrap metal carefully buried to protect and maximize contact with the rock.

Secondary Conductors for Other Metal Objects

Metallic objects which might be found in and around the building can be classified into two groups: bodies of inductance and bodies of conductance. No definite rule exists for determining which is which.

If the metallic object is likely to be charged at times with a potential opposite that of the grounded system, it is considered to be a body of inductance. Generally, they can be found in the first story above ground, both inside and outside. Should a body of inductance be located within six feet (1.8 m) of the lightning conductor it may induce a flash across the gap. Therefore, connect each body of inductance to a main conductor with a secondary conductor not less than 20,000 c.m. (no. 7 AWG) in size.

Bodies of conductance are also inside and outside of structures, though usually higher up. Since they may conduct some of the current direct from a lightning stroke they must be grounded by main-size conductors.

A short article of this type cannot cover all aspects of lightning-protection systems. The references listed below include extensive information on installation requirements. But if this presentation has sharpened your interest in reducing the potential hazards in your ham shack, then it has served its purpose.

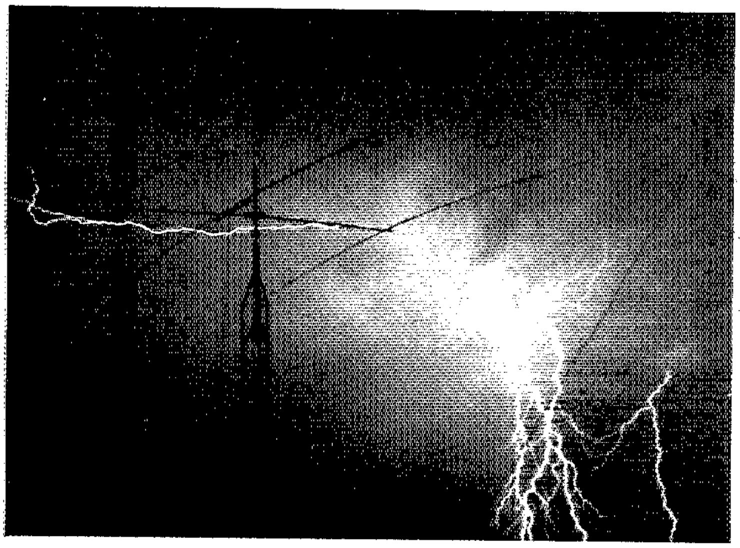
References

Installation Requirements, Master Labelled Lightning Protection Systems, UL 96A, 8th ed., 1963. Underwriters Laboratories Inc., 333 Pfingsten Rd., Northbrook, IL 60062.

The National Electrical Code (NFPA no. 70), Article 810, Section C, National Fire Protection Association.

The Radio Amateur's Handbook, 1978, 55th ed., ARRL, pp. 643-645.

150,000 megawatts heading in the wrong direction. *(WA6YVA photo)*



Heed the ARRL Safety Code

While there's no reason for you to be involved in a ham-related accident, that possibility always exists if you are not thinking safety. Following the ARRL Safety Code will make your ham experience more enjoyable. Read it, understand it, and practice it.

ARRL Safety Code

1) *Kill all power circuits completely before touching anything behind the panel or inside the chassis or the enclosure.*

2) Never allow anyone else to switch the power on and off for you while you're working on equipment.

3) Don't troubleshoot in a transmitter when you're tired or sleepy.

4) Never adjust internal components by hand. Use special care when checking energized circuits.

5) Avoid bodily contact with grounded metal (racks, radiators) or damp floors when working on the transmitter.

6) Never wear headphones while working on gear.

7) Follow the rule of keeping one hand in your pocket.

8) Instruct members of your household HOW to turn to power off, and HOW to apply artificial respiration. Instruction sheets on the latest approved method of resuscitation can be obtained from your local Red Cross office.

9) If you must climb a tower to adjust an antenna, use a safety harness. Never work alone.

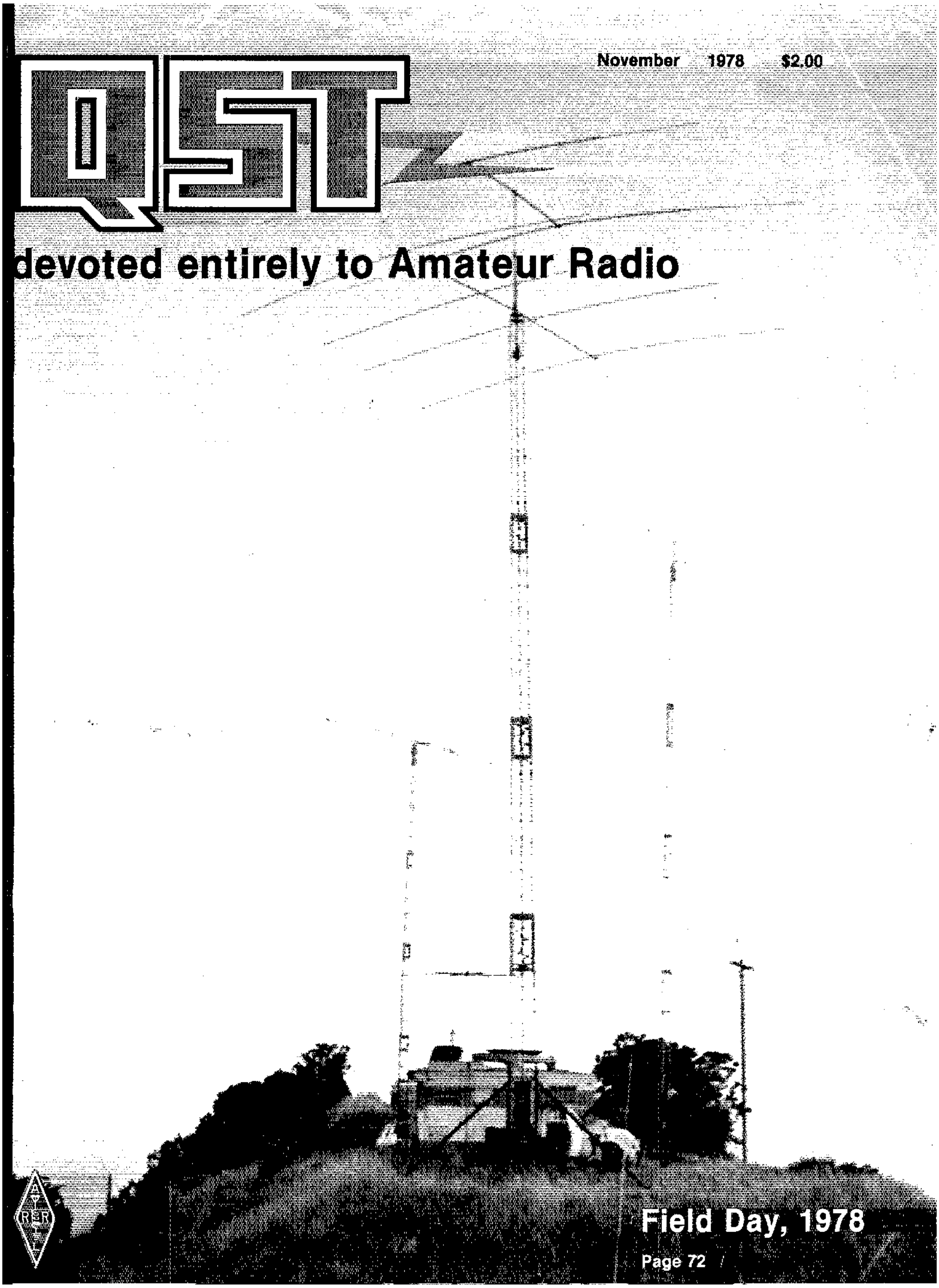
10) If you must climb into a tree, or work on a roof, remember that you're not standing on the ground. That first step down can be a very long and painful one. Never work alone.

11) Develop your own safety technique. *Take time to be careful. Death is permanent.*

November 1978 $2.00

QST

devoted entirely to Amateur Radio



Field Day, 1978

Page 72

QST

November 1978
Volume LXII Number 11

QST (ISSN: 0033-4812) is published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by International postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

The sun rises at the N6CW/6 site. For a look at how you fared, see page 72.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A Baseband Communications System

Part 1: Narrow-band voice modulation may be one of the biggest breakthroughs in Amateur Radio in three decades. This, the first of two parts, will enable you to understand how it works.

By Dr. Richard W. Harris,* and J. F. Cleveland,** WB6CZX

The December 1977 issue of *QST* heralded a unique method to conserve communications bandwidth and still allow high-quality voice transmissions.[1] This technique works at baseband (voice frequency range, in the case of speech), as opposed to an intermediate frequency or radio frequency. Thus it is applicable to virtually all types of analog and digital transmission systems. The system described in this article includes not only a newly developed frequency compandor,† but also the well-known but not extensively used amplitude compandor.‡ Use of both of these devices within the same baseband system offers significant improvements in adjacent-channel rejection and signal-to-noise ratio (SNR).

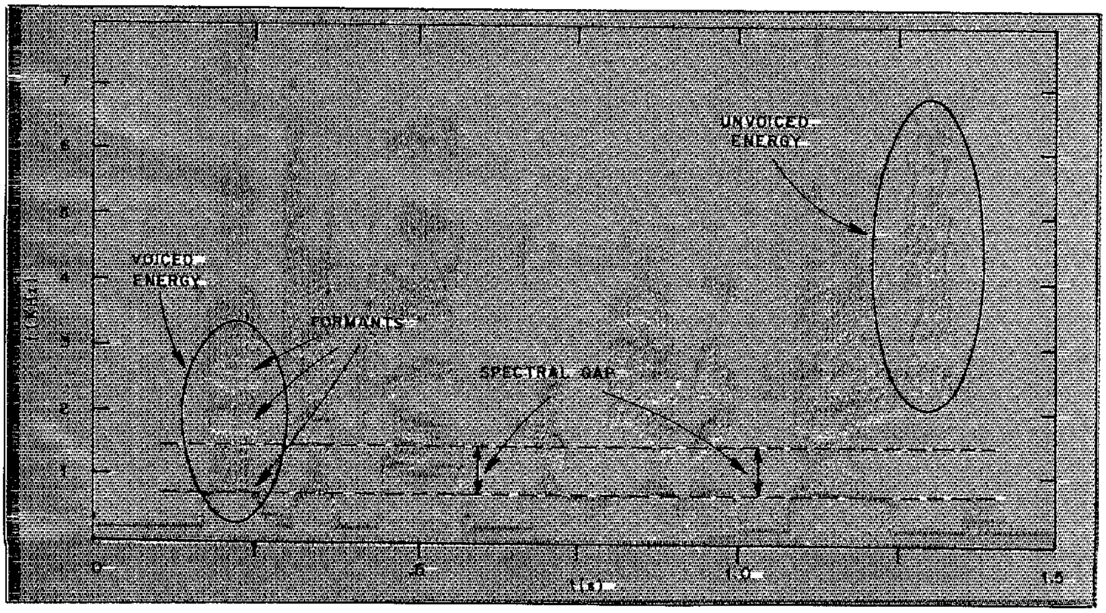
The transceiver baseband system operates just after the microphone on transmit and just prior to the speaker on receive. The frequency compandor filters the essential parts of speech and down-converts these electronically on transmission, thus providing a significant reduction in transmitted bandwidth. The narrower bandwidth creates less cochannel interference and allows the use of a

*President, VBC, Inc., 1111 W. Robinhood Way, Suite Z, Stockton, CA 95207
**305 Germaine Ave., Santa Cruz, CA 95065

[1]References appear on page 18.

†A frequency compandor compresses signal bandwidth on transmission and expands signal bandwidth on reception.
‡An amplitude compandor compresses signal amplitude on transmission and expands signal amplitude on reception.

Fig. 1 — A speech spectrogram of the utterance, "digital communication." The vertical axis represents frequency (80-8000 Hz), and the horizontal axis represents time (0-1.5 seconds).



narrower reception filter, which improves the system signal-to-noise ratio. Tests conducted for the FCC of the baseband system indicate that a signal 40 dB stronger and 2 kHz away from the operating frequency will not cause harmful interference.[3] A significant advantage of narrower reception bandwidth is that less noise power competes with the signal. Comparing the frequency-compandor noise bandwidth with that of a "typical" amateur receiver indicates that up to 3 dB can be achieved in signal-to-noise-ratio improvement.

The amplitude compandor, known since the 1930s but recently made practical and economical, provides significant advantages. It compresses the amplitude on transmission, and on reception expands the signal back to its original proportions. The FCC tests indicate that the SNR improvement is at least 13 dB, and as high as 15 dB in some cases. Adding the amplitude compandor allows higher voice quality over the usable communications range of currently designed ssb transceivers.

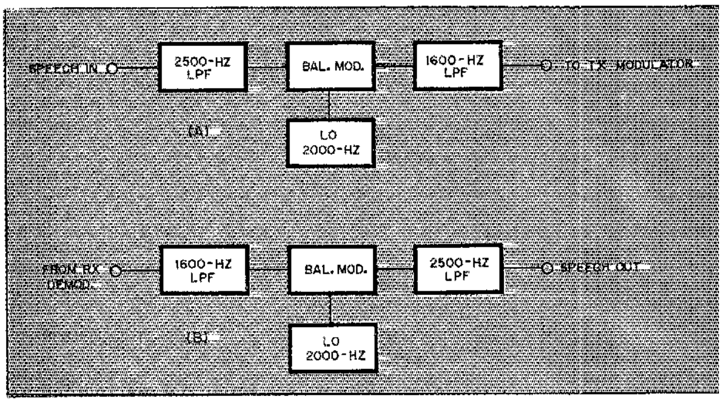


Fig. 2 — Block diagram of an early experimental version of the frequency compandor. LPF = low pass filter. At A is the transmitter frequency compressor and at B the receiver frequency expander.

What Is Speech?

A better understanding of how the frequency compandor works is achieved by considering the composition of speech itself. Acoustically, human speech consists of two types of sounds, voiced and unvoiced.

Voiced sounds originate by passing air from the speaker's lungs through the larynx (voice box), a passage in the human throat. The opening of the larynx is obstructed by vocal cords. As air is passed by these vocal cords they vibrate, causing puffs of air to escape into the aural cavity consisting of the throat, nasal cavity and mouth. Studies indicate that the acoustic waveform produced by the vocal cords contains many harmonics of the fundamental vibration. Because of the irregular shape of the aural cavity, the spectral amplitude distribution of the harmonics tends to show peaks at distinct points. As speech is produced, changes occur in the aural cavity shape, thus changing the spectral location of these peaks.

Fig. 1 shows a spectrogram or voice print of the utterance, "digital communication." The darkness of the bands indicates amplitude or voice strength. The fine structure of amplitude peaks very close together in the horizontal dimension is a measurement of vocal-cord vibration frequency or fundamental.

Notice the rather strong amplitude concentrations below 4000 Hz. These are the spectral peaks referred to above. They are called formants. The first three formants are shown in Fig. 1 at the beginning of the utterance. Properly processing these three formants is a major part of bandwidth conservation in speech.

Unvoiced sounds in speech occur when there is no vocal track excitation. They are caused by the speaker using his tongue, lips and teeth to cause clicks, hisses and popping sounds. These sounds, or evidence of their occurrence by formant extensions into or from an unvoiced sound, are very important in the intelligibility of speech. The spectral amplitude distribution of unvoiced sounds is generally above 1500 Hz and is "noise-like" in that very little periodic structure is present.

One other important aspect of speech is the pause between acoustic sounds. Juncture pauses carry meaning and cannot be eliminated without impairing intelligibility. Some long pauses can, however, be shortened and thereby reduce message length.

Briefly, then, speech is the continuous production of voiced and unvoiced sounds with appropriate pauses to add clarity and distinctness. Our measurements of voice from different speakers indicate that the first three formants lie predominantly below 2500 Hz. Speech consisting of these three formants is of good quality both from an intelligibility and listenability standpoint. Sufficient information as to the existence of some unvoiced sounds appears to lie in this range also. For example, to produce "s" sounds the frequency range must extend to about 4000 Hz, but this is not usually required for intelligibility since contextural clues provide sufficient evidence for the listener to "hear" an "s."

From a frequency point of view, evidence from theory and practice indicates a bandwidth of 300 to 2500 Hz is adequate for good-quality speech.

From an amplitude standpoint our tests, using single coherent tone interference, indicate a dynamic range of 40 dB is quite adequate for good-quality speech. Many communications channels only allow 10-30 dB of SNR, so equip ment designed to preserve more thai 40-dB dynamic range is not warranted.

To take advantage of the structure o speech for more efficient transmission w will first consider bandwidth conservatioi and power. Bandwidth can be conserve basically at rf and baseband. Rf band width conservation involves the choice o modulation type, such as a-m, fm or ssb Amateur users have played a significan role in developing ssb, which is efficien with respect to bandwidth. Voice modulation methods more efficient thai ssb are not presently known. Thus, t conserve even greater bandwidth, it ap pears that audio bandwidth reductio prior to rf modulation and transmission i the only possibility.

Audio Bandwidth Reduction

The idea of conserving bandwidth a baseband is not new. Many technique have been used such as vocoder transform coding, waveform iteration time sampling, variable band vocodin and analytic signal rooting. Two of th more useful of these techniques emplo vocoders and time sampling.

Vocoders have been moderately suc cessful but typically reproduce voic which sounds mechanical, and they ar quite costly. There are many differen types of vocoders. Let us briefly describ the channel vocoder used in some militar communications.

Basically, speech can be thought of a being the sum of amplitude-modulate sinusoids. In a channel vocoder, 10 to 3 band-pass filters of 300- to 100-Hz banc width are used to separate speech into in dividual sinusoidal components. Th amplitudes of the filter outputs ar measured and sent to a distant poin Knowledge of the transmitter-filter cente frequency allows the speech at the receive to be reconstructed by modulating the measured amplitudes back onto a series of oscillators, the outputs of which can be summed to reconstruct the voice. Bandwidth is conserved because the component amplitudes vary only by a small amount. Vocoders can successfully communicate with only 600-Hz bandwidth, and higher quality systems with about 1200-Hz bandwidth. The poor quality in the past has discouraged widespread use of the vocoder.

The other more successful technique of those mentioned above has been time sampling. Because of the redundancy in speech (for example English is estimated to be 50-percent redundant), small segments of the time waveform (10 to 20 milliseconds) can be thrown away without serious degradation of speech intelligibility or acceptability.[3] Bandwidth is conserved by lengthening the time waveforms (compressing bandwidth) on transmission, and then shortening the time waveform (expanding bandwidth) on reception.[4,5]

Some commercial products using this technique are now available. Speech quality using this technique is good, but an inherent motorboating effect is heard which is caused by in-band sampling transients. This effect cannot be entirely removed.

Considerable effort has been expended to develop digital communications in recent years. The major motivation for this effort has been to provide secure voice, mostly for military users, by encrypting the voice when in digital form. However, digital communication is inherently broadband. The digital bit samples are not bandwidth conservative simply because their basic square waves have a much greater bandwidth than the basic sinusoidal analog waveforms of the speech they represent.

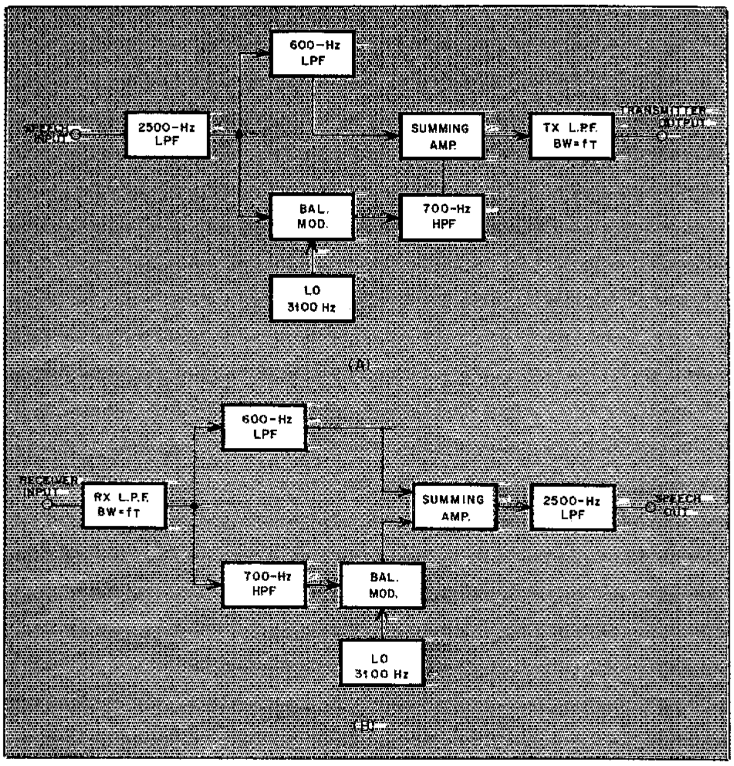


Fig. 3 — Block diagram of the final version of the frequency compandor. At A, the system for transmission, and at B, the system for reception. Audio frequencies in the range 1500 to 2500 Hz are inverted and transmitted as frequencies in the range 1600-600 Hz, for a total transmitted bandwidth of 1600 Hz. Intelligibility is excellent when processed through the receive circuitry. A system demonstration tape is available.* (System patents pending, VBC, Inc.)

The Frequency Compandor

Bandwidth-efficient techniques investigated by the authors have been only those which are of high quality from a communications standpoint, and can be produced in large quantities at reasonable cost with current technology. The system we devised allows flexibility in transmission and reception bandwidth so that reproduced audio quality can be tailored to an extent and still allow bandwidth conservation of up to a factor of two.

To explain the approach taken, again consider the spectrogram of Fig. 1. Notice that there are natural gaps between the first and second and between the second and third formants. There is little energy present in these gaps. An electrical system that could take full advantage of this fact would measure and track the first three formants and place narrow variable-bandwidth filters around each formant. Such a tracking system has been reported previously.[6] In this sytem the first formant filter was fixed and the second two formants were tracked with digitally implemented tracking band-pass filters. Although quality was reported to be good, the movement of the upper two band-pass filters produced a noticeable "swishy" noise in the background.

Observing the two major gaps between formants and also the fact that unvoiced and voiced sounds tend to be temporally independent led to the development of the system described here. It does not involve costly tracking filters which produce the objectionable swishing sound.

During system evolution it was first decided to conserve bandwidth by electrically reducing the gap between the second and third formants. The transmission and reception systems are shown in Fig. 2. The balanced modulator produced a spectral gap centered at 2000 Hz, which is close to the natural gap in speech (see Fig. 1). Although this system produced reasonable-quality speech, the distortion caused by high frequencies mixed to low and low frequencies mixed to high was objectionable. (However, much of this distortion can be eliminated by appropriate shaping of the 2500-Hz filter.) The biggest failing of this system is the fact that the second and third formants move over a fairly large excursion during speech. This is illustrated in Fig. 1 in which at some points the second and third formants essentially merge.

After extensive listening tests and consideration of various filtering and mixing combinations, it was found that the first formant is not as essential to intelligibility as the second and third formants. Furthermore, the gap between the first and second formants is wider than between the second and third formants, and it is more constant with time. As a result the system shown in Fig. 3 was developed.

To understand how the system works, note that two bands of speech are preserved, dc to 600 Hz and f_1 to 2500 Hz. The frequency f_1 is the low end of the second formant preserved and is variable depending on the transmission and reception low-pass filter cutoff frequency, f_T.

*To aid in the establishment of a data base as to the acceptability of the VBC, Inc. system, a demonstration cassette tape has been prepared. This tape presents male and female speakers in actual communications using ssb with and without baseband processing. Current plans are to make results of this acceptability evaluation available at a future date. To obtain a demonstration tape, send $5 to VBC Tape Request, P. O. Box 1289, San Mateo, CA 94401.

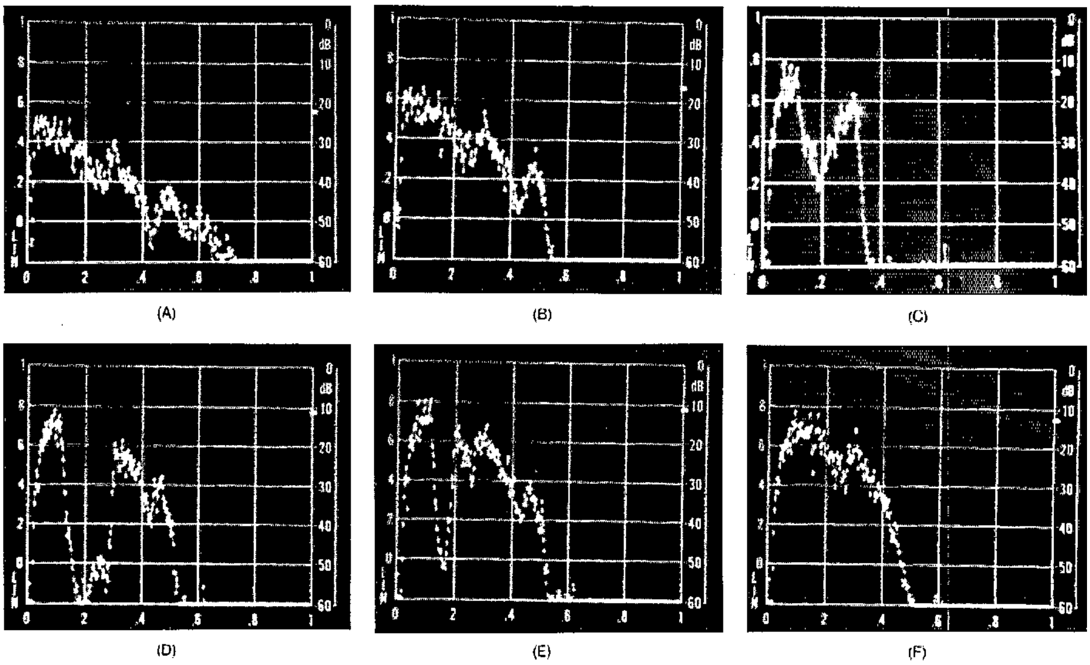


Fig. 4 — Long-time audio spectra for various points in the frequency-compandor system (see text). E and F show spectra for an expanded-range frequency-compandor system. The horizontal scale in each photo is 1000 Hz per division, and the vertical scale 10 dB per division.

In equation form

$$f_1 = 3100 - f_T$$

For example the two filter options developed by the authors provide either $f_T = 1600$ Hz or $f_T = 2100$ Hz. Both the transmission and reception filters have a 1.3 shape factor (3 to 30 dB). Thus the narrow system with a transmission bandwidth of 1600 Hz is designed to preserve speech from 350-600 Hz, which is the first formant approximation, and from 1500-2500 Hz, which is the band of contiguous second and third formants. The wider system with a 2100-Hz transmission bandwidth preserves speech from 350-600 Hz, as before in the narrower 1600-Hz system, but it also preserves the region from 1000-2500 Hz, which includes more of the lower end of the second formant.

Operationally, the first formant, 350-600 Hz, passes essentially straight through the system. The second and third formants are inverted and down-converted on transmission, then reinverted and up-converted on reception. Use of the 700-Hz high-pass filter aids in eliminating potential distortion products arising from high frequencies mixed to low on transmission and low frequencies mixed to high on reception.

Frequency Spectra in the Compandor

The various facets of baseband audio processing are more clearly understood by considering the following sequence of spectra in the system. Fig. 4A shows a long-time amplitude spectrum of input speech. The vertical amplitude scale is 10 dB per division and the horizontal frequency scale is 1000 Hz per division in all cases. In Fig. 4A note the presence of the first three formants and that speech components above 2500 Hz are 20 to 25 dB lower than those below 2500 Hz. The 2500-Hz low-pass filter at the input to the processor has an output spectrum as shown in Fig. 4B. The communications quality of this speech is very good. The baseband processor transmits this speech in a very narrow band and recovers it during reception.

The final transmitted spectrum using $f_T = 1600$ Hz is shown in Fig. 4C. Notice the extremely sharp roll-off above 1600 Hz. This signal has little chance of interfering with adjacent channels and allows an identical, very narrow 1600-Hz low-pass filter to be used at the receiver audio output. The receive 1600-Hz low-pass audio filter eliminates adjacent-channel interference.

The final compandor audio output for the 1600-Hz case is shown in Fig. 4D. Notice that the spectrum has been expanded and approximates the shape shown in Fig. 4B. While a gap does exist in the final output spectrum, the speech is of high intelligibility and recognizability.

If some additional speech features are desired, the transmission bandwidth can be widened by 500 Hz and the gap narrowed by using the 2100-Hz audio filter. This expanded output is shown in Fig. 4E In comparing Fig. 4E with Fig. 4D, it i obvious that more speech is present in th second formant region. A common ques tion is, "What would happen if we jus used the final transmission low-pass filte only and listened to that speech?" A spec tral output filtered by the 2100-Hz low pass filter only is shown in Fig. 4F. Notic the absence of the third formant in com parison with Fig. 4E. This formant i essential for clear enunciation of words. I is preserved by the 2100-Hz compando system. Loss of the third formant is perhaps, the major reason why re searchers in the past were not successful i merely cutting the spectrum down fron the high end.

Comparing this bandwidth-compres sion scheme with the time-samplin method, it is interesting to note that smal time gaps of *all* spectral components ar lost in the time-sampling method. But i the frequency method presented here th loss of some energy in the frequency gap does not cause motorboating sound because the frequency errors tend to b spread over time.

A comparison of the roll-off charac teristics of the 1600- and 2100-Hz fina low-pass filters with respect to a typica amateur transceiver are shown in Fig. 5 Here it is obvious that both systems pro vide extremely sharp audio filterin capable of significantly attenuatin adjacent-channel interference an nonlinearities not eliminated by the i-filter. However, it may be pointed out that audio filtering has significant advantages over i-f filtering for eliminating nonlinearities.

Bandwidth conservation of the two systems can be estimated from Fig. 5 by computing the bandwidth reduction at several points along the roll-off characteristics and then finding the average savings. Performing this shows that for the 1600-Hz system a 50-percent bandwidth reduction is realized; the 2100-Hz system can yield a 33-percent bandwidth reduction. Converting the bandwidth savings to noise-power reduction and computing the increase in signal-to-noise ratio yields a 3-dB improvement for the 1600-Hz system, and 1.5-dB improvement for the 2100-Hz system. Laboratory measurements made for the FCC using actual speech did verify that a net SNR improvement is achieved. However, no extensive on-the-air testing has yet been performed.

Efficient Power Usage — The Amplitude Compandor

Compressing the audio signal prior to modulation to achieve more efficient use of transmitter power has been widely used by amateurs. However, by compressing only the amplitude peaks, the background noise increases relative to the peaks. A significant advantage can be achieved by expanding the compressed audio at the receiver.

The positive effects of this expansion are illustrated in Fig. 6. A short segment of the speech time waveform is shown in Fig. 6A. When compressed and transmitted this waveform becomes noisy because of the compression and also because of the added circuit and radio-channel noise. This is shown in Fig. 6B. Notice the increased noise between the two passages of speech. After the waveform is processed by an amplitude expander (the receiving portion of an amplitude compandor) the waveform appears as shown in Fig. 6C. Now the noise during the quiet passage has been reduced relative to the high-level passages. The key point to improvement is that although the SNR during the loud passage is not as good as the input waveform, the SNR of the overall passage is much better than the passage would be if it had not been expanded. Noise during loud passages is not nearly as objectionable as noise between passages of speech.

Using a two-to-one amplitude compandor (Signetics NE571N),* our tests for the FCC indicated a measurable 12- to 15-dB improvement when using the full amplitude compandor (compression on transmission and expansion on reception) as compared to the case when it was not used. When only compression was used, significant SNR reduction resulted, even though a higher average transmitter power was being used.

*A compandor with a compression of 1 dB out for every 2 dB in and an expander with 2 dB out for every 1 dB in.

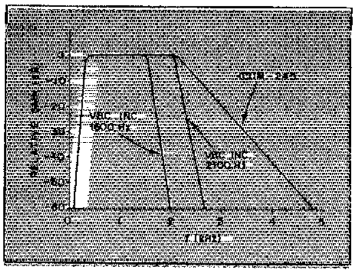


Fig. 5 — The audio amplitude response of two different options of the baseband communications system, compared to the frequency response of a commercially available amateur transceiver.

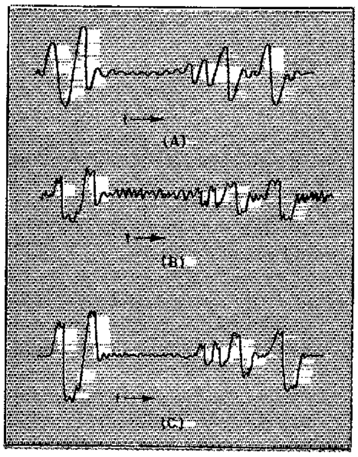


Fig. 6 — Speech waveforms for the amplitude compandor, showing amplitude (vertical axis) versus time, t. At A is the input waveform, at B the compressed waveform with additional circuit noise as might be received, and at C the expanded waveform. Note the improvement in signal-to-noise ratio upon expansion after reception.

It is important to realize that the amplitude compandor will improve SNR, but only when it has sufficient signal to use as a reference. Thus it has a thresholding effect. As long as the received signal is a few dB above the noise, the expander can expand on the basis of the reference to make the communications channel have a cleaner signal over a wider dynamic range. But when the signal level drops into the noise the expander will not operate properly. Thus the SNR improvement has its limitations in providing significantly greater range, but it makes the signal much better over the range of usefulness than would be the case without compandor use.

If we consider that a certain SNR and corresponding voice quality were required, use of an amplitude compandor would allow the achievement of this goal with less transmitter power. In this respect, then, the amplitude compandor can achieve the same quality SNR with 12-15 dB less transmitter power. This is a significant power savings and can have a definite impact on the quality of communications per watt of transmitter power.

It is important to note that the frequency compandor, unlike the amplitude compandor, does extend communications into the noise because there is no thresholding effect inherent in the frequency compandor. Thus, use of both devices will save even more transmitter power and thereby provide more efficient communications.

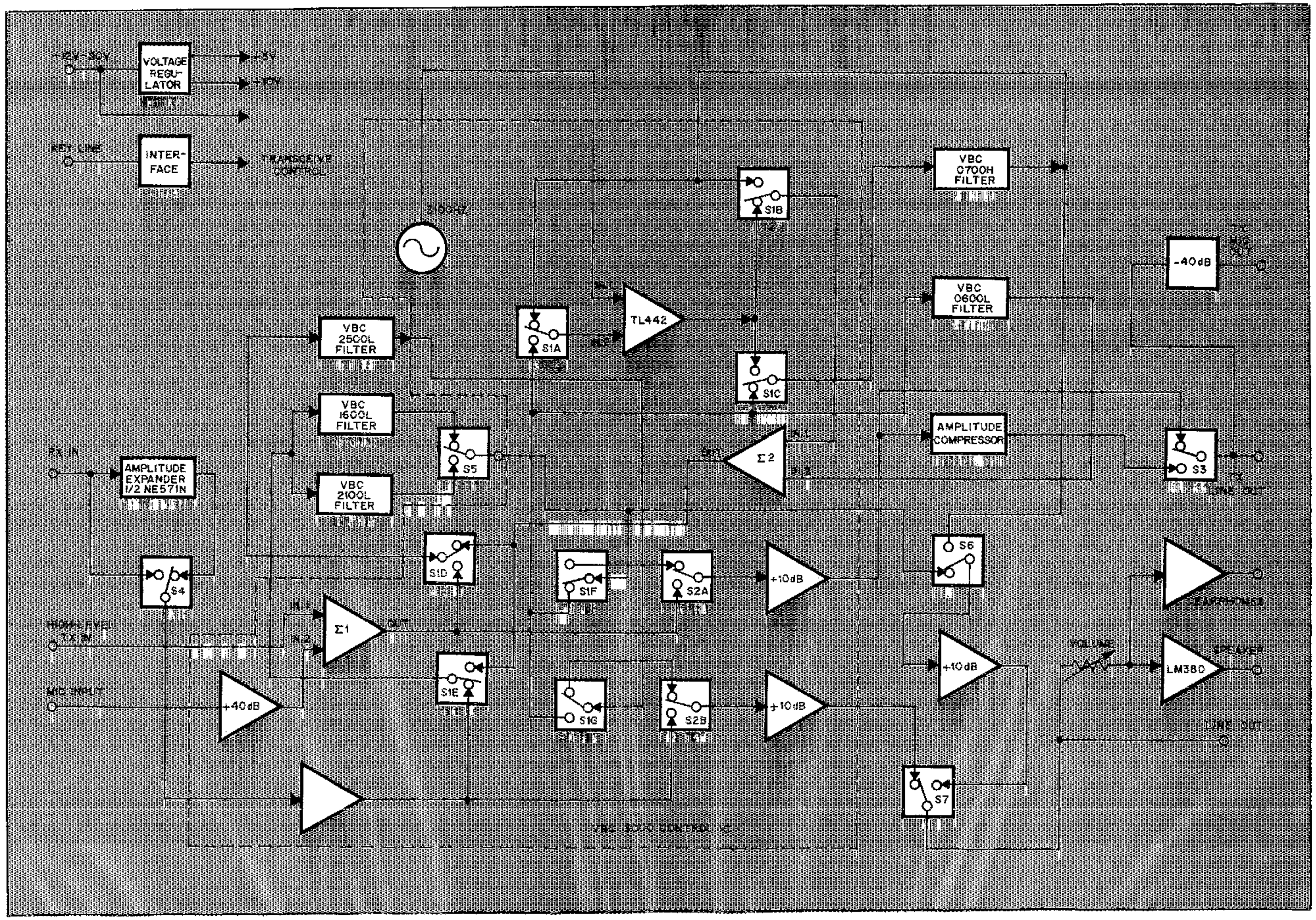
Hardware System

The frequency and amplitude compandor baseband system is designed as an add-on package. Because the system has not been extensively used in actual practice, considerable flexibility has been designed into it. For example, the user will be able to switch frequency-companding modes (2100-Hz and 1600-Hz bandwidths) and will be able to use the transmit and receive low-pass filters alone as audio filters. The amplitude compandor can be used independently from the frequency compandor, and it can also be used in the expansion-only or compression-only modes. Combination of the various filters also provides a band-pass filter for use in cw reception. The system is designed for use at baseband as an add-on unit for virtually all existing modulation formats for speech communications, such as a-m, ssb and fm.

The block diagram of a prototype voice-processing accessory developed specifically for amateur use is shown in Fig. 7. Five custom hybrid integrated circuits make up the basic frequency compandor circuitry which includes provision for baseband transceive operation and system bypass (provided by sections of S1 and S2). A sixth hybrid IC plus an amplitude compandor and other peripheral circuitry has been added to increase the usefulness and flexibility of the overall device to the amateur. Since a considerable amount of audio signal switching takes place, CMOS analog switch elements are used wherever possible to minimize signal path lengths and therefore audio crosstalk. Dc control of the switch elements allows a much simpler logic-oriented selection of system functions and keeps control panel wiring to a minimum.

Refer again to the block diagram. The seven sections of S1 provide the transceive switching, shown in the receive mode. S2 allows receive and transmit audio to be connected directly through the system, thus bypassing the frequency compandor for standard voice operation.

In the transmit mode, S1 is in the


+12V-30V
VOLTAGE REGU- LATOR
+5V
+10V
KEY LINE
INTER- FACE
TRANSCEIVE CONTROL
3100HZ
VBC 2500L FILTER
VBC 1600L FILTER
VBC 2100L FILTER
S1A
TL442
S1B
S1C
Σ2
IN 1
IN 2
OUT
VBC 0700H FILTER
VBC 0600L FILTER
AMPLITUDE COMPRESSOR
-40dB
TX MIC OUT
S3
TX LINE OUT
RX IN
AMPLITUDE EXPANDER 1/2 NE571N
S4
S5
S1D
S1E
S1F
S1G
S2A
S2B
+10dB
Σ1
HIGH-LEVEL TX IN
MIC INPUT
+40dB
S6
S7
VOLUME
EARPHONES
LM380
SPEAKER
LINE OUT
VBC 3000 CONTROL IC

position *opposite* to that shown in Fig. 7. Low-level audio from the station microphone is first fed to a 40-dB-gain preamp. The preamp output is summed with high-level audio energy, if present, and fed through S1D to the 2500L low-pass filter which limits the input bandwidth to 2500 Hz. The band-limited signal then passes through S1G to the input of the 0600L filter and also through S1A to the input of the TL442 balanced mixer. The 600-Hz low-pass filter passes the first speech formant to the summing circuit. The 3100-Hz oscillator at the other input to the TL442 mixer causes the output to contain a double-sideband audio signal with sidebands extending 2500 Hz either side of the suppressed 3100-Hz carrier. This signal passes through S1C to the 0700H filter which rolls off audio components below 700 Hz. The 0700H output passes through S1B to the other summing-circuit input. The output of the summing circuit then contains the original audio up to 600 Hz, plus the inverted audio from 700 to 3100 Hz, plus the opposite sideband above 3100 Hz. All that remains is to cut off this composite signal at the appropriate frequency to accomplish bandwidth narrowing. The summing-circuit output feeds through S1E to the 1600L and 2100L low-pass filters. The 1600L cuts off sharply above 1600 Hz and the 2100L does likewise above 2100 Hz. Thus if the 1600L filter is selected, the complete transmission signal includes the original components of the speech up to 600 Hz and the original components between 1500 and 2500 Hz, which are now inverted and transmitted between 600 and 1600 Hz. Use of the 2100L filter is the same except that original speech components between 1000 and 2500 Hz are inverted and transmitted between 600 and 2100 Hz. Some rolloff does begin on the upper (inverted) segment below 700 Hz due to the 0700H filter. This signal is fed through S1F and S2A to an output buffer amplifier. Neglecting the amplitude compressor momentarily, the signal is finally fed through S3 to a high-level line output and through a 40-dB pad to the low-level microphone output.

Comparison of the receive configuration diagram allows the reader to follow the reconstruction sequence of the narrow-bandwidth received audio from the receiver audio output. The process is essentially just the reverse of the transmission process. The recovered voice spectrum has a gap in energy between 600 and 1000 Hz or 600 and 1500 Hz depending on which transmission filter is used (1600L or 2100L). As explained previously, this spectral gap occurs in the region where less vital voice energy is present.

Table 1 lists the basic specifications of the frequency compandor portion of the baseband device operating as a stand-alone unit. Note that although the device responds to 50-Hz signals, moderate voice energy rolloff below 400 Hz performed by the transceiver is not only acceptable but highly desirable to obtain a pleasing tone balance in the recovered voice. Thus, the effective audio bandwidth at the input to the transmitter modulator is about 350 to 1600 Hz using the 1600 system. Linearity of subsequent rf stages in the transmitter affects the ultimate transmission bandwidth.

The basic operation of the Signetics NE570/571 amplitude compandor has been dealt with in a previous article,' except that major emphasis was not placed on the primary design purpose of the IC — amplitude compression and expansion. The NE571 has two identical halves, each of which can serve as an amplitude compressor or expander. The basic transfer function is 2:1. That is, in the compression mode, every 2-dB change in amplitude at the input is compressed to a 1-dB change in amplitude at the output. The expander performs the inverse function. The transfer curve is highly linear in nature except where purposely distorted as discussed below. This feature keeps harmonic distortion products to insignificant levels. The 0-dB gain point in the NE571 is set at 0.775 V rms input (0 dBm in 600-ohm systems) and its range extends plus 20 and minus 80 dB from that point. A 50-dB dynamic range is deemed adequate for voice communications and is also easily realized with the frequency-compandor circuitry. This is then reduced to about 25-dB range for transmission and is expanded back to 50 dB at the receiving station. Noise picked up via the transmission path is not compressed but, being lower in level than the desired signal, is expanded to an even lower level by the amplitude expander.

The excess dynamic range capability of the NE571 at very low amplitudes is not used in this system. Borrowing from telephone industry practices, the compressor is essentially turned off below a certain input level so that ambient acoustical noise at the microphone is not amplified to an annoying level by the compression process. Another interesting phenomenon occurs at the expander. If the full dynamic range is used and the signal input is quite low, the expander decreases this level to the point of inaudibility. In early telephone companding experiments the called party could hear nothing between voice passages and was inclined to prematurely hang up on the caller. So it appears that the expander should cease to expand signals below a certain input level so that a feeling of presence is maintained. This is accomplished by distorting the expander transfer curve so that little or no expansion occurs below a certain input level. The NE571 compandor allows this to be accomplished easily.

The compressor/expander continuously measures the level of the incoming voice signal. From this measurement a gain-control signal is developed to vary the "throughput" amplification (or attenuation) factor. The level measurement responds at a maximum 100-Hz rate, which corresponds to the shortest segment of typical speech at 10 ms duration. Faster response provides less compression advantage, and slower response distorts the time relationship of the speech passages. The process depends upon an amplitude

Table 1
Frequency Compandor Specifications

Parameter	Input: Transmit	Input: Receive	Output: Transmit	Output: Receive (Recovered Voice)
Cutoff Frequencies (Hz)				
1600 System	50-2500	50-1600	50-1600	50-600 and 1500-2500
2100 System	50-2500	50-2100	50-2100	50-600 and 1000-2500
Stopband Attenuation, min. (dB)				
1600 System		−30 @ 2000 Hz	−50 @ 2000 Hz	
2100 System		−50 @ 2000 Hz	−50 @ 2650 Hz	
Maximum Voice Levels (dB) (0 dB = 0.775 V rms)	line in, +10 mic in, −30*	+10	line out, +10 mic out, −30	line, +10 dB earphone, +10 dB (2-kΩ load) speaker, 1.5 watts (8-Ω load)
Signal Port Impedances	line, 10 kΩ mic, 30 kΩ	10 kΩ	line, 1 kΩ mic, 600 Ω	line, 1 kΩ phone, 50 Ω
Suppression of 3100-Hz carrier, min. (dB)			line, −35	line, −65

*Mic level set at maximum

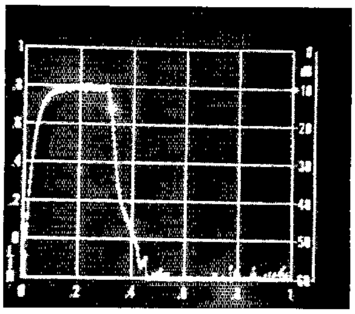


Fig. 8 — Spectrograph of the 350- to 1600-Hz receive filter.

Table 2 Overall System Features			
Mode	Transceive	Transmit Only	Receive Only
Frequency Compandor			
1600 Hz	X		
2100 Hz	X		
Amplitude Compandor			
Compressor	X	X	
Expander	X		X
Receive Filters			
1600 Low Pass (Fig. 8)			X
2100 Low Pass (Fig. 9)			X
700-2100 Band Pass (Fig. 10)			X
700-1600 Band Pass (Fig. 11)			X
Straight Through	X		

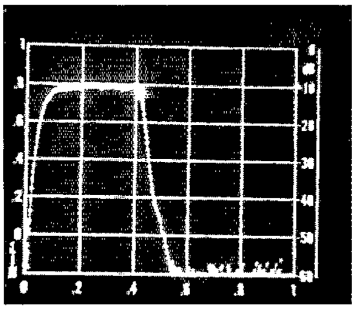


Fig. 9 — Spectrograph of the 350- to 2100-Hz receive filter.

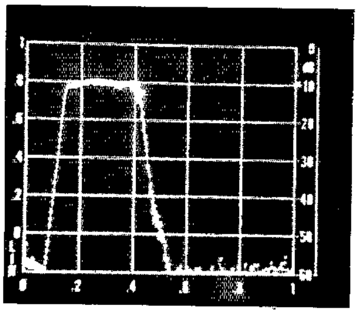


Fig. 10 — Spectrograph of the 700- to 2100-Hz band-pass filter.

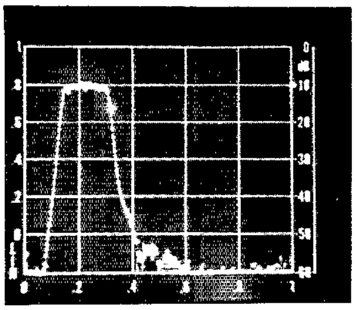


Fig. 11 — Spectrograph of the 700- to 1575-Hz band-pass filter.

modulation envelope to provide SNR improvement; therefore the amplitude compandor is "transparent" to constant-amplitude signals or signals which have modulation envelopes greater than 100 Hz. Fortunately, the typical on-off keyed cw modulation envelope falls within this range and the amplitude expander can provide an SNR advantage in this mode.

As shown on the block diagram, additional switching has been added to the prototype device to allow use of some of the active filters when the unit is not being used in the frequency-compandor mode. The additional switching is active only in the receive mode, the transmit signal being passed unmodified to the amplitude compressor or output. S7 puts the unit in the filters-only mode. S5 selects between the 1600- and 2100-Hz low-pass filters and S6 allows addition of the 700-Hz high-pass filter to provide a band-pass characteristic. Switch control lines (not shown) are fed to the front panel switches.

Also not shown on the block diagram is a voice feed-around switch operated by the keying circuit during frequency-compandor VOX operations. The frequency compandor is normally in the receive mode, and the microphone audio is fed directly to the transmit output. When the operator speaks, the radio transmitter VOX circuit energizes the transmitter, and the transmitter key line is fed back to the voice processor transceive control to put the unit into the transmit mode. In actual operation, this occurs so rapidly that the transition is not noticed.

The overall features of the amateur voice processing accessory are listed in Table 2. Note that the amplitude compressor, amplitude expander, and frequency compandor can all be selected to operate simultaneously or independently. Assuming reception of standard ssb transmissions, the receive filter options allow suppression of upper or lower adjacent-channel interference with voice degradation increasing with decreasing bandwidth. The 1600-Hz low-pass filter is not recommended for standard ssb reception but the 700- to 1600-Hz band-pass combination appears to be very useful in conjunction with the amplitude expander for cw reception. Bode plots of these receive filters, taken on a Spectral Dynamics model SD340 analyzer, are shown in Figs. 8, 9, 10 and 11. The plots include the typical low-end rolloff caused by the amateur transmitter.

The reader may question why the high-level inputs and outputs are provided by the system. The immediately obvious use for these inputs and outputs is for easy interface with a tape recorder for recording and playback of radio messages.

During development of this system, cost and quality have been considered at each stage. The desire is to provide technological solutions for the ever-increasing demand for greater communications volume with acceptable quality at a reasonable cost.

Part 2, to appear in a subsequent issue of *QST*, will present in detail schematic drawings of the system and information on how the amateur user can build or buy one of his own. QST

References

'Harris and Gorski, "A New Era in Voice Communications," *QST*, December, 1977.

'Wilmotte and Lusignan, "Spectrum-Efficient Technology for Voice Communication," *UHF Task Force Report*, Office of Plans and Policy, FCC, Washington, DC, February, 1978.

'Miller and Licklider, "The Intelligibility of Interrupted Speech," *JOASA*, 22:2, March, 1950.

'Lee, "Time Compression and Expansion of Speech by the Sampling Method," *JOASA*, 20:9, November, 1972.

'Schiffman, "Playback Control Speeds or Slows Taped Speech Without Distortion," *Electronics*, August, 1974.

'Crochiere and Sambur, "A Variable-Band Coding System for Speech Encoding at 4.8 kb/s," *BSTJ*, 56:5, May-June, 1977.

'Jung, "Gain Control IC for Audio Processing," *ham radio*, July, 1977.

Additional References

Flanagan, *Speech Analysis, Synthesis and Perception*, 2nd Ed., Springer-Verlag, 1972.

Harris, Cleveland and Howland, "A Unique Narrow Band Voice Modulation System" *1977 IEEE International Conference on ASSP*, May, 1977.

Voiers, *Intelligibility Testing at Dynastat: The Diagnostic Rhyme Test*, Dynastat, Inc., Austin, TX.

Voiers, *Speech Acceptability Evaluation at Dynastat: The Diagnostic Acceptability Measure (DAM)*, Dynastat, Inc., Austin, TX.

Frequency-Measuring Tests Using a Product-Detector SSB Receiver

Costly frequency-measuring equipment preventing you from becoming an FMTer? Read how this author resolved the problem. Now he's really competing in the precision tests.

By Donald L. Upp,* WB8STQ

When I became acquainted with *QST* eight years ago, those reports on the quarterly frequency-measuring tests seemed rather dull and routine. The accomplishments appeared to be ones in a narrow field of interest. I wondered why anyone except those amateurs concerned with the official observing program would even become involved. After all, the FMT activities were established many years ago for the OOs and would-be observers. My attention to this section of *QST* was most casual. Little did I realize then that the future would bring about a surprising change of attitude.

What did not escape my attention was that two notable amateurs in my area consistently gained prominence on the FMT honor-roll listings. In time, as my general activity increased, I was most fortunate to meet both W8OK and W8CUJ. These two distinguished gentlemen readily impressed me as men of sincerity and character. Their warm friendship, interest and concern have shaped the course of my Amateur Radio life.

*52 East Sherry Dr., Trotwood, OH 45426

A Start in Frequency Measuring

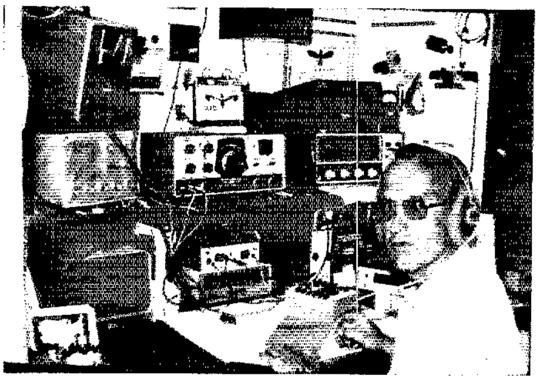
Conversations with W8OK and W8CUJ, as a natural course of events, aroused my curiosity about frequency measuring in general. I soon realized that I was giving more attention to the quarterly FMT reports. Other than these reports in *QST*, little additional written material seemed available on frequency-measuring activities. Perhaps the lack of information indicated that interest was not widespread. Nevertheless, W8OK and W8CUJ had motivated me to the point where I wanted to be part of the scene.

With a measure of impatience to get started, I launched my first attempts at frequency checking, limited by what little equipment I possessed. These efforts were crude and unreported. Yet they were the beginnings. While my station lacked the more refined equipment essential to precision measurements, inadequate reception clearly needed to be resolved. Could I really expect optimum performance from my HW-100 while depending on a ground-mounted vertical without radials? Those 80-meter signals, for instance, did little more than push the meter up to S3 at best. Performance on 40 meters was more decent, with S9 signals a common occurrence. But, on the negative side again, I was never able to bring in W1AW signals on 20 meters.

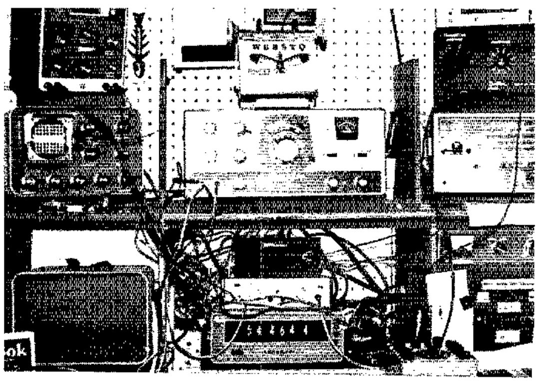
On Deck with the SB-650

Planned improvements for my installation included the acquisition of a Heath

WB8STQ during the November 1976 frequency-measuring tests.



The station setup at WB8STQ for FMT using divide-by-100 mode.



SB-650 frequency display. My reason for this particular choice is that it is compatible with the HW-100. This display operates with the Heath amateur receivers and five-band transceivers of the SB and HW series, covering the 3- to 30-MHz range. It calculates the received frequency to 1/10 kHz. The measured frequency is read out on six display devices.

Not long after the SB-650 went into service, I found that with a home-constructed, extremely narrow-band 750-Hz filter in the audio circuit, my equipment could measure the frequency of CHU (7,335,000 Hz) to within 25 Hz. But the final step in making the frequency check, admittedly, was done by ear and by "guesstimating" the relative length of the last-digit jitter. Satisfaction with this accomplishment was eventually overruled by a need to be honest with myself, admitting that 25 Hz was not good enough.

To make the honor roll in the FMT at the time I got started, 0.4 ppm was a requirement.* Results had to be better than 3 Hz (average) for all three frequencies used in the quarterly frequency-measuring tests.

While considering my intentions to achieve more accurate measurements, I did not fail to keep in mind the reception problem. Failure to hear even a whisper from W1AW on 20 meters was a significant loss, for the measurements on this band offered the greatest tolerance. Reception on 40 meters provided good signal strength but this was offset by heavy nighttime QRM that often makes activity on that band nearly a total loss. My frequency measuring seemed destined to be carried out on the 80-meter band where frequency checks had to be held within 1.8 Hz. Should the propagation produce a shift of 1/2 hertz and the umpire decided on the next higher (or lower) reading, all room for error would be lost — including any allowance for digital-display jiggle or line-voltage shifts. Tackling the reception problem, nevertheless, was not given top priority, all immediate effort being devoted to the electronic devices that perform the actual measurements.

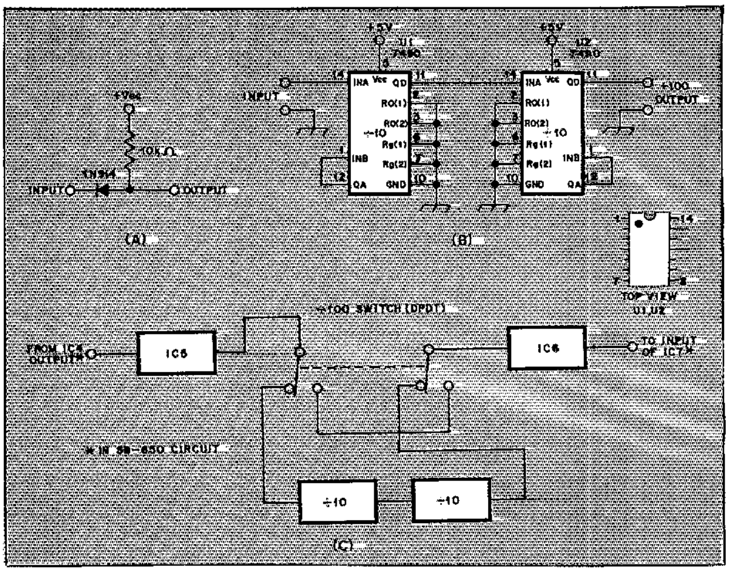
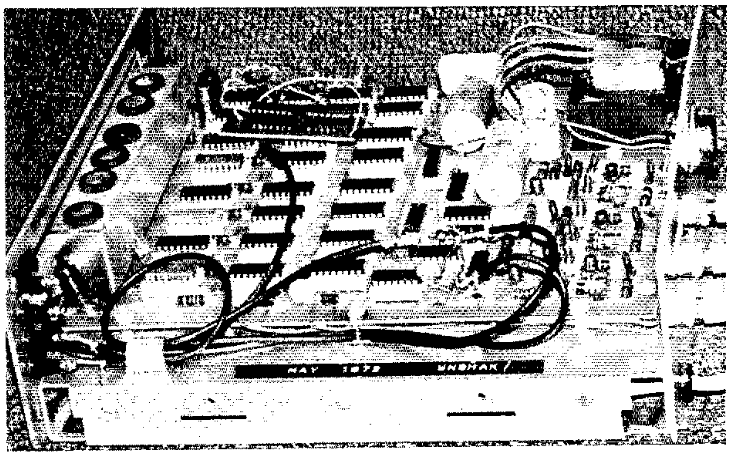


Fig. 1 — Circuits added in the modification of the Heath SB-650 frequency display. At A, a nonloading signal tap for TTL circuits using a high-speed switching diode. At B, details of the divide-by-100 circuit. Switching of the divide-by-100 system is illustrated at C. U1 and U2 are TTL decade-counter ICs. No connections are made to IC pins not shown in B.



The SB-650 with case removed. Pin jacks used in frequency reading are at the lower left. The divide-by-100 circuit board is at the upper left.

An Oscilloscope and a Frequency Counter

The Dayton Hamvention flea market furnished me with the next addition to my equipment inventory. After a $20 bill changed hands, I owned a second-hand oscilloscope which became a useful adjunct to an inexpensive but very stable Southwest Technical Products signal generator I'd recently constructed. Upon calibrating the generator against the 60-Hz power-line frequency, my equipment had the capability of measuring down to the 1.5- to 2.0-ppm range.

Progress is seldom achieved without some disappointment, and so it was with a frequency counter I built which did not increase the accuracy of my measurements. What the device did offer was an instantaneous readout of the frequency being checked. Work continued as I responded to an inner voice that kept saying, "Just have to get closer results!" The efforts produced a modest improvement with the range being lowered to the 0.8- to 1.5-ppm region.

Refer to the photograph of the SB-650 with the cover removed. The front-panel jacks, which you see from a side view, are for the buffered outputs of the HFO, BFO and VFO in addition to the 1-MHz crystal time base.

By going "down stream" one stage

*[Editor's Note: The procedure for the ARRL-sponsored FMT has been changed since Mr. Upp wrote his article. No longer is ppm used for measurement tolerances. Instead measurements are made now in terms of hertz. In order to qualify for Class 1 OO the new requirement stipulates that the frequency check must be within 100 Hz. In order to make the honor roll, the requirement is 5 Hz. Both tolerances, of course, must be within the umpire's readings. See page 76, May 1978 *QST*. At the time Mr. Upp made his frequency checks, the degree of precision under the 0.4-ppm requirement was 1.4 Hz at 3.5 MHz.]

from the inputs, a square-wave-conditioned signal can be taken off by means of a 10-kΩ resistor and a 1N914 switching diode (Fig. 1A). This arrangement allows the BFO and the HFO signal to be read with a frequency counter just prior to and just after the measurement run. Alternate readings of the audio beat frequency and the VFO frequency can then be taken rapidly.

This procedure is fine, provided that the line voltage does not change. A 1-volt displacement can induce a 2-Hz error. In my area, for instance, the line voltage may vary substantially during the late reading periods. Perhaps with a little practice I might have been able to obtain measurements within the 0.4-ppm limit, but I was convinced I'd find a better way.

Many of the dedicated FMTers might have volunteered the question, "Why not use a stable signal with 5- or 10-kHz points and just measure the beat note?" Surely that's a time-honored way, except that if one has a product-detector receiver in which the BFO cannot be turned off, there will be *two* beat notes. This simply means that by locking on one beat note, a product detector will provide two frequencies. Picking the right one could be troublesome, as in my case. Something up my sleeve resolved the difficulty: a number of SN7490Ns I had in stock. I jokingly tagged them "Destination SB-650," feeling quite certain that the search for a better way had ended.

Adding a Divide-by-100 Step

The digital modification of the Heath frequency display that followed paved the way to the real game of FMT. My plan involved the addition of a divide-by-100 step to the time chain with connections made at the output of IC4 (pin 11) and the input of IC5 (pin 14). See Fig. 1B. Going any further down the chain than the IC6 to IC7 stages would change the up-down counter time relationships. The board layout is shown in Fig. 2, and you may see the board positioned in the upper left of the uncovered SB-650. The picture does not include the dpdt switch which I added later and appears in Fig. 1C.

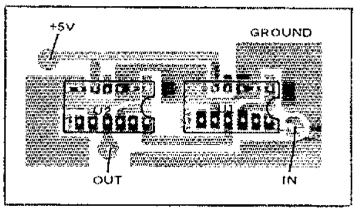


Fig. 2 — Parts placement guide for the WB8STQ divide-by-100 circuit. The shaded area represents an X-ray view of the copper pattern, the ICs being placed on the nonfoil side. The etching pattern for this board appears in the "Hints and Kinks" section of this issue.

Modification of the SB-650 was a rewarding effort. After a warm-up period of two hours, for stability, calibration against the frequency of CHU disclosed that at last my equipment had the capability of meeting those tight frequency-measuring requirements. With only 15 minutes of warming the error appeared better than 1 ppm. Following the more thorough warm-up the error remained constant and could be factored in any reading.

The Performance Report

My total score in the February 1977 FMT was 0.24 ppm. On the late 80-meter reading, I had five measurements that were exactly on the umpire's reported frequency. My other readings were plus or minus 1 Hz. A typical series in which the usb mode was used, so that all readings add, is as follows:

Band switch at 3.5 MHz.

SB-650 reading — 543561.

Audio to lock a single O on the oscilloscope — 882 Hz.

Calibration correction — add 3 Hz.

To apply the above information, add the numbers in this manner: 3.543561 MHz + 882 Hz + 3 Hz = 3544446 Hz.

By using the usb mode and adding the mathematical components, except possibly the correction factor, the chance for error at a sleepy-eyed 1 A.M. is minimized.

"Where did the variable error correction originate?" you might ask. The variation is mostly drift in the SB-650. The unit was not intended for this type of application, and thus has only a minimum of frequency stabilization. Furthermore, adjusting the time base to within 3-Hz error is nearly impossible, even on a short-time measurement using CHU as a standard. Because of the circuit delays and the timing/counting arrangement, the time base on mine must be set at 1000002.7 Hz to even be *that* close. But any error in ppm is virtually constant on the 80-, 40- and 20-meter bands. The short-time stability accounts for this feasibility. The poorest reading I obtained occurred in the early 80-meter run. My measurement was 0.57 ppm off that of the umpire, a difference of only 2 Hz. Therefore, you may appreciate what I mean about the need for close measurements.

If the high price of equipment for frequency checking has discouraged you from participation in the FMT, I trust that these alternatives just outlined will renew your interest. I enjoy the challenge and also enjoy making equipment modifications to suit various needs, and I'm sure you will, too. As for modifying the antenna system, that too is in the works, with full anticipation of catching that elusive 20-meter signal from W1AW. So, in the months to come, you may see more of "STQ" in *QST*. QST

Strays

$5 FILTER SOLVES OSCAR MODE J DESENSE PROBLEM

If your 435-MHz receive system is sensitive enough to get desense from your 2-meter uplink, this filter should solve the problem. The filter, developed by ARRL's Club and Training Department, can be built from simple materials for less than $5.

To receive the description and drawing of this filter send a self-addressed, stamped envelope to ARRL C&TD Filter, 225 Main St., Newington, CT 06111. — *W9KDR*

More than 250 science educators from around the U.S. "met" OSCAR at the ARRL booth at the NSTA Annual Convention in Washington, DC. Jim Jipping, W8MRR, science teacher at Holland (MI) Christian HS, gave an excellent presentation on his classroom OSCAR work. At the Smithsonian's NN3SI, an OSCAR 7 demo was given by (l-r) K3RJA, AA4BE, WA4DMF and AA4SI.

The Two-Tone Tester

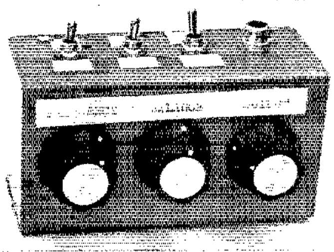
When used in conjunction with an oscilloscope, this simple device makes proper adjustment of ssb transmitters possible.

By Fred Brown,* W6HPH

Single-sideband transmitters require a perfectly linear input-output relationship in all stages between the sideband filter and the antenna. Any nonlinearity may cause splatter and "buckshot" extending many kHz either side of the ssb channel. A number of different techniques can be used to test transmitter linearity; three posible ways are shown in Fig. 1.

In Fig. 1A an audio-frequency sinewave generator is connected to the microphone input and relative transmitter output is indicated by an rf voltmeter. The audio voltage at the mic input is measured with an ac VTVM. These two meter readings make possible a plot of rf output vs. audio input, as shown in Fig. 2. If the plot is a perfectly straight line passing through the origin, it means the transmitter is probably linear. The reason this method is seldom used should be fairly obvious: it is tedious, time consuming, and every new adjustment requires plotting another curve.

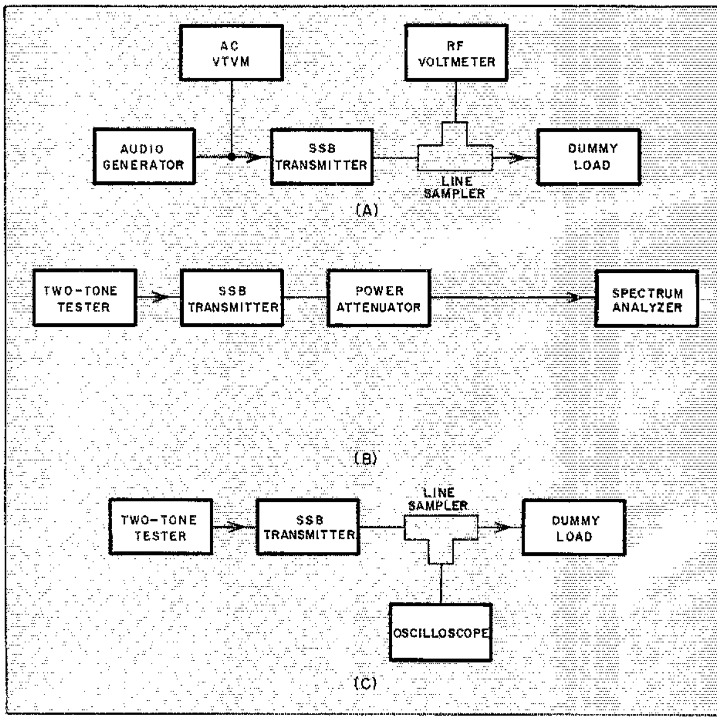
*Box 2053, Rancho Santa Fe, CA 92067



With miniature components and careful layout it is possible to fit all parts into a 4 × 2 × 1-3/4-inch (102 × 51 × 44-mm) box. The 9-volt battery is mounted on the rear of the box for easy replacement. All components except the controls and R5 are mounted on a 1-3/4 × 3-inch (44 × 76-mm) perf board.

Fig. 1B shows another method of checking transmitter performance, one that is frequently used in the ARRL lab. Here, two audio tones are applied to the microphone input, and the transmitter output is observed on a spectrum analyzer. If the two audio tones are perfect sine waves, and if the spectrum analyzer has a calibrated amplitud response, it is possible to measure the ex act level of the distortion products relativ to full power output. This is the idea setup, and works beautifully, but i seldom adopted by the average ham sinc most of us do not have access to tha $10,000 spectrum analyzer.

Fig. 1 — Three ways in which transmitter linearity can be checked are shown below. The method at A requires laboriously plotting a curve of output vs. input. The method at B requires an expensive spectrum analyzer. The most popular method, at C, requires only a scope and two-tone tester.



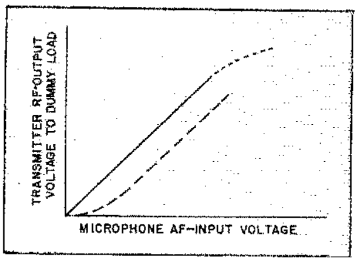


Fig. 2 — A properly functioning transmitter will result in a straight-line relationship between rf output voltage and microphone af input voltage, as shown by the solid line. The dashed line shows the type of nonlinearity caused by too much bias on the final amplifier or some intermediate amplifier stage. The dotted line shows the result of "flat-topping," or amplifier saturation.

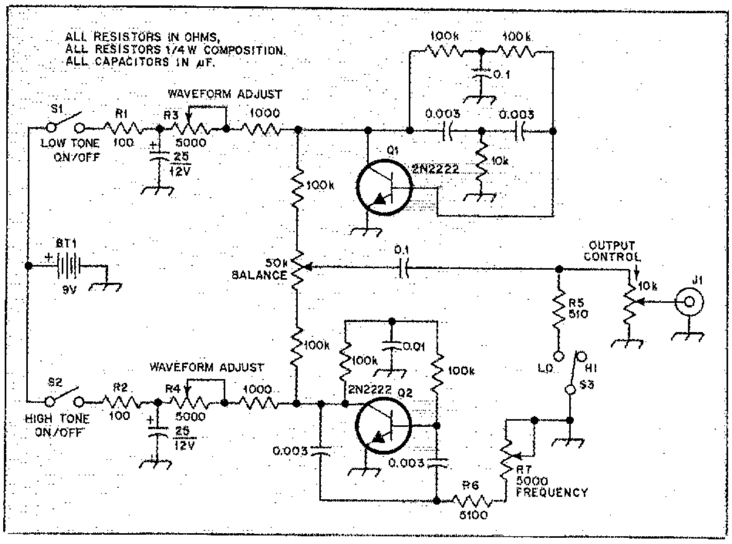


Fig. 3 — The two-tone tester utilizes a pair of twin-T oscillators. Transistors Q1 and Q2 can be 2N2222s, or similar npn silicon transistors. The waveform adjustment resistors, R3 and R4, are miniature trimmer pots, linear taper.

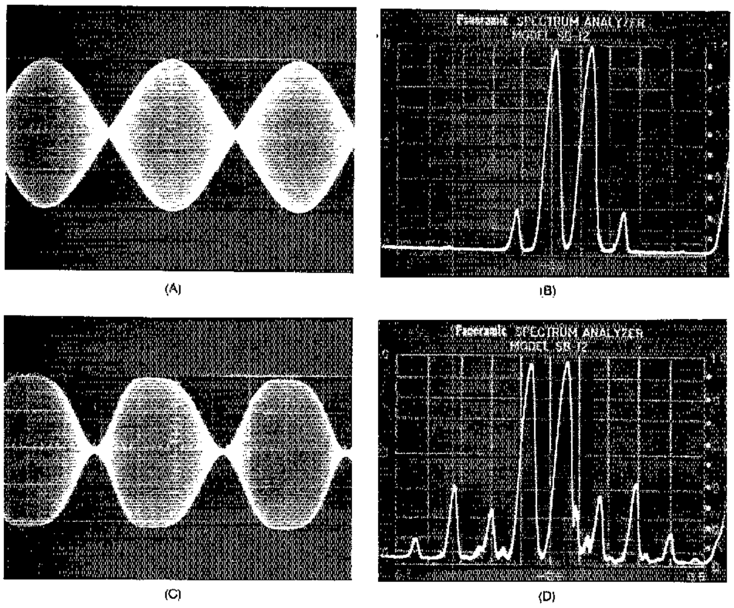


Fig. 4 — Scope patterns for a two-tone test signal and corresponding spectrum-analyzer displays. The pattern at A is for a properly adjusted transmitter; consequently the IMD products are relatively low, as can be seen on the analyzer display at B. At C, the drive level was increased until the flat-topping region was approached. This is the most serious distortion of all since the width of the IMD spectrum increases considerably, causing splatter, D.

Fig. 1C shows the technique most widely used, and one that is discussed thoroughly in *The Radio Amateur's Handbook*. All that is required in this case is a two-tone input and a garden-variety oscilloscope. Any nonlinearity in the transmitter sufficient to generate distortion products higher in level than roughly 20-dB below the desired output will be visible as a distortion of the normal two-tone test pattern. Photographs of sample rf envelope patterns, along with their interpretation, are available in the *Handbook*. Some are reproduced here.

The two audio tones can be improvised with a pair of sine-wave audio generators, but this is a clumsy expedient, and also creates a procurement problem, as the average ham seldom owns even one audio generator. A compact two-tone tester in one package would be a very worthwhile addition to almost any station that uses single sideband.

Some desirable features of a good two-tone tester would be (1) pure sine-wave output with frequencies somewhere between about 600 and 2400 Hz, but not harmonically related to each other; (2) adjustable frequency of at least one tone so that the test pattern can be made stationary on the oscilloscope screen; and (3) adjustable amplitude of one sine wave so the two tones can be equalized in amplitude after passing through the sideband filter.

The Circuit

A complete schematic of the two-tone tester is shown in Fig. 3. Twin-T oscillators were chosen because they are simple and, with proper adjustment, they can be made to produce quite pure sine waves. Q1 oscillates at a fixed frequency of about 1000 Hz, and the frequency of Q2 is adjustable between 1000 and 1300 Hz. The frequency difference of 0 to 300 Hz is about right for use with scopes having a horizontal sweep rate of 60 Hz, as it permits display of from one to five cycles of the rf envelope pattern.

The frequency range of Q2 can be made wider by substituting a 10-kΩ pot for R7, and then reducing R6 to about 3300 ohms, but it will be at the expense of less vernier in the frequency control. If this is done, it would be advisable to use a 10-turn pot for R7, to provide sufficient vernier action to easily stabilize the scope pattern. A 10-turn pot was not used in this unit because of space limitations.

Experimentally it was found that the twin-T oscillator is capable of producing a quite pure sine wave if the collector resistance is carefully adjusted. It's not possible to specify values since the optimum resistance will depend on individual transistor parameters, and there is a wide variation from one transistor to the next. Accordingly, trimmer resistors are used for R3 and R4 in Fig. 3. These resistors are set for best waveform when the corresponding oscillator output is viewed on an oscilloscope. If you are a perfectionist, you can set the values with a distortion analyzer, but an ordinary scope will easily get you below 5 percent total harmonic distortion.

The two oscillators are independently switched by S1 and S2, which makes it possible to use one tone at a time for general lab work or for single-tone testing. Separate isolating resistors, R1 and R2, and decoupling capacitors, C1 and C2, are used in the supply leads to prevent any interaction or frequency-locking of the two oscillators.

The oscillator frequencies are determined primarily by the RC values used in the twin-T feedback networks. It's not important exactly what these frequencies are, so long as the frequency of Q2 comes close to that of Q1 with R7 set near one extremity of its range. The frequency o[illegible] either oscillator can be fudged by shunting any of the resistors or capacitors in the twin-T networks.

Single-tone output of the tester is about 120 mV, with S3 in the HI position. In the LO range, S3 connects R5 across the output control, and the maximum output is then about 10 mV, a convenient level for low-impedance microphone inputs.

One final word of caution: Remember that the two-tone tester will not produce meaningful scope patterns if applied to a transmitter that employs clipping or speech processing.

Strays

EL HOMBRE Y LA MAR EXPEDITION

☐ Aided only by 20th-century Amateur Radio for five adventure-filled months, Vital Alsar, XF1LM and his crew of 15 traversed the Atlantic in three primitive ships. Their voyage retraced a 16th-century gold and silver route. Having sailed on three 11-meter (35-ft) replicas of Spanish galleons 9000 km (5600 miles) from Tampico, Mexico, they were preparing to drop anchor in Santander, Spain.[1]

During the entire trip communications were maintained with radio amateurs via net operations on 14.135 and 14.280 MHz. Roberto Romero, XE1NF, ably handled the master of ceremonies chores at the Mexican end, while Manolo Estevez, EA1TI, was NCS in Spain.

In July, while sailing south of Florida the flotilla developed equipment problems. Juan Granados, WD4LCD, who had been in contact with XF1LM since the voyage's start, suggested they lay over in Key Biscayne for assistance from the Radio Club Interamericano. For two days RCI hosted the voyagers while the hams repaired their two transceivers, rebuilt an auxiliary engine, and provided much-needed medicines and other supplies.

Once more the three galleons, *Anna de Ayola, Quitos-Amazonas* and *Cantabria* set sail for Spain. Across the sea they braved the raging 100 mi/h winds and tempestuous 14-m (45-ft) waves of hurricane Ella. For a time the *Anna de Ayola* was blown away from the others, which created some anxious moments on both sides of the Atlantic until it was located.

The voyage actually began in an Ecuadorian jungle. On the bank of the Napo river, an Amazon tributary, Alsar and some fellow expeditionaries built the vessels. When completed, they sailed them down the Napo to the Amazon and on to the Atlantic port of Belem, Brazil.

Among the crew of 15 were 11 Mexicans, two Frenchmen, a Spaniard and an American. Most are city dwellers — a painter, three dentists, an engineer, an architect and an artist. They say they made the primitive voyage to prove man can overcome language barriers and rise above personality differences and the spoils of modern living. Certainly Amateur Radio on both sides of the Atlantic helped strengthen this view.

Many amateurs contributed to the success of this exciting adventure. Space limits prevent us from acknowledging all of them, but watch for a follow-up that will duly recognize the individuals who devoted countless hours to this team effort. — *W1TKG and K1UJ*

[1]At our deadline, they were within 160 km (100 miles of their destination.

Calculating Component Values

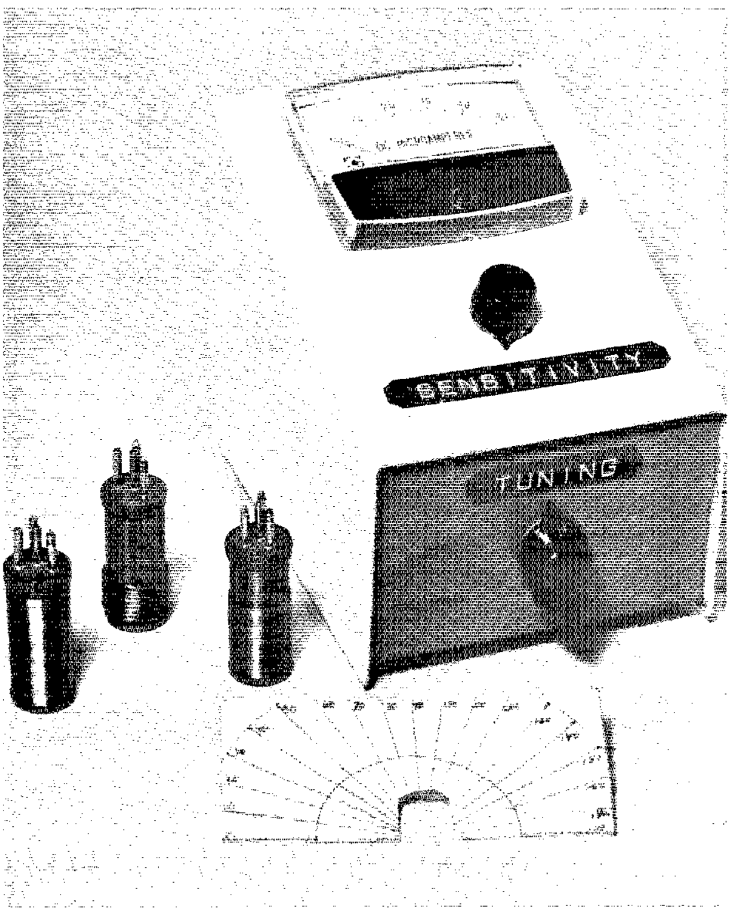
Basic Amateur Radio: How do you find the value of an unmarked capacitor or inductor? With a dip meter and a general coverage receiver, you can make use of those "bargain-house" parts!

By Jim Bartlett,* K1TX

If you've ever built any electronic gadgets, you probably know what it's like to hunt for parts. Neighborhood electronic outlets are carrying fewer capacitors and inductors every day. Parts racks are being replaced with stereo displays, video games and the like. Many builders without large junk boxes are having to turn to the mail-order parts outlets for a large percentage of the items on their parts lists. Naturally the biggest savings on parts comes from buying bulk quantities of mixed values. Parts dealers buy many of these components from manufacturers who sweep them off production line floors. Unfortunately, many of these components are unmarked, or stamped with a manufacturer's part number at best. The newcomer may look at all those little blobs of wax with wires poking out the ends and decide not to buy any more "bargain bags." After all, you can't use them if you don't know what they are — right?

Most capacitors and inductors can be identified with the use of a *dip meter*, even if they contain no markings. If you've never used one of these gadgets, you don't know what you've been missing! Grid dip meters, and the newer FET dip meters are basically variable-frequency rf oscillators capable of indirectly monitoring the amount of rf energy absorbed from the instrument by a tuned circuit. When the resonant frequency of a tuned circuit is matched by the output of a dip meter, the tuned circuit begins to absorb some of the rf energy being radiated by the dip meter. As this happens, the grid or gate current

A lab-built prototype of the FET dip meter described in this article.



*Basic Radio Editor, *QST*

decreases. Therefore, by varying the oscillator frequency slowly and monitoring a meter that displays grid, gate or base current, you can determine the point at which the dip-meter frequency is equal to the resonant frequency of the tuned circuit.

Using this technique, you can determine the value of any unknown capacitor or inductor simply by matching up unknowns with known components of the opposite type (match unknown capacitor with known value of inductance, and vice versa). For example, let's say you had an unknown inductor, and you wanted to determine its value. In order to use the dip meter to find the inductance, you would first need to attach a capacitor of known value in parallel with the unknown component. This parallel combination would form a tuned circuit with a resonance at one frequency. The point of resonance is determined by the values for both the capacitor (which you know) and the inductor (the unknown), so therefore you can use this formula to determine the unknown value if you know the frequency and the value of the other component.

$$\text{Unk.} = \frac{\left(\frac{1000}{f \times 2\pi}\right)^2}{\text{known}}$$

where: f is frequency in MHz,
Unk. is either L or C,
Known is either L or C,
C is in pF, and L is in μH

This formula was derived from the one used to calculate the resonant frequency of a tuned circuit where both L and C values are known.

To find the value of our unknown inductor, we attach a known value of capacitance in parallel with it and then find the resonant frequency of the combination with the dip meter. After finding the resonant frequency, we apply this figure to the above equation, plug in the known value of C and solve for the unknown L. The equation is written so as to be easy to work with using common radio units of MHz, μH and pF, however, you can alter the formula if you wish to work with other units.

Let's look at some sample problems. In Fig. 1A we have an inductor of unknown value attached to a standard value of capacitance — in this case 100 pF. The resonant frequency of this combination is determined with a dip meter and found to be approximately 7.12 MHz. Using this figure along with the 100-pF value for our standard capacitor, we solve for the unknown in the equation above and determine our L to be about 5 μH. Next, we solve for an unknown value of capacitance. See Fig. 1B. Here we attach a 5-μH inductor in parallel with our unknown capacitor and use the dip meter to find resonance at approximately 13.7 MHz. Again, using the formula above, we solve for the unknown and find it to be

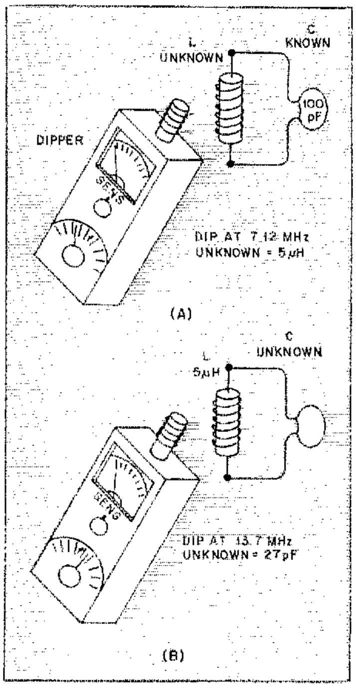


Fig. 1 — At A, a dip meter is used to determine the resonance of the unknown L and 100-pF standard-value capacitor to be 7.12 MHz. These figures plugged into the formula in the text yield a value of 5 μH for the unknown inductor. At B, the same process is used to find a value of 27 pF for an unknown capacitor.

about 27 pF. So you see, we can determine the value of practically any unknown capacitor or inductor simply by putting it in parallel with a standard value reactive component of the other type, and dipping to find the resonant frequency of the combination.

Standard Values

In the above examples, we used components of known value, which we called "standard values." Actually, any value of inductance or capacitance can be used as a standard value, as long as you know exactly what the value is. Since you must enter this value into the equation every time you solve for an unknown, it is easier to use an even number — one that is easy to remember and which requires less keystrokes on the old calculator. The 100-pF and 5-μH values used in the examples are good enough for most calculations, and are also easy to find. One way to pick your standard value capacitor is to borrow or arrange to use a very accurate capacitance meter. Then obtain a batch of capacitors that are all marked 100 pF (or whatever value you wish to use). Preferably, these should be mica, and if they are 1-percent jobs that's even better. Measure each of the capacitors on the capacitance meter and determine whic one is closest to the exact value you ar seeking. If an accurate capacitance mete is not available and you have to use som other means to measure the components select the capacitor that represents a average value of all components you test

Once you have selected your standar value of capacitance, it is a simple matte to do the same for your standard value in ductor. Again, if an accurate laborator instrument is available for use in testin your value, use it. If you can't find one don't worry. Simply use your standar value of C and your dip meter to obtai the values of prospective standard induc tors.

Air-wound coils such as Miniductor Polycoil and Air Dux make excellent stan dard values. They are easily cut to th proper size to yield the desired inductanc value. In addition, they are less likely t exhibit self resonance than inductor wound on certain types of coil forms. Air wound coils are also likely to have higher Q than similar coils wound o forms. High Q is desirable in standar values of C and L because you can't con trol the Q of an unknown you wish t measure. In order to measure th unknown, you must be able to see the di on the meter face. Sometimes this dip i very small or possibly appears as only hesitation in the movement of the mete needle. To enhance the dip or make i more pronounced, a high Q is necessary i the tuned circuit under test. Therefore since you don't know what the Q will b of any unknown you might happen to ru across in the future, it's wise to keep the C of your standard values as high as possi ble. Finally, make up your standar values as accurately as possible Remember, the accuracy of all th measurements you make with your di meter and standard values will be directl proportional to the precision of the stan dard values.

Using the Dip Meter

If you've ever used a dip meter before you're probably aware that the dia calibration on most dippers is somewha crude. To increase the accuracy of you measurements, use a general-coverag receiver or frequency counter to ascertai the exact frequency. If you use th receiver method, simply bring the dippe and LC combination within close prox imity of the receiver. Then obtain the di on the meter and note the frequency in dicated on the dial. Tune the general coverage set to the frequency shown o the dipper dial, and hunt for the audi beat note that should be produced in th receiver as it receives rf energy from th dipper. (See Fig. 2A.)

If you have a frequency counter an wish to use it to measure the operating fre quency of the dip meter, you can coupl the rf from one unit to the other through

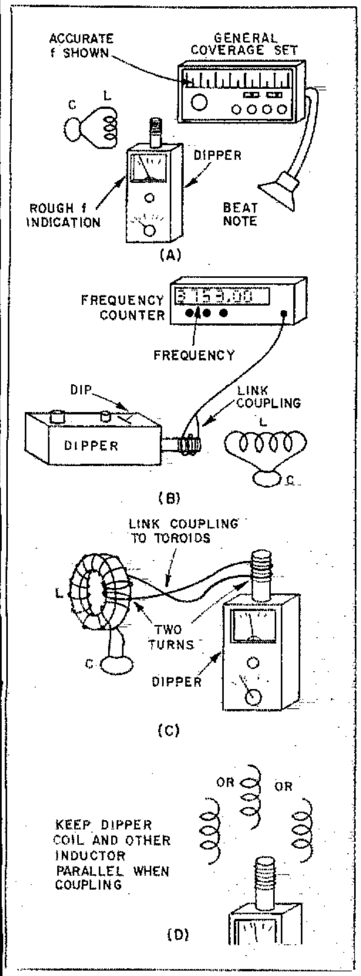


Fig. 2 — At A, the dipper is used in conjunction with a general-coverage receiver to achieve better accuracy in the measurement of frequency at the dip. At B, a frequency counter is used for the same purpose. Link coupling to a toroidal inductor is shown in C, and D illustrates the proper orientation between dipper coil and unknown inductor for coupling.

link wrapped around the dipper coil. See Fig. 2B. Alternatively, you may be able to couple enough energy from the dipper to the counter by simply hooking a short length of wire to the counter high-impedance input and bringing the dip meter close to the pick-up wire. This second method is less likely to cause the dipper reading to change since no extra turns are placed on the meter coil form.

Coupling to toroidal coils can't be done as easily as to conventional inductors because of the toroid's inherently superior shielding. To circumvent this, wrap a turn or two of insulated wire around the dipmeter coil and feed the end of the wire through the toroid core twice as shown in Fig. 2C. Connect the two ends of the wire together so that a complete loop exists between the dipper and toroidal inductor. Attach the parallel capacitor, and you're ready to hunt for the dip. Adjust the degree of coupling by sliding the turns which are wrapped around the dipper coil. Slide them up and down so they change in proximity to the coil windings themselves.

When you are using the dip meter, try to keep the coil away from any metal objects that could affect the tuning of the oscillator. Be especially wary of desk tops containing metal. If you must use a tabletop that you know or suspect contains metal, elevate the circuit under test and dipper a few inches using a stack of newspapers or magazines.

As you couple the dipper to the inductor of a tuned circuit, you will notice that the closer you get, the more pronounced the dip. A strong dip looks good, but try to resist the temptation to couple extra close on all measurements. If you *do* couple closely and obtain a sharply pronounced dip, you'll also probably notice that the dip is not symmetrical. That is to say that as you sweep the frequency-tuning knob through its range you will notice that although the meter dips slowly *down*, it doesn't return at the same rate on the other side of resonance. This occurs because overcoupling causes the oscillator to pull, keeping it from tracking properly with the tuning dial. This kind of dip is not only unstable, it is undesirable because it does not occur when the frequency dial is showing the actual resonant frequency, and therefore creates inaccurate measurements.

To avoid the overcoupling problem, dip your coils in this manner: Bring the meter slowly toward the inductor as you are repeatedly sweeping the dipper through the frequency range. When you notice a dip in the meter reading, pull the dipper away from the inductor. If the dip you observed was a true dip and not one due to a self-resonance inside the dipper or coil, it should disappear when the dipper and inductor are separated. When the dip is no longer evident, bring the dipper closer to the inductor under test again, watching closely for the dip to reappear. The point at which you can just detect the dip is the point of optimum coupling between the dipper and inductor, and the point at which the most accurate measurements can be made.

Building the FET Dipper

If you don't already own a dip meter, you might consider buying or building one. Commercial dip meters, both new and used, can be found at hamfest flea markets, and some kits are available. As an alternative, you may want to build a meter from scratch. Fig. 4 shows the schematic diagram for an FET dip meter that can be built inexpensively. Many parts are available from Radio Shack or

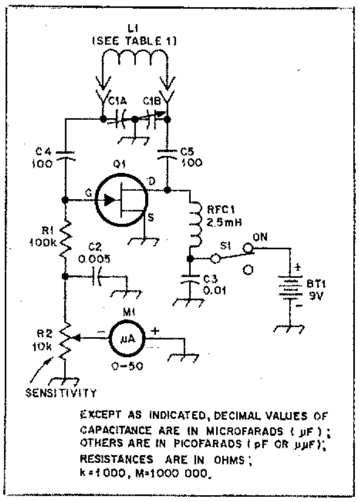
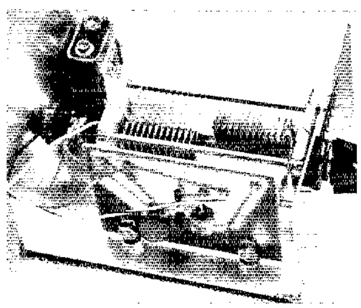


Fig. 3 — The schematic diagram for an FET dip meter using a single active device. Part numbers in parentheses are Radio Shack's unless stated otherwise.

BT1 — 9-V transistor radio type battery (23-464).
C1 — Air-variable capacitor, 2 sections, 100 pF per section (Johnson 167-53).
C2 — 0.005 μF disk ceramic (272-130).
C3 — 0.01 μF disk ceramic (272-131).
C4, C5 — 100 pF silver mica (Calectro A1-006).
L1 — See text and Table 1.
M1 — 0-50 μA meter movement (22-051).
Q1 — MPF102 FET transistor (276-2036).
R1 — 100-kΩ 1/4-watt composition (271-1300 or 271-000 series).
R2 — 10-kΩ potentiometer (271-1715) with spst switch for S1 optional (271-1740).
RFC1 — 2.5-mH choke (2.2 mH Miller 73F223AF).
S1 — Spst toggle switch (or switch ganged with R2).
Misc. — Cabinet, battery holder, battery clip connector, knobs, enameled and insulated wire, coil forms, coil socket, rubber feet, paint. (2-pin plugs and sockets suitable for use with pill vials to make plug-in coils are Radio Shack 274-342.)



The inside layout of the FET dipper. Note the short leads used between the pc board and the coil socket and C1. Although commercial forms and socket were used in the prototype, you can use an old tube socket and wind your coils on old pill vials or plastic 35-mm film containers fitted with pins salvaged from vacuum tubes. Alternatively, you can use pill vials with the 2-pin plugs and sockets indicated in the parts list of Fig. 3.

Table 1
Recommended Coil Values for L1

Inductance	*Coverage in MHz (approx.)*	*Construction†*
300 μH	1.2-2.4	76 t. no. 32 e.w.
82 μH	2.3-4.7	36 t. no. 30 e.w.
21 μH	4.6-9.2	18 t. no. 24 e.w.
6.5 μH	8.2-16.6	8 t. no. 24 e.w.
1.7 μH	16.2-32.6	5 t. no. 16 e.w.
0.9 μH	22.2-44.8	3 t. no. 16 e.w.
0.3 μH	38.4-77.6*	3 t. no. 12 on 1-inch OD form, spaced to give 2-inch total length
0.08 μH	74.5-150*	"Hairpin" no. 12, 2 inches long, 3/8-inch wide

t. = turns, e.w. = enam. wire

*Depending upon construction techniques, the dipper may not operate well above 50 MHz.

†First six coils all close wound on 20-dram pill vials (1-1/2-inch or 38-mm outside diameter).

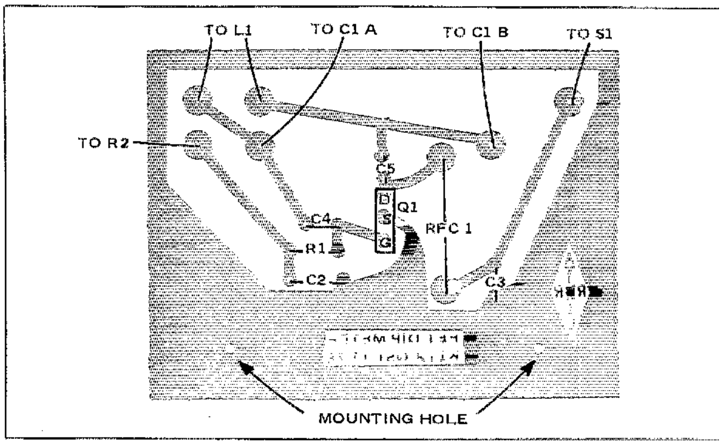


Fig. 4 — Parts-placement diagram showing where parts should be installed on the pc board. The etching pattern appears in the "Hints and Kinks" section of this issue. The above view is from the nonfoil or component side of the board.

similar parts houses. A parts-placement diagram for the pc board is shown in Fig. 4. The prototype FET dipper was built in a homemade aluminum cabinet. Plug-in coils are used to cover the range from 1.2 to 150 MHz (see Table 1). The frequency dials were made by hand to match each coil by using a frequency counter to monitor the dipper operating frequency at various points along the tuning range. A general-coverage receiver could also be used to perform the calibration although its use would be more time-consuming, and probably lead to less accurate measurements.

As you can see in the photos, the circuit board was mounted on edge next to the tuning capacitor, while the on/off switch, sensitivity control and meter movement were mounted on the top cover. Interchangeable coils plug into a socket located on the rear panel of the unit. When coils are changed, a new dial face is slipped over the tuning knob on the front panel.

Construction of the instrument is straightforward. Lead lengths should be kept as short as possible, especially those going to L1 and C1 from the pc board. When you make up the coils for your meter, use air-core coils such as those discussed earlier for use at the higher frequencies (above approximately 30 MHz). Doing this keeps the coils from exhibiting self-resonance that would appear as false dips on the meter. For vhf coils, you may want to use a hair-pin loop for L1. Exact values for L1 and specific dial faces cannot be provided here because they will differ with each instrument according to lead lengths, specific values used and the rate of change of capacitance in C1. See Table 1 for suggested L1 values.

Good luck with your dip meter. There are many other uses for dippers, some pertaining to radio and some not. A number of articles have been written about the use of a dip meter as a treasure or metal detector (when used in conjunction with a receiver), weak-signal source, mutual-inductance or coupling-coefficient calculator, and so on, not to mention its use for tuning antennas, output pi networks and such, and for calculating unknown values of C and L. The uses for a good dip meter are almost endless, and no amateur should be without one. QST

Strays

Otto McVey, W8RZ (center), recently received both the National Certificate of Merit and the Elmer Award in addition to being named an ARRL official instructor. Larry Armstrong, K8ZIP (left), made the presentations, along with Bob Lawrence, K8PUM, who represented the many students "Mac" has helped over a span of 23 years.

YANKEE GETS LIVE DEMO

□ Evan Wylie, who wrote the excellent articles in *Yankee* magazine on the sinking of the *USS Indianapolis* and the blizzard of '88 visited ARRL headquarters on August 18 to research a possible story on Amateur Radio.

Near the end of his tour, at 1430 EDT we received a phone call from Tony Brunton, WA1QHS, of CBS Radio in New York. Could we help? There had been an earthquake in Guatemala, and commercial communications were interrupted.

At W1AW Jim LaPorta raised YN1AZ on 15 meters, who found TG8QV and TG9UL on 40 meters and relayed the information back to Jim. There had indeed been a 35-second quake. It registered 5 on the Richter scale, and was 50 km south of Guatemala City. Communications had been interrupted, but there was little structural damage and no reports of personal injuries.

At 1507 EDT this information was passed along to CBS, and the unexpected live demonstration for *Yankee* magazine was over — accidental, but first rate! — *W1UED*

QST congratulates . . .

□ Mickey LeBoeuf, K5ML (ex-K5LVB) whose book, *Working Smart*, will be published by McGraw-Hill.

New England Division Director John Sullivan, W1HHR, presents a 50-year affiliation certificate to Norfolk County (MA) Radio Association President George Rummell, W1WTF.

Shoes, Size 220 AB or C

Going barefoot can be frustrating. Turn your meek 10-watt rig into a roaring, legal-limit machine!

By Wayne Overbeck,* K6YNB/N6NB

Interest in the 220-MHz band has been growing all over the United States and Canada lately. Among both fm and cw/ssb enthusiasts, there has been an awakening to the DX potential of 220. Only a few hardy souls are running high power on 220, an amazing fact when you consider that it's no more difficult to build a kilowatt amplifier for 220 than for 2 meters. This article presents such a final for 220, a simple and proven design using 4CX250B tubes in a push-pull configuration. Just 10 watts of drive will produce at least 600 watts output. And this final does it with components that are commonly available at low cost on the surplus market.

*Contributing Editor, *QST*

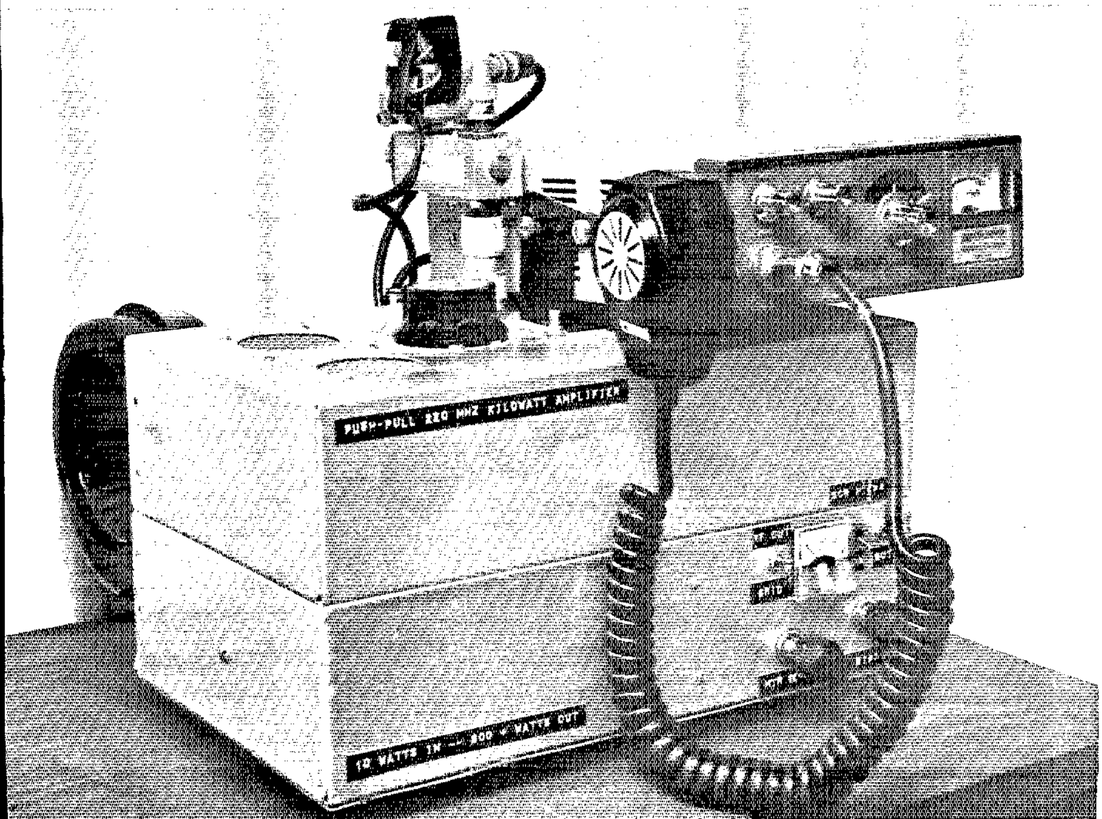
Circuit and Construction Details

Fig. 1 shows the schematic of the 220 kilowatt. Any of the tubes in the 4CX250 family may be used in the amplifier, including the easy-to-find 4X150A. Its grid and plate circuits are half-wavelength tuned lines. Depending on the bias and screen-voltage levels, it may be operated in Class AB_1 or Class C. If only occasional fm use is intended, Class AB_1 will suffice for all operation. More efficient operation on fm or cw is possible with Class C, if desired.

The amplifier is constructed in a two-chassis arrangement that may remind some readers of the K2RIW amplifier for 432 MHz, although this particular unit existed before Knadle's now-classic design appeared in *QST*.[1] It employs an entirely different approach inside the boxes. Like

[1]References appear on page 32.

A California-style 220-MHz contest station: commercial fm transceiver and a homemade amplifier.



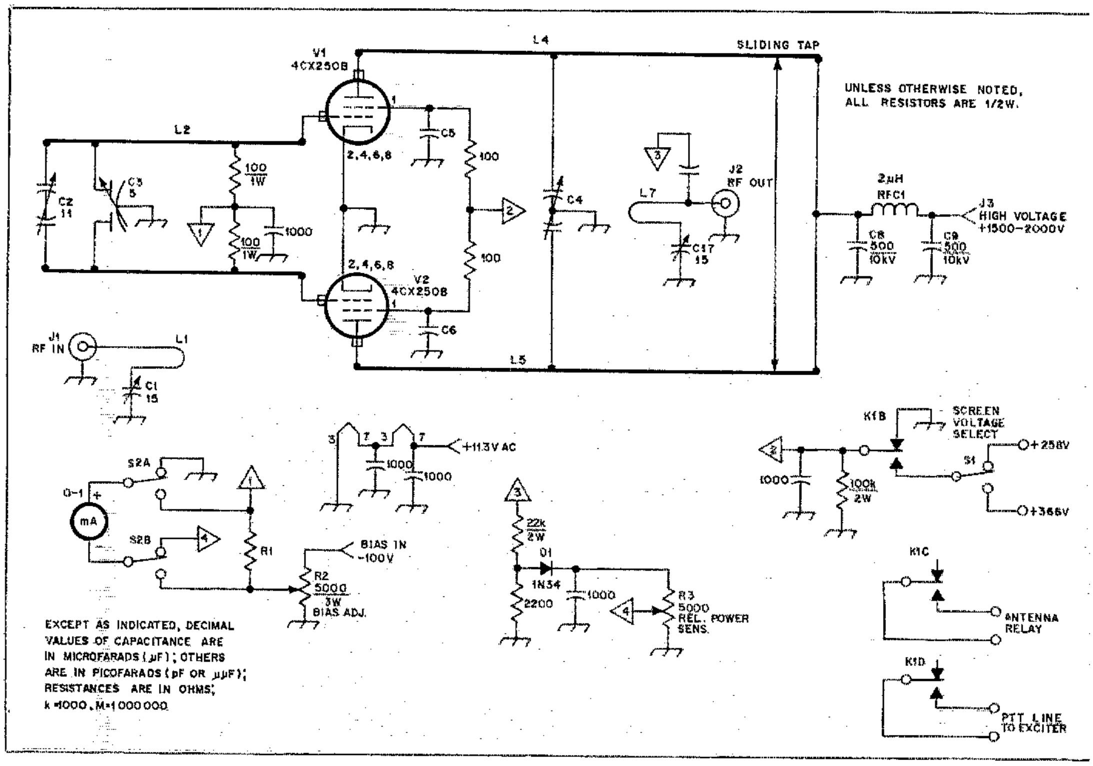


Fig. 1 — Schematic diagram of the 220-MHz amplifier. Although 4CX250B tubes are indicated, any of the tubes in this series may be used. Tube sockets should be EIMAC SK-620 or SK-630, or E. F. Johnson 124-115 for best performance. The amplifier should be cooled with a 60-ft³/min blower (Dayton 4C441 or equivalent). All 1000-pF capacitors should be low-inductance bypass or feedthrough types.

C1 — 2- to 15-pF miniature variable (Johnson 189-565-1).
C2 — 2- to 11-pF dual-section butterfly variable (Johnson 160-211-1).
C3 — 1- to 5-pF differential with all but two rotor plates and one stator plate removed from each side (Johnson 160-205-1).
C4 — Brass disk, 2.5 inches (64 mm) in diameter, soldered to a piece of 1/4-20 threaded brass rod. The rod passes through two 1/4-20 nuts mounted on the top chassis.
C5, C6 — Screen-bypass capacitor built into tube sockets.
C7 — 2- to 15-pF miniature variable (Johnson 160-107-1).
C8, C9 — 500-pF, 10-kV "doorknob" capacitor.
D1 — Germanium diode, 1N34 or equivalent.
J1, J2 — Type-N female coaxial connector.
K1 — 3pdt relay, 12-V dc coil (Potter and Brumfield R10-E6-X4-V185 or equivalent).
L1 — Input coupling loop; 4-inch (100-mm) piece no. 12 copper wire. Bend as shown in Fig. 2.
L2, L3 — Half-wavelength grid line, 6.5-inch (165-mm) length of 1/4-inch (6-mm) diameter copper tubing. Bend 4.5 inches (114 mm) from tube ends (see Fig. 2). Inductors are also bent 3/8-inch (10-mm) down at tube end to clear socket assembly.
L4, L5 — Half-wavelength plate line, 8-inch (203-mm) length of 1/2-inch (13-mm) copper tubing. A shorting bar, made from sheet copper, is used to resonate the lines. See Fig. 3 for details.
L6 — Output coupling loop, 4-inch (100-mm) piece no. 12 copper wire. Bend as shown in Fig. 4.
M1 — 0-1 milliammeter.
R1 — Meter shunt. Must be selected for meter movement used, to provide 50-mA full-scale deflection for grid current measurement.
R2 — 5000-ohm, 3-watt wirewound potentiometer (Clarostat 58C1 or equivalent).
S1 — Toggle switch, spdt.
S2 — Toggle switch, dpdt.

the K2RIW final, this one is housed in two standard 8 × 12 × 3-inch (203 × 305 × 76-mm) aluminum chassis. The lower chassis houses the grid lines and — behind a shield — the switching and metering circuits. The upper box encloses the plate lines and output circuit.

A 60-ft³/min blower mounted on the lower chassis forces air up through the two tubes and out through screening on top. The tube sockets are mounted about 2-3/4 inches (70 mm) apart and equidistant from the two sides of the chassis. As much as possible, the layout is kept symmetrical in relation to the chassis sides to avoid unbalancing the push-pull circuit. As with all vhf amplifiers using this type of tube, sockets with raised screen-grid rings and built-in screen-bypass capacitors are highly recommended. EIMAC SK-620, SK-630 or E. F. Johnson 124-115 sockets are ideal. With any of these sockets in use, no neutralization is needed to achieve stability under all normal operating conditions. Any instability encountered in this amplifier probably means there is a stray resonance or feedback path somewhere, one that neutralization will not likely cure.

The half-wave grid lines are tuned by means of C2, a small butterfly variable capacitor soldered between them at the end farthest from the tubes (see Fig. 2). Made of 1/4-inch (6.4-mm) copper tubing, the grid lines are supported at one end by the center terminals of the tube sockets and by C3, a small differential trimmer capacitor, near the other. C3 compensates for mismatched tubes and unbalance as a result of circuit layout, by adjusting the capacitance of each side of the grid line to ground. All wiring that must pass through the grid compartment is shielded and bypassed, except the input line of course. Low-inductance bypass capacitors, such as the feedthrough type, are used liberally.

Bias is applied to the grid lines at the point of minimum rf voltage, one-quarter wavelength from the ends. This is about 1/2 inch (13 mm) toward the tube sockets from the bend in the lines. The two 100-ohm resistors through which bias is applied may be seen at right center in Fig. 2. If desired, the precise placement may be determined by applying a few watts of rf to the input circuit (with the tubes in place and the lines resonated) and tapping a pencil along the lines to find the point of minimum arcing.

The upper chassis is a model of simplicity. As may be seen in Fig. 3, it contains only the tubes, sockets, air-system chimneys, high-voltage circuitry and plate lines. EIMAC SK-606 or E. F. Johnson 124-111 chimneys may be used. The use of a shorting bar on the plate lines makes tuning the amplifier to resonance simple, even if the copper-tubing diameter varies from that specified. To resonate the plate lines, slide the short along to the approximate point of resonance and then do the final tweaking with the rotating disk, C7. A piece of threaded rod stock is used as the shaft of C7. A nut soldered to this shaft prevents the disk from contacting the plate line. Some builders may prefer to adapt a rotating vane arrangement to allow fine tuning the plate circuit. McMullen and Tilton's 144-MHz final offers an excellent example of this approach.[2] The top chassis also houses a small shielded compartment for the rf-output sensing circuitry. A 2.5-pF 4000-volt capacitor is soldered to the center conductor of the output connector and delivers a small rf sample to the detection circuit housed in the small black box at the top of Fig. 4. Actually, a gimmick or almost any other low-value capacitor is fine for rf sampling.

While only relative output and grid current are monitored internally in this amplifier, remember that screen and plate current must be monitored as well. If one supply powers more than one amplifier, it is usually more convenient to install these meters in the power supply cabinet.

If operation in both Class AB_1 and Class C is desired, two values of regulated screen voltage are required. A simple way to derive these voltages from a nominal 400-volt supply is shown in Fig. 5. T1 may be a TV-replacement transformer or similar type capable of supplying about 100 mA. Values of the other components are not critical. This transformer may also be used to supply the filament needs of the tubes, as shown in Fig. 5. Filament voltage should be somewhat less than 6 volts to obtain maximum tube life. This is because, at vhf, back bombardment of the cathode raises its temperature above normal and increases its emission. Operation at 6 volts would serve to heat the cathode even more, stripping off its oxide coating and eventually diminishing its emission. With the windings in series, a total voltage of 11.3 volts is obtained. If the tube filaments are placed in series, each tube will have a heater voltage of about 5.7 volts. Be sure that *both* filament windings of the transformer are capable of supplying 3 amperes. Grid bias may also be obtained from this supply, as shown in the schematic.

One other circuit detail worth noting is the T-R keying sequence. This is critical if you don't want to destroy antenna relays and receiver front ends! The amplifier relay should be keyed *first,* and contacts on that relay should key the exciter. This should allow the antenna relay to close firmly before drive is applied and the high-level rf starts flowing. The ideal arrangement is one in which drive is applied last when going to transmit and removed first when returning to receive. When the final is interfaced with the exciter, this requirement should be considered.

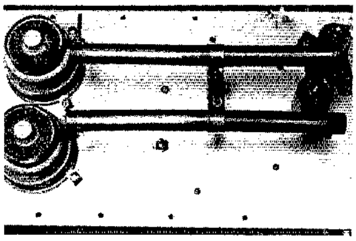


Fig. 3 — A view of the plate compartment with the top chassis removed. The plate lines are supported by the tube straps on one end, and by a TV-type doorknob capacitor on the other.

Tune-up and Applications

Tune-up is straightforward with this amplifier. First, use a dip meter to make sure both the grid and plate circuits resonate. Then activate K1 (with plate voltage applied but no drive), and adjust R2 so that idling plate current is at the

Fig. 2 — The interior of the amplifier grid compartment. The grid lines, L2 and L3, and the way they are installed on the sockets, may be seen. Note that all dc and filament wiring is done with coaxial cable and that all inputs to the compartment pass through low inductance bypass capacitors. In the author's station, a 6.3-volt transformer supplies the tube filaments. The coil of plastic-covered wire is a dropping resistor to lower the filament voltage to 5.8 volts. With the exception of the grid lines and related components, component placement in this portion of the amplifier is not critical.

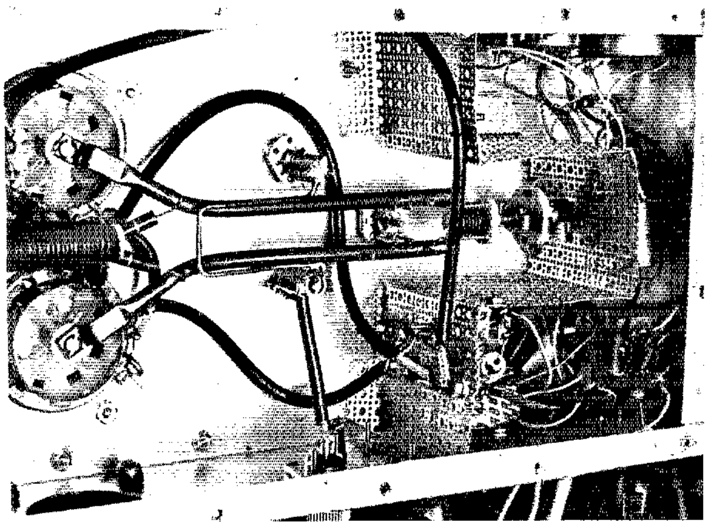
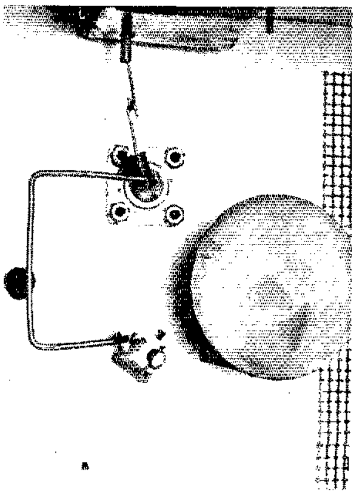


Fig. 4 — A view of the inside of the top chassis. L6, the output coupling loop, C7, the antenna loading control, and C4, the brass disk which serves as a plate-tuning capacitor may be seen. Just visible at the top of the photo is a small metal box containing the relative-power monitor components. Metal screening used to shield ventilating holes in the chassis may be seen at far right.



proper level. For Class AB_1, the higher screen voltage is recommended. Bias voltage should be adjusted to produce 160-200 mA of idling plate current. For Class C operation, use the lower screen voltage. Adjust R2 so that bias is slightly more negative than the value at which idling plate current becomes zero.

Finally, apply drive and peak the grid and plate circuits for maximum output. Positioning of the input and output coupling loops may have to be adjusted slightly for optimum energy transfer. Ultimately, 60-percent efficiency should be realized and full-output plate current should be 500-600 mA. Now there is one last adjustment, balancing the tubes. If the grid current of each tube can be individually monitored temporarily, C3 should be adjusted to equalize the currents. If that is not possible, C2 and C3 should be alternately adjusted for maximum amplifier output.

Conclusion

A kilowatt input is possible with as little as 1500 plate volts, and that voltage should not be greatly exceeded in fm service. For cw and ssb, plate voltages in excess of 2000 volts are permissible. Wearing "shoes" like this can make the difference between being limited to local ragchewing and long-haul DX capability on this very interesting band! QST

[Editor's Note: Part 97 of FCC Rules and Regulations states that any spurious emission from an amplifier operating below 235 MHz shall be at least 60 dB below the mean power of the fundamental. It was not possible to test this amplifier in the ARRL lab. We feel that an amplifier built and operated as described in this article will comply with FCC requirements. A stripline filter may be connected to the amplifier output if additional attenuation of spurious emissions is desired. One such filter is described in the *VHF Manual*, third edition, p. 335.]

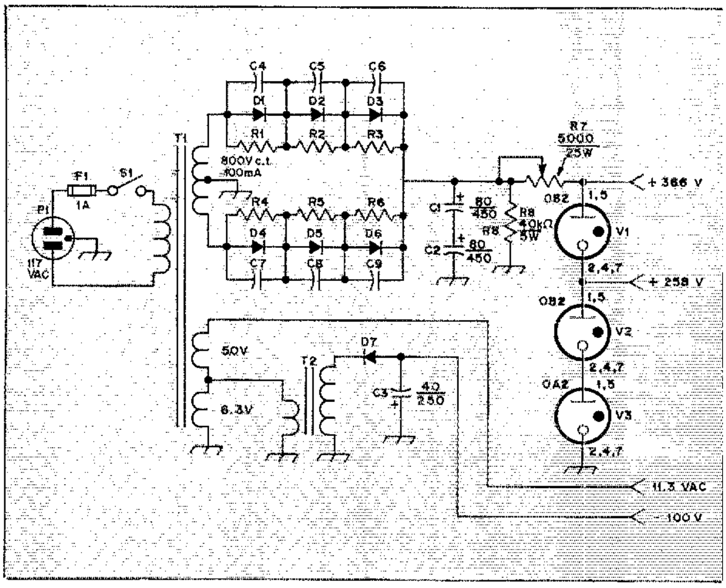


Fig. 5 — A power supply suitable for the filament, bias and screen-voltage requirements of the 220-MHz amplifier. T1 may be any transformer capable of providing the necessary voltages. A unit salvaged from an older TV set is ideal.

C1, C2 — Electrolytic capacitor, 80 µF, 450 volt (Mallory TC 80A or equivalent).
C3 — Electrolytic capacitor, 40 µF, 250 volts (Mallory TC48A or equivalent).
C4-C9, incl. — Disk-ceramic capacitor, 0.01 µF, 1000 volt.
D1-D7, incl. — 1000-volt PIV, one-ampere silicon rectifiers (HEP R0170 or equivalent).
F1 — 1-A fuse.
P1 — Three-wire line plug.
R1-R6, incl. — 470-kΩ, 1/2-watt resistor
R7 — 5000-Ω, 25-watt adjustable wirewound resistor (Ohmite 210-25-0382). Adjust for no-load regulator current of 30 mA.
R8 — 40-kΩ, 5-watt resistor.
S1 — Spst switch.
T1 — Power transformer, 800 volts center tapped, 100 mA; 6.3 volts, 3 A; 5 volts, 2 A (Stancor PC-8412 or equivalent).
V1, V2 — 0B2 gas-filled voltage regulator tube.
V3 — 0A2 gas-filled voltage regulator tube.

References

[1]Knadle, "A Strip-Line Kilowatt Amplifier for 432 MHz," *QST*, April, 1972.
[2]McMullen and Tilton, "New Ideas for the 2-Meter Kilowatt," *QST*, February, 1971.

Feedback

□ *QST* binders ("What's So Rare as a *QST* from 1915?" August 1978 *QST*, and "Feedback," October) are $6 for the small size (through 1975) and $7 for the large size (1976 on).

□ In "A 2-Meter Frequency Synthesizer" (August 1978 *QST*), author WB8ZBA suggests that the following corrections be made. In Fig. 4 the HI and LO labels on the MSD block should be reversed. In Fig. 5 the point labeled +12 V should be ignored. Power is brought into the circuit through the output cable. In this way power to the synthesizer is shut off when crystal control is used. In Fig. 7 the 220-ohm resistor connected to the base of Q13 should be changed to 68 kΩ. Also, in the TR-22 TX interface circuit, a 1-mH choke should be added in parallel with the 47-ohm resistor. D1 in the parts list should be an HEP R2502. And the inductance values for T1, T2 and T3 are 0.2-0.4 µH.

It should also be made clear that, because the TR-22 rig uses phase modulation, some sort of external modulator is required when using the modulator. The author feels that use of his circuit with rigs other than the TR-33C should not be attempted by beginners.

□ When modifying the Heath HA-201 amplifier to accommodate a COR, as described in "Hints and Kinks" for July 1978, a jumper wire should be installed in place of D1 and D6, or D2 and D5. Either a 24- or 12-volt relay may be used in the modification. The latter is preferable.

Strays

QST congratulates . . .

□ Hal Steinman, K1FHN, who finished 252nd (of 394 starters) in his very first 26-mile, 385-yard, marathon run in 90-degree heat through a group of islands in Lake Champlain in Vermont.

HOW SAFE IS *YOUR* HAMSHACK

□ From now on, Bill Schuchman, W7YS, will heed those *QST* covers. While at the rig, he smelled smoke and tracked it down to his June 1978 issue of *QST* ("How Safe Is Your Ham Shack?"). He had been using a circuit magnifier to work on a May 1978 *QST* project, but Old Sol had other ideas for the magnifier and ignited the June issue with it. In addition, May's cover depicted an event similar to one that actually happened to Bill — during July 1977, lightning struck and vaporized his antenna and destroyed two transistors, two pilot lights, three power switches, two banana plugs and an antenna relay.

A Logic Circuit for Phasing the Telefax

The problem of phasing sending and receiving drums is unique to facsimile. This simple coincidence circuit provides a reliable method of synchronization.

By W. Conley Smith,* K6DYX

With the deregulation of the rules governing Amateur Radio in the United States, the transmission of drawings and photographs from a Western Union Telefax may eventually be permitted on the hf bands. Proposals contained in the Federal Communications Commission Docket 20777 indicate the possible authorization of this mode on the lower frequency amateur bands. Essentially the same practices and standards with regard to frequency and modulation that apply to SSTV seem likely to be adopted. Accordingly, audio tones fed into the phone-patch input of an ssb transmitter, with 2300 Hz for white copy and 1500 Hz for black copy, would become standard. The frequencies between these limits would produce intermediate shades of gray. Under special temporary authorizations (STA), a number of radio amateurs have been experimenting successfully with this mode.[1]

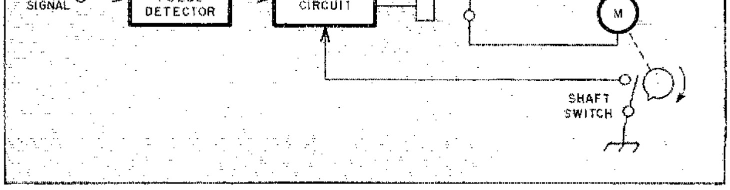
Many machines, purchased through the surplus market, generate a signal of approximately 2500 Hz by photoelectrically scanning a paper placed on a revolving drum. The signal is amplitude modulated, having a peak amplitude when the photocell sees white and a minimum amplitude when it sees black. This will produce a negative picture on a receiving machine where the blackness depends upon the strength or amplitude of the received signal. There are methods of inverting the modulation,[2] but remodulating or converting the 2500-Hz a-m signal to a frequency-modulated audio signal before transmission seems to be the better approach. At the receiving end a limiter and some form of a discriminator or audio filter can be used for slope detection. The superiority of this narrow-band f-m, when combating interference and fading, is indeed apparent.

The auxiliary circuits for accomplishing the remodulation and detection are relatively simple to construct. There are many examples of such circuits in SSTV literature. Unique to the facsimile mode, however, is the problem of phasing the receiving drum with the sending drum. Whereas in SSTV each frame and line is triggered by a synchronizing pulse, the Telefax drum turns at a constant speed of 3 rev./s. All that is necessary is to phase it so that the edge of the receiving paper moves under the recording stylus at the same time the edge of the copy being sent is scanned by the photoelectric system. Several methods of accomplishing this are in use.[2,3] The author is using a system based on the simple logic of a coincidence circuit which proves quite reliable and is simple to construct and install.

How It Operates

The general scheme is shown in Fig. 1. A dc pulse (logic 1) is produced by a phase pulse detector from the received signal. This pulse can be generated by the sending machine in several ways. By modifying the switch activated by the detent on the shaft, it can be used to short out the picture information and cause a momentary "black" 1500-Hz tone on each revolution. For the detector then, a toroid, tuned by a suitable capacitor, does the job. Needless to say, the picture information should be all "white" during the phasing interval, which is usually the first four or five seconds of a transmission.

Fig. 1 — The general scheme of phasing control for a Telefax machine by means of the logic of a coincidence circuit.



*67 Cuesta Vista Dr., Monterey, CA 93940

[1]Footnotes appear on page 34.

The same sort of phasing signal can be generated without the use of the detent switch by wrapping a narrow strip of white paper around the sending drum and securing it with a bit of black tape where the picture to be sent overlaps.

The received phasing pulse normally passes through the coincidence circuit and opens a relay which, with the contacts wired in series with the drum motor, causes the motor to repeatedly lose speed. On each revolution of the receiving machine shaft, the detent switch closes and introduces a logic 0 into the coincidence circuit. Eventually, as the receiving drum loses speed, a logic 0 will occur at the same time as does a logic 1 from the detector. This event causes the coincidence circuit to lock out and the relay remains closed. The receiving motor now runs continuously at a constant speed and in phase with the sending drum. Resetting the coincidence circuit for the next transmission is necessary since, once phasing is accomplished, the relay remains closed.

A minimum of rewiring of the Telefax machine is required. If you already have one, the chances are that you have modified it to eliminate most of the unnecessary items such as the relays and buzzer. The switch activated by the shaft detent is normally closed. It can be changed by inverting the leaves for normally open operation, enabling it to make the phasing pulse when sending besides providing the logic 0 pulses needed when receiving. This is not a necessary inversion if you can generate a phasing signal in another way because the coincidence circuit can be made to respond to the simultaneous occurrence of two logic 1s instead of a logic 1 and a logic 0. See Fig. 2.

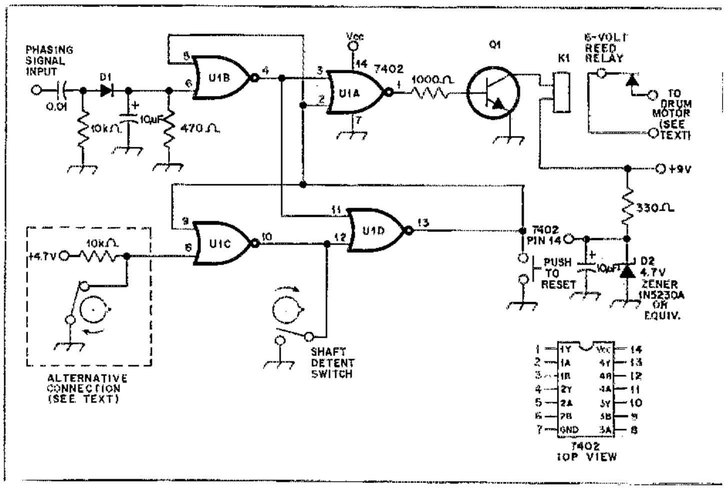


Fig. 2 — This coincidence circuit is built around a type 7402 quad, 2-input NOR gate. If the alternative connection enclosed in the dashed line is not used, pin 8 of the 7402 should be connected to ground at pin 7. Substitution is possible. Important is the logic. See Dahl, "New Symbology for Digital Logic Diagrams," August 1974 *QST*. Q1 is a general purpose type S0014 silicon transistor or equivalent.

If the contacts of the relay, used in Fig. 2, will handle the motor voltage and current, they can be connected across the points of the test switch on the machine. This switch should then be left open for the phasing circuit to work. The author uses a small reed relay at the output of the coincidence circuit to operate the unused LR relay of the machine, the contacts of which are used to carry the motor current.

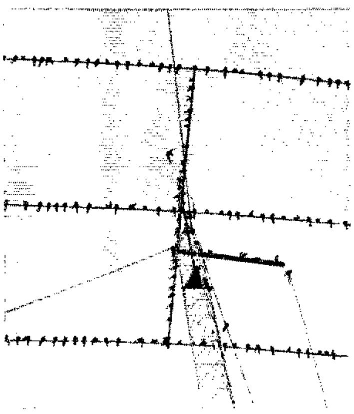
Footnotes

[1] "High Frequency FAX," *QST*, December 1975, p. 67.

[2] King, "Conversion of Telefax Transceivers to Amateur Service," *QST*, May 1972.

[3] Righini and Emiliani, "Sync the Desktax," *QST*, October 1976, p. 20.

Strays



Is this antenna "for the birds," or is it a new way of linear "loading" of a Yagi beam? It is rumored the signal has "chirps and birdies." Ron Scherman, WBØOZT, who resides beneath this perch says he counted 153 birds, with one making its final approach.

I would like to get in touch with . . .

☐ airline hams interested in ragchewing about the commercial airline industry and Amateur Radio. The International Association of Airline Hams (IAAH) net meets Sunday at 1600 UTC on 14.280 MHz. Carl Crumley, N4VD, 512 N. Harrison Ave., Cary, NC 27511.

DIGITAL COMMUNICATIONS SEMINAR

☐ The University of Ottawa will present a three-day seminar on Digital Communications and Signal Processing, December 11-13, 1978. Dr. Kamilo Feher, one of the many international authorities giving the seminar, will introduce state-of-the-art material on digital modulation.

NO MORE AIR

☐ The Air Force MARS program recently retired the call sign AIR after more than 20 years service. The changeover to AFA, the Air Force command MARS station, marked their move to new, permanent facilities at Andrews AFB, VA.

Who says there are no hams in Monaco? From left: Louis, 3A2HB; Jean, 3A2BF; Henry, 3A2AH; Jean, 3A2EE, attempting a QSO amidst the clamor; and a visiting sightseer, Rudi, W6GVB. *(photo by W6AQ)*

GASOLINE AND HAMMING DON'T MIX

☐ Why tempt fate? Switch to safety and don't transmit while your car is being gassed up. There could be sparks . . . there could be fumes . . .!

Product Review

Yaesu FT-901DM Transceiver

A new model of an existing product does not denote improved performance. Rather, it usually means that a frill has been added here and there to entice new customers or stimulate the buying urges of old customers. That's why we feel it is important to point out early in this review that the FT-901DM is not a reworked version of the long-popular FT-101 Yaesu series. This is a new box with a completely different circuit design. There are numerous operational features which do not appear in the '101 transceiver series. There is little similarity in the design when comparing the FT-901 to the FT-301, the latter of which followed the '101 to the U.S. marketplace.

These are the highlights: frequency coverage from 1.8 to 29.9 MHz in nine band positions, plus WWV in the 10th position; operational modes are lsb, usb, cw, fsk, a-m and fm. Dc input power to the PA stage is 180 watts during cw and ssb. For the rest of the modes it is 80 watts.

Significant among the circuit features are digital *plus* analog frequency readout, PLL local oscillator, built-in Curtis keyer, memory frequency control, dual-filter variable i-f bandwidth tuning, and for cw, built-in RC active audio filter.

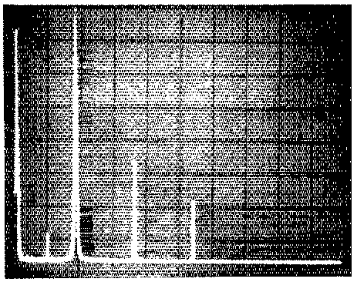
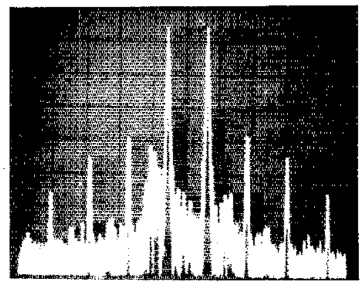
Some of the more common highlights are semi-break-in delay (not full QSK), sidetone, VOX, 25-kHz calibrator, noise blanker, rf speech processor, and time-delay tune-up position (prevents damage to the PA stage by limiting carrier-on time to short periods). There is also a 20-dB rf attenuator in the receiver front end (selectable) and two agc choices (fast or slow).

Solid-state circuitry is used throughout the transceiver except for the driver and PA sections. Sweep tubes are not used in the final amplifier. Instead, a pair of 6146Bs is used to enhance tube longevity and improve transmitter IMD. Mobile operation is made possible by using the dc-to-dc converter which is built into the '901. Changing from ac to dc operation is achieved by simply attaching the appropriate external power cable. The only optional accessories for the FT-901DM are the a-m and cw i-f filters. Various other models of the '901 are available (901D, 901SD and 901DE) which have many of the features contained in the 901DM available as accessories. The FT-901SD is a QRP (10-watt) version of the other models.

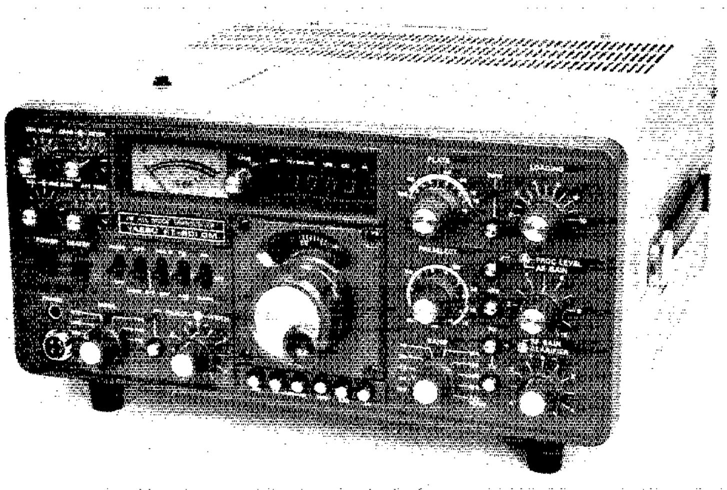
Audio output is greater than 3 watts at 10 percent total harmonic distortion. Although a built-in speaker is included, external speakers can be used. The output impedance is 4 to 16 ohms. The audio filter is variable for peaking between 400 and 900 Hz. Passband tuning is continuous from 2.4 kHz to 300 Hz. Ssb selectivity is 2.4 kHz, a-m is 6 kHz, fm is 12 kHz and cw is 600 Hz. All are specified at the −6-dB points on the filter response curve.

The memory feature should appeal to those who operate in split-band fashion. This circuit eliminates the need for an external VFO. When the M button (memory) is pushed a frequency can be stored. This will be the frequency which is displayed before the M button is activated. Once the frequency is stored, it can be recalled for use on transmit by pushing the TX button, or for receiving by punching the RX button. In effect, these are memory-recall buttons. However, when the MR button is activated, the stored frequency is used for the transceive mode. An EXT (external) button is available for transferring the frequency control to an outboard VFO, such as the FV-901, if that type of operation is desired. On our review unit there was evidence of a T8 cw note when the operating frequency was controlled by the built-in memory. This condition was not noted while using the straight VFO function. On-the-air checks with other FT-901DM owners showed their signals to be clean, suggesting that our unit may have had a local ground-loop problem or small internal anomaly.

The receiver dynamic range turned out to be substantially better than that of earlier Yaesu equipment. The MDS (noise floor) on 20 and

At left, the transmitter output of the FT-901 on 160 meters, as displayed on a spectrum analyzer. Vertical scale is 10 dB per division and horizontal divisions are each 1 MHz. The tall pip at the extreme left of the photo is generated in the analyzer and represents 0 MHz. This photo was taken while the FT-901 was operating at rated input power on cw. The most significant spurious emission is the second harmonic at 3.6 MHz, which is down 46 dB with respect to the fundamental, shown here at full scale. Other spurs are at least 57 dB down. The FT-901 meets or exceeds the FCC requirements for spectral purity. The right-hand photo shows the output of the FT-901 during a full-power, 7-MHz, two-tone test. Each vertical division is 10 dB and each horizontal division equals 1 kHz. Third-order products are approximately 38 dB down from the PEP level. Measurements were taken in the ARRL lab.



The FT-901 is top of the hf line at Yaesu, with several models available. Shown here is the '901DM which contains almost all possible features as standard. The only options on the "DM" are the a-m and cw i-f filters which go for $45 each.

80 meters is −137 dBm. Blocking above the noise floor is 118 dB (20 meters), 114 dB (80 meters) and IMD checks out at 90 and 85 dB respectively. These tests were done in accordance with the technique outlined by Hayward in July 1975 *QST*. Transmitter IMD characteristics are shown in the spectral display which accompanies this review.

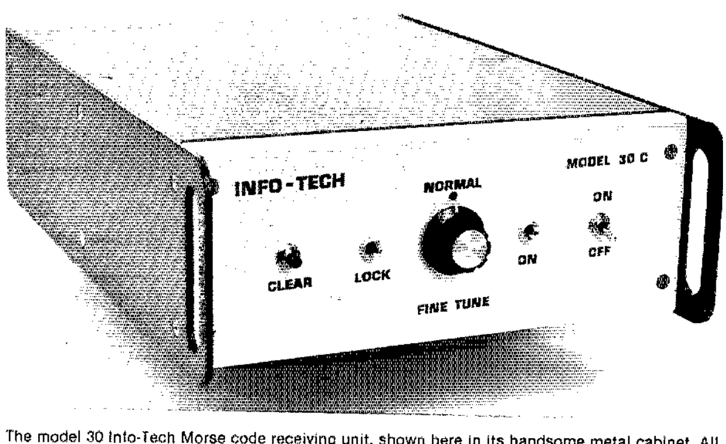
Subjective Analysis

This reviewer has used all models of the Yaesu transceiver equipment which were available during the past 10 years, and it is felt that the FT-901DM is the finest of the lot for performance and features. The rig is easy to operate, just plain "sounds nice" with respect to the receiver, and apparently sounds good to those who have checked the quality of the ssb signal during on-the-air discussions of the unit.

Although the '901 is somewhat larger and heavier than the older 101s, it's the type of transceiver that a reviewer hates to send back to the U.S. distributor after running it through its paces at the home station. Going back to the older station transceiver may require biting the well-known bullet for awhile, at least! — *Doug DeMaw, W1FB*

Yaesu-Musen FT-901DM Transceiver

Frequency range: 1.8 to 29.9 MHz, plus WWV.
Modes: Cw, ssb, a-m, fm and fsk.
Power input: 180 watts cw and ssb, 80 watts for other modes.
Selectivity: See text.
Power requirements: 117 V ac — 70 W on receive, 320 W on transmit; 13.5 V dc — 5 A on receive, 21 A during full-power transmit.
Color: two-tone gray.
Dimensions (HWD): 6-1/8 × 13-1/2 × 12-3/4 inches (154 × 342 × 324 mm).
Weight: 39.6 lb (18 kg).
Price class: $1460.
U.S. Distributor: Yaesu Electronics Corp., 15954 Downey Ave., Paramount, CA 90723.



The model 30 Info-Tech Morse code receiving unit, shown here in its handsome metal cabinet. All controls are located on the front panel; clear button, lock light, fine tuning knob, power-on indicator, and power switch. Four rubber feet are attached to the cabinet bottom.

INFO-TECH MODEL 30C CW TO VIDEO CONVERTER

If you're in the market for an automatic cw-receiving device, you might want to consider the Info-Tech model 30. This device converts audio cw to video characters which can be displayed on a video monitor or modified TV.

Audio from your receiver is fed to the input jack on the rear apron of the cabinet. Inside the unit, the cw signal is detected, and the corresponding video characters are generated and sent to the video output jack. This composite video signal can then be applied to the input of a video monitor.

The source of audio must be capable of delivering at least 0.1 V peak to peak into a 500-ohm load. To operate the cw receiving device, you tune in a cw station and adjust the receiver tuning so that the audio note is approximately 1000 Hz. The "Morse Fine Tune" control on the front of the model 30 should be left in the center of its tuning range. As the signal is detected, the red LED "lock" light flashes in time with the received dots and dashes. The fine-tuning control can be used to adjust the input passband of the model 30 between 800 and 1200 Hz. This can be used to tune in a signal from a receiver that doesn't have a variable BFO.

The model 30 copies Morse code quite well, and even copies most punctuation marks as well as the standard alphabet and numerals. Some of the procedural signals are also known to the model 30, as it prints out a "<" for $\overline{AS}$, "=" for $\overline{BT}$, and "−" for $\overline{SK}$.

The video display generated by the model 30 is a standard 32-character by 16-line format. (A 72-character by 16-line format is available also.) Each of the characters is displayed on the video screen as a 5 × 7 dot matrix. When the unit is turned on and code is received, the first video line is generated so as to appear at the bottom of the screen. As new lines are started, the first line scrolls up and eventually goes off the top of the screen. The "clear" button on the front panel of the model 30 wipes the video display clean when pressed.

The model 30 was able to copy most cw signals on the bands, having trouble only with poorly sent Morse. There was no difficulty copying weak signals, and in fact the unit sometimes could copy signals that were practically inaudible. The passband of the audio input circuitry isn't as narrow as a few we've seen, but it caused no problems. There was never any need to retune the signal because of slight drifts, as copy was solid regardless. Of course, there will always be many signals too garbled, weak or otherwise deformed to be copied by anything other than the human ear. When the model 30 receives characters it can not recognize, it prints nothing on the video display.

Interconnections

Directions concerning the hook-up to a video monitor or converted television set are included with the model 30. An important warning states the dangers involved in using monitors that are not transformer-isolated from the power line. Although this is true with all types of equipment that are attached to video monitors or TV sets, it was reassuring to see Info-Tech make the dangers clear in its product literature.

Besides the video output and audio input jacks on the model 30 rear panel, another RCA-type jack labeled AUX is included. This connection can be used to feed a local cw signal to the model 30, such as the output from your keyer. To use the AUX jack, you use a relay so that the model 30 sees a series of opens and shorts at the input of the AUX line. This type of operation allows you to see both sides of the conversation displayed on the video monitor screen.

Appearance

The Info-Tech model 30 is packaged in an all-metal enclosure, as shown in the photo. All controls are located on the front panel, which is partially protected from damage by the two small decorative-type handles on each side. The handles are actually functional, being handy for carrying the model 30 when necessary. The real panel contains the three RCA-type jacks previously mentioned, a three-wire line cord, and the fuse holder. The cabinet appears to be well shielded, and the instrument operated flawlessly inside W1AW while the station was transmitting with full power on eight bands. If the unit were subject to RFI, it certainly would have been apparent under such operating conditions.

Inside

When the cover is removed, you can see the two glass-epoxy pc boards mounted one on top of the other in piggy-back fashion. A 12-pin connector ties the two boards together, and by removing four nuts you can remove the top board by lifting it upward. The connector separates, leaving only two wires attached to the upper board. The upper board is the video board, which generates the video characters for ASCII input. The lower board is a Morse-to-ASCII converter. All components are mounted on these two double-sided, plated-through boards except for the power supply transformer, two disk-ceramic capacitors and an LM309 5-volt regulator. These components are mounted on the rear panel of the model 30. This layout seems to be one that would be easy to work on, and it would seem also that an ASCII output could be easily added if desired for driving printers, computers, etc. Full schematic diagrams were supplied with the model 30. For more information contact Info-Tech, Inc., 2349 Weldon Parkway, St. Louis, MO 63141. — *Jim Bartlett, K1TX*

Info-Tech Model 30C Specifications

Price class: 32-character video, $325, 72-character video, $345.
Power requirements: 117 V ac, 50-60 Hz, 20 watts (220-V, 50-Hz model available for additional $10).
Dimensions (HWD): 3 × 9 × 12 inches (76 × 229 × 305 mm).
Weight: 7 lb (3.2 kg).
Input: Morse code audio from receiver (nominal 100 mV).
Output: Composite video, approximately 1.5 V peak to peak, negative sync, crystal controlled, 5 × 7 dot matrix. 32-character by 16-line or 72-character by 16-line formats. Displays 64-character ASCII set.
Materials: Glass-epoxy, double-sided, plated-through pc boards, ICs all socket-mounted.
Speeds: Will automatically copy Morse code from 5 to 60 words per minute.

GENAVE GTX-800 2-METER FM TRANSCEIVER

Early in the spring of 1978 the *QST* "Product Review" editor plopped a box on my desk and said, "Here is your chance to do a product review." Upon inspection, I found inside the box a new Genave GTX-800 2-meter fm rig. This is a nominal 25-watt output fm rig for 2 meters with 800-channel capability in 5-kHz steps from 144 through 148 MHz. Since the first part of a product review is a series of tests for compliance with FCC regulations, the transceiver was turned over to the ARRL laboratory for spectral-purity checks. After a unit is found to satisfy FCC requirements, the actual review begins. (The review unit did not initially meet FCC specifications, but *did* subsequently, after it had been realigned at the factory.)

Physical Characteristics

The GTX-800 is packaged in a high-impact ABS plastic case with a pleasant brown front and cream cabinet. The controls are all located on the front panel and consist of the following: a lighted S meter that doubles as a relative rf-output indicator during transmit; three frequency-selector lever switches for selection of 144, 145, 146, 147 and 148 MHz and 0.00 through 0.99 in 10-kHz steps; an LED indicator that lights if the synthesizer fails to lock or if the user tries to transmit below 144 or above 148 MHz, in either case resulting in no rf output; a row of switches (bottom) which includes, from left to right a +5-kHz offset switch that permits transceive operation on the 15-kHz standard channels, a fixed 600-kHz selector that chooses +600, simplex or −600 kHz of the transmit frequency, as displayed on the frequency-selector levers, a HI-LO power switch to select respective outputs of 25 and 1 watt, and an ON-OFF power switch mounted on the same shaft as the volume control; and the squelch threshold control. The remainder, about one half of the front panel, is devoted to a three-inch oval speaker. On the right front side of the control head is a three-conductor 1/4-inch microphone jack. A sturdy, metal U bracket is provided with plastic-handled bolts for mounting. Adjacent to the heat sink, on the rear of the transceiver, you will find an SO-239 rf output connector and a 15-pin combination power and accessory receptacle.

Electrical Details

The transceiver consists of two glass-epoxy boards on a main frame with a detachable control head connected by three 13-pin edge connectors. The synthesizer board is carefully divided into three compartments with extensive shielding, top and bottom, to prevent spurious rf responses. The main board contains the receiver, transmitter and rf-power amplifier. The main board is virtually identical to that used in the GTX-1212 (crystal version of this rig) and in Genave's line of marine vhf radios. The transmitter uses a TRW 2N6082 rf transistor to obtain the rated power output. Input power required is the standard 13.6-V dc automotive supply. Less than 7 A of current are required in high-power transmit. The manufacturer's specifications, as have been verified in the ARRL laboratory, are shown in the specifications table.

Installation and Operation

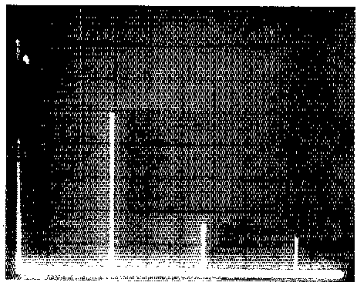
I first attempted to install the GTX-800 in my Peugeot, but this was not possible because of the size of the radio. My wife "loaned" her full-size Ford for the review period. The only place large enough to mount the '800 was in the passenger leg-well, making it somewhat inconvenient to operate while in the driver's seat. Some solutions to this problem were found subsequently, and will be explained later in this article.

Problems and Corrections

Several contacts were made using the GTX-800 while I switched between it and my personal vhf equipment. In all cases the audio sound of the Genave was termed by those contacted as being "constricted" both on simplex and through several different repeaters. The '800 was compared to my ICOM IC-215 and IC-245E. Nevertheless, the audio was considered to be of communications quality.

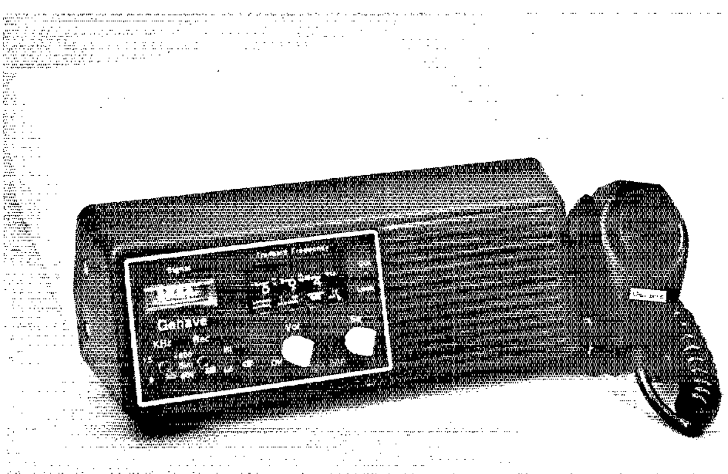
While using cruise control on the test vehicle, I discovered that the GTX-800 would shut down the fuel flow to the 1976 Ford LTD whenever I transmitted in the high-power position. Since this does not occur with the IC-245E driving a 140-watt Class C amplifier using the same antenna, I assumed the problem was not with the automotive system. Attempts to reroute the dc supply leads for the GTX-800 did not resolve the matter, and the final solution was to place the rig in the trunk with the mic cord passed through the back-seat recess. At this point the problem completely disappeared. It is assumed that the unshielded main board of the '800 presents a sufficient rf field to disrupt the electronic speed control, while the completely enclosed ICOM does not. (This problem occurred across the entire 144- to 148-MHz spectrum in simplex as well as both repeater modes.)

In resolving this problem, I discovered a very excellent feature of the GTX-800. Available for the marine version of this radio is a modification kit to extend the control head. Discussion with the Genave engineering staff revealed that you can make up a similar control cable for the '800 without regard to length (this assumes about 25 feet maximum length).



Output of the GTX-800 as displayed on a spectrum analyzer. Vertical scale is 10 dB per division. Horizontal divisions are each 50 MHz. The top reticle line in the photo represents full amplitude of the fundamental, which is partially notched out here to enhance the dynamic range of the analyzer. The most significant spurious emission is the second harmonic at 293 MHz, which is down 63 dB with respect to the fundamental. All other spurs are down at least 67 dB, meeting the FCC regulations concerning spectral purity. These measurements were taken in the ARRL lab.

The GTX-800 was large enough to create some mobile mounting problems. However, it seems to have capability for remote mounting of all but the control panel. The thumbwheel-control frequency switches aren't lighted and are difficult to read at night when operating mobile.



Unfortunately, the marine modification kit will not work on the GTX-800. The same engineer advised me that conversion data for MARS operation of the GTX-800 are available for an s.a.s.e. to Genave.

For nighttime operation, you might want to consider a small dash extension light, as the GTX-800 frequency-selector levers are not lighted. A recent "Hints and Kinks" article in *QST* offers a solution for a similarly switched rig (Heath HW-2036).

Overall

It is pleasing to find a moderately priced entry into the marketplace from a U.S. manufacturer. At first glance the size of the radio may seem to be disadvantageous. But when you consider the low-cost remote control capability, the ample space inside the housing to add peripheral modifications such as tone burst and room to do maintenance on the unit yourself, the large size might easily be rationalized. — *Jim La Porta, N1CC*

Genave GTX-800 Transceiver Specifications

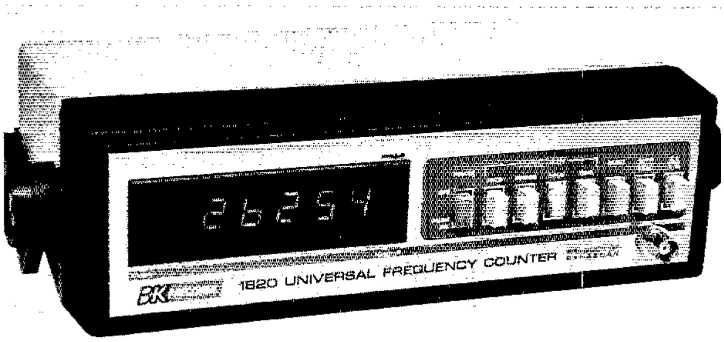
Power requirements: 13.6 V dc at 6.5 A maximum.
Receiver sensitivity: 0.35 µV for 12 dB sinad.
Rec. spurious response: −65 dB or better.*
Rec. selectivity: ±7.5 kHz.
Rec. frequency range: 144-148 MHz in 5-kHz steps, plus 143-144 and 148-149 at reduced sensitivity.
Transmitter power output: 25 watts (HI), 1 watt (LOW).*
Trans. spurious emissions: −63 dB (25 watts.)*
Trans. stability: ±0.001 percent.
Trans. frequency range: 144-148 MHz in 5-kHz steps.
Dimensions (HWD): 3-3/8 × 9-3/4 × 12 inches (86 × 248 × 305 mm).
Weight: 6 lb (2.7 kg).
Mfr.: General Aviation Electronics, 4141 Kingman Dr., Indianapolis, IN 46226.

*Measured in ARRL lab.

B AND K MODEL 1820 FREQUENCY COUNTER

This counter is designed for use up to 80 MHz. If you never operate above 6 meters, the range will suit your needs. Actually, the counter I tested in the ARRL lab made it up to 110 MHz before the display became erratic (it required every last microvolt I could squeeze out of our venerable model 80 signal generator to do it). At 80 MHz, sensitivity was about 8500 µV. The 1820 is installed in a lightweight plastic cabinet, which does nothing to shield the unit. No problems were encountered with interference *to* the counter, but the oscillator which multiplexes the display created havoc with any receiver nearby. By carefully routing power cords and other cables I was able to minimize this problem. Many new counters and most calculators use multiplexed displays to reduce power consumption and cost. Unless the user is careful, such devices can effectively disable receivers operating near them.[1]

Measuring 3 × 9.5 × 8 inches (76 × 240 × 200 mm), the counter is housed in an attractive tan and black case, provided with an adjustable



The B and K Precision model 1820 frequency counter. Note the adjustable handle shown here in the fully back position.

stand. This allows the user to control the viewing angle. Provision is made via rear-panel connectors for external time-base and elapsed-time control. B and K instruments are available from Dynascan Corp., 6460 West Cortland Ave., Chicago, IL 60635, or through dealers. Price class of the model 1820 is $260. — *Jim Kearman, W1XZ*

DECIBEL PRODUCTS, INC. VAPOR-BLOC COAXIAL CABLE

Moisture and other external impurities have a pronounced effect on the life span of flexible coaxial cable. This is a significant problem in areas of heavy rainfall. It is especially pertinent to installations which require coaxial cable to be buried underground in the soil. Most ordinary RG-8/U cables, for example, are severely contaminated after a few years in the soil. When this happens the line becomes very lossy, and is relatively useless.

Decibel Products, Inc., has solved the moisture problem by developing what it calls the Vapor-Bloc line of coaxial cable (VB-8). With ordinary cables of the 50-ohm type, moisture and various impurities can enter the cable through cuts or scratches in the outer insulating jacket, or via improperly installed coaxial connectors. Even minute quantities of water vapor will condense to water, the latter of which will migrate through the shield braid to contaminate the entire length of cable eventually. If the water contains impurities (especially prevalent in high-pollution areas) it will ruin the copper in the braid. This will alter the attenuation and impedance characteristics of the cable, making it necessary to replace the line. Not only is the reliability of the antenna system questionable, the cost of replacement can be considerable.

Decibel Products has effected a significant improvement in moisture immunity for RG-8 and RG-11 types of cable. Not only is the outer jacket of their Vapor-Bloc cable especially formulated to resist sun, moisture and corrosion, but an inert semi-liquid compound fills all space between the polyethylene dielectric and the outer cable jacket, flooding the copper braid. This compound adheres strongly to the braid and the dielectric materials. It is not affected by temperature, moisture or time. Even though the outer jacket is cut, the compound keeps moisture and gases from migrating beyond the immediate area of the "wound."

Vapor-Bloc cable also features a solid inner conductor rather than the usual twisted-wire center. This ensures that unwanted moisture and impurities can't travel through the center of the cable to cause deterioration.

VB-8 cable is comparable in all electrical parameters to regular RG-8/U. Standard coaxial fittings can be used with it. Some of the characteristics are 50-ohm impedance; 30.8-pF capacitance per foot; 5-kV rating; velocity factor of 65.9 percent; 1.4-dB loss per 100 ft (30.5 m) at 50 MHz, 2.4 dB at 150 MHz and 4.4 dB at 450 MHz. The current price is 52 cents per foot.

Amateurs who operate marine mobile should find this information especially interesting. Those who reside near salt water and in polluted metropolitan areas may wish to replace existing coaxial transmission lines with VB-8. But on general principles, the longevity of any permanent amateur installation should be enhanced through the use of this type of cable. Vapor-Bloc cable is manufactured by Decibel Products, Inc., 3184 Quebec St., Dallas, TX 75247. — *Doug DeMaw, W1FB*

NEW BOOKS

Optoelectronics: Theory and Practice, by Texas Instruments, Inc., published by McGraw-Hill. Hardback edition 7 × 10 inches, 464 pages. Price: $21.50.

This new book, written under the auspices of Texas Instruments, with input from their engineers and scientists, provides thorough coverage of the design, use and methods in the field of optoelectronic devices. In addition to theoretical discussions, the book also contains practical usage information for engineering, consumer, commercial and technical applications. Hundreds of line drawings illustrate the physics of optoelectronics, including diode and transistor characteristic curves, and circuit diagrams.

Those amateurs interested in the more technical aspects of optoelectronic devices might find useful the volume's in-depth examination of such topics as infrared detection, opto-coupling, modulated radiation and data transmission, just to name a few. A number of sample circuits provided might be interesting for experimental use by amateurs. — *Jim Bartlett, K1TX*

[1] [Editor's Note: Operation of a multiplexed or scanned display is discussed more fully in an earlier equipment review. See "The Heath GC-1005 Electronic Clock," December 1973 *QST*, p. 43.]

Hints and Kinks

MOUNTING A COAXIAL FITTING ON HARDLINE

Want a practical method of adapting and mounting a PL-259 connector on the end of that new 50-ohm hardline cable? Then try this. After removing the center pin and surrounding insulation from the inside of the PL-259 connector, prepare the hardline in the following manner.

Remove six inches (152 mm) of the outside jacket of the hardline, exposing the solid aluminum shield. Expose and trim enough of the foam dielectric material to permit the end of the cable to be inserted in the PL-259. The foam replaces the fiber insulation and the end of the hardline center conductor takes the place of the former center pin. The foam must be pared sufficiently to allow the 0.162-inch (4.1-mm) copper inner conductor to protrude from the PL-259 the same distance as the original center pin. (Refer to the related drawing.) The PL-259 is screwed onto the foam until it contacts the end of the aluminum shield.

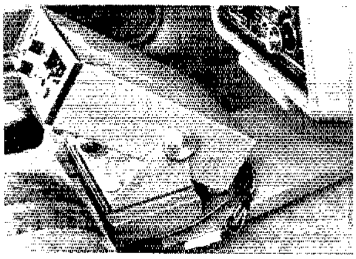
Depicted in the illustration is the manner in which a short length of copper braid, removed from a piece of RG-8/U, is placed over the aluminum shield and soldered to the PL-259 connector. The two stainless-steel hose clamps, shown in the drawing, secure the braid to the aluminum shield. After installation, waterproofing of the entire connection may be accomplished by applying a liberal amount of Johns-Manville Dux Seal, a nonhardening putty-like substance, available at many hardware stores. The WRØAGP antenna transmission line is installed in this manner, showing essentially no SWR change over a period of months even though subjected to severe ice, snow and rain. — *Paul Grauer, WØFIR*

ANOTHER MOBILE-INSTALLATION CONCEPT

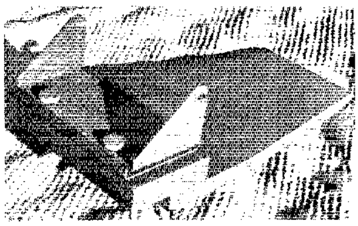
Every new car purchase poses a different set of mobile-rig installation problems even for the popular and compact 2-meter fm gear. Here is a concept that met all my installation criteria, including convenient location, easy removal, nice appearance, full access to the glove compartment or ash tray, no hole drilling, and low cost. One acceptable compromise is the necessity to remove the rig to accommodate the occasional third passenger in the front seat.

The photography illustrates the design of this mount better than words, particularly as each combination of automobile and transceiver will require variations of this arrangement. The basic materials are scraps of 1-and 1-1/4-inch clear white pine, two large common nails (about 40-penny spikes) and a few wood screws. The width and length of the baseboard, the height of the mounting block and the length of the nails are all a function of the size of the transceiver, the space between the transmission hump, front seat and dash, plus the amount of transceiver tilt desired. Adjustment is made to suit the need.

The nails, which serve as legs and nicely grip the carpet on the transmission hump, should be driven as a force fit through pilot holes to avoid splitting the baseboard. Once adjusted to the right length, the remaining "head-end" portion of the nail is sawed off flush with the baseboard. The nails will not back out because they are held in place by the mounting block, which is secured with wood screws from the bottom side of the baseboard. Note that in this installation (a 1978 Grand Prix) the rear of the baseboard is wedged under the ashtray housing, making the installation even more secure. The coaxial cable and power leads disappear through an existing slit in the carpet under the driver's seat. A couple of coats of semi-gloss paint in an appropriate color completes the job. — *Al Robertson, K8BLL*

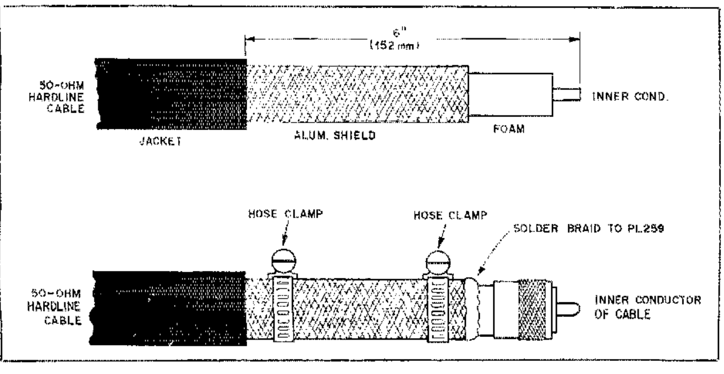


This neat and inexpensive arrangement for mounting a mobile rig, designed by K8BLL, provides easy removal, full access to the ash-tray or glove compartment, and no drilling is required.



The K8BLL mobile transceiver mount. Both the baseboard and mounting block are made of wood. Two spikes serve as legs.

These drawings illustrate a method of mounting a PL-259 connector on the end of a length of 50-ohm hardline coaxial cable. Six inches (152 mm) of the jacket are removed in order to expose the shield and foam. Remaining steps are given in text. The exposed area may be weatherproofed by applying Dux Seal from the jacket to the connector.

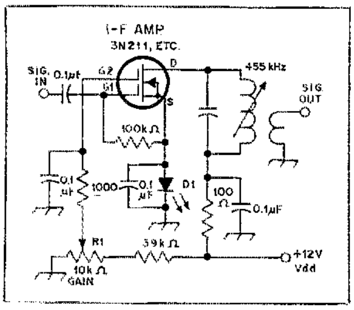


A 1.5-VOLT REFERENCE

When the need arises to use a low-voltage reference, it is common practice to employ silicon diodes singly or in series, depending upon the voltage needed. Typically, a silicon diode will act as a regulator or reference at approximately 0.6 to 0.7 volt. By using one or more in series the voltage level can be elevated.

Following a hint given to the writer by W7ZOI, an LED was used to provide a 1.5-volt reference as shown in the illustration. The diode will illuminate of course, which may give rise to a mild psychological trauma for those who view the pc board with a red, green or yellow glow beaming up from amid a group of passive and nonglowing components!

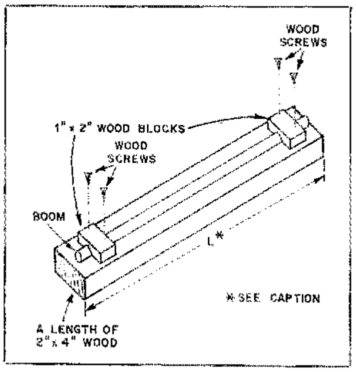
The diagram illustrates one use to which the writer has put an LED for the goal of obtaining a 1.5-volt reference. The requirement was to place gate 2 of the FET at −1.5 volts respective to gate 1 during minimum gain of the i-f amplifier. This was necessary in order to realize



A nifty circuit employing an LED providing a 1.5-V reference.

a wide range of manual gain control by means of R1. This method of bootstrapping the stage proved quite effective, even though the curves for the TI 3N211 indicate that −2 volts at gate 2 is the preferred reverse bias.

This concept for LEDs is entirely suitable for other applications which call for a 1.5-volt reference. In many instances the LED can serve double duty as a panel-mounted function indicator or on-off lamp. — *Doug DeMaw, W1FB*



A holding fixture for proper alignment of the elements of a 2-meter beam. Length L should be equal to or greater than the boom length of the antenna. The blocks, made from 1 × 2 wood, should be placed about every foot along the 2 × 4 but apart from the location of the beam elements.

FOR ALIGNING 2-METER BEAM ELEMENTS

While constructing a circularly polarized 2-meter beam, I came upon this idea to assure that all of the elements are in line with one another. Score the boom at the center spacing of the elements. Attach the boom to a straight length of a wooden 2 × 4 as shown in the diagram. Use small pieces of wood (1 × 2) with V notches cut out of them. Place these blocks over the boom and attach them to the 2 × 4 with wood screws. This holds the boom securely, allowing the boom to be drilled by means of a drill press and have all the elements end up in line. This method worked quite well for me. — *Anthony Campbell, WD5HJB*

TRANSCEIVER DIAL-LAMP REPLACEMENT

The Clegg FM-76 and similar transceivers frequently suffer burned-out dial and meter lamps. The Radio Shack lamp no. 272-1141, rated at 12 volts, 25 mA is a suitable substitute, but only if a small dropping resistor is installed in series to prevent future burn-outs. I chose a 1/4-watt, 100-ohm resistor from my junk box. It drops the voltage about two volts, dimming the light only slightly. I placed the resistor inside a piece of shrink tubing to prevent unintentional grounding. I find this solution quite satisfactory. — *Jerry Murphy, K8YUW*

USING A CB BEAM ANTENNA ON 10 METERS

My 10-meter beam antenna is a modified Radio Shack Archer Crossbow III three-element CB beam antenna, catalog no. 21-933. In order to obtain resonance at 28.6 MHz, I trimmed the elements to these lengths: reflector 17 ft, 6 inches (5.33 m), driven element 16 ft, 7 inches (5.05 m), and director 15 ft, 10 inches (4.83 m). The driven element is spaced 49 inches (1.24 m) from the director and the reflector 87 inches (2.21 m) from the driven element. Only a slight adjustment of the preset gamma match was required although this may vary according to the individual installation.

The elements must be cut an average of six inches (152 mm) from each end to conform to the dimensions given above. When cutting the elements an inexpensive pipe cutter does the work better than a hacksaw. At 28.6 MHz I find the SWR is 1.2:1, while over the entire band the readings are less than 2.0:1. — *Dan Kernan, WA2KOK*

PRV DIODE CHECKING

To check the PRV rating on unmarked diodes, the circuit I have shown can be used. The voltmeter is read in ac volts (rms × 1.414) when the oscilloscope shows reverse breakdown as the voltage is increased. Transformer T1 should be rated for a 117-V primary with a secondary in the expected range of the PRV. The circuit will also detect open or shorted diodes. — *Duane Meyer, K9PVY*

SB-220 MODIFICATIONS

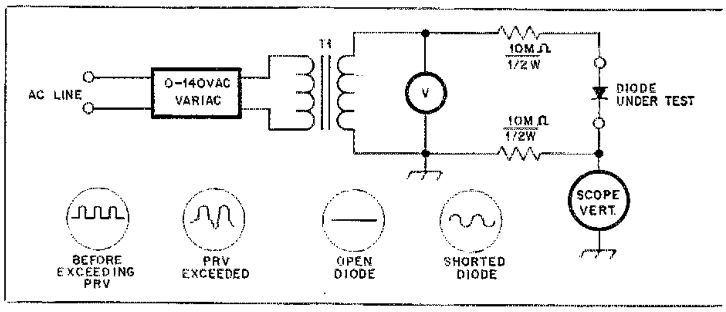
After burning up two main-tuning capacitors (C55-250 pF) on my Heathkit SB-220 linear amplifier from arcing (and the third one als[o] going rapidly), I sought a solution to the prob[lem]. The answer was found in William I. Orr' 19th edition of the *Radio Handbook* startin[g] with page 22.30, which refers to the 3-500Z 2-kW PEP linear amplifier for 10 through 8[0] meters. The designs of that amplifier and th[e] SB-220 are similar. The parasitic chokes fron the plates of the 3-500Z tubes are thre[e] 100-ohm, 2-watt resistors in parallel. Space wound about one resistor are 3-1/2 turns of no 18 wire. I happened to have some no. 1[4] enameled antenna wire and used four turns o[n] one resistor with the other two resistors i[n] parallel. One set is used for each plate, replac[ing] PC-1 and PC-2. I have not observed arcin[g] in the main-tuning capacitor since. Some of th[e] plates of the third capacitor had been previous ly damaged by arcing. I filed these plates an[d] sanded them with smooth sandpaper.

I called the Heath factory for help in solvin[g] another problem with the SB-220; it delivere[d] only 250 watts output on 10 meters. The SW[R] between the driver and the amplifier was 6:1. [I] was advised to add 5 pF of capacitance acros[s] the 10-meter coil (L1) in parallel with C33-C3[4] and then to tune the coil slug for minimum SWR between the driver and the linear with the latter feeding a 50-ohm dummy load. Having a 10-pF silver-mica capacitor on hand, I placed i[t] across the coil and then backed the tuning slu[g] 1/4 inch from the original setting to obtain a 1.8:1 SWR at the driver with 900 watts outpu[t] from 28 to 29 MHz. The Heath engineer sai[d] that the SWR normally goes higher toward th[e] high end of the 10-meter band past 29 MHz. *[A] strong word of caution for anyone making th[e] slug adjustment. First disconnect the power, then ground the power supply with an insulate[d] screwdriver after a two-minute wait. Take you[r] time and work safely! It may take several ad[-]justments to find the minimum SWR, but b[e] sure to shut the power off again before eac[h] adjustment.*

My SB-220 is driven by an FT-101EE. A ser[-]vice representative at Yaesu suggested I use a 5000-ohm potentiometer across the SB-220 al[c] to avoid faulty alc operation, particularly on 1[0] meters. There have been times where the alc di[d] not work and the signal could be completely clipped off on ssb. The movable contact is con[-]nected to the alc controlled output from the FT-101EE. — *Kenneth M. Wold, P.E., N6I[H]*

[Editor's Note: *Pay strict attention to the warning i[n] the SB-220 manual with respect to high voltage.* Do take particular note of page 81 where SB-220 owners are warned also that the amplifier must not be turned on while the top cover is removed, as the high-voltag[e] supply is short circuited under this circumstance.]

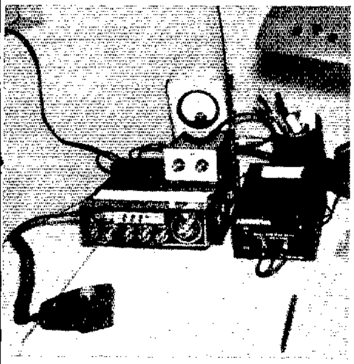
A circuit for checking the PRV ratings on unmarked diodes. Representative oscilloscope patterns are also shown.



QRP ON 10 METERS

The bargain sales of CB sets enabled me to pick up a Midland 13-893 for under $100. I converted it to 10 meters by removing the four 11-MHz crystals with the following crystals being substituted: 12,638.5 kHz; 12,648.5 kHz; 12,658.5 kHz and 12,668.5 kHz. My tune-up equipment consisted of a signal generator on 10 meters, a dummy load, and a home-constructed SWR bridge. The use of Sams' Photofact diagrams and service information simplified setting the power output to maximum, turning off the alc, and adjusting the clarifier to provide 10-kHz range on each crystal channel. The unit now operates from 28.680 MHz to 28.880 MHz.

While operating this unit aboard the *SS Pennsylvania* on a run from Baton Rouge to Panama, the results were exciting. Stations were contacted in England, Germany, Belgium, South Africa, New Zealand, Canada and the USA. Signal reports ranged from S7 to 10 dB over S9. The antenna was a 300-foot (90-m) long wire. — *Andy Sullet, W1TG*



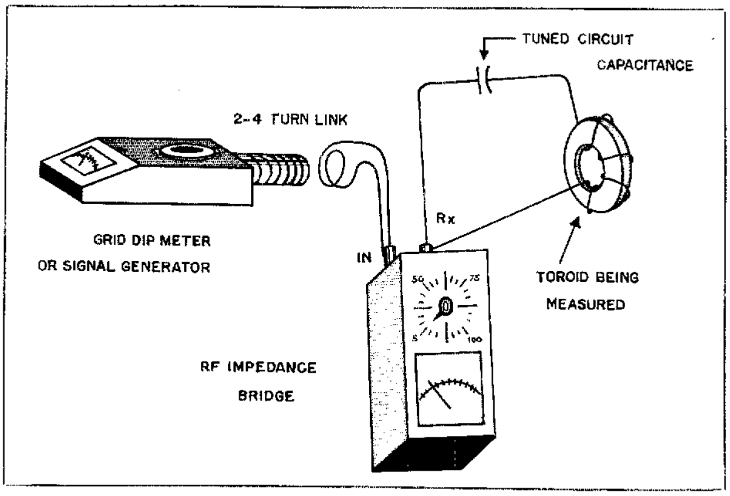
This Midland CB set, converted to the 10-meter band, provides W1TG with plenty of DX.

ANOTHER METHOD OF MEASURING TOROIDAL-WOUND INDUCTORS

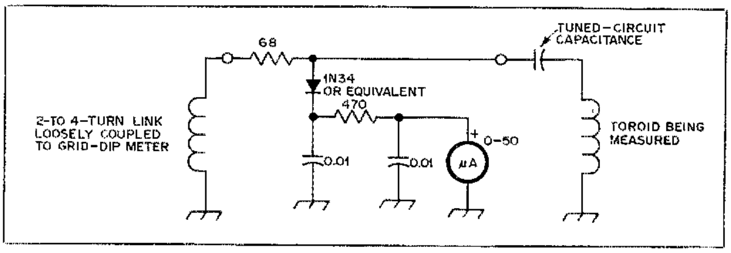
Toroids can be grid-dipped as described by W1FB ("Hints and Kinks," April 1973 *QST*) but the link will cause some loading and detuning of the circuit. Usually the method is quite adequate, but here is an alternative that may be of interest.

The resonant frequency of a toroid and capacitor can be checked by connecting them in series to the R_X terminals of an antenna impedance bridge. The GDO or signal generator is then tuned for a null on the bridge. The bridge may be the one described in *The Radio Amateur's Handbook* or *The Radio Amateur's VHF Manual* (1st edition, page 286). The latter is easy to construct and also works well at low frequencies. It contains a potentiometer instead of the hard-to-find differential capacitor. The bridge is actually being used to measure the apparent series resistance of the LC circuit. This will usually be near the low-resistance end of the scale, but if it is on the scale the coil Q may be calculated using X_C/R (or X_L/R).

This method works well with any other type of coil. The bridge may also be used to determine the number of turns required for a link or tap point to present a given impedance. If an rf bridge is not available, the alternative circuit shown in the illustrations may be used for measuring the resonant frequency of toroids. When the vhf impedance bridge is set to 0 ohms it is essentially an rf voltmeter across the R_X terminals. If the Q of the coil is high (R_S <15 ohms) the meter will show a good null. A complete null is obtainable even with a lower Q circuit simply by alternately adjusting the R dial and the GDO frequency. — *Daniel H. Hopper, K9WEK*

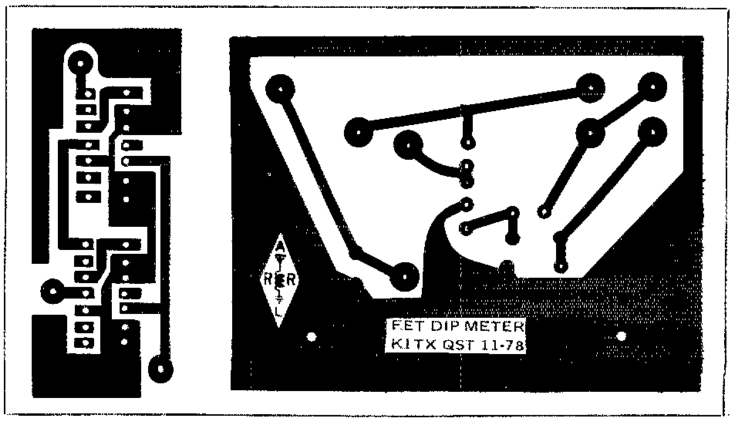


Test set-up for measuring resonance of toroids using an rf impedance bridge.



A circuit that may be used instead of an impedance bridge for indicating resonance. Resistance is in ohms, capacitance in microfarads.

Circuit-board etching patterns for construction projects contained in this issue of *QST*. The boards are single-sided, shown here at actual size from the foil side; black represents copper. At the left is the pattern for the divide-by-100 circuit addition to the Heath SB-650 frequency display (see Fig. 2, page 21). Right, the pattern for the FET dip meter (see Fig. 4, page 28).



The Aerial Performers of the Radio Circuits

Basic Amateur Radio. Part 1: Antennas are as different as the hams who use them. This two-part series will bring you a measure of expertise on this all-important subject.

By Margaret Koerner,* KØIQ (ex-WBØBEM)

The first thing to be said about antennas is that they are *different.* Not only are they different from all other types of equipment in Amateur Radio stations, but they also differ greatly among themselves. True, as far as genetic makeup is concerned, they all belong to the same family. They are all employed in the same line of work. However, they vary widely in appearance, and they differ in such individual characteristics as efficiency, attention to gains and losses, and ability to adjust to change.

The *lifestyle* of antennas is different from that of most other Amateur Radio components. Unlike receivers and transmitters, the vast majority of antennas do not live out their lives in the comfortable security of ham shacks but instead are subjected to all the perils of outdoor existence. They face struggles with burdens of snow and ice and can get corroded by salt and grime. Strong winds can make them fall flat on their baluns; squirrels can chew their support ropes to shreds. For all sorts of reasons, change is their lot. An antenna's life is not an easy one.

Antennas require installation, and here, too, is a difference. Other equipment can be bought or built, plugged in to a source of power, and be on its way. With antennas it's rarely that easy. Antennas must be installed by a process involving problems (expected and unexpected), decisions and work. This is particularly true of hf (high-frequency, 3-30 MHz) antennas, the kind we will primarily consider in this article.

In addition to *being different,* antennas *make a difference.* They can make the difference between a signal that really gets out and one that really doesn't; between a signal that lets you keep schedules, make radio friends, provide solid copy to a listening world — and one that, on the other hand, hides timidly below the noise level. As far as antenna work is concerned, each amateur is in competition with himself as well as with others, and the slogan of antenna-minded persons is forever the same as that of 4-H youth: "To Make the Best Better."

Prime Candidates for Discussion

Antennas are one of the leading subjects for amateur discussions on and off the air. One reason for the wide differences of opinion is that an antenna that works well for one amateur may not work equally well for another. Also, antennas cannot usually be adjusted or performance-tested on the bench. Other equipment can be checked, component by component, in the shack. Antennas must be tested *on the air.* They must be worked on *in place* ("place" being, perhaps, a precarious spot 50 feet or more above the ground), or they must be taken down, adjusted, and again be put up and tested on the air. They are repaired and improved by experimentation, by consultation, by guess and by gosh, or by something more explicit thrown in.

Much has been written about antennas. The latest edition of the *ARRL Antenna Book* contains 329 pages on the subject, and many other books and articles deal with antenna design, construction and ex perimentation.

What Antennas Are and What They Do

The study of antennas involves a mix ture of fact and theory; a mixture of th tangible and the intangible. On the on hand, antennas are tangible, material ob jects with physical proportions which ca be measured. They are made of meta usually in the form of wire or tubing Metal, in general, is a good conductor o electrical currents, and practically a metallic objects can be made to radiate signal. How effectively they do thi radiating, however, is something tha varies tremendously. How any antenn manages to do it at all is another matter one which takes us out of the world o material things and into the world o theory. This world of theory is inhabite by electromagnetic waves of variou lengths (light, heat, X-ray, radio), all o them traveling through free space at th speed of approximately 300,000 kilo meters (186,000 miles) per second. Amon these waves we find our Amateur Radi signals — combinations of electrical an magnetic energy sent at radio frequencie from our transmitters to our antennas an from our antennas into the atmospher and space.

As radio waves move into the atmo sphere, their wavelength and frequenc remain essentially the same as they wer when they left the transmitting antenna but their *field strength* (volts per meter varies inversely with the distance from th antenna. This means that at twice th distance away from the antenna, the fiel

*2133 9th St., Boulder, CO 80302

strength of the wave is only half as much. At the same time, the *power* per unit area of the radiated wave falls off inversely as the *square of the distance* from the transmitting antenna, so that at twice the distance the power density (watts per square meter) is only *one-fourth* as much as it was originally. Remember that as the wave moves away from the transmitting antenna it becomes weaker the farther it goes.

Radio waves spread out from different types of antennas in characteristically different patterns. Excluding the effect of nearby objects, the shape of the pattern depends primarily on the kind of antenna and its height above ground. From most vertical antennas, radio waves leave more or less in the shape of a horizontal doughnut. No one has actually *seen* them leave in this shape, but we can accept this fact in theory because measurements taken of the radiated field show equal strength in all horizontal directions. Illustrations of radio-wave patterns and types of antennas producing them can be seen in the *ARRL Radio Amateur's Handbook*, the *ARRL Antenna Book*, and numerous other publications.

Before we go on to discuss types of antennas, let's consider a source of confusion that stems from our use of common names in referring to our radio bands. The common amateur band names (40 meters, 80 meters, etc.) are *approximations*, not precise wavelengths for the different bands. But the names have great practical value as far as ease of communication, time-saving and brain-saving are concerned.

The FCC has allocated — in accordance with International Telecommunication Union (ITU) regulations — certain groups or segments of the radio spectrum for amateur use. Each allocated group includes many individual frequencies and some groups include more frequencies than others. For example, the so-called 40-meter amateur band includes all frequencies from 7000 kHz to 7300 kHz. The 10-meter amateur band is much broader, including frequencies from 28.0 MHz to 29.7 MHz.

Antennas are constructed so that their physical length corresponds in some way to the theoretical wavelength of the bands for which they were designed, and so we designate them quarter-wave (1/4 λ), half-wave (1/2 λ), five-eighth-wave (5/8 λ), full-wave, etc., antennas. (The Greek letter lambda, λ, is commonly used in scientific work to indicate wavelength.) These physical antenna lengths, however, do not correspond exactly to the theoretical wavelengths, which are based on the velocity of the waves in free space — 300,000,000 meters per second, as indicated by

$$\text{Wavelength in meters} = \frac{300{,}000{,}000}{\text{freq. in Hz}} \text{ or}$$

$$\frac{300}{\text{freq. in MHz}} \qquad \text{(Eq. 1)}$$

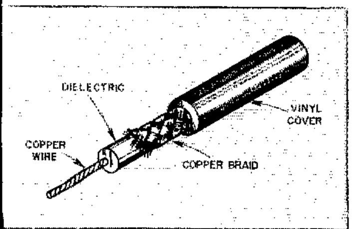
When a wave is traveling in a conductor such as an antenna, rather than in free space, it travels at a slightly slower speed and the antenna needs to be shorter than its free-space wavelength would indicate. These practical formulas

$$\text{length (ft)} = \frac{468}{\text{freq. (MHz)}}$$

$$\text{length (m)} = \frac{143}{\text{freq. (MHz)}} \qquad \text{(Eq. 2)}$$

automatically take care of this difference in length for the most-common horizontal antenna used by amateurs — the half-wave dipole. Don't confuse these two very important formulas: Eq. 1 is used for calculating wavelength (in meters). Eq. 2 is used for determining the physical length (in feet) of a half-wave wire dipole antenna.

Fig. 1 — Coaxial cable is the feed line used by most radio amateurs.



A Look at Transmission Lines

The transmission line is the life line linking the receiver and transmitter to the antenna. There are three kinds in general use in Amateur Radio: *coax, open wire* and *twin-lead.*

The purpose of any feed line is to transport as much energy as possible from the transmitter to the antenna or from the antenna to the receiver, but under certain conditions the line can "lose" much of the energy it is supposed to be transporting. A very small amount of energy is lost from even the best feed line — typically, about one or two percent per 100 feet of open-wire line at frequencies of 3-30 MHz — but we are talking here about more than that very small amount. If, for example, a coax line has been damaged or was made of inferior material to begin with, or if it is not properly matched electrically to the antenna, it can lose energy. A good grade of coax is a good investment. A poor-grade, "lossy" length of coax can drain away your hard-earned radio-frequency energy in a distance of just a few feet.

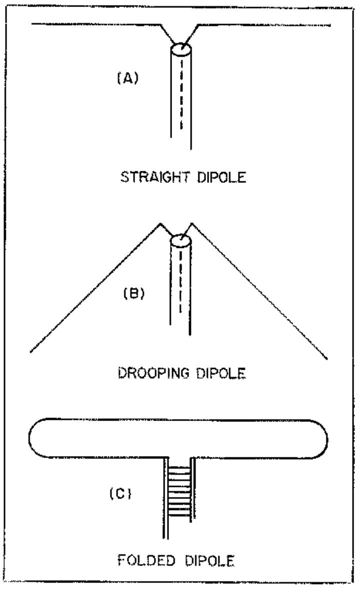


Fig. 2 — The dipole antenna is a favorite with beginners. Most antennas can be considered to be some form of dipole.

Kinds of Antennas

In this section we will describe, very briefly, five of the most common kinds of antennas used by amateurs. Any of these types can be *monoband* antennas, designed for operation on only one band, or *multiband,* designed for operation on several bands. Multibanders often make use of *traps* — not traps which catch and hold radio waves, as their name might imply, but rather traps which act as electrical gates, letting energy through on some bands and keeping energy out on other bands.

The Dipole

The dipole antenna is a favorite with beginners. It is a fundamental type of antenna and most antennas can be considered to be some form of dipole, even though their dipole ancestry may not be guessed from their appearance.

Dipole antennas are constructed of two equal-length pieces of metal, usually wire. For the half-wave dipole, the most common type, each of the two pieces is one-quarter wavelength long; the total length, therefore, is a half wavelength for the band being used. The less common full-wave and 1.28-wave dipoles yield a stronger signal for both sending and receiving, but they require more space than do shorter length ones. They may also require provision for "matching impedances," and are frequently fed with

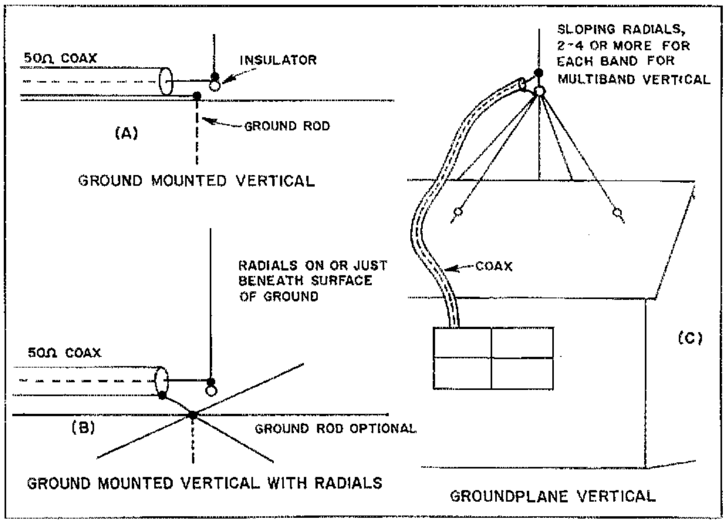


Fig. 3 — Three common methods for mounting quarter-wave vertical antennas.

open-wire feed line. (See the *ARRL Radio Amateur's Handbook* and *The ARRL Antenna Book*, for discussion of impedance matching.)

Several forms of the dipole antenna are in use. In addition to the *straight dipole* form (Fig. 2A), and the *drooping dipole* with wires drooping at an angle to form an inverted V (Fig. 2B), we occasionally see a *folded dipole* with the wire doubled back on itself, as in Figure 2C. The maximum radiation from a dipole is at right angles to the direction of the wires. Minimum radiation is off the ends of the wires.

The majority of dipoles are center fed, with energy from the transmitter entering at midpoint through a transmission line or feed line. [Note: Practical information on the construction and installation of a simple, coax-fed, half-wave dipole will be given in Part 2 of this series.]

The Vertical

Vertical antennas are commonly 1/4-, 1/2- or 5/8-λ long, with the 1/4-λ vertical being most often used by amateurs. Like the longer length dipoles, the taller verticals yield a stronger signal for both transmitting and receiving. But they, too, require more space, a fact that must be taken into consideration. Not that there is usually any shortage of space in the upward direction, but guy ropes are needed to keep taller verticals in position and prevent them, when hit by a strong wind, from suddenly finding themselves horizontal junk instead of vertical antennas.

There is an interesting electrical phenomenon and behavioral oddity common to all verticals — a *nonphysical mirror image* which appears, ghost-like, in the ground directly below the antenna whenever a signal is being transmitted or received. This mirror image forms the other half of the vertical and makes it into what is basically a "vertical dipole."

When we stand in front of a flat mirror and direct the beam from a flashlight toward it, the light in the mirror seems to come from a point as far back of the mirror's surface as we are standing in front of it, and the quality of the mirror determines, to a large extent, the quality and strength of the image we are seeing. An antenna's mirror image is an *electrical* one, with the ground acting as a mirror, and the conductive quality of the ground largely determining the strength of the mirror image. Excluding the effect of nearby surrounding objects, the mirror image and the height of the antenna, for the most part, determine the radiation pattern of the antenna's radiated wave.

The quarter-wave vertical is usually constructed and installed in one of three different ways:

1) As shown in Fig. 3A, the antenna is set on an insulator of some kind (a glass bottle, for example) placed on the ground. If it is coax fed, the copper wire in the center of the coax is connected directly to the quarter-wavelength-long aluminum tubing, or to some other radiating element such as a vertical wire or tower. The copper braid of the coax is connected to a metal ground rod pushed into the ground near the antenna base. This is the least efficient of the three methods we are discussing. (Efficiency is the amount of power radiated from the antenna compared to the amount of antenna input power.

2) The antenna is again mounted on the ground and fed by coax, but in addition has a group of copper wires called *radials* extending out from the base of the antenna as spokes of a wheel. These radials — the more the better — add *conductivity* t the ground. They can be laid out directl on the ground or placed underground at very shallow depth, just deep enough t protect them from physical damage bu not so deep as to put "lossy" ground be tween them and the vertical portion of th antenna (Fig. 3B). By tradition, eac radial is 1/4 λ long. But if you can't fi 1/4-λ radials into the space you hav available, a denser network of shortc ones or a mixture of shorter and longe ones may be the best way to go.

3) The most efficient of the thre methods is to mount the antenna hig above the ground, away from all energy absorbing objects, including the groun itself. In this installation, a circle of thre to five radials, each 1/4-λ long, extend out from the base as in method 2, bu because they are up high they form a artificial ground or *groundplane*. Thi antenna is referred to as a *groundplan vertical* (Fig. 3C).

Table 1 gives a comparison of the mos common horizontal dipole and vertica antennas.

The Yagi

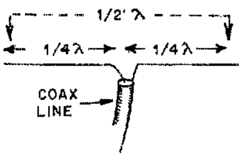
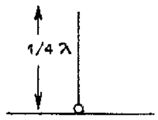
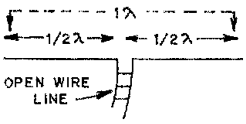
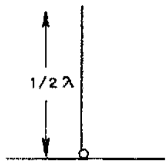
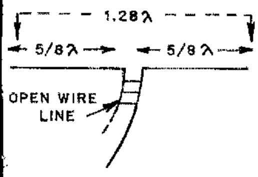
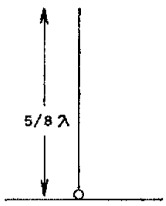
When we consider the Yagi antenna, w move into a group called *beam* antennas Most beam antennas, including Yagis, ar unidirectional, having the strength o their radiated energy primarily concen trated in one direction at the expense o other directions, somewhat similar to th beam from a flashlight.

Yagis, the most popular of the bear antennas, are commonly horizont dipoles with parasitic elements. Th elements are called "parasitic" becaus they have no direct *electrical* connectio to the transmitter or the receiver but in stead are coupled (electromagnetically) t an element which *is* coupled directly (by feed line) to the transmitter or receiver.

Normally, all of the Yagi elements ar made of aluminum tubing. One element, half-wave dipole called the *driven ele ment*, is attached to the transmission lin and receives energy from the transmitte The parasitic elements are called *director* and *reflectors*. All elements are placed o a horizontal support called a *boom* an are spaced at selected distances from eac other — the reflector on one side of th driven element and the director on th other side. The reflector is about three t five percent longer than the driven ele ment; the director is similarly shorter. Th dimensions of these elements, as well a the spacing between them, must b carefully worked out if the antenna is t give its best performance.

The three-element Yagi is shown in Fig 4. Yagis usually have only one reflecto but can have as many directors as desired Since the Yagi is normally rotatable, th beam can be pointed (with the director o directors in front) in a desired direction t

Table 1
Comparison of the Most Common Horizontal Dipole and Vertical Antennas.

Horizontal Dipoles		*Verticals*	
 1/2-wave dipole	Usually fed with coax transmission line.	 1/4-wave vertical	Usually fed with coax transmission line at base of antenna.
 Full-wave dipole commonly called double zepp or two half-waves in phase.	Usually fed with open-wire transmission line through antenna tuner at transmitter. Has about 2 dB gain over 1/2-wave dipole.	 1/2-wave vertical	Usually fed with coax to a matching circuit at base of vertical. Has about 2 dB gain over 1/4-wave vertical.
 1.28-wave dipole commonly called extended double zepp	Usually fed with open-wire line through an antenna tuner at the transmitter. Has about 3 dB gain over 1/2-wave dipole.	 5/8-wave vertical	Usually fed with coax to matching circuit at base of vertical. Has about 3 dB gain over 1/4-wave vertical.

Note: The terms "gain" and "dB" (decibels) will be discussed in part 2 of this article.

transmit or receive maximum signal strength. The antenna can be monoband or multiband, depending on its construction.

The Quad

Elements of the quad antenna are basically folded dipoles (see Fig. 2C) pulled out into a square shape. The quad is a rotatable beam antenna, usually consisting of at least two four-sided continuous loops — the antenna elements. These loops, spaced at selected distances from each other, are placed on a horizontal support, the boom. The driven element is directly coupled to the transmitter by a feed line, and a reflector is parasitically (electromagnetically) coupled to the driven element. In addition, many quads have one or more directors which are also parasitic, and you will hear amateurs say they have two-element, three-element, or four-element quads. These elements, each of which has four sides approximately a quarter-wavelength long (thus making up a complete wavelength for a desired band), can be placed on the boom as squares (Fig. 5A) or as "square diamonds" (Fig. 5B) in a plane perpendicular to the ground. Seen from even a short distance away, all the elements look alike, although the reflector is slightly larger than the driven element, and the directors are slightly smaller. *Spreaders*, usually made of bamboo or fiberglass, support the loops and hold them in place. The loops may be very large — an element for a 20-meter quad, for example, is about 17 feet on each of the four sides of the continuous wire loop.

Quads can be constructed as monoband (Fig. 5A) or multiband (Fig. 5B).

Fig. 4 — Three-element monoband Yagi consists of a driven element and two parasitic elements.

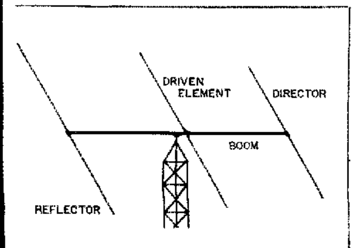
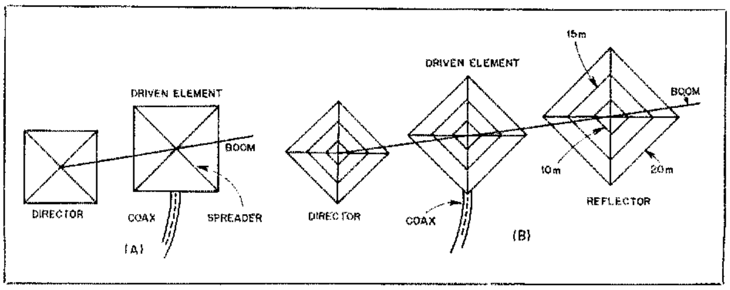


Fig. 5 — The quad antenna is basically a folded dipole pulled out into a square shape.



Multiband quads employ concentric loops for the various bands, with the band having the longest wavelength and therefore the largest loop on the outside and the others nested in the center (Fig. 5B).

Yagis and quads are the two most popular beam antennas, and amateurs can endlessly compare their relative merits. Yagis, according to those who prefer them, are (1) easier to construct and install, (2) less prone to receive damage from ice storms or strong winds, and (3) have a more attractive appearance. On the other hand, amateurs who prefer quads say they (1) are better for multiband operation, (2) possess greater "gain" for equal boom lengths, and (3) are easier to adjust since there is less interaction between elements, element spacing is less critical, and they are more broad-banded than Yagis.

The Longwire

The simplest antenna mechanically and electrically is just what its name implies, a long wire, with emphasis on the "long." Any piece of wire can be made to radiate or receive a signal, but an antenna does not deserve the name "longwire" unless it meets one important requirement: It must be more than one wavelength long for the band or bands being used and, if possible, should be several wavelengths long. A "random length" of wire can be called a longwire antenna, but the wavelength should still be taken into consideration. In general, the longer the wire, the stronger the radiation in certain directions. (Note: In most cases, longwire antennas require the use of an antenna matching unit, such as a Transmatch or "Match Box" to make possible the most efficient transfer of power from transmitter to antenna. See *The Radio Amateur's Handbook* for descriptions of these units.) Longwire antennas are usually at least one or more wavelengths long, using the lowest desired frequency band (which has the longest wavelength) to determine the length of the wire. They can be single wires (a type popular with beginners) or they can be constructed of wires combined in a number of ways, such as in the so-called V beam and the rhombic, which are more sophisticated longwire antennas.

There they are: five general types of antennas, each one with its subtypes — the straight, drooping and folded *dipoles;* the quarter-, half- and other-wave *verticals;* the *Yagis* and *quads,* each with varying numbers of elements and the *longwires* — simple and compound. Within each subtype, if we could but see them, are millions of individual antennas, all alike in some ways; all different in others. All of them are engaged, with varying degrees of success, in sending our radio signals out into all parts of the world. All of them leave us filled with amazement at their aerial performances, and always wondering — but never quite sure — just what their next act may be.

Update: Project Goodwill

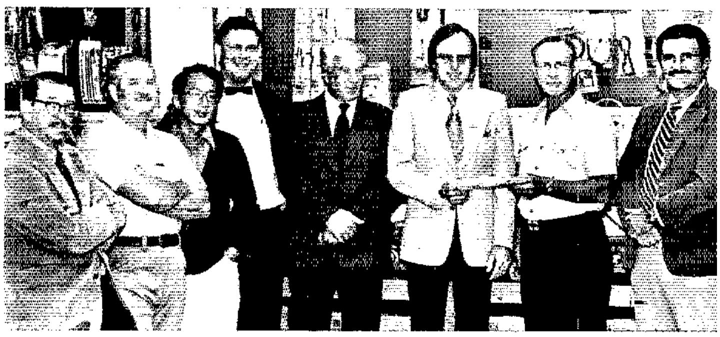
The fund that will help foster the growth of Amateur Radio in Developing Countries of Africa and Asia is off to a flying start! As of early October, more than $5000 has been received, and when the Northern California DX Foundation's matching fund ("League Lines," October *QST*) is added in, the total to date is almost $7000. If you have yet to make a contribution please do so now, as the NCDXF program ends December 31. For every contributed dollar up to $10,000, NCDXF is matching with 35 cents; on the second $10,000 they will provide 50 cents for each dollar. Contributions can be sent to ARRL WARC Fund, c/o International Services Officer, ARRL Hq., Newington, CT 06111.

Even before last month's announcement in "International News," Hq. speakers were spreading word of these stations. Thus, many individuals and groups have already taken the initiative of contributing to the special fund.

Those who have contributed so far are (in chronological order) Greater Bridgeport ARC, Stratford, CT; Sangamon Valley RC, Springfield, IL; Baker Springfield, W4HYY, Memphis, TN; Lockheed ARC, Burbank, CA; Jackson ARC, Jackson, MS; Daytona Beach (FL) ARA; Santa Clara County ARA, San Jose, CA; Sheboygan (WI) County ARC; Onalaska Area ARC, West Salem, WI; Enfield (CT) Radio Amateurs Group; San Fernando Valley RC, Van Nuys, CA; Louis J. Lyell, WA5YMK, Jackson, MS; Egyptian RC, Granite City IL; Nickolaus E. Leggett, N3NI Washington, DC; Radio Amateurs Clul of Knoxville (TN); Woodbridge Wireless Dale City, VA; Platinum Coast ARS Melbourne, FL; Allen B. Harbach WA4DRU, Melbourne, FL; Glenn F Mulligan, N6FZ, Brea, CA; Music Cit Repeater Association, Nashville, TN; Dr Norman L. Chalfin, K6PGX, Pasadena CA; Lloyd C. Sigmon, W6LQ, Sherma Oaks, CA; Hamfesters RC, Oak Lawn IL; Richard F. Barrett, W6CFK, Sa Jose, CA; Southern California Chapter Quarter Century Wireless Association, E Segundo, CA; Chickasaw Amateu Association, Hernando, MS; Johnso City (TN) RA; Paul E. Grauer, WØFIR Wilson, KS; Harold and Verna Cobb W6KDJ and W6JOJ, Pollock Pines, CA Peter N. Borsi, W4HII, Sterling, VA Jerry King, W4MLA, Miami, FL; Bruc Frahm, KØBJ, Colby, KS; Silver Dolla Chapter, 10-10 International Net an Southern Nevada DX Club, Las Vegas NV; Owensboro (KY) ARC; John C McGinty, K5HMI, Oklahoma City, OK Muskegon Area (MI) Area Amateu Radio Council; John B. Cree WB3GXW, Silver Spring, MD; Claude D Pressler, W5VVR, Houston, TX; Centra Illinois Radio Club of Bloomington, Nor mal, IL; K. A. Johnson, W6NKE Canoga Park, CA.

On behalf of the amateurs around th world who will benefit from you generosity, our heartfelt thanks. — *K1U*

The first installment of the Northern California DX Foundation matching fund for IARU receiver and transmitter kits is presented by Don Schliesser, K6RV, NCDXF president, to John Troster, W6ISQ/N6IQ, NCDXF trustee representing the ARRL. Foundation officers are (l-r) W6WB, K6DC, K6KQN, W6CF, WA6AUD, K6RV, W6ISQ/N6IQ, W6RJ; Not shown: K6AN, N6NB, O. G. Villard, Jr.




QST
December 1978
The IARU "Project Goodwill" Transmitter
Page 11
TUNE
SPOT
TX
RX
KEY

December 1978
Volume LXII Number 12

QST (ISSN: 0033-4812) is published monthly as its official journal by the American Radio Relay League, Newington, CT, U.S.A. Official organ of the International Amateur Radio Union.

Offices

225 Main Street
Newington, Connecticut 06111
Tel: 203-666-1541

Subscription rate $12.00 per year postpaid, U.S. funds, U.S. & Possessions; $13.50 in Canada; $14.50 elsewhere. Single copies $2.00. Foreign remittances should be by international postal or express money order or bank draft negotiable in the U.S. and for an equivalent amount in U.S. funds.

Second-class postage paid at Hartford, CT and at additional mailing offices. Postmaster: Form 3579 requested.

QST is available to the blind and physically handicapped on magnetic tape from the Library of Congress, Division for the Blind and Handicapped, Washington, DC 20542.

Indexed by Applied Science and Technology Index, Library of Congress Catalog Card No.: 21-9421. Microform editions available from Xerox University Microfilms, Ann Arbor, MI 48106.

THE COVER

What better gift is there to amateurs-to-be around the developing world than the IARU 20-meter pair? The transmitter is described, beginning on page 11.

Contents

Technical

Basic Amateur Radio

General

Operating

Organizational and Regulatory

Departments

A 20-Meter, VXO-Controlled, 6-Watt Transmitter

Here's a mate for the 20-meter, high-performance, direct-conversion receiver featured in April 1978 QST.

By Jay Rusgrove,* W1VD

Rockbound with 6 watts on 20 meters. . . . Somehow that just doesn't sound very appealing. Everyone *knows* you need at least 100 watts and a beam to barely make contacts, let alone bust pileups. Not so!

During the initial testing period, this 20-meter transmitter was operated from the ARRL laboratory station, W1INF, using an 80-meter dipole for the antenna. Solid contacts were made with W9, WØ, W6, W7 and a KV4 station, with the worst report received a 549. Heartened by this turn of events, several 3 × 3 CQs were sent and sure enough a chirpy, somewhat-frequency-unstable UD6 station answered the call. Several exchanges were made with the UD6 and all pertinent data were recorded. A few minutes later, amidst the snickering of a few onlookers, the writer was handed a homemade UD6 QSL card. At that point it began to sink in. There, across the laboratory, was a signal generator, straight key and a few clip leads — my UD6 contact. Snookered again!

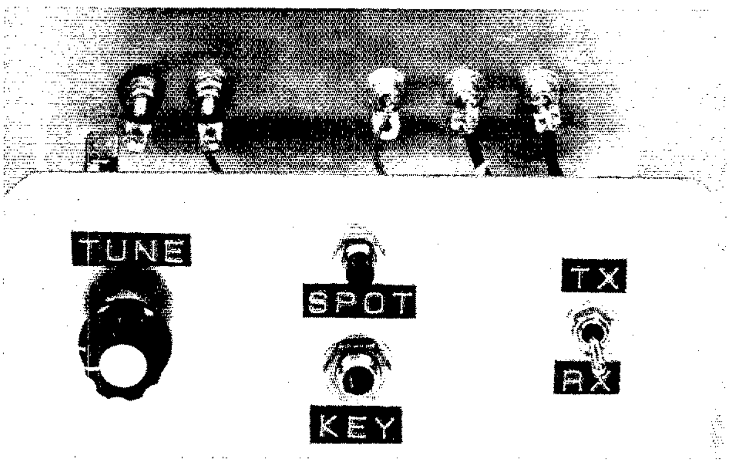
*Senior Asst. Technical Editor, ARRL

The Circuit

The circuit diagram of the transmitter is shown in Fig. 1. Q1 and associated components comprise a variable-frequency crystal oscillator (VXO). With this circuit the frequency of the crystal can be "pulled" above and below the natural crystal frequency, the amount dependent on the type crystal and the frequency. With 14-MHz, fundamental-type crystals at Y1, a total swing of 10 kHz was obtained with the circuit shown.

C2 is a front-panel-mounted variable capacitor that is used to adjust the operating frequency. C1, in parallel with C2, is included in the design to limit the oscillator frequency span. Without this limit capacitor, the oscillator stage may no longer be under the direct control of the crystal. When this happens the oscillator frequency stability is rather poor.

The front panel of the 20-meter VXO-controlled transmitter described in this article.



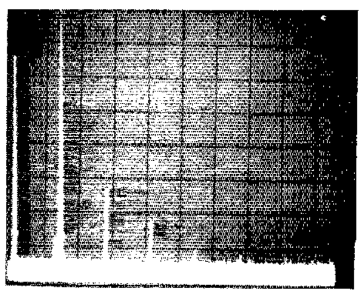
A Zener diode is used to regulate the dc voltage supplied to the oscillator stage. Operating voltage is present at the oscillator only during transmit and spot periods. Since the oscillator operates on precisely the same frequency as that being received, some means must be included to shut down the oscillator during receive. A section of S2 performs this function.

The oscillator is lightly coupled through a 50-pF capacitor to the buffer stage. In addition to providing approximately 10 dB of gain, this stage effectively isolates the oscillator from the succeeding keyed stage. This buffering prevents pulling and chirp. A 2N2222A transistor in a grounded-base configuration is used at this position.

Q3, a rugged 2N3866 transistor, serves as the driver. This is the only keyed stage in the transmitter. The base and emitter resistors are grounded through J1. This stage uses series and shunt feedback to stabilize the input and output impedances in the vicinity of 50 ohms. The 0.1-μF capacitor across the key connection shapes the transmitted waveform. Although the keying is rather hard, there is no evidence of clicks.

Q4 and Q5 are used in a Class C,

Spectral output of the transmitter, as displayed on a spectrum analyzer. The pip at the far left is generated inside the analyzer. The vertical scale is 10 dB per division, and horizontal scale is 10 MHz per division.



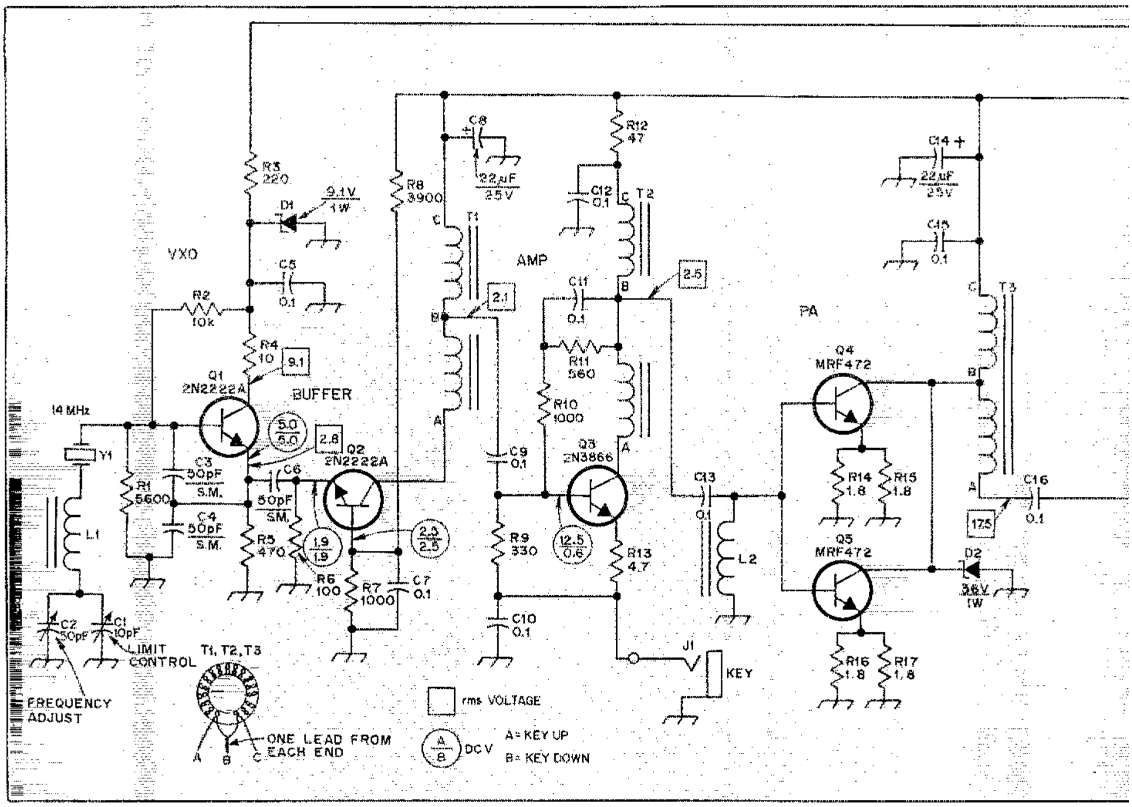


Fig. 1 — Schematic diagram of the transmitter. All resistors are 1/4-watt composition types with the exception of the 1.8-ohm resistors, which are 1/2-watt composition. All capacitors are disk-ceramic or Mylar types except for the ones noted as silver mica or polystyrene or those with a polarity marking. Polarized capacitors are electrolytic or tantalum. Numbered components not listed below are identified for circuit-board placement.

C1 — Miniature trimmer, 10 pF maximum.
C2 — Panel-mount variable, 50 pF maximum.
C3, C4 — Polystyrene capacitor, 240 pF.
D1 — Zener diode, 9.1 V, 1 W.
D2 — Zener diode, 36 V, 1 W.
D3 — Rectifier, 50 V, 2 A.
J1 — Key jack, builder's choice.
J2, J3 — Binding post, builder's choice.
J4-J6, incl. — Coaxial receptacles, builder's choice.
L1 — Toroidal inductor, 36 turns no. 32 enam. wire on a T37-6 core.
L2 — Ferrite-bead inductor, 8 turns no. 26 enam. wire on an FB-73-801 core.
L3, L5 — Toroidal inductor, 16 turns no. 24 enam. wire on a T50-6 core.
L4 — Toroidal inductor, 19 turns no. 24 enam. wire on a T50-6 core.
Q1, Q2 — Transistor, 2N2222A.
Q3 — Transistor, RCA 2N3866.
Q4, Q5 — Transistor, Motorola MRF472 or HEPS3044
S1 — Spst, normally open, momentary, push button.

final-amplifier stage that operates at the 10-watt input level. The efficiency is on the order of 60 percent. L2 is a choke wound on a ferrite bead and is used as a base return. The MRF472 transistors were designed primarily for use in rf power-amplifier stages in citizens band communications equipment. The rated power dissipation is 10 watts per device with a good heat sink. A relatively large margin of safety was gained by using two of these devices in parallel. T3, a broadband transformer, steps up the collector impedance to 50 ohms. A five-pole Chebyshev filter consisting of L3, C3, L4, C4 and L5 is used to reduce the harmonic energy reaching the antenna. The second and third harmonics are 55 and 63 dB, respectively, below the carrier level. D2 is provided to clamp the collector waveform should the transmitter be inadvertently operated into an open circuit or a very high-SWR load. The transmitter is designed to operate into a load of approximately 50 ohms resistive.

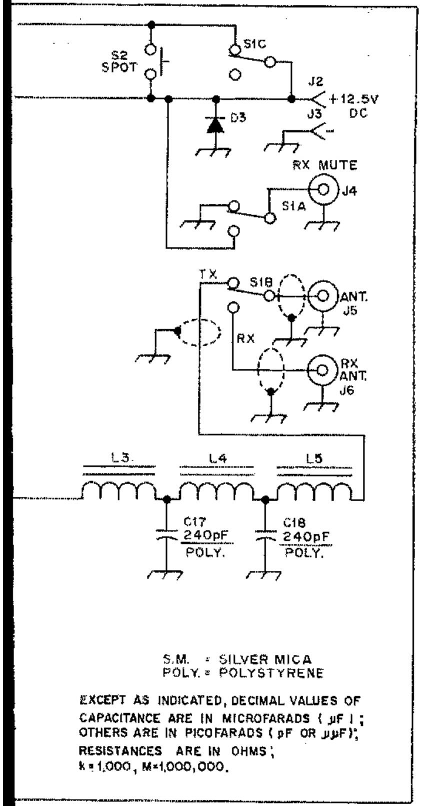
S2 is used to transfer the station antenna to either the transmitter or the receiver, turn off the oscillator during receive periods, and provide a means for muting the receiver. A three-pole, double-throw switch is used at S2. S1 is a normally open, momentary-type toggle switch which is used to activate only the oscillator. If this button is pressed during receive, the frequency of the oscillator can be adjusted without sending out a signal over the air.

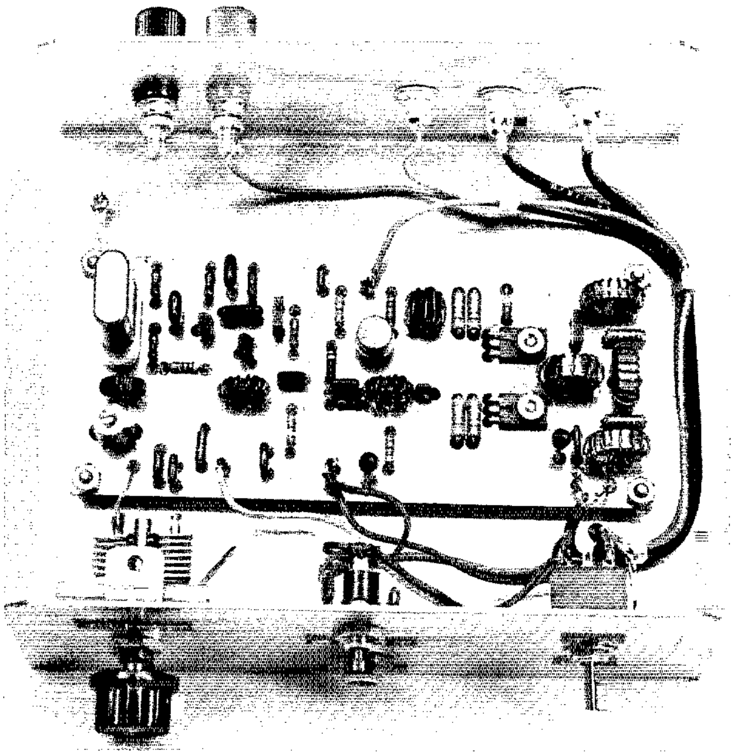
Construction

The majority of the circuit components are mounted on a double-sided circuit board (one side of which is a groundplane) that measures 2-1/4 × 5-1/4 inches (57 × 133 mm). The black etching pattern is shown in the "Hints and Kinks" section of this issue and the parts overlay is displayed in Fig. 2. Q4 and Q5 are mounted to the groundplane side of the board using the circuit-board foil as a heat sink. Mica insulating washers and a small amount of silicone grease should be used between the transistor and the board. No. 4 hardware is used to secure the transistors to the board. Tighten the screws securely, but do not overtighten.

The chassis used to house the transmitter was cut from a piece of scrap aluminum and formed into the shape of a U. The dimensions are 6 × 5 × 2-1/2 inches (152 × 127 × 64 mm). Mounted to the front panel are the frequency-adjust capacitor, transmit-receive switch, spot switch and key jack. The rear panel supports the power-supply binding posts and the antenna, receive antenna and mute receptacles.

Insulated hookup wire is used for all dc connections between switches, receptacles and the circuit board. Miniature coaxial cable (RG-174/U) is used for all rf runs.





Inner workings of the 20-meter transmitter. D3 should be mounted directly at the power-supply binding posts. Cable ties are used to dress the leads.

S2 — 3pdt, toggle.
T1, T2 — Toroidal transformer, 11 bifilar turns no. 26 enam. wire on an FT37-61 core.
T3 — Toroidal transformer, 11 bifilar turns no. 26 enam. wire on an FT50-61 core.
Y1 — 14-MHz fundamental crystal.

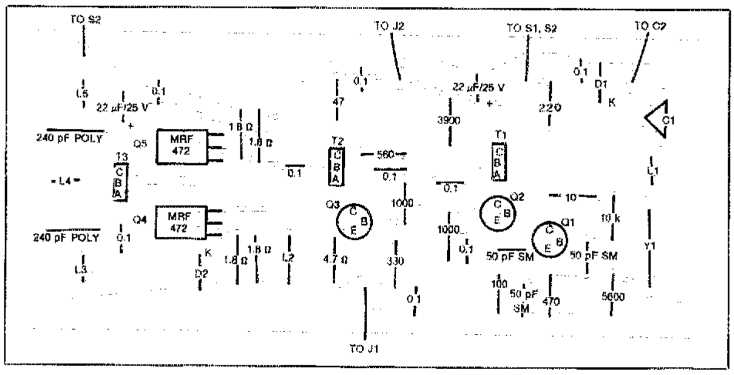


Fig. 2 — Parts-placement diagram for the transmitter circuit board. The board has foil on both sides, the side on which the components are mounted being only a groundplane. Component-lead clearance holes in the groundplane may be etched or drilled. The shaded area here represents an X-ray view of the interconnecting copper pattern, shown in the "Hints and Kinks" section of this issue. Whole-number values with no units represent resistances in ohms. K indicates the cathode of a diode. Transistors Q4 and Q5 are mounted to the board using mica insulating washers and silicone grease. POLY = polystyrene; K = cathode; SM = silver mica.

Dymo labels affixed to the front panel complete the unit.

Alignment and Interconnection with Mating Receiver

Alignment of the transmitter involves only one adjustment, that of C1. This capacitor should be set so that the maximum frequency excursion obtained with the oscillator is limited to 10 kHz. This can be done with the aid of a calibrated receiver or a frequency counter. Should the frequency span exceed the 10-kHz figure, simply increase the amount of capacitance at C1. If it is less than 10 kHz, decrease the amount of capacitance.

In order for the transmitter to be used with the high-performance receiver featured in April 1978 *QST*, a slight modification must be made to the receiver. This involves mounting an additional phono connector to the rear panel. It will be necessary to connect a length of hookup wire from the center connection of this receptacle to the end of R9 that originally was connected to the 12-volt bus. This can be done easily by standing the resistor on end. The end of R9 that is connected to the mute receptacle should not be connected to the 12-volt bus in the receiver.

Chances are that *you* won't be snookered by a bogus contact. However, it might seem so when you start working your share of DX with 6 watts!

A Baseband Communications System

Part 2: The technology behind the NBVM system, circuit details, and most important of all, how you can get one on the air are included in this part.†

By Dr. Richard W. Harris* and J. F. Cleveland,** WB6CZX

The first part of this article describes the development of a baseband system which allows significant communications improvements in a narrow bandwidth. In this concluding part, detailed hardware and development information is given to allow the reader to build or procure the system.

By way of brief review, the baseband transceiver system operates just after the microphone on transmit and just prior to the speaker on receive. It uses the newly developed frequency compandor and the well known but not extensively used amplitude compandor.[8] The use of both of these devices within the same baseband system provides significant improvements in adjacent-channel rejection and signal-to-noise ratio (SNR).

Tests of the frequency compandor conducted for the FCC[9,10] indicate that an interfering signal can be 40 dB stronger and only 2 kHz away and yet be essentially eliminated. Results of amplitude-compandor tests showed that background channel noise can be reduced so significantly that an increase of 13-15 dB SNR is obtained. The use of the baseband system offers up to 50 percent bandwidth savings with the frequency compandor. This bandwidth savings translates to an improvement of 3 dB SNR.

System Options

During the hardware evolution it became apparent that several optional modes of operation could be made available to enhance the overall capability of the baseband system. During on-the-air tests thus far conducted, it has become apparent that a 1600-Hz transmission bandwidth with a shape factor of 1.3:1 is a very narrow system indeed. In some cases a wider system, between the narrow 1600-Hz audio and the typical 2400-Hz audio used, for example, by the ICOM IC-245 and the Kenwood TS-820, would be desirable. Thus the system developed uses two frequency-compandor modes, 1600 Hz (50 percent bandwidth savings) and 2100 Hz (33 percent bandwidth savings). These savings are compared to a 2:1 shape factor audio filter of 2400-Hz bandwidth.

With the 2100-Hz option available it becomes obvious that use of a 2100-Hz stand-alone audio filter may be very useful, particularly if the user's transceiver does not already have a very narrow i-f or audio filter. Use to date has shown both the 2100-Hz frequency compandor and stand-alone audio filter modes to be valuable additions. Although the frequency compandor has a very sharp transceiver filter and on ssb reception eliminates audio frequencies outside the voice-frequency range of the desired signal, elimination of undesired signals in the "opposite" sideband is dependent primarily upon the receiver i-f filter. (Some receivers may not have sufficient opposite-sideband rejection.) Use of the 700-Hz high-pass filter within the frequency compandor in conjunction with either the 1600-Hz or 2100-Hz low-pass filter provides a very narrow band-pass filter which helps significantly to reduce opposite-sideband interference while allowing reasonable intelligibility. (The 2100-Hz low-pass filter is preferable to the 1600-Hz filter.)

Many amateurs compress their audio level on transmission to allow higher average transmitter power, but few amateurs take advantage of audio expansion on reception. As long as the amplitude expander has sufficient signal level to use as a reference, suppression of channel noise and interference significantly improves the received audio SNR. Independent switches for the amplitude compressors and for the expander seem to be very desirable. This feature has been included in the baseband system and allows the use of the expander as a stand-alone feature on receive to allow expansion of amplitude-compressed signals.

The narrow band-pass filter (BPF) option from 700 Hz to 1600 Hz offers the user a moderate bandwidth with sharp skirts for cw use. Furthermore, preliminary tests using the amplitude expander in conjunction with the BPF indicate that exceptionally quiet code reception can be obtained. This increased SNR provides fewer decoding errors and less annoyance, particularly for weaker signal contacts.

The baseband system described here has evolved over a period of three years. It

Table 3
Active Filters

Filter	Type	Number of Poles	Cutoff freq., Hz	Shape Factor (−6 to −60 dB)
VBC0600L	Low Pass	8	600	2.50
VBC0700H	High Pass	8	700	2.50
VBC1600L	Low Pass	16	1600	1.19
VBC2100L	Low Pass	16	2100	1.29
VBC2500L	Low Pass	8	2500	

*President, VBC, Inc., 1111 W. Robinhood Way, Suite Z, Stockton, CA 95207
**305 Germaine Ave., Santa Cruz, CA 95065
†Part 1 of this article appeared in November 1978 *QST*.
[8]Notes and references appear on page 20.

provides many options for communications improvement so that, depending upon the environment, the user may select several modes for optimizing radio communications.

Choice of Hardware Technology

The system was developed for use by a potentially large number of users. Several technologies were considered, such as digital, hybrid analog, and discrete analog devices.

A system providing good control and versatility is one which uses an analog-to-digital (A/D) converter and then processes the signal in a fast microprocessor to obtain the bandwidth compression. It then converts the digital signal back to analog (D/A) form for transmission. On reception another A/D converter would be used with the microprocessor for bandwidth expansion, followed by a D/A converter to present an analog signal to the user. Cost is a major reason why such a system was not used. Cheap microprocessors are available, but not *fast* cheap microprocessors. Cycle times on the order of 100 nanoseconds are required. The digital filtering necessary in performing the frequency compandoring would require the use of several 8-bit digital multipliers with multiply times on the order of 100 to 200 nanoseconds. These devices currently cost $100 to $200 each. This cost, when added to the cost of the A/D and D/A converters and other associated fairly high-power digital electronics, is currently prohibitive for widespread use.

Discrete analog-device implementation was also considered. This technology uses mainly discrete resistors, capacitors and operational amplifiers. To perform the audio filtering it is necessary to use low-sensitivity realizations of active filters. The achievement of fast roll-off filter characteristics (shape factors as low as 1.3:1) requires the use of multiple-pole filters having part tolerances of one percent or less. Consideration of the assembly time and high parts cost as well as the overall reliability of such circuits using discrete components led to the conclusion that hybrid-chip technology was a better hardware solution.

The baseband system developed uses six high-performance hybrid chips with laser-trimmed one-percent resistors, very stable long-life capacitors, and low-noise operational amplifiers. This modular system provides flexibility in interconnections for future improvements. The hybrid chips operate over a wide temperature range (0-70°F or −18 to +21°C), dissipate very little power (the greatest being 0.25 watt), occupy very little volume (1.25 cubic inches or 20 cm^3 including all six hybrid chips), and provide excellent reliability.

Detailed Hardware Discussion

In the paragraphs which follow, a detailed discussion of the hardware used in the baseband system is given. Reference may be made to the block diagram (Fig. 7, Part 1 of this article). Considered during development of this system were cost and performance (audio and electronic) to provide many improvements in radio communications for a wide variety of environments and user equipment.

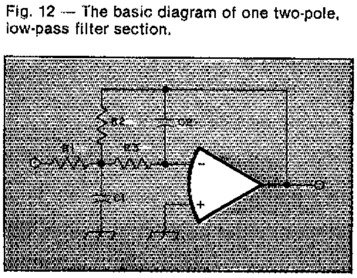
Audio Filters

Four active audio filters are basic to the frequency compandor. All are based on 0.1-dB-ripple Chebyshev low-pass prototypes. Higher ripple could be tolerated to obtain faster cutoff rates than with these filters, but another important factor must be considered. It is well known that all filters exhibit delay, and this delay is not constant across the passband of Chebyshev filters. The delay variation (also known as differential-delay distortion) across the passband of the filter can be quite large for audio filters compared to similar filters at radio frequencies. Voice information can only tolerate up to about 10 ms of delay distortion over its spectrum before garbling begins to occur. Since the voice information must pass through the four filters of the frequency compressor at the transmit end and four more filters at the receive end, each end can have about 5 ms total differential delay distortion. The filters used here each exhibit an average of about 1 ms delay distortion, so the total is 4 ms on transmit and 4 ms on receive. Thus the 10-ms maximum is adhered to.

Table 3 lists the characteristics and typical performance of the five filters used. It is important to note that the 1600L and 2100L are not used simultaneously. The two 16-pole filters each consist of two identical cascaded eight-pole designs to minimize delay distortion. Each two-pole pair requires a stage such as shown in Fig. 12 for the low-pass case. From this information the experienced amateur may duplicate these filter designs with discrete components, if he so desires.

The advantages of the hybrid implementation of these circuits are significant. High-order discrete filters were built by the authors in early stages of development, but they can be very difficult to tame. Problems which arise with discrete layouts are the unavailability of an infinite variety of resistor values, instability, inadequate ultimate rejection, and excessive noise. Size is also important when one is talking about a total of 26 active filter stages, not to mention the oscillator, mixer and switches.

Fig. 12 — The basic diagram of one two-pole, low-pass filter section.



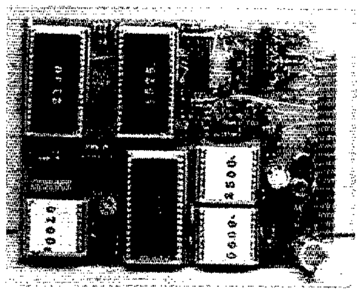


Fig. 13 — The entire circuit except for controls and switches is built upon a single circuit board as shown here. The board must be mounted in a shielded enclosure to prevent rf feedback problems.

The hybrid approach allows the total prototype system minus external controls to be contained on a standard 4-1/2 × 6-inch (114 × 152-mm) plug-in printed circuit card (see Fig. 13). The 16-pole active filters each measure 1 × 2 inches (25 × 51 mm) and the other filters are 1 inch (25 mm) square. Texas Instruments' TL074 low-noise bi-FET quad op amps are used throughout. Since the audio passes through about 20 op amps in each direction, low-noise amplifiers are critical to attaining adequate dynamic range. Typical ultimate rejection is improved from 50 dB in the discrete version to 65 dB in the hybrid version. Feedback and unwanted oscillation is easily controlled and power supply decoupling is less critical. Dc offsets in the direct-coupled stages are minimized by low input currents of the TL074 op amp. Laser trimming of the thick-film hybrid resistors assures reliable reproduction of the desired filter characteristics in quantity production. The low temperature coefficients of the thick film-resistors and COG-dielectric capacitors assures that the filter will remain in specification over a wide temperature range (limited only by the op-amp performance with temperature). All filters have band-pass gains near 0 dB and can handle +10-dBm inputs with a total supply voltage of 10. They were designed for so-called single-supply operation. Supply voltages used in this device are regulated at +10 and +5 dc. Supply sources must exhibit very low impedance at audio frequencies.

Control Circuit

The control hybrid (VBC3000C, shown in Fig. 14) contains the 3100-Hz oscillator,

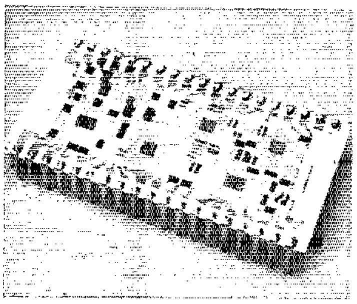
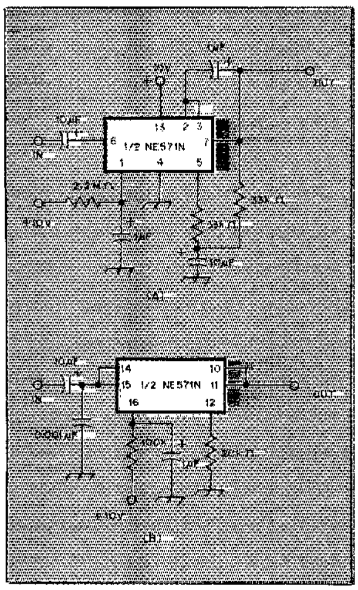


Fig. 14 — Here is an interior view of the hybrid control circuit used in the processor.

balanced mixer, mic preamplifier, CMOS analog switches and buffer amplifiers for the basic frequency compandor. The oscillator uses two op amps and has amplitude limiting to minimize harmonic distortion. Frequency trim and output connections are externally available. The doubly balanced mixer is a TI TL442 which operates reasonably well at audio frequencies. Signal input is about −20 dBm at the rf port, −10 dBm at the LO port, and output is about −20 dBm at the i-f port.

Most voice signals throughout the control chip are at −10 dBm to allow plenty of headroom below the +10-dBm saturation limit of the filters. In addition to the filter inputs and outputs shown in the block diagram, other external connections allow for additional carrier balance, buffer gain and logic reference adjustment.

Fig. 15 — Amplitude compressor circuit (A) and expander circuit (B).



The peripheral circuitry includes an extension of the switching capability for receive-only filtering. Spare op amps in the 0600L and 0700H filters are used for the additional buffer amplifiers. An LM380N is used to provide about 1 watt of audio-output capability into 8 ohms. The gain of this device is reduced to 10 with negative feedback from the speaker terminal to the inverting input. This reduces instability problems and microphonics inherent with the LM380 when used at its maximum gain of 50.

Fig. 15 is a schematic of the actual connections to the NE571 amplitude compandor. At A, the 100-Hz time constant for the internal rectifier is set with an internal resistor and the external 1-μF capacitor. The 2.2-MΩ resistor provides the transfer curve mistracking at low levels, as described earlier. The combination of two 33-kΩ resistors and the 10-μF capacitor sets the dc gain of the compressor internal op amp. The 20-kΩ resistor in Fig. 15B biases the expander internal op amp to +5 V dc for maximum signal-handling capability.

The total system is powered from a 12.5- to 20-V dc source at 75 mA idle and approximately 300 mA at 1 watt audio output. All circuitry, excluding the LM380, is powered from +10- and +5-V dc regulators (LM340LAH-10 and -5).

One last circuit was devised to provide interface between the radio transmitter key line and the audio transceiver accessory. Since differing transmitters have a variety of voltages and impedances on the key line during key-up conditions, the circuit in Fig. 16 was developed to handle most situations. The circuit requires a low-impedance ground closure to go into the transmit mode. If the impedance becomes very high or the voltage exceeds ±0.5 from ground, the unit returns to the receive mode. This allows for positive or negative key-up voltages and assumes a grounded line during transmit. There is no load on positive key lines and approximately a 100-kΩ load on negative key lines. Key-line voltages must remain within the reverse breakdown voltage of the diode-transistor combination (about 60 volts).

Construction

The schematic diagram of the voice processor is shown in Fig. 17. Figs. 18 and 19 show the control circuitry and the connections to the circuit board. An etched circuit board with all necessary parts to complete a basic processor board is available commercially.[11] [The etching patterns for the double-sided board, not available from the authors in time for printing in this issue of *QST*, are offered separately.[12] — Ed.]

Layout of a printed circuit board for this application is tricky at best. Ground loops are hard to avoid and can make the whole unit sound like a squawking chicken. Keeping the local-oscillator signal out of where it doesn't belong is the hardest part since it is a coherent tone and is audible at levels lower than normal voice sounds. Additional power supply decoupling of the oscillator stages is helpful. Rf bypass capacitors are used liberally on the audio input and output lines. *The unit must be mounted in a well-shielded enclosure.* Stray rf getting into any of the audio circuitry can cause "gravelly" sounding audio or even blocking.

One of the photos shows the prototype-unit front panel, which includes control switches, mic input, mic level control, and the receive volume/on-off switch. The rear panel uses phono and phone jacks for other inputs and outputs. The 12.5-volt power is provided by an external dc power pack such as those used for calculator recharging. A 13-volt automobile system is also suitable.

Interface with a radio transceiver is quite simple. The unit is connected permanently, since its functions can be bypassed if desired. The station microphone is connected to the processor front-panel mic jack. The push-to-talk line is routed directly to the processor mic output jack (and is tapped by the audio processor control circuit). A shielded cable is installed between the processor mic and PTT output and the equivalent transceiver input. The receive audio is brought from the station transceiver speaker or earphone output (after the volume control) and is connected to the receive input on the voice processor. A speaker or earphone is connected to the appropriate audio output jack. In operation, the voice processor volume control is preset to a desirable listening level and the receiver volume control is then used to adjust volume to keep the input level to the voice processor fairly constant with varying signal strengths. If the station receiver has very good agc characteristics, volume adjustment requirements will be minimal. If not, the volume will need periodic adjustment to keep strong signals from overdriving the amplitude expander, since a 1-dB increase in level at the input is converted to a 2-dB increase at the output of the amplitude expander. (Future pilot-carrier narrow-bandwidth ssb systems will have an absolute agc reference, and this potential overdrive problem will be minimized.)

The unit can be used with simple double-sideband transceivers which use direct-conversion receivers. The audio filters provide abundant selectivity so all that is needed is a "front end" with a low-noise audio preamplifier to receive ssb or dsb transmissions and an rf balanced modulator and rf amplifier fed from the high-level microphone audio output to transmit dsb. The authors are investigating low-cost but high-quality hybrid active audio phase-shift networks which would allow construction of simple phasing ssb transceivers as well.

Audio-System Performance

Two measures of audio-quality performance are intelligibility and acceptability of the reproduced voice by the user. Intelligibility can be measured as the percentage of correctly received words or phrases that were transmitted, while acceptability involves the difficult task of assessing user opinion regarding voice tonal qualities and speaker recognition.

There are many statistical tests used to measure intelligibility characteristics, such as the Fairbanks Rhyme Test, the Modified Rhyme Test, Harvard Test Sentences, Harvard P-B Word Test, and the Diagnostic Rhyme Test. Of these, the Diagnostic Rhyme Test is widely accepted by the military and has a considerable data base available, particularly for digital systems.

A prototype VBC frequency-compandor system that uses about 60-percent less transmission bandwidth than a normal baseband communications system scored 90 percent on a male speaker and 87 percent on a female speaker. (Typical long-distance telephone conversations score about 93 percent.) An amateur ssb system (ICOM IC-245) scored 95 percent using the same male speaker.

Since the last major system improvements have been made, at least 50 people have heard the audio quality at baseband, under varying conditions. Virtually all of those listening have stated that from an intelligibility standpoint the VBC 1600-Hz system provides adequate performance.

When no comparison between the frequency-compandored mode and the nonfrequency compandored mode was available, the listeners did not state that the system lacked acceptable voice quality. To these listeners sufficient identifiable speech characteristics were present and the speech quality was acceptable.

When the straight-through mode (no frequency compandor present) is compared with the 1600-Hz frequency compandor, nearly all of the listeners prefer the straight-through mode. However in communications practice, as later tests have shown, there are conditions when communication using the straight-through mode is seriously degraded or not possible. This occurs when heavy adjacent-channel interference or noise is present. In many cases use of the frequency compandor does allow communication to be established or to continue even in the presence of heavy interference.

Listener tests of the wider bandwidth VBC 2100-Hz frequency compandor have been very positive. There is little degradation in voice quality in comparison with the straight-through mode at baseband. In use on radio communications the straight-through mode may be preferred on very high SNR contacts (about 30 dB, which rarely occurs). However when the SNR is in the range of 10-25 dB (which is usually the case) the 2100-Hz frequency compandor mode is often preferred over the straight-through mode. This is primarily because the 33-percent reduction in bandwidth reduces background noise and significantly reduces adjacent-channel interference.

The amplitude compandor (Signetics NE571) does not degrade audio quality. It should be noted that some care must be taken to use proper signal levels. When proper signal levels are used, performance over the range from 5 to 30 dB SNR is excellent.

Prior to August 1978, two preliminary tests and three rather extensive tests involving several amateurs were completed. (These tests do not include the extensive bench and field tests made for the FCC in the mobile radio bands in the fall 1977.) The first extensive test was performed during the afternoon of July 19, in San Mateo, CA. Amateur participants were Tom Lott, VE2AGF/W6; Marvin Kolber, K6PJU; Bill Burris, WA6CXJ and Bob Ferrero, K6AHV/W6RJ, along with R. W. Harris. A major goal of this test was to determine the performance of the 1600-and 2100-Hz frequency-compandor interference rejection.

Three stations were set up. Kolber was using a Drake TR-3 transceiver, Burris a Kenwood R-599/T-599, and Lott a Collins KWM-2. Tom Lott and Marvin Kolber each had baseband systems and Bill Burris operated with a normal amateur ssb transceiver. To facilitate the tests a secondary communications net was set up by all three stations using 2-meter transceivers.

For this test, Tom Lott transmitted the "wanted" signal and Bill Burris provided

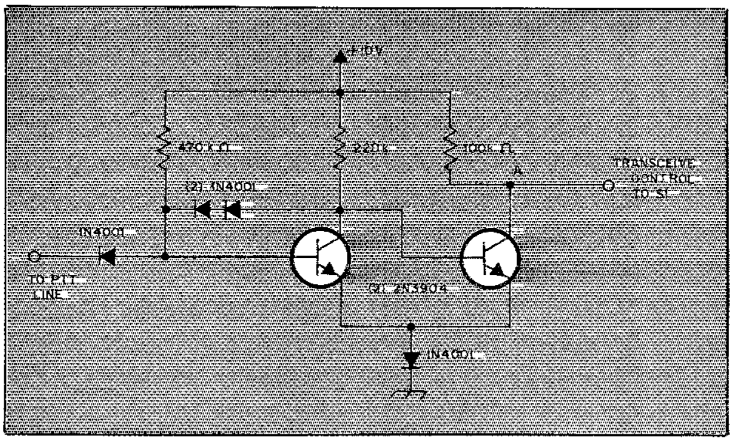
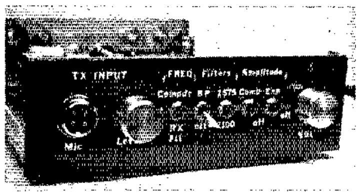
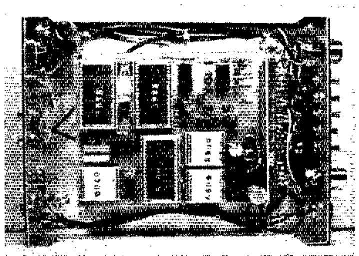


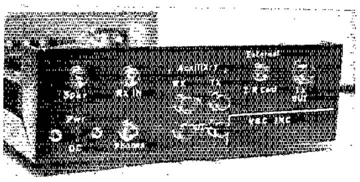
Fig. 16 — PTT-line interface to voice processor. Point A is at +10 V dc during receive and +0.5 V dc during transmit.



Front-panel view of a prototype compandor system. As outlined in the text, considerable flexibility has been designed into the system. Various modes of operation can be selected with the flip of a few switches.



A peek directly into the compandor system prototype. The edge connector for the circuit board facilitates easy removal.



This view shows the rear panel of the processor. Layout is not particularly critical, but leads should be kept as short as possible. The use of a completely shielded enclosure is mandatory.

the "unwanted-interference" signal. At the receive station of Marv Kolber, manned by Kolber, Ferrero and Harris, the performance quality was assessed. To begin with, all three stations were on the same frequency in the 40-meter band. Transmitter power was adjusted to provide comparable SNR and audio level for the wanted and unwanted signals as received at Kolber's station. Then by request, Burris moved off frequency until the characteristic "Donald Duck" close-interference sound was heard. At this point Tom Lott was asked to talk continuously, as was Bill Burris, providing the interference signal. So far in the test all 40-meter rigs were being operated in the straight-through mode. A good assessment of the interference level was made and then the frequency and amplitude compandors were switched in (sometimes separately).

In nearly all cases the compandor circuits provided a dramatic reduction in the interference signal, the exception being when the interferer was virtually on top of the wanted signal. The dramatic improvement occurred because the major portion of the interferer's voice was being filtered out by the sharp reception filter of the frequency compandor, while the transmitted voice was narrow enough to be properly received. The amplitude compandor also significantly aids in this rejection because it suppresses unwanted lower level interference with the amplitude expander. It has the effect of making the reception filter skirt seem even sharper.

The above adjacent-channel interference test was repeated several times. We also assessed the effects as the interferer was made stronger than the wanted signal. Again, the interference was significantly reduced by use of the compandors. These results verified the earlier extensive tests made for the FCC on the 2-meter mobile band.[9,10] Significantly, however, they were being performed on the air instead of on the bench, as was primarily done in gathering data for the FCC report.

In addition to adjacent-channel tests, several tests in the presence of heavy noise were performed using the compandors. When the SNR was low, but high enough to hear the wanted speaker (about 5 dB), use of the amplitude compandor dramatically reduced background noise and interference. In several instances a nearly unusable voice signal sounded like it jumped out of the noise and became a pleasantly readable signal. When the transmitting signal dropped until the SNR was about 0 dB, the amplitude compandor did not improve communications. This effect indicates, as predicted, that sufficient signal must be present to obtain a reference.

Several of the receiving modes such as stand-alone filters and expander only on the baseband system were also tested. The general conclusion of those present was

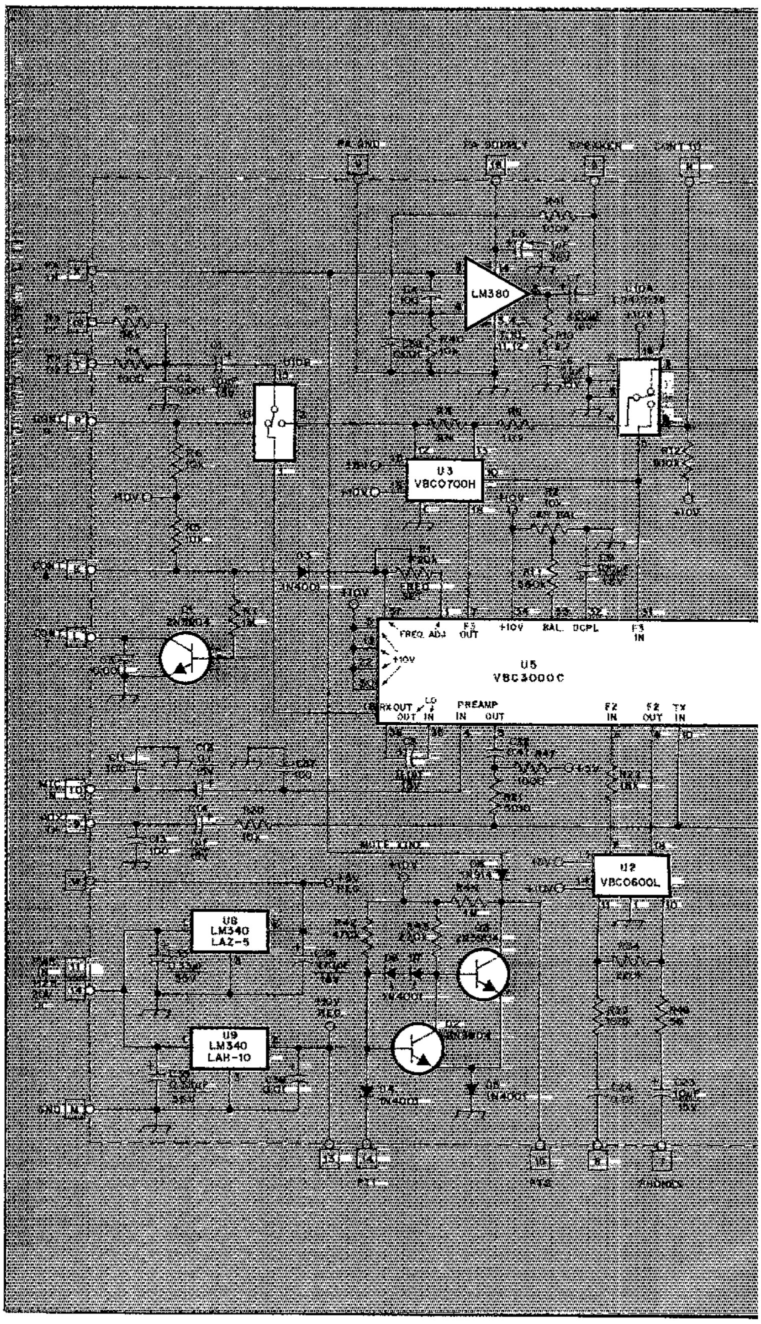


Fig. 17 — The schematic diagram of the compandor system. All numbered squares represent circuit board foils which mate with a standard edge connector.

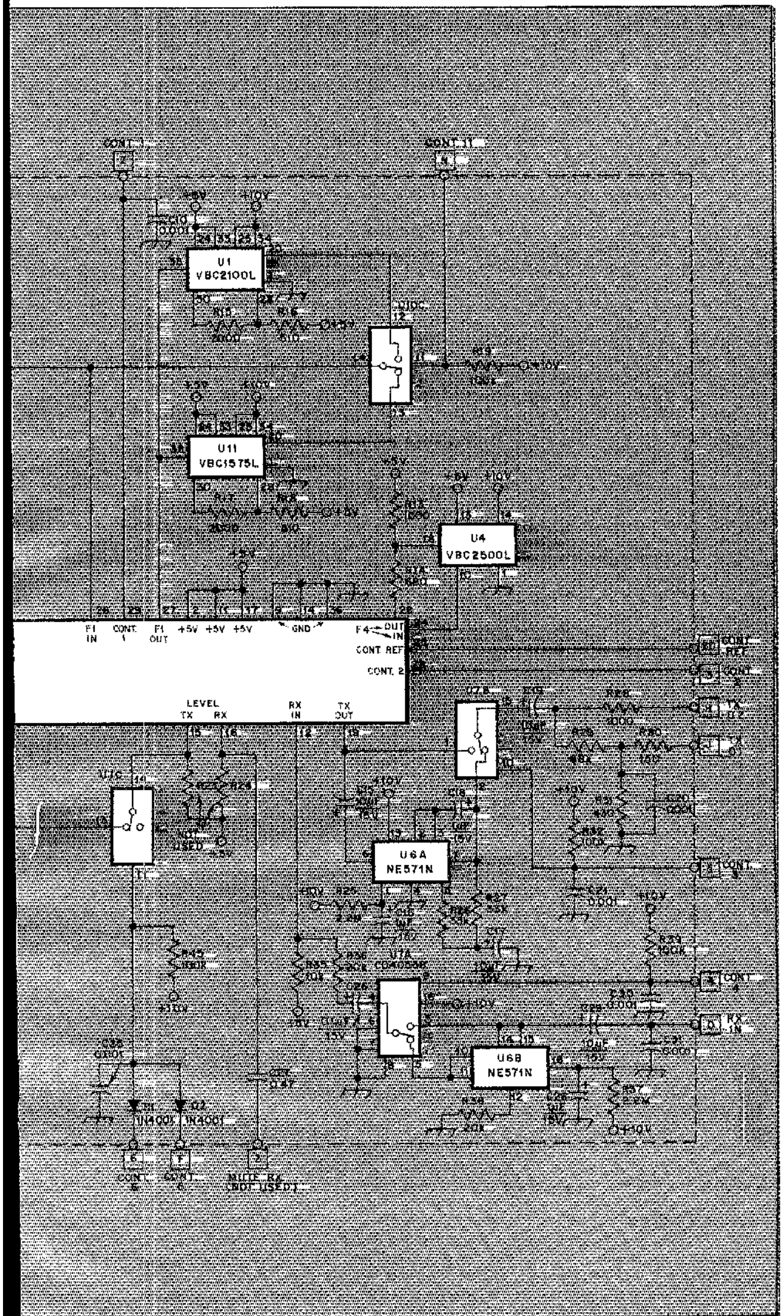
C1, C15, C17, C19, C23, C29 — 10 µF, 15 V, electrolytic or tantalum.
C2, C3, C10, C20, C21, C25, C30, C31, C32 — 0.001 µF, 50 V, disk ceramic.
C4, C11, C13, C37 — 100 pF, disk ceramic.
C6, C8, C12 — 0.1 µF, 15 V, tantalum.
C7 — 220 µF, 16 V, electrolytic.
C9 — 100 µF, 15 V, electrolytic.
C14, C16, C18, C28 — 1 µF, 15 V, tantalum.
C22 — 0.47 µF, nonpolarized.
C24, C38, C40 — 0.01 µF, 50 V, ceramic.
C27 — 0.047 µF, 15 V nonpolarized.
C33, C35 — 0.33 µF, 35 V, tantalum.
C36 — 470 µF, 16 V, electrolytic.
C39 — 22 µF, 15 V, tantalum.
C41 — 1000 µF, 25 V, electrolytic.
D1-D8, incl. — 1N4001, or equiv.
D9 — LED.

that the baseband system would be a valuable addition in a wide variety of amateur operational conditions.

On July 17, a short test session used baseband systems at two stations on 15 meters. Fred Cleveland, WB6CZX; Dale Dunmire, W6SJV and R. W. Harris performed transmitting and receiving tests. These tests were primarily voice-quality tests to aid in performing the later, more extensive tests on July 19. Results of these tests, using several different speakers, indicated good intelligibility and communicability for the frequency-compandor systems.

On several other occasions Dunmire tested the system in various receive modes for several hours. The results were very positive as to the communication enhancement provided. This was particularly so when using filters only and when using the expander only. Dunmire also reported several instances when he used the expander to test whether the voice signal being received was compressed on transmission. When compression was being used he noticed a significant reduction in background noise when he switched in the expander on the baseband receiver system.

Another extensive test was performed on July 24, between Tom Lott and Dale Dunmire, with R. W. Harris being present at Dunmire's station. Again the test was performed on 40 meters, but the contact was over a longer distance than before, approximately 75 miles. Good results were obtained. Audio quality was reported to be adequate in both frequency-compandor modes. Several times the amateurs noted how quiet and free of interference the background was when compandors were being used.



J1 — Edge connector, 22 pin, 44 contact.
J2-J12, incl. — Builder's choice.
Q1-Q3, incl. — Switching transistor, 2N3904.
R48 — Potentiometer, 50 kΩ.
R49 — Potentiometer, 25 kΩ.
S1 — Toggle switch, dpdt.
S2-S5, incl. — Toggle switch, spdt.
S6 — Toggle switch, spst.
U1 — Hybrid circuit, VBC2100L.
U2 — Hybrid circuit, VBC0600L.
U3 — Hybrid circuit, VBC0700H.
U4 — Hybrid circuit, VBC2500L.
U5 — Hybrid circuit, VBC3000C.
U6 — IC, Signetics NE571N or equiv.
U7, U10 — IC, CD4053B or equiv.
U8 — Voltage regulator, LM340LAH-5.
U9 — Voltage regulator, LM340LAH-10.
U11 — Hybrid circuit, VBC1575L.
U12 — Audio amplifier, LM380.

Future Amateur Participation

Although tests to date have been very successful, many more tests are desired on other bands and under varying conditions. Large numbers of amateurs should be involved. Only then will a sufficient data base be established as to the full usefulness of the baseband system. The results may provide guidance for future improvements.

As currently designed, the baseband internal local oscillator is fixed at 3100 Hz. This choice was made to allow a wide range of transmission and reception filters to be used with cutoff frequencies between 1500 Hz and 2500 Hz. Hardware for amateur use now provides filters of 1600 Hz and 2100 Hz. VBC is also making an 1850-Hz filter for mobile radio bands, which could be obtained as an option for amateur use. Many amateurs may wish to experiment by using their own transmission and reception filter designs. It is hoped that amateurs will be heavily involved in the evolution of the system. Results of their experimental work will prove very valuable for future efforts in

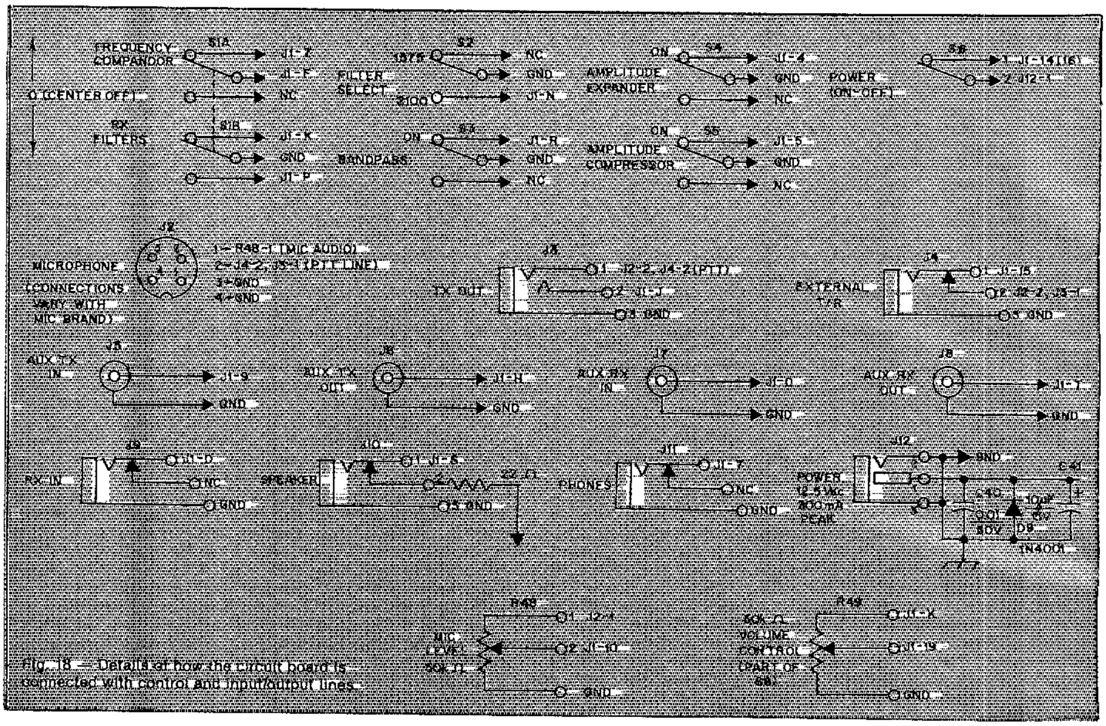


Fig. 18 — Details of how the circuit board is connected with control and input/output lines.

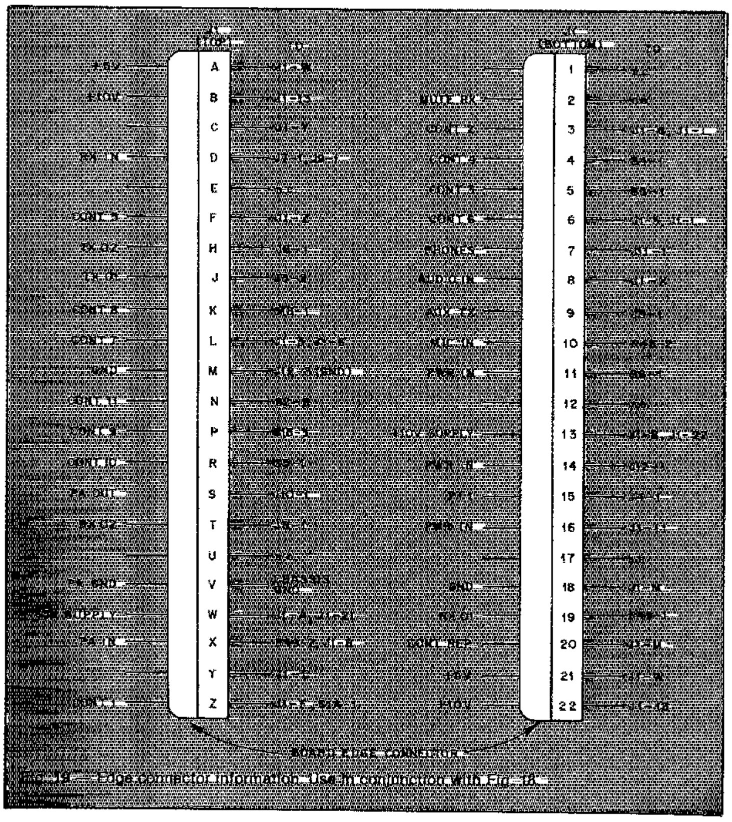


Fig. 19 — Edge connector information. Use in connection with Fig. 18.

bandwidth and power conservation.[13]

Future Improvements and Conclusions

VBC, Inc., is now participating in a shared FCC contract with Stanford University (directed by Dr. Bruce Lusignan) to produce prototype ssb transceivers for potential use in the 30- to 50-MHz mobile radio band. This work includes the development of a convenience circuit to allow automatic frequency control (afc), automatic gain control (agc), tone-operated squelch, and selective calling. Progress to-date is encouraging. Upon completion, these circuits will be made available to amateurs. Important to amateur users will be the potential use of the narrow-band technology (including compandors and the convenience circuits) in the vhf and uhf amateur bands. In these bands a channelized format similar to that of commercial land-mobile bands is used.

The combination of these newly developed baseband technologies in several bands is expected to continue to evolve for many years to come. The ultimate goal is a better and larger number of communications opportunities for all users. The authors hope to continue to be engaged in pursuing this goal.

Notes and References

[1]A frequency compandor compresses signal bandwidth on transmission and expands signal bandwidth on reception. An amplitude compandor compresses signal amplitude on transmission and expands signal amplitude on reception.

[2]Wilmotte and Lusignan, "Spectrum-Efficient

Technology for Voice Communication," *UHF Task Force Report,* Office of Plans and Policy, FCC, Washington, DC, February 1978.

[10]Lusignan, "Single Sideband Transmission For Land Mobile Radio," *IEEE Spectrum,* July 1978, pp. 33-37.

[11]For further information on chips or products, write VBC, Inc., P. O. Box 1289, San Mateo, CA 94401, or call 415-348-8400.

[12]Write to ARRL, Dept. TD-NBVM, 225 Main St., Newington, CT 06111. To expedite mailing, please include a stamped return business-size envelope and 50 cents to cover handling (IRCs accepted from outside the U.S.).

[13][Editor's Note: Because the portion of the speech spectrum containing most of the intelligence is inverted by the processor for transmission, the communication may not be readily understood when the received signal is tuned in the normal manner. However, a compandored ssb signal *can* be tuned for some degree of intelligence (but with degraded fidelity) without processing equipment at the receiving end. Tune the signal as if it were on the opposite sideband, to receive the inverted portion of speech in right-side-up fashion. Because the signal is not coded in a way to obliterate intelligence, no STA is required for transmission.]

New Books

The Radio Amateur's Handbook for 1979, 56th edition, by the ARRL headquarters staff, Newington, CT. 544 pages in an 8-1/4 × 11 inch (210 × 280 mm) format. Paperback edition: U.S. and possessions, $9.75. Canada, $10.75. Elsewhere, $12. Clothbound edition: U.S. and possessions, $15.75. Canada and elsewhere, $18. Weight: approximately 2-1/4 lbs.

First introduced more than a half-century ago, the *Handbook* has come to be regarded as virtually indispensable; not only in every ham library, but to many electronics industry professionals as well. It has long set the pace in the evolution of radio technology, while providing a wealth of practical and proven designs.

This edition is the most highly revised in many years. Some of the more "weighty" theory material has been replaced by new text which is easier to comprehend by those with minimal electronics knowledge. However, the editors have avoided "talking down" to the more experienced readers. Mathematics have been kept at the high school algebra level, for the most part, and worked-out examples of the equations are included where applicable.

What's in this dramatic new edition? A highlight is complete, practical coverage of narrow-band voice modulation (nbvm), a discovery hailed by some as a major technological breakthrough which reduces the bandwidth required for single-sideband signals. Sections rewritten in full or in part include Electrical Laws and Circuits, Solid-State Fundamentals, Power Supplies, and the six sections of hf and vhf/uhf transmitting, receiving and antennas. Considerable data has been added on the use of ferromagnetic devices (toroids, etc.) in narrow- and broadband applications.

The semiconductor chapter has been completely rewritten and doubled in size! It contains data on PIN and impatt diodes, GaAs FETs, solar-electric cells, VMOS power FETS and KEDs plus excellent coverage of standard semiconductor devices. There are 80 schematic diagrams in this chapter which clearly illustrate the applications of most of the semiconductor devices used by amateurs and engineers today.

The theory portions of the hf and vhf/uhf transmitting chapters emphasize frequency stability, spectral purity and state-of-the-art design techniques. Likewise, the receiving chapters emphasize low noise, dynamic range and high performance. Circuit examples abound and are clearly explained.

The new *Handbook* is also a bonanza for the workshop enthusiast. Construction projects are presented in progression from simple beginner-type transmitters and receivers to a complex receiver project and high-power linear amplifiers. Also, the Antennas chapter has new projects for all kinds of vertical and beam antennas.

This heavily revised *Handbook* is one that no amateur will want to pass up when updating his or her technical library. Professional electronics persons will find this volume essential as an important reference in the field of rf communications. — *John Nelson, W1GNC*

The VNR Concise Encyclopedia of Mathematics, published by Van Nostrand Reinhold, division of Litton Education Publishing, Inc., New York, NY. Clothbound, 6-1/2 × 9-1/4 inches, 816 pages. Price: $14.95.

Let's see now . . . if my new repeater can be heard 50 miles away in all directions, how many square miles of coverage do I have . . . , hmmm, A = 2 pi r . . . no, that's wrong — oh yeah, A = pi r squared! Wow! 7854 square miles of coverage!

Going to school is great. You learn all those neat (and some not so neat) equations, theorems and formulas so you can solve any problem that comes your way. But the old noggin doesn't remember all that stuff unless you keep using it. If you've kept all your old text books, you may have all the references you need, but if you sold them, or pitched them into the senior bonfire, this new volume from VNR should fill the bill.

As an encyclopedia, this book does not attempt to *teach* as much as to provide an easy reference guide. Practically every specialized area of mathematics is explained concisely in this compact edition. Illustrations play a key role in the presentation, with more than 700 of the 950 diagrams, drawings, photographs and plates containing at least one color (in addition to black). Important definitions and formula groups are highlighted by yellow, examples by blue, and theorems by red. These and other colors are also used to point up notable features in the diagrams.

The encyclopedia is systematically subdivided and contains numerous sectional headings. Part I deals with history and the traditional areas of elementary math. Part II introduces diverse aspects of higher mathematics, and Part III contains surveys of various facets of contemporary math. Examples are interspersed with straight text, using both traditional and metric units, and with an emphasis on practical applications in science and technology.

The VNR Concise Encyclopedia of Mathematics should be a welcome addition to the library of anyone wishing to improve his understanding of mathematics, or who wants a complete yet handy reference for the fascinating science of mathematics. — *Jim Bartlett, K1TX*

Season's Greetings from the Hams at ARRL/IARU Hq.

(Listed in alphabetical order of call sign.)

Kathy Kearman	WB1AAE	Stan Gibilisco	W1GV/WAØOKV	Arline Bender	WA1VMC
Craig Clark	N1ACH (ex-WA1QWW)	Ed Tilton	W1HDQ	Rita Tilley	WA1WEV
Bobbie Chamalian	WB1ADL	Lew McCoy	W1ICP	Bill Jennings	K1WJ (ex-WA1AHI)
Micheie Bartlett	N1AGD (ex-WB1FAU)	Stu Leland	W1JEC	Chuck Bender	W1WPR (ex-W3ODU)
Jim La Porta	N1CC (ex-W5LA)	Joe Moskey	W1JMY	Bob Halprin	K1XA (ex-WB2NOM)
Jeannie DeMaw	W1CKK (ex-W8REI)	Clarke Greene	K1JX (ex-WA1JLD)	Bob Myers	W1XT (ex-W1FBY)
Garry Bartels	WB1CPM (ex-WB2CFE)	Tom Frenaye	K1KI	Jim Kearman	W1XZ
Don Waters	WB1CUJ	Stan Horzepa	WA1LOU	Sandy Gerli	AC1Y (ex-WA1EEA)
Laird Campbell	W1CUT (ex-W5TQD)	Jeanie Zaimes	AB1P (ex-WB1FAH)	Joel Kleinman	WA1ZUY
George Grammer	W1DF	George Woodward	W1RN (ex-K3TQM)	Dave Sumner	K1ZZ/K1ZND
Chris Schenk	W1EH (ex-WB2SEZ)	Dick Baldwin	W1RU (ex-W1IKE)	Don Search	W3AZD
Michelle Fuini	WB1ENT	John Huntoon	W1RW (ex-W1LVQ)	W. Dale Clift	WA3NLO
Steve Place	WB1EYI (ex-WB2IGW)	Lee Aurick	W1SE (ex-W2LE)	Louise Moreau	W3WRE
Doug DeMaw	W1FB (ex-W1CER)	Rosalie White	WA1STO (ex-WB9FJT)	Bill Tynan	W3XO/W3KMV
Jim Westbrook	K1FD (ex-WA4ZUI)	Jerry Hall	K1TD (ex-K1PLP)	Bruce Johnson	WA6IDN
Hal Steinman	K1FHN	Jim Bartlett	K1TX	John Troster	W6ISQ/N6IQ
Marian Anderson	WB1FSB	Perry F. Williams	W1UED	George Barker	WB8PBC
Marge Tenney	WB1FSN	Jim Morris	K1UJ (ex-KH6HQG)	Bernie Glassmeyer	W9KDR
Barbara Johnson	WB1GHT	Jay Rusgrove	W1VD (ex-WA1LNQ)	Maxim Memorial Station	W1AW
John Nelson	W1GNC (ex-WØDRE)				

Some Experiments with High-Frequency Ladder Crystal Filters†

For the radio amateur, ladder filters have several advantages. These include no matching, grinding or etching, and low insertion loss. They're simple to build, and effective!

By J. A. Hardcastle,* G3JIR

Although electrical-network textbooks have long acknowledged the existence of high-frequency ladder crystal filters, almost nothing has been written about them in Amateur Radio journals. Perhaps this article will rectify the situation and will show how simply an effective filter may be produced using only a handful of crystals and capacitors. The crystals used are of identical frequency, while the capacitors having a two-percent tolerance are of the silver-mica and preset trimmer type. An experimental approach has been adopted throughout, and full details of test procedures and the results obtained are given.

Half-Lattice Filters

Early attempts by the author to make high-frequency crystal filters using 8.3-MHz 10X and type FT-243 surplus crystals in the familiar half-lattice, four-crystal configuration (Fig. 1) produced such poor results that they never progressed beyond the breadboard test stage. They suffered from too narrow bandwidth (2 kHz), poor stop-band discrimination (40 dB), and numerous spurious responses immediately adjacent to the hf cut-off frequency. While they would be suitable for an ssb upper-sideband filter for a transmitter, they were considered unusable in a receiver.

Ladder Filters

Ladder type filters are not so vulnerable to the effects of the additional series resonances present in the crystals. This is so because of the unlikelihood of these resonances occurring at identical frequencies in all crystals. Therefore, the resonances of one section are attenuated by all the other sections.

Armed with this knowledge, the author sought an inexpensive source of suitable crystals. Fortunately, HC-9/U crystals were being advertised in *Radio Communication* at an attractive price and the advertiser readily agreed to supply a batch of his choice of frequency between 9 and 10 MHz.

Crystal Measurements

The width of the passband of any crystal filter is dependent on the spacing of the series resonant frequency and the parallel-resonant frequency of the crystal. The test circuit shown in Fig. 2 was made so that these frequencies could be checked, and comprises a signal generator, a digital frequency meter, and a sensitive hf electronic voltmeter. A typical test measurement made with this equipment is shown in Fig. 3. In order to demonstrate the presence of numerous series and parallel resonances the response has been drawn out in full, but it is generally sufficient to check only the first pair of these frequencies. Table 1 summarizes measurements made on a number of different types of crystals. Immediately

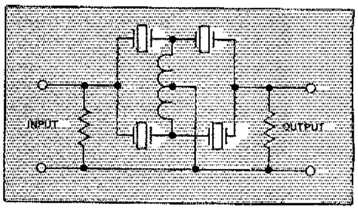


Fig. 1 — Four-crystal half-lattice filter.

apparent is that the plated type of crystal is capable of a much wider bandwidth than the older type which utilizes a clamped mounting. Clearly the 9.6-MHz HC-6/U crystals will readily achieve the 2.4-kHz bandwidth required for an ssb filter.

First Steps

Before attempting to produce a high-performance, multiple-section ladder filter, two shunt capacitors were added to the test circuit of Fig. 2, transforming it into a simple band-pass filter (Fig. 4).

In order to obtain some idea of the size of components required for a full-sized filter, various values of capacitance for C1

Table 1
Crystal Measurements

Nominal Frequency f_o (kHz)	Case Reference	Mounting	Series Resonant Frequency f_s(kHz)	Parallel Resonant Frequency f_p(kHz)	$f_p - f_s$ (kHz)	$\frac{f_p - f_s}{f_o}$ %
8,300	FT-243	Compression	8,310.99	8,312.45	1.46	0.018
8,300	CR1AR	Compression	8,306.09	8,308.2	2.11	0.025
8,300	10X	Compression	8,309.7	8,312.52	2.82	0.034
8,325	10XJ	Plated	8,324.05	8,328.86	4.81	0.057
3,250	HC-6/U	Plated	3,250.8	3,254.7	3.9	0.12
40,500 (13,500)	HC-6/U	Plated (overtone)	13,507.6	13,524.1	16.5	0.12
9,681.2	HC-6/U	Plated	9,672.55	9,687.95	15.4	0.16

*82 Acacia Ave., Huyton, Liverpool, England L36 5TP

†Adapted from an article of the same title in *Radio Communication* (RSGB) for December 1976.

and C2 were used and the frequency responses were measured. The result of one of these tests is shown in curve B of Fig. 3, where C1 and C2 were each rated at 150 pF.

An Intermediate Stage

Expanding the simple filter of Fig. 4 to three sections proved to be an easy operation. When three identical filter sections (Fig. 5A) are combined, the resulting circuit becomes that of Fig. 5B. Note how connecting similar stages in tandem results in the end-section capacitor being half the value of the others.

A quick scan over the frequency band disclosed that the circuit was behaving like a band-pass filter with a sharp cutoff on each side of the passband. The shape of the passband, however, left a great deal to be desired and the test setup was insufficiently sensitive to enable adequate stop-band measurements to be made.

In order to solve the sensitivity problem, a simple superhet receiver, shown in broad outline in Fig. 6, was constructed. All the tests described subsequently were made using this receiver.

The shape of the passband was improved by providing the correct source and load impedance in the form of preset variable resistors, as shown in Fig. 7. The frequency characteristics of these two filters (Fig. 8) show how careful adjustment of R1 and R2 resulted in a band-pass ripple of less than 1.5 dB. R1 is a shunt resistor that reduces the output impedance of the buffer amplifier and R2 is a series resistor to increase the input impedance of the rf amplifier. When the filter is used in a circuit of the correct impedance, R1 and R2 will no longer be required, but for the purpose of these tests, they enabled a variety of filters to be tested quickly, without the necessity of continually modifying the test equipment.

Note the fringe of spurious responses which were found above 9710 kHz. More than six of these extremely sharp responses were found. They are only about 100 Hz wide. Reference to Fig. 3 shows how they correspond with two of those shown there. However, as mentioned previously, they have been greatly attenuated by the other two stages.

Bandwidth

The bandwidth of the three-section filter can be controlled by selecting the size of the shunt capacitors. By increasing their capacitance, the bandwidth can be reduced, but this also reduces the filter impedance and so necessitates the readjustment of R1 and R2. Fig. 7 and curve B of Fig. 8 show the result of a 50-percent increase in capacitance which reduced the 3-dB bandwidth from 3500 Hz to 2600 Hz. Achievement of a completely satisfactory band-pass ripple by adjusting R1 and R2 was impossible, but when C4 was reduced to 50 pF, a ripple of 1 dB was obtained. Note also how the stop bands have been affected by the change (the lf being improved and the hf being degraded).

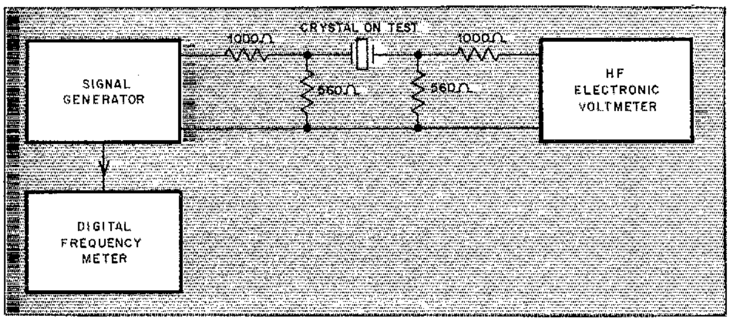


Fig. 2 — Crystal measurement circuit.

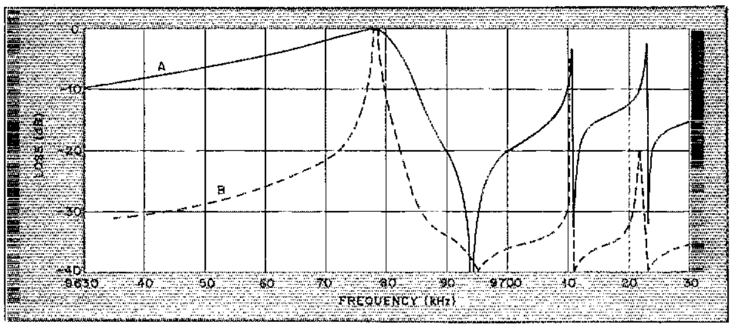


Fig. 3 — Curve A represents the function of parallel and series resonances. Curve B is for a simple band-pass filter.

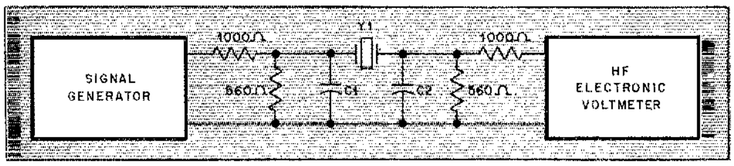


Fig. 4 — Single-section band-pass filter.

Six-Section Filter

By adding three more crystals, the filter in Fig. 9 was produced. Values used for the capacitors were derived from the three-section filter described previously. As expected from the previous measurements, stop bands of greater than 70 dB were easily produced and the region requiring the most effort was again the passband. Besides adjusting R1 and R2, adjustment of C1 and C7 also became necessary. In fact, C7 was eventually removed altogether, stray capacitance alone being sufficient in this position. As a final contribution to a flat passband, C2 and C6 were also slightly reduced and the resulting ripple in the response dropped to 1 dB.

The bandwidth at −3 dB is 2757 Hz, at −6 dB 2923 Hz, and at −60 dB 6698 Hz, giving a 60:6-dB shape factor of 2.29:1. The insertion loss, measured between points A and B in Fig. 9, is 3 dB. Fig. 10 shows the full frequency response.

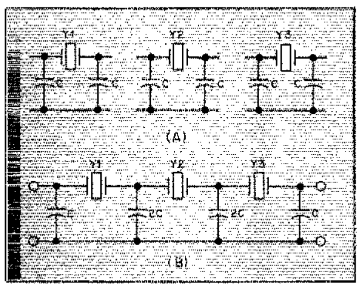


Fig. 5 — Addition of three single-filter sections (A) to produce a three-section filter (B).

Filters with the same capacitor values,

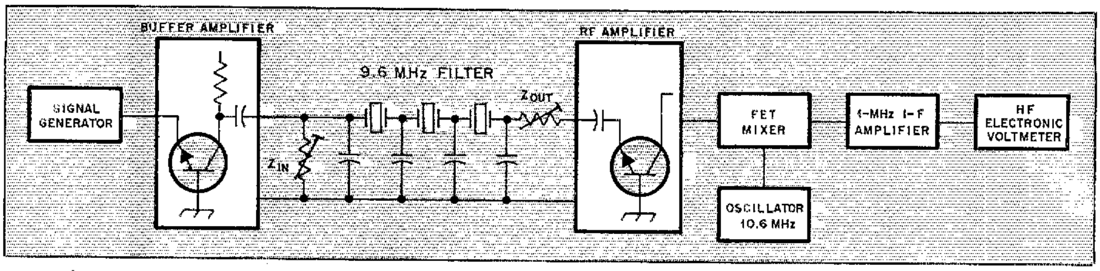


Fig. 6 — Filter test set.

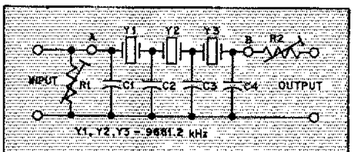


Fig.	R1	C1	C2	C3	C4	R2
7a	3 kΩ	50 pF	100 pF	100 pF	50 pF	330 Ω
7b	1.8 kΩ	75 pF	150 pF	150 pF	50 pF	200 Ω

Fig. 7 — Three-section filters. The tabulation shows the effect of a 50-percent increase in capacitance values.

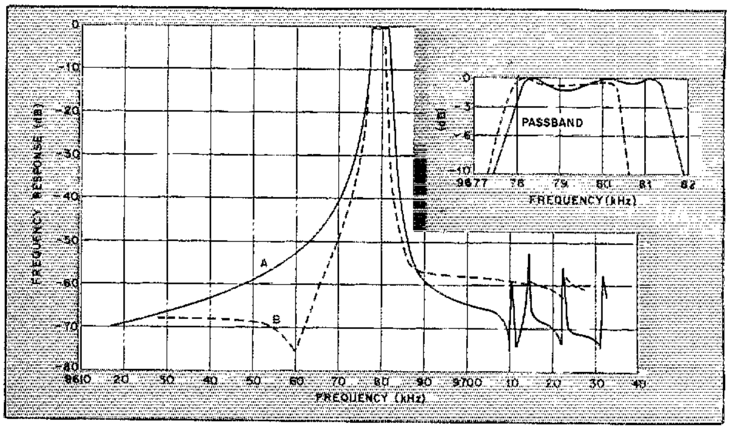


Fig. 8 — Three-section crystal ladder filters. See text concerning bandwidth.

using five and seven crystals, were also checked. The characteristics of these filters have not been given here, but the five-crystal filter had a shape factor of 2.93:1 and the seven-crystal filter exhibited a shape factor of 1.89:1. In both cases the 6-dB bandwidth was almost identical with the six-crystal filter. The response, at −60 dB only, is plotted in Fig. 10 for ease of comparison.

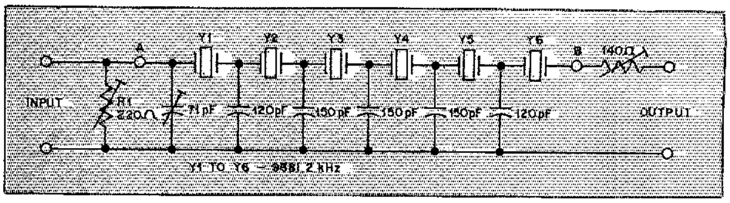


Fig. 9 — Six-section crystal ladder filter.

Conclusion

These experiments with high-frequency ladder filters have led the author to conclude that they have several advantages over lattice-type filters where usage by amateurs is concerned. They may be summarized as follows:

1) All crystals are of the same frequency and no matching, grinding or etching is required.

2) Spurious responses are not so detrimental to overall performance of the filter and, for filters having more than four sections, may be virtually undetectable.

3) Filters may be constructed using an odd or even number of crystals. This is a useful attribute when one is dependent upon surplus sources for the supply of crystals.

4) The only other components required are two-percent-tolerance silver-mica capacitors and preset trimmers, which are readily available.

5) Because of the very low equivalent series resistance of modern crystals, the insertion loss of these filters is very low.

Job lots of suitable HC-6/U crystals have been offered by advertisers in *Radio Communication*, usually as batches of "our choice of frequency." Perhaps these may become available as lots of one frequency, or an enterprising crystal manufacturer may decide to mass-produce 9-MHz crystals at a price attractive to amateurs. Finally, when buying groups of crystals, remember to buy an extra one for use as a carrier crystal.

Bibliography

Hamish, "An Introduction to Crystal Filters," *RSGB Bulletin*, January and February 1962.

Hirst, "PE Wideband HF Communications Receiver," *Practical Electronics*, February 1970.

Sykes, "A New Approach to the Design of High-Frequency Crystal Filters," *Bell System Monograph 3180*.

Zverev, *Handbook of Filter Synthesis*, John Wiley and Sons, 1967.

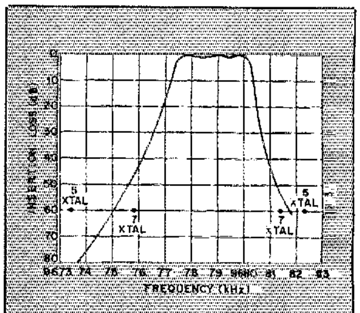


Fig. 10 — Six-section filter response. Response of five- and seven-section filters is also indicated.

What Next After Moonbounce? Venus Bounce!

Moonbounce has become old hat these days. So have home computers. Merge the two technologies and head for Amateur Radio's next frontier!

By Richard A. Simpson,* W6JTH (ex-K1KRP)

Radio echoes from the moon were first obtained in 1946, by a U.S. Army Signal Corps team. Their achievement was heralded in the world press. *Time* mused that this longest distance human communication said nothing. Held to kilowatt power levels, it was 1953 before radio amateurs were successful in receiving their own echoes. From its simple beginnings, the moonbounce work developed into the field now known as radar astronomy — study of the solar system using controlled radio waves. Research on celestial mechanics, planetary surfaces and atmospheres, solar physics, and other topics is carried on today from several major facilities. Among them are the National Astronomy and Ionosphere Center, in Arecibo, PR, and the Goldstone Tracking Station, near Barstow, CA. Using transmitters with hundreds of thousands of watts output, state-of-the-art receivers, and sophisticated signal-processing techniques, these observing stations have gone far beyond the capabilities of the individual radio amateur, or even the well-funded professional scientist. Radar echoes were obtained from Venus in 1961, Mercury in 1962, and Mars in the following year. The frontier now is at the satellites of Jupiter and the rings of Saturn.

With recent developments in hobbyist computers, EVE (Earth-Venus-Earth) experiments are now within the range of radio amateurs. Advances in microwave-component technology and somewhat more tolerable price levels are helpful. In this article I'll discuss some technical aspects of the problem and make an estimate of EVE potential for amateur-scale operation.

Radar Equation

To estimate the amount of signal returned from a planet or other target, the "radar equation" is used. If the transmitted power is known, this expression can be used to account for factors such as antenna gain, distance to and reflectivity of the target, and give the power which reaches the receiver. Though many of the factors in the equation are imperfectly known, the equation can be used to at least estimate the detectability of a target. For the general case, let's say that our transmitter has a power output of P_T watts. When connected to an isotropic antenna, the power would be radiated uniformly into space. The power *density* at a distance R from the antenna would be equal to

$$P_D = \frac{P_T}{4\pi R^2} \quad \text{(Eq. 1)}$$

That is, power would be evenly distributed over a spherical surface of radius R meters. An antenna at R with a collecting surface area A would intercept

$$\frac{P_T A}{4\pi R^2} \text{ watts}$$

Instead of an antenna, we have a planet at R, which first intercepts the outgoing wave, then scatters part of it back toward our receiver. We can visualize the process by supposing that we replace the planet with a transponder; this analogy relates rather directly to the mathematics of the radar equation and will lead easily to the concept of "radar cross section." A transponder is a device which sends out a signal proportional to the one it receives. In this case, the transponder input terminals are connected to a receiving antenna with effective collecting area of σ meters. Assume this particular transponder radiates exactly the same amount of power as it receives. If a power density of one watt per square meter reaches it, then σ watts will be taken in by the antenna and reradiated isotropically; at a distance R_x from the transponder, the power density of the new wave will be

$$\frac{\sigma}{4\pi R_x^2}$$

Our hypothetical receiving antenna of area A will collect

$$\frac{\sigma A}{4\pi R_x^2} \text{ watts}$$

Radar workers use σ to describe the efficiency of a target. The stronger the signal reaching the receiver, other factors remaining the same, the higher the radar cross section, which is the name associated with the σ previously discussed. Highly absorbent targets may have small radar cross sections, even if they are physically large. Physically small targets which behave like corner reflectors will have high radar cross sections. In general, for natural targets such as planets, radar cross section is proportional to the area of the projected disk.

If the characteristics of the transmitting and receiving systems are known, and we can model the planetary target as a transponder, it should be possible to estimate the amount of transmitted power returned in an echo. This value is given by the radar equation, the development of which we can now complete. Antennas having gain increase the transmitted power density in some directions and diminish it in others. If the transmitting antenna has a gain of G_T, the power density at distance R will now be

$$\frac{P_T G_T}{4\pi R^2}$$

rather than the value given in Eq. 1 for an isotropic source. Invoking our transponder model of the planet located

*3326 Kipling St., Palo Alto, CA 94306

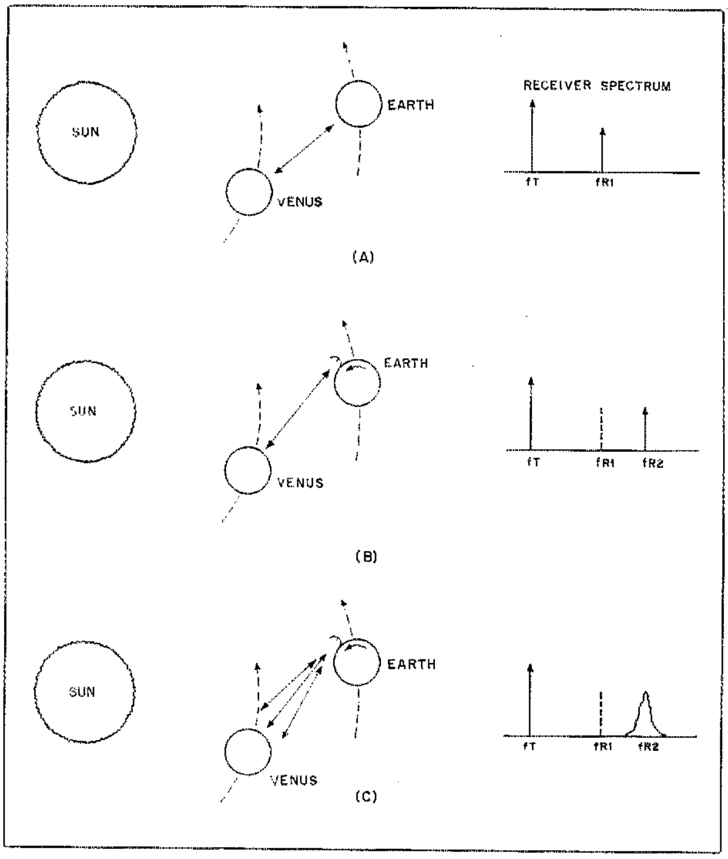


Fig. 1 — The effects of Doppler shifts caused by planets in motion with respect to each other, and the result of planetary rotation. At A, net motion of Venus toward Earth causes the echo to be received at a frequency greater than the transmitted signal ($f_{R1} > f_T$). At B, rotation of Earth causes station velocity to be superimposed on net motion. At Venus rise, net velocity is increased and the echo is shifted upward to f_{R2}. At C, rotation of the target causes a broadening of the echo, which is centered at f_{R2}.

at R, we find it takes in and reradiates

$$\frac{P_T G_T \sigma}{4\pi R^2} \text{ watts}$$

A receiving antenna of area A at a distance of R_x from the planet will collect a power of P_R, which is equal to

$$\left(\frac{P_T G_T}{4\pi R^2}\right) (\sigma) \left(\frac{1}{4\pi R_x^2}\right) (A) \text{ watts}$$

The statements of this equation contained in parentheses correspond to the transmitter factor, target factor, reradiation factor and receiver factor, respectively, of the general or bistatic form of the radar equation. In most radar systems however, the same antenna is used for transmitting and receiving. In these, the equation may be simplified by substituting R for R_x. We can also take advantage of the rule of thumb that gain and collecting area are related by

$$G_T = \frac{4\pi A}{\lambda^2}$$

where λ = signal wavelength.

These two modifications give

$$P_R = \frac{P_T \sigma A^2}{4\pi R^4 \lambda^2}$$

By substituting plausible values, we can estimate the detectability of the target.

Doppler Shift Effects

Although the radar equation gives the total power we expect to be returned from a target, it tells us nothing about how that power is distributed in frequency. Because our target is moving relative to Earth, the echo will not appear at the transmitted frequency; in fact, for Venus the echo frequency will not even be constant. Relative motion of Earth and Venus causes a shift, f_D, of

$$\frac{-2V}{\lambda}$$

where V = velocity between the two bodies measured along the Earth-Venus line (see Fig. 1A).

We adopt the convention that negative values of V mean that the two bodies are approaching each other; in this case the echo will be slightly higher in frequency than the transmitted wave (f_D is positive).

In addition to gross planetary motion, we must also include planetary rotation in predicting Doppler shifts. Because Earth spins on its axis, there will be a velocity component either toward or away from Venus of up to 400 m/s, owing to motion of the station resulting from the rotation. When Venus appears to be rising in the eastern sky, the station is moving toward the planet and the echo will be slightly higher in frequency; when Venus appears to be setting, the station is moving away and the frequency will be lower. But Venus also rotates, albeit slowly, so that the response from the approaching part of the planet will be at a higher frequency than the response from the receding part (Fig. 1C). If we transmit a continuous carrier, it will be reflected as a smeared (or broadened) replica of the original because of the different amounts of Doppler shift imparted by various parts of the target.

As if the Doppler shifts and spreadings were not annoying enough, we should also note that they all vary with time. The Doppler *spreading* caused by rotation of Venus does not vary much during the course of a day, but the *shifts* can change drastically. The solar system is on such a large scale that we often forget that the planets are quite literally hurtling through space, by terrestrial standards. For example, on July 1, 1978, Earth was traveling at over 30 km/s. At the same time, Venus was approaching at a relative velocity of more than 12 km/s. Of course we didn't collide because the trajectories of the two planets are ellipses which do not intersect, but Earth and Venus do pass within 40 million kilometers from time to time. In 1978, this "inferior conjunction" occurred on November 9. At conjunction, the Doppler shift passes from positive through zero to negative, and the planets then drift apart. During the 24-hour period around the time of closest approach, the Doppler shifts from gross planetary motion will change by about $1000/\lambda$ Hz; Earth rotation superimposes another $1600/\lambda$-Hz shift between Venus rise and Venus set. The echo, which is only a few hertz wide, can best be detected with the aid of a narrow-bandwidth receiver. However, because the signal is constantly drifting, the passband must be constantly relocated. This combination of narrow bandwidth and accurate tuning is a challenging hardware requirement for today's radio amateur. Let's discuss the implications of these challenges.

Prospects

In this final section we consider the requirements for detecting a Venus echo and match the requirements against capabilities of state-of-the-art equipment. Not all of this equipment is within range of a typical radio amateur's budget. The possibility exists, however, that enough of it could be assembled by a team of technically adept amateurs, and the feat accomplished within a few years. First consider the radar equation. At its closest approach on November 9, Venus was at a distance R of approximately 4.0×10^{10} meters from Earth. From astronomical studies, the radar cross section of Venus is known to be in the neighborhood of 10 percent of its disk area, or $\sigma = 10^{13}$ m^2 (the radius of Venus is about 6100 km). If we have a parabolic antenna 10 m in diameter, this gives us a geometrical area of about 80 m^2. Taking an efficiency factor of 50 percent, we're left with 40 m^2 for reception. The gain-to-area rule of thumb translates this to 45 dB gain at 2300 MHz. If we assume the transmitter final amplifier power input is 1000 watts and its efficiency is also 50 percent, $P_T = 500$ watts. From these values the radar equation allows us to compute the expected received power,

$$P_R = \frac{(500)\,(10^{13})\,(40)^2}{4\pi\ (4.0 \times 10^{10})^4\ (0.13)^2}$$

$$= 1.5 \times 10^{-23} \text{ watts}$$

Because Venus rotates, this power is spread over approximately 4 Hz under typical conditions, leaving us with 4.0×10^{-24} watts/Hz power density in the received spectrum. This isn't much, but under good conditions it might be distinguished from the background noise.

Noise power which appears at the output of a receiver system arises from two principal sources. First are the natural emissions of the target and of the deep-space background. Venus has a surface temperature on the order of 800°K (1000°F), which makes it an important source of microwave energy. The planet occupies such a small portion of the beamwidth of the 10-meter-diameter antenna, however, that its radiation is effectively lost in the much colder background and it may be neglected here. When Venus is closest to Earth, it will be viewed against a background of maximum solar radiation, however, decreasing the possibilities for success of this experiment. Observations earlier or later than inferior conjunction will move the planet away from the sun and result in less solar noise but at the cost of increased range, which enters the radar equation as R^4. The critical factors for determining optimum observation dates will be the beam pattern and distribution of solar noise across the sky. These can be obtained on a station-by-station basis and the results evaluated in terms of the EVE problem. For the remainder of this article we will assume that solar noise is not a problem. In practice, however, the probability for detection based on the conditions given here would have to be reduced somewhat.

The second source of noise is the receiving system itself, and for 2300-MHz work is more important than natural noise. Microwave maser front ends are capable of equivalent noise temperatures less than 25°K; we will assume that the receiver available for amateur work is not quite this good — say T = 50°K, which corresponds to a noise figure of about 0.7 dB. The noise power, P_N, produced can then be computed from the simple equation

$$P_N = kTB$$

where k = Boltzmann's constant
(1.38×10^{-23}) watt-seconds/°K
B = receiving system bandwidth

For the sake of simplicity, we will keep things on a per-unit bandwidth basis and set B = 1 Hz. The 50°K system then has a noise-power density of about 7.0×10^{-22} W/Hz, or about 175 times that of our hypothetical echo! Readers who have trouble reading S5 signals on 40 meters may detect a problem lurking here.

This is where the story of the Doppler drifts comes in. It is possible to take recordings of a large number of signals buried in noise and average them together to improve overall signal to noise ratio, if the signal is the same in each case. This may be done in either the time or frequency domain. Since we are already working with W/Hz, we'll continue to use the latter and assume that some kind of spectrum analyzer is available to be attached to the receiver output. If the noise characteristics of each echo are the same (in a probabilistic sense), the random fluctuations will tend to cancel out when they are averaged, and the deterministic components of the signal will begin to peak through. Probability theory tells us that if N is the number of averages performed, the random fluctuations die out as $\sqrt{N}$. If we want our Venus echo to have approximately a 50-percent chance of being detected in the noise, we must boost its prominence by a factor of about 175, or average together about 30,000 signals. If we obtain one spectrum each second from the analyzer, over eight hours of data are required. Under normal circumstances, several days would be needed to accumulate this much data.

Over an eight-hour period, the echo will have drifted a considerable amount, so it is important that tuning to compensate for Doppler shifts be accurate. Otherwise, the echoes will be averaged with noise, instead of with each other. The easiest solution to the tuning problem is to use a programmable local oscillator in the receiver; its frequency could be controlled by a small computer operating on predictions available from any number of sources. The computer might also be able to handle the spectral analysis and averaging, leaving the operator to monitor and control the transmitter and antenna.

This combination of 10-meter-diameter parabolas, kilowatt 2300-MHz transmitters, narrowband receivers with 50°K equivalent noise temperatures, and small computers operating programmable local oscillators is not to be found in every ham's garage. Receiver front-end components with noise figures in the 1.5-dB range are available in the $100 price class and single-digital ICs are obtainable to perform the spectral analysis. The practical problems associated with signal detection, such as insuring that both transmitter and receiver frequencies are accurate to at least 1 Hz over periods of several days, are imposing enough that even the equipment described here would probably be insufficient to obtain echo detection. It is likely that those who obtain the first echoes from Venus will find short cuts through the radar-equation calculations given in this article — using a shorter wavelength might have some advantage, for example. Use of a larger antenna would lead to an immediate improvement in signal-to-noise ratio. Though the task will never be easy, there are now individuals in the amateur ranks with the necessary expertise to work EVE. The prospects for two-way communication (with exchange of signal reports) are quite discouraging, but successful detection of the echo itself sometime in the not-too-distant future should not come as a complete surprise.

Acknowledgements

The helpful suggestions supplied by W1XZ, W6HD, K6HWJ and WA6VBA during preparation of this article were appreciated.

Strays

***QST* congratulates . . .**

☐ Ronnie Milsap, WB4KCG, who received the coveted Best Country Western Album of the Year award for his latest one, "It Was Almost Like a Song." Last year Ronnie was recognized for having earned the titles of Entertainer of the Year, Best Single Recording, Best Album and Best Male Vocalist in the country western area.

An Inexpensive Multiband VHF Antenna

A low-cost discone antenna, usable on 144, 220 and 420 MHz.

By David Geiser,* WA2ANU

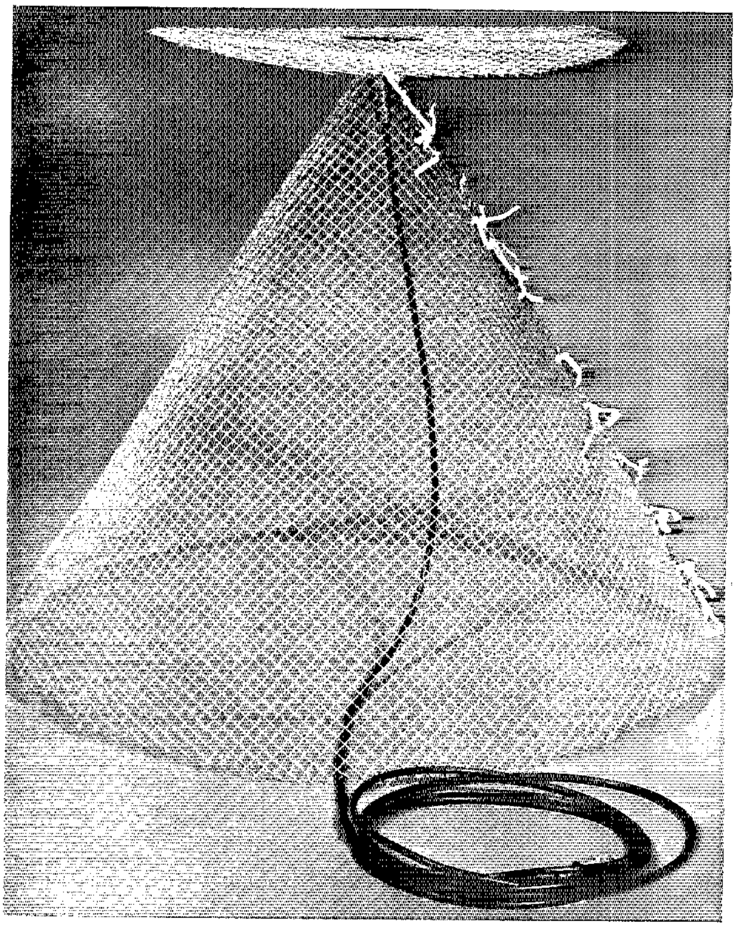
When I brought my new 2-meter transceiver home, I wanted to get on the air quickly to try it out. Needing an antenna, I tried a quarter-wavelength rod. It worked, but after a few contacts I began to worry about high SWR and the effect it might have on the transmitter PA transistor. Remembering some work I'd done several years ago, I decided to build a disc-cone, or discone antenna. While my antenna was made cheaply and simply, and intended for installation in the attic, I've given some hints to help you ruggedize your discone for outdoor mounting. If you think you might want to use a single vhf antenna on more than one band, or if you just want to try something different, you may decide to build a discone, too.

How It Works

The discone antenna functions as a wide-bandwidth, impedance-matching transformer, coupling a low-impedance transmission line to the higher impedance of free space. In the process, it radiates with a pattern similar to that of a quarter-wavelength vertical antenna above a groundplane. Waves form at the feed point (cone apex) and travel on the antenna surface to the edges of the cone and disk. The dimensions and geometry of the antenna are chosen so as to make the impedance at the edges similar to that of free space. We know that maximum energy transfer occurs when impedances are matched, so the antenna radiates. A discone antenna acts like a high-pass filter. Below some cutoff frequency, the SWR will increase rapidly. Above this frequency, the antenna SWR remains low up to a maximum of 10 times the cutoff value, depending on the design

*RD 2, Box 787, Snowden Hill Rd., New Hartford, NY 13413

A completed discone antenna suitable for use on the 144-, 220- and 420-MHz bands. This antenna wouldn't last long in the outdoors, but is fine for indoor use. For outside installation a more robust construction is required.



proportions. The unit described here shows less than 2:1 SWR from 140 to 450 MHz. At 1300 MHz, the SWR measured 5:1. Fig. 1 gives dimensional information for the antenna. The slant height and diameter of the cone are the same, about 110 percent of a quarter wavelength at the lowest operating frequency. Diameter of the disk is about 66 percent of a quarter wavelength.

Construction

At first I planned to use roofing copper to build the antenna, but quickly dropped that idea when I found that material would cost nearly $30. I spotted a roll of hardware cloth, sometimes called "chicken wire," and decided to use that instead. It cost less than $5 for a five-foot-long piece of two-foot-wide (1.5 × 0.6-m) material. The galvanized-steel wire that makes up the hardware cloth is spaced 1/4 inch (approximately 6 mm).

Cutting information for the discone may be ascertained from Fig. 1. A felt-tip marking pen is useful for drawing a pattern on the hardware cloth. Forming the cone may require some help. Leather-palmed gloves will protect your hands from the sharp ends of the wire. While my wife held the cone in position, I used bread-wrapper ties to hold the edges together. To make sure it stayed in place, I soldered the seam in a few locations. This was only for mechanical reasons — current flows down the cone, not around it, so electrical continuity isn't required. I found it easier to use the bread-wrapper ties if I formed them into the shape of a J, pushed the bent end through from the outside, then pulled it back out so that the loop formed around the wire. After the seam is soldered, the ties should be removed.

A 1 × 3-inch (25 × 76-mm) piece of sheet copper is supported by the SO-239 connector, and is soldered to the disk. The connector is soldered to the cone with its threaded end pointed down. The disk is supported about 1/2 inch (12 mm) above the cone.

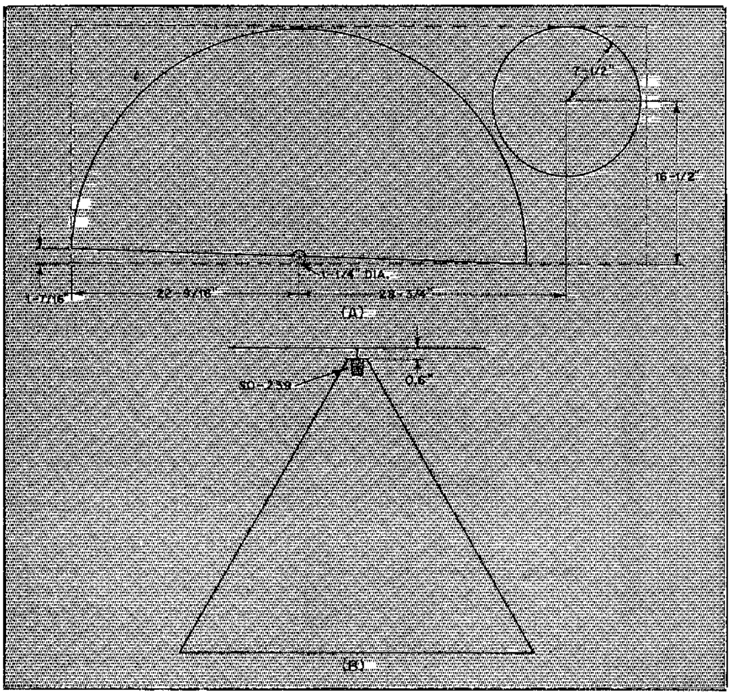


Fig. 1 — At A, cutting dimensions for the 140- to 450-MHz discone. At B, placement of the disk above the cone. Dimensions given may be scaled for other frequencies. Inches × 25.4 = mm.

It Works!

Naturally, as soon as I'd finished building the discone I placed it on a table, hooked up the rig and tried it out. From my rural location I could key three repeaters (it helps to live on a hill). The next day I took the antenna to work and measured its SWR in the lab. At 146 MHz it measured 1.6:1, rising to only 2:1 at 440 MHz. That night I took the antenna home and installed it in my attic. Now that it's up higher and above the aluminum siding, it works very well. The lower edge of the cone is at the same potential all the way around, allowing the antenna to be mounted on a metal surface, although this will change the radiation pattern somewhat. A support mast that extends into the cone will have little effect on the antenna performance. Lower frequency discones may be built using a number of individual wires to make the cone and disk. The disk may be approximated with metal rods if desired. If necessary, thin, nonconductive insulators may be used to support the disk.

Strays

QST congratulates . . .

☐ Phil Goetz, N6ZZ (ex-W6DQX), who has been promoted to methods and procedures manager of the Transamerica Insurance Group, Los Angeles.

OOTC PRESIDENT

☐ Ray Meyers, W6MLZ, former Southwestern Division director, assumed duties as president of the Old Old-Timers Club recently, as Col. Fred Elser, KH6CZ, resigned to pursue a doctoral degree at the University of Hawaii at Manoa.

I would like to get in touch with . . .

☐ judges who are radio amateurs, especially other federal judges. J. Foy Guin, Jr., W4RLS, 354 Federal Courthouse, Birmingham, AL 35203.

SOCAL FAST SCAN

☐ Southern California amateurs who are interested in uhf ATV may obtain information from the Southern California ATV Club, c/o John Ruckert, WB6ZPN, Secretary, 953 S. Beacon Ave., Los Angeles, CA 90015, or call the club station, WA6EVQ, on 146.43 MHz.

ROBERT E. FOX, WA6TXI

☐ Among those involved in the September 25 midair collision over San Diego was the PSA copilot, Robert E. Fox, WA6TXI. Licensed as a General since 1973, he had lived in nearby La Mesa.

KA6-TO-KA6 TRANSPACIFIC

☐ KA6AKF/California and KA6DX/Okinawa report what they believe to be the first KA6-to-KA6 QSO across the Pacific.

Product Review

ICOM IC-211 Multimode 144-MHz Transceiver

Think ham radio is expensive? On the contrary, a good argument can be made that amateur gear is reasonably priced and is getting more reasonable all the time, at least as a long-term trend. Consider this: Back in 1961, when the ham population on 2-meter a-m reached its peak, the standard of comparison for self-contained 144-MHz rigs was the Gonset Communicator IV. According to the *QST* review published in that year, for $375 the purchaser of a fourth-generation Communicator got a 20-watt input a-m transmitter with six crystal-controlled frequencies, a tunable a-m receiver covering the entire band, and a self-contained ac/dc power supply. Thousands of hams who were using earlier "Gooney Boxes" and "Benton Harbor lunch boxes" (Heath Twoers) must have drooled over the features of this little beauty.

There's no need to dwell on what the ensuing years have done to the Consumer Price Index, except to say that for today's equivalent of 375 1961-dollars you can select one of several multimode 2-meter rigs having features undreamed of in that year. The one that probably best illustrates our point — that your Amateur Radio dollar buys a lot more these days — is the ICOM IC-211. This handsome black and gray box sports capabilities which were simply inconceivable in the days before manned space flight and large-scale integrated circuits. The IC-211 will not operate on a-m; but that's about all it won't do. This is a reflection of the changes in mode preference on the band, not of the capabilities of the ICOM engineers.

The key word in any description of the IC-211 is *versatility*. It's equally at home on the local repeater (regardless of what "split" is being used), on OSCAR, chasing DX or ragchewing on ssb/cw at the low end. The heart of this versatility is found behind the VFO tuning knob. Here reside not one, but two VFOs, controlled by a common knob, yet capable of completely independent operation. For normal repeater operation, one VFO can be programmed to track the other, 600 kHz away. If you encounter an oddball split — something other than 600 kHz — just uncouple the VFOs. A front-panel switch reverses the transmit and receive frequencies instantaneously, so you can monitor the repeater input frequency or go from a "low-in" to a "high-in" repeater. The two VFOs also permit you to select one of two calling frequencies on ssb without touching the tuning knob. On fm (and on any mode above 146 MHz) the VFOs tune in 5-kHz steps; on ssb and cw below 146 MHz, in 100-Hz steps. A push button near the tuning knob overrides the 100-Hz step tuning if you want to go to the other end of the band in a hurry; another push button locks the frequency so it won't change if the knob is accidentally bumped. The accuracy of the frequency readout appears to be extremely good; comparisons with several other IC-211s never resulted in as much as a 1-kHz discrepancy.

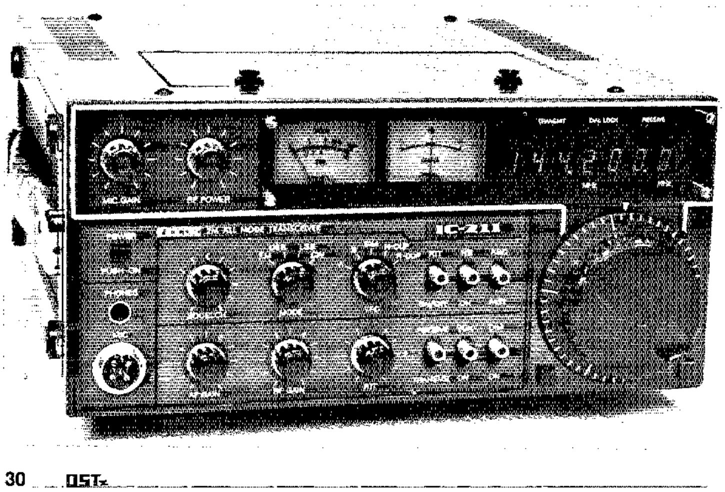
The tuning knob itself has two different degrees of "drag" that are automatically selected, depending on how fast the knob is being spun. At normal tuning speeds there is enough resistance to give "feel" to the knob, but if you want to QSY in a hurry, a faster spin on the knob releases an electrical brake and allows the knob to freewheel with a minimum of resistance.

In addition to the features you might expect to find in a 2-meter multimode transceiver in this price range, the IC-211 has separate signal strength and discriminator meters, selectable agc (fast or slow), a front-panel control to adjust fm power output for anything from 1 to 10 watts, a built-in SWR indicator, separate delay controls for cw and VOX operation, and some limited — but nonetheless impressive — ability to be controlled remotely. The last of these is worth special mention. What ICOM has done is to provide access to the frequency-control LSI through a rear panel connector. Ingenious amateurs already have used this feature to good advantage in such applications as mountaintop installations of "remote bases" and the like.

For operating from a fixed-station location, the IC-211 leaves little to be desired. An ac supply is built in. For mobile operation, however, its versatility actually becomes something of a disadvantage. Unlike a set of click-stop switches, the continuous-tuning knob that controls the frequency gives no clue as to where you are in the band unless you take your eyes off the road to look at the digital readout display — a display that is not easy to read in bright sunlight. There are enough other controls and switches on the front panel to cause confusion if you're reaching for the squelch or audio gain without looking down. The SWR-protection circuitry can cause some strange effects on ssb when the rig is operating into an antenna with a high SWR, as sometimes encountered in mobile operation. If you remove the rig from its source of power, such as to stow it in the trunk when parked, the programming of the VFOs is erased and you have to start all over again — a job that takes only a few seconds, but which is still an annoyance. While the IC-211 is very compact, considering all of its features, it is substantially larger and heavier than the average fm rig. If your mobile operating is limited to occasional forays, the IC-211 will fill this need, but you're more likely to consider it for fixed-station operation than for regular mobile use.

Chances are, if you are interested in

Front-panel view of the ICOM IC-211 144-MHz multimode transceiver.

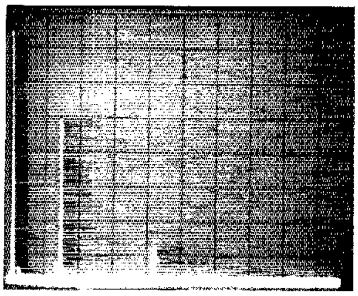


ICOM IC-211 Specifications

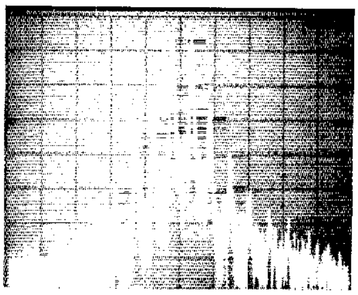
	Claimed by manufacturer	*Measured in ARRL lab*
Power output (minimum, 144-148 MHz):	10 watts.	15 watts.
Spurious radiation	Better than −60 dB.	Better than −66 dB (third harmonic)
Maximum current drain @ 13.8 V:	3.3 A (tx). 1.1 A (rx).	3.0 A. 1.2 A.
Receiver sensitivity (ssb):	0.5 microvolt for 10 dB S+N/N.	0.14 microvolt for 10 dB S+N/N.

Size (HWD): 4-3/8 × 9-1/2 × 10-3/8 inches (111 × 241 × 264 mm) exclusive of knobs, connectors, and feet.
Weight: 15 pounds (6.8 kg).
Price class: $850.

Importer: ICOM West, Inc., Suite 3, 13256 Northrup Way, Bellevue, WA 98005.



Spectral display of the IC-211 transmitted signal at 15 watts output on 146.52 MHz. The vertical axis is calibrated in steps of 10 dB per division; horizontal scale is 100 MHz per division. The large pip at the far left edge of the display is generated internally by the analyzer. The fundamental shown here was attenuated approximately 30 dB by a two-cavity notch filter to prevent overload distortion in the analyzer. The most significant spurious output, at 439 MHz, is down approximately 66 dB with respect to the unnotched fundamental. Other spurious outputs are all down at least 75 dB. The IC-211 complies with the FCC regulations regarding spurious emissions.



The IC-211 output during a two-tone IMD test. The horizontal scale is 2 kHz per division; vertical scale is 10 dB per division. Third-order distortion products are down approximately 28 dB from the PEP output. Individual tone outputs are down 6 dB from the PEP output.

investing this much money in a 2-meter rig you intend to do something more than just key up local repeaters. Operation on cw and ssb with the IC-211 is very much like what it would be on hf with a similar transceiver. The 100-Hz step tuning is not too difficult to get used to, and the receiver incremental tuning (RIT) can be used for fine adjustments of the receive frequency. (Incidentally, the RIT goes off automatically whenever the main tuning knob is turned.) For cw and ssb operation, a transceiver such as the IC-211 has a couple of disadvantages when compared with an hf transceiver and transverter. For one, there is no provision for a cw filter. For another, receiver noise figure (sensitivity) likely will not be as good as can be obtained with a high-quality converter. Finally, there is no provision for actuating an external amplifier; if you want to boost your power, you will have to use an additional switch or an rf-sensing circuit. On the other hand, for many operators these disadvantages are more than outweighed by the desirability of having a complete station in one small, independent, attractive package. This reviewer caught his first-ever 2-meter Es opening because the IC-211 happened to be tuned to the new ssb calling frequency of 144.2 MHz on a Saturday morning. The main station was tuned up on hf at the time, since everybody *knows* nothing is happening on 2 meters at that hour. Four stations in Florida were worked as a result, including one who was using a barefoot IC-211 and an indoor antenna! — *David Sumner, K1ZZ*

ALDA 103 HF TRANSCEIVER AND PS-130 POWER SUPPLY

There is a trend today toward solid-state hf-band transceivers. In general, they're smaller, lighter and easier to operate than their tubed counterparts, the most obvious convenience being no-tuneup operation. The Alda 103 is a fully solid-state newcomer to this area.

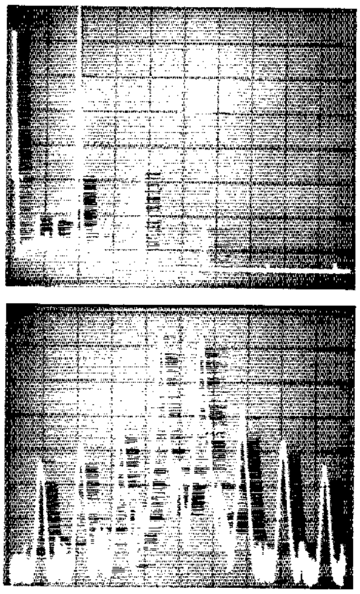
The '103 offers up to 250 watts input on cw or ssb with a power requirement of 13.8 V dc at 15 A. Cw operation is semi break-in. The power level is adjustable from the front panel; the operator can have any level he wishes, from QRP to full output.

The broadband final amplifier stage, cooled by a large heat sink, gives reasonable power output even with a mismatched load. Approximately 80 watts output has been measured at this writer's QTH with an SWR level of approximately 3:1. Also, the PA is completely protected against transistor failure due to excessive SWR. I encountered an open-circuit condition temporarily with full output applied: No damage occurred! It was discovered that the manufacturer regularly demonstrates this feature at conventions by operating the '103 on, and then off a dummy load! The unit has a sidetone that is adjustable for a comfortable level via the audio-gain control. Ssb operation is by means of push-to-talk only, as no VOX is available on this transceiver. Alc is built-in, so the microphone gain is not particularly critical except under conditions of high background noise. Band coverage on 80/75 meters goes up to 4050 kHz, making the '103 suitable for MARS use, and additional coverage is provided up to 7500 and 14,500 kHz.

Cw operation is afforded by tone modulation of the ssb transmitter, using audio from the sidetone oscillator — approximately a 1000-Hz note. The initial tests with the spectrum analyzer showed a pair of discrete spurs (related to this oscillator) about 35 dB down with respect to the carrier. The manufacturer was informed of this, and adjustment instructions were promptly sent to correct the difficulty. There have been no further problems, and the unit meets current FCC requirements for spectral purity of emissions.

The receiver section of the Alda 103 is impressive for such a small rig. RIT, often standard on more elaborate hf transceivers, is also incorporated in the Alda. It is effective for minimizing QRM in crowded bands. Frequency readout resolution is to 5 kHz on 80 meters, and to 10 kHz on 40 and 20. The dial drive is a two-speed device: The user tunes past the desired signal at a 6:1 ratio, then can back up at a much slower 30:1 ratio — more than adequate for careful tuning, even during mobile use.

Two options worth noting were included in the review unit: a noise blanker and a two-position crystal calibrator. The blanker has



The Alda 103 transmitter output as displayed on a spectrum analyzer. The photos were both taken with the '103 operating at full rated input power. In the top picture, the operating frequency was 3.9 MHz. The vertical axis is calibrated in steps of 10 dB per division; the horizontal scale is 2 MHz per division. The large pip at the far left edge of the display is generated internally by the analyzer. The fundamental is shown here full scale, and the most significant spurious output, at 7.8 MHz, is down approximately 46 dB with respect to the fundamental. All other spurious outputs are down at least 60 dB. The Alda 103 complies with FCC regulations regarding spurious emissions. For the bottom photo, the Alda was operated at 7 MHz during a two-tone IMD test. The vertical scale is 10 dB per division; the horizontal scale is 1 kHz per division. Third-order distortion products are down approximately 30 dB from the PEP output. Individual tone outputs are down 6 dB from the PEP output.

Alda 103 Transceiver

Frequency range: 3.5- to 14.35-MHz amateur bands.
Modes: Cw, lsb and usb.
Maximum power input: 250 W PEP, ssb; 250 W, cw.
VFO stability: Less than 100 Hz/hour drift from cold start to approx. one hour later, at 25°F to 65°F (3°C to 18°C).
Sensitivity: Approx. 0.5 watt audio output for 0.5-μV input.
Selectivity at −6 dB: 2.5 kHz, ssb or cw.
Audio output: Approx. 3 watts at 8 ohms.
Power requirement: 13.8 V dc at 15 A, nominal, negative ground.
Dimensions (HWD): 3.25 × 9 × 12.5 inches (83 × 229 × 317 mm). Weight, 8-1/4 pounds (3.66 kg).
Color: Two-tone gray with brushed aluminum front panel.
Price class: $500, transceiver only. 30-A supply, $150.
Available options: Noise blanker; 100/25 kHz crystal calibrator; 15-A unregulated power supply; 30-A regulated supply.
Manufacturer: Alda Communications, Inc., 215 Via El Centro, Oceanside, CA 92054.

The Alda 103 and its optional 30-A supply, the PS-130. The dial on the '103 is available in Braille for the blind ham.

been quite effective in reducing ignition-pulse interference, and this writer's car has a particularly noisy ignition system! I'm fairly sure that the pulse noise could have been eliminated if some basic ignition shielding had been employed. However, an effective noise blanker makes one lax about taking care of this type of problem at its source. The optional calibrator has ample output; it is heard easily amongst the outside signals. The 10-kHz setting is particularly convenient. The "dial set," used in conjunction with the calibrator, rather than the usual mechanical type, is a variable capacitor in the VFO circuit. Reducing the rf gain was particularly effective in helping to separate strong stations from weaker ones, indicating some tendency toward strong-signal overloading. This was especially noticeable when the '103 was used with the audio gain "up full" under noisy mobile operating conditions.

A six-pole crystal filter provides good selectivity, and the 3 watts of audio output are more than enough for home or car use. VFO stability is good, appearing to have less drift than the 100 Hz per hour claimed by the manufacturer — even from a cold (25°F/−4°C) start in a car. The S/rf meter, although not damped for smooth readings during ssb operation, nevertheless gives adequate relative signal-strength readings.

Operating Impressions

This writer has found the Alda 103 to be a versatile and easy rig to operate. Having been used to tube-type rigs, I found that this solid-state, broadband, "no-tune" unit to be convenient, indeed. Excellent audio reports have been received from all stations contacted on ssb, and cw QSOs have yielded reports of clean, crisp keying. Mobile operation, which requires little space with this rig, has been an enjoyable experience; the combination of noise blanker, slow tuning feature, and rf-gain control make signal reception fairly simple. The Alda has more than adequate power to drive modern linear amplifiers: The writer's SB-220 mated very well with the '103 during the evaluation test period. There is one area that might distress some who are used to 1-kHz readouts: The Alda has, as mentioned previously, 5-kHz readout at best. It seems to be adequate, though, and really is a convenience in mobile operation, especially the wide dial pointer, which is very readable. Important! Alda has available at no charge a full Braille dial for the '103. Hats off to the manufacturer! This is just the sort of step we'd like to see other amateur-gear manufacturers take.

The power supply, model PS-130, is a husky piece of gear, indeed. It is rated at 12 volts at up to 30 A continuous duty. It has a 20 percent overload safety factor, so there's plenty of power to run the Alda 103, with room to spare! A smaller, unregulated 15-A supply is available as well. Zener-diode regulation is built into the transceiver, so a fully regulated power supply is not a necessity.

The Alda 103 transceiver is manufactured by Alda Communications, Inc., 215 Via El Centro, Oceanside, CA 92054. Price class for the '103 is $500, and for the PS-130 is $150. — *Sandy Gerli, AC1Y*

DAYTRONICS MIMIC PROGRAMMABLE MEMORY KEYER

If the prices of some commercial memory keyers have kept you from trying this nifty type of sending device, maybe you should consider a kit version. The MIMIC, by Daytronics, is a four-memory, programmable keyer that sells for about $80 in kit form, and can be assembled easily in one evening by most hams who have building experience.

The low price is aided through the elimination of a few controls. The MIMIC contains no volume or pitch control for its built-in sidetone oscillator. Also deleted is a weighting control. A repeat feature can be added to the keyer, however, by connecting a switch and two wires to the terminals provided on the printed circuit board.

Construction

All components for the MIMIC — except for the voltage regulator, speed adjustment potentiometer, a couple of jacks, eight push buttons and two LEDs — are mounted on one double-sided, plated-through, G-10 epoxy pc board. Soldering the 18 ICs and various other parts on the board doesn't take much time, but the finished board must then be connected to the switches, jacks and other controls. This requires soldering both ends of about a dozen 24-gauge wires. It takes a while, but when all the leads are dressed neatly against the board, the insides of the MIMIC look uncluttered.

A step-by-step set of directions is provided by Daytronics. Most builders' questions have been anticipated and answered in the literature. When the keyer kit was completed and the unit was turned on, it "played" the first time.

However, two problems were observed: First, the keyer sidetone seemed to "pull," decreasing just slightly in pitch as a string of dits was sent, and would then return to its normal pitch on the last bit after the paddle lever was released. A number of paddles were tried, and the problem remained. A quick call to the manufacturer revealed that the problem we were experiencing was due to a poor ground path on the keyer board. A wire was added in a location indicated by Daytronics, and the problem disappeared. The manufacturer informed us that this "hint" would be included in the instructions provided with future MIMIC kits sold.

The second problem involves the MIMIC's tendency to make a leading dit (when first starting to send a charcter) longer in length than those following it. The difference in length is slight, and in fact was not noticed at first until pointed out by a good friend, W1JA. According to the manufacturer, this is because the MIMIC's triggered clock does not run continuously, thus running only when characters are being sent. This makes the first dit sent slightly longer. There seems no way to correct this except to replace a 7413 IC — Daytronics provides these free of charge when necessary. This problem doesn't seriously affect operation of the keyer, however, and is difficult to notice unless you are listening for it.

Operation

Operation of the MIMIC is similar to that of most other memory keyers in many respects, although a number of differences do exist. The MIMIC is an iambic keyer providing either negative (for grid-block keyed rigs) or positive (for cathode-keyed or solid-state final rigs) keying. It has both dit and dah paddle memories, self-completing characters, automatic letter and word spacing, and automatic weighing.

Four 512-bit memories can be programmed, played back, erased, and so on, *all from the front panel.* (Each can contain 256 dits or dahs.) Eight push-button switches control all functions associated with the memory operation except for REPEAT, which is turned on by an optional switch located on the rear panel if desired. The buttons on the front panel select the desired memory, access the memory for "writing" or storing information, and SEND or play back the contents in a particular memory.

To record a message, press the memory number you wish to use. After the "write" button is pressed, an LED lights telling you the memory is set for recording. The message is then keyed in with a paddle, just as if you were sending "live." The triggered clock helps here, because it allows much more margin for operator error without causing a mistake to be recorded.

When the halfway mark is approached in each memory, the sidetone shifts lower in pitch to let you know you've used half of the total memory space or 256 bits. Although this is a nice feature, it takes a little getting used to. The first few times the sidetone jumped pitch, I made errors and had to start over, especially if I was going pretty fast to begin with. The dual-pitch sidetone functions in the playback mode also, letting you know how much message is yet to be sent.

At the end of a recorded message, the END button is pressed. This releases the clock, letting it run out the rest of the unused memory bits placing spaces or blanks in them. (Since the MIMIC uses a triggered clock, when you stop sending the memory will not automatically continue spacing itself — eating up memory — but will insert a maximum of three spaces and mark time until you resume sending or push the END button.)

Unlike some programmable keyers, with the MIMIC you can rerecord or edit the tail end of a message if it is incorrect without disturbing the rest of the message. For instance, if the message "now is the time for all good *med* to . . ." was sent in, you could stop the recording, hit the END button, let the memory light go out, and then play back the message to the point just before the error ("med") occurred. At the end of "good," simply hit the WRITE button, and anything else keyed in after that erases what was already in those memory bits. Therefore, if you want to store fairly long messages, and you're the type who gets nervous (and sloppy) when you know you're being recorded, this feature will allow you to correct your mistakes more easily.

As with most memory keyers, the MIMIC will stop sending from memory whenever you hit the RESET button or tap the dit side of the paddle. When the keyer is in the REPEAT mode, however, the message cannot be stopped by these means. If a programmed message that is being played back is stopped by tapping the paddle, the memory is not reset to the beginning, thus allowing you to insert an RST or serial number and continue with the rest of the message by pressing the SEND button again. To reset a memory to the beginning after stopping a message part way through, simply press the RESET button.

An interesting feature of the speed control on the MIMIC is that it also functions as a tune switch, depending on the exact setting. With the potentiometer at full counterclockwise setting — just clockwise from the off position, or about 9 o'clock — if the paddle is tapped the keyer locks up, sending a continuous note for tune-ups, or other functions. To unlock, you simply increase the setting to 11 o'clock (or farther clockwise), as which point the keyer shuts off and is ready to run at 5 wpm or more. The MIMIC is capable of sending at speeds from 5 to more than 60 words per minute.

Daytronics MIMIC Programmable Memory Keyer

Speeds: 5 to 60 wpm.
Keying: Transistorized; grid block (negative) or cathode/solid-state (positive). Will key up to 60 volts at 600 mA. (250 volts at 1 A with optional 2N3440 transistor — $1.75.)
Memory: Four 512-bit memories, each individually accessible.
Features: Dot and dash memories, automatic weighting, automatic spacing, built-in sidetone monitor, iambic compatible.
Power requirements: 117 V ac (with wall plug), or 8-15 V dc (400 mA at 12 V dc).
Size (HWD): 2-1/2 × 4 × 6 inches (64 × 101 × 152 mm).
Weight: 1 lb (0.45 kg) with wall-plug transformer.
Price class: $80 in kit form, $100 wired and tested.
Manufacturer: Daytronics Co., P. O. Box 426, Selden, NY 11785.
Optional features: Repeat switch, straight-key jack.
Warranty: 90 days parts and labor (limited).

The Daytronics MIMIC programmable memory keyer with triggered clock.

The MIMIC power supply arrangement is a convenient one, consisting of a full-wave bridge rectifier and dc regulator circuit inside the keyer and an external wall-plug transformer with 12-volt output. The two power supply leads going to the MIMIC can be attached to the screw terminals on the wall transformer, or connected directly to a dc power supply to provide from 8 to 15 volts. Polarity of the power leads is not critical, since a bridge rectifier is used inside. Thus, the keyer is protected against improper connection of the power supply leads.

The cabinet is an all-metal LMB enclosure with a two-tone (blue and white) paint job. Four rubber stick-on feet keep the keyer from scratching or sliding across tabletops. A two-circuit, 1/4-inch (6.3-mm) phone jack is used to accept keying input from any squeeze-type paddle, and the transmitter keying output is through an RCA-type phono jack.

As a final note of interest, Daytronics has done a considerable amount of rf bypassing inside the MIMIC cabinet. During operation on the 80- through 10-meter bands at power levels up to 1000 watts input, no rf-related problems were encountered. — *Jim Bartlett, K1TX*

THE HAMCO SCOTIA PADDLE

When the original W8FYO paddle appeared on the market more than 15 years ago, a few lucky souls managed to get their hands on one of these jewels. Several years ago, HAL Communications came out with their double-levered version of the "FYO" paddle that was compatible with iambic keyers. In addition to the fact that HAL has since ceased production of their paddle, another problem faces the prospective buyer of such a paddle, if he can find one — it has a tendency to "fly apart at the handle," if you will, whenever it is knocked a bit hard in the wrong direction. (I've had to go hunting for the spring on hands and knees several times after such an experience.)

Recently, several new versions of W8FYO's paddle hit the amateur market. One is manufactured by HAMCO of California. A small outfit, HAMCO purchased all inventory, jigs and rights from HAL, and after a considerable amount of design work, came up with a *new* double-paddle version they christened the Scotia.

When the box is opened, your immediate reaction is a soul-satisfying "Ahhh!" A combination of brush-finished solid brass and polished hardwood, the Scotia is definitely a fine piece of workmanship. This paddle is so aesthetically pleasing that you shouldn't mind placing it next to anything else in the house (although it might make your old boat anchors seem inadequate). Stability is the next obvious plus. At just under two pounds (1 kg), the Scotia is heavy to say the least. Even the most "jack-hammer" operator will find *this* paddle stays put. Three broad, low-profile, rubber feet also play an important role in keeping the Scotia in place.

All three variables are adjustable to match the most finicky ham's taste. Two sizes of Allen wrenches and a small screwdriver are required — not supplied by HAMCO. Paddle width can be set from extra wide to almost touching. The contacts, which are solid silver, by the way, can be adjusted from the point where they actually touch to any gap desired.

Finally, we come to tension. By now you've probably noticed the absence of springs on the Scotia. Instead of a spring which might wear out, become stretched by little fingers, or otherwise be placed out of commission, HAMCO has utilized a unique *magnetic* tension system. Each of the paddle arms has a strong, permanent bar magnet behind it providing the constant pull necessary to keep each set of contacts separated. The magnets slide forward and backward in their slots providing a wide range of tension at the paddle tips. Once the optimum tension is reached, the magnets can be secured with Allen-head setscrews that press down from the top. There is absolutely no way to derail the Scotia's paddle levers, and each lever can be adjusted for a different tension.

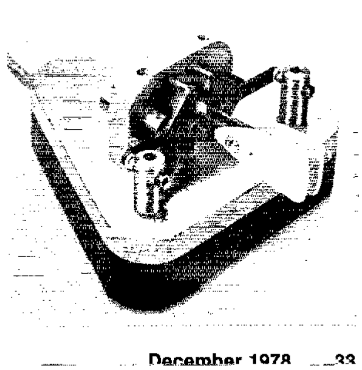
HAMCO thoughtfully includes an attached length of two-conductor shielded cable and a two-circuit, 1/4-inch phone plug. The plug is not attached to the wire, thus allowing you to wire to match your keyer, and select left- or right-hand operation. All connections between the cable and contact points are made *inside* the paddle base, leaving no exposed connections or wires underneath the paddle.

As with a toothbrush, a paddle or key and its *feel* are things which can be very personal, and agreeing on the "ideal" setting may be subjective to say the least. However, I can't imagine anyone not being able to set the Scotia to his individual taste. HAMCO does ship the Scotia with reasonable preset adjustments. Only slight changes were necessary to make mine play the way I wanted it to.

The Scotia's paddle tips are made from ABS plastic, the same material used in telephones. (ABS should not chip or crack, probably the reason HAMCO selected it.)

The final note of pleasure is the warranty.

The Scotia paddle is a handsome combination of brass and hardwood. A total of five separate adjustments make the unit easy to adapt to individual operator preferences.



HAMCO provides the original owner with an *unlimited lifetime* warranty on the Scotia. They say that means "If it breaks, we fix it."

The Scotia is manufactured by HAMCO, P. O. Box 3042, Eureka, CA 95501. Price class: $55, plus shipping. Other available models similar in design to the Scotia, are the Trinidad (engine-turned finish on brass) at $65, and the Carson (hand-polished smooth-brass finish, with personalized call- or name-plate) at $75. — *Jim Bartlett, K1TX*

RIW 432-19 19-ELEMENT 432-MHz YAGI

K2RIW's 432-MHz Yagis are well-known to most vhfers. In the past, however, these antennas had to be built by hand, as none were available commercially. For you who were waiting for the day when you could go out and buy one of Dick Knadle's antennas, here it is: the RIW Products 432-19.

Last May, we received a long cardboard tube from George Flanagan, W2KRN, the manufacturer of these antennas. George is a mechanical engineer, and he said he had worked with Dick, using Dick's original specifications, to come up with a commercial version that would be durable, easy to assemble, and a good performer.

"Yipes," I thought. "This guy's taken an antenna that has been proven to be a winner, and changed it around to make it easier to manufacture! Sure hope he knows what he's doing." Well, it didn't take too long to convince myself that George *did* in fact know what he was doing. That night, with the help of a well-written and generously illustrated set of instructions, I had the antenna put together in just under an hour. The next morning, the 19-element array took the top spot on my mast as a weather-beaten 15-element quagi was gingerly lowered to the ground. Now we'd find out how the antenna *worked*, I thought.

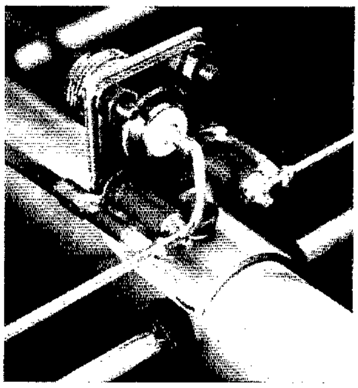
Performance

I'd neglected to check the SWR of the 432-19 before installing it, and was therefore a little nervous about hooking up the transmitter. With a Bird model 43 wattmeter in the line, however, I measured the SWR at 432.1 MHz to be just over 1.1:1. I didn't make too many contacts on 432 right off the bat, but several weeks later I had the opportunity to use the antenna in the June VHF QSO Party. It worked very well with 10 watts of transmitter output netting me seven states on 432, including Virginia (during an Es opening). Several Connecticut stations who had worked me previously when I was using the homemade quagi commented that my signal was much better.

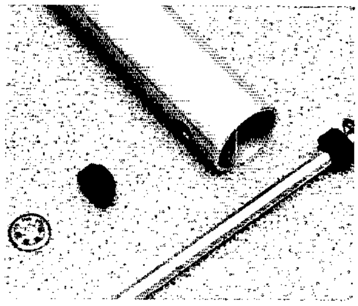
Actually, though, contests aren't much help in testing the performance of an antenna. What *is* impressive is the fact that the 432-19 won its class in the 12th annual East Coast VHF Society Antenna Measuring Contest held at Trenton (NJ) State College. Compared with an EIA reference antenna assumed to have a gain of 7.7 dB over a dipole, Dick's RIW 432-19 measured a gain of 14.3 dBd. He also entered an array of four RIW Yagis [6-foot (1.8 m) stacking], which measured a gain of 18.6 dBd.

Construction

The 13-foot (4-m) long Yagi is quite light at 2.8 pounds (1.27 kg). The three-section boom bolts together, and all 19 elements are installed *through* the one-inch (25-mm) boom, yet are *insulated from the boom*. The elements are color-coded both in the middle where they go through the boom, and on the ends so that each can be identified even after assembly. A set of Delrin insulator shoulders and stainless steel retaining rings are used to isolate each element from the boom. During assembly of the review antenna, I accidentally reversed the order of two of the elements part way down the boom. The retaining rings are "one-way" jobs with little fingers that grip the solid aluminum elements once they're in place. This presented no problem, though, as the antenna was supplied with a half-dozen extra rings just in case some fool were to do what I did! The misinstalled rings were snapped off with needle nose pliers, the elements were swapped, and new rings slipped onto the elements using the tool supplied with the antenna.



The driven element on the 432-19, with the feed point, T-match, balun and element mounting scheme all visible.



The RIW element mounting system, with the insulating shoulder and retaining ring already in place on one side. The element is then placed through the boom, and the other shoulder and ring are installed, holding the element tightly in place, yet insulated from the boom. Assembly of each element takes less than one minute.

The 432-19 is supplied with a weatherproof type-N connector, a 4:1 balun, and all necessary hardware. Except for the mast-mounting hardware, which is zinc-plated steel, every nut, machine screw, retaining ring, and washer supplied is solid stainless steel to prevent rust. All plastic parts are UV-stabilized to withstand long exposure to sunlight without deterioration.

A T-match is used on the 432-19 with all but two connections soldered. Two compression joints are used, although they are placed at high-impedance points so that any resistance or capacitive reactance that may occur in the joints should have a negligible effect on performance. A preformed 1/2-wavelength section of RG-402/U hardline cable forms the 4:1 balun used for matching to 50 ohms.

One final design detail of interest is the use of *two* reflectors on the 432-19 instead of the typical single one found in almost every other Yagi. According to the manufacturer, K2RIW added the second reflector in order to maximize the antenna forward gain and simultaneously reduce the strength of the minor lobes in the pattern.

Another version of this antenna is also available for use in the ATV segment of the 440-MHz band. The 441-19 has identical specifications to those of the 432-19 except for its frequency coverage (the 441-19 is centered at 441 MHz). — *Jim Bartlett, K1TX*

RIW 432-19 Yagi

Elements: 19; 16 directors, 1 driven element, 2 reflectors.
Boom length: 13 feet (4 m).
Weight: 2.8 lbs. (1.27 kg).
Input impedance: 50 ohms, with integral balun.
Connector: Type N.
Power rating: 1 kW cw, 2 kW PEP.
VSWR: Less than 1.2:1 at 432 MHz; less than 1.6:1 from 426 to 438 MHz; less than 2:1 from 424 to 442 MHz.
Mounting: Clamp assembly fits masts up to 1-1/2 inches (38 mm) OD.
Price class: $60.
Manufacturer: RIW Products, Box 191, Babylon, NY 11702.

NEW BOOKS

English-German QSO Language Instruction for Amateur Radio Operators, by Leo Craven, G4EQI.

"Thousands of operators across the world QSO with only a hundred words in a second language. It gives them great satisfaction and a sense of achievement and hundreds of contacts which would otherwise have been impossible," says the author in this new booklet published privately in England.

Lest any readers be scared off by the ominous title, let us assure you that the booklet is small, easy to read, and only 23 pages in its entirety. Yet the author has done in these few pages a masterful job of providing clear instruction for the use of German on the air. Sample QSOs are offered, along with all the phrases one might want to use during a complete contact. The German-language version of the phonetic alphabet is included, along with the numbers, time expressions, etc.

Almost every radio amateur has at least once sensed the warm delight of a fellow amateur when he's tried a simple "gracias" or "danke." The use of other languages on the air goes far toward promoting international goodwill — something for which radio amateurs are worldwide renowned.

The booklet may be purchased for $3.50 U.S. (International money order) sent to Mr. Leo Craven, G4EQI, "Grass Moor," Radford Rd., Alvechurch, Birmingham B48 7DT, England. — *Bruce Johnson, WA6IDN*

The Club Filter

Let this simple, inexpensive cw filter become your club's next project. It's both fun to make and useful. A bit of magic for cw!

By Spencer Schubbe,* N8AP (ex-WB8GBD)

Keeping radio amateurs actively interested in a radio club and maintaining its vitality is a matter of concern for many radio associations. Once the club radio station has been built and is on the air, the fun and enthusiasm of the construction days often give way to a measure of lethargy unless steps are taken to prevent that from happening.

Our Eastern Michigan University ARC maintains members' interest by planned programs in which they actively participate. For instance, at a recent meeting a decision was made to find a simple project that each member could build. Because the majority of members were Novice-licensed college students (their fortunes yet to be made!), our plan included these requirements for choosing a project: It had to be (1) simple, (2) useful, (3) inexpensive and (4) educational. Selection of the project fell into my hands, mainly because I was the senior member and staff advisor.

With those four objectives in mind, I searched through several radio publications for ideas. What caught my attention was an active filter described on page 271 of my 1973 *Handbook*. Could that fill the bill? Would there be real interest in it among the members? I rationalized that most members operated on 40-meter cw. The device seemed well suited to their needs, as it would be economical to build, simple and, indeed, educational. Would the members respond favorably to the plan? I felt that if I could produce a demonstration model that proved the value of an active filter to these brass pounders, their acceptance would be won. So, off to the workbench I went.

The initial performance of my active filter, somewhat disappointing as it was, led me to consider some modifications that resulted in what the members found to be a superior filtering device. Their approval was most heartening.

Modifications

By changing the 1300-Hz band-pass filter frequency to 750 Hz, the audio response closely matches that produced by most receivers when a cw signal is centered in the passband. Use of the 1300-Hz band-pass frequency would necessitate detuning the receiver during filter operation.

An additional output (half filter) modification of the original circuit is included in Fig. 1. This change allows the signal to be taken from the first stage of the filter and makes tuning in a cw signal easier. This is so because the effects of the narrow passband of the full filter and the squelch action of diodes D1 and D2 are overcome.

The absence in Fig. 1 of Q1, which appears in the original filter diagram shown in the *Handbook*, resulted from the removal of a faulty transistor I had placed in my filter. I found the additional gain offered by Q1 was unnecessary; a good cw note was produced without it and a better match for low-impedance headsets is available at the output of the MC1741CP.

Proper shielding, bypassing and grounding are important for trouble-free

The author's club filter, housed in a contemporary style enclosure, rests atop his transceiver. Position of the mode switch and the presence of the straight key indicate his operating preference. The LMB model CO-3M enclosure is used for this unit.

*11315 W. Clement Cir., Livonia, MI 48150

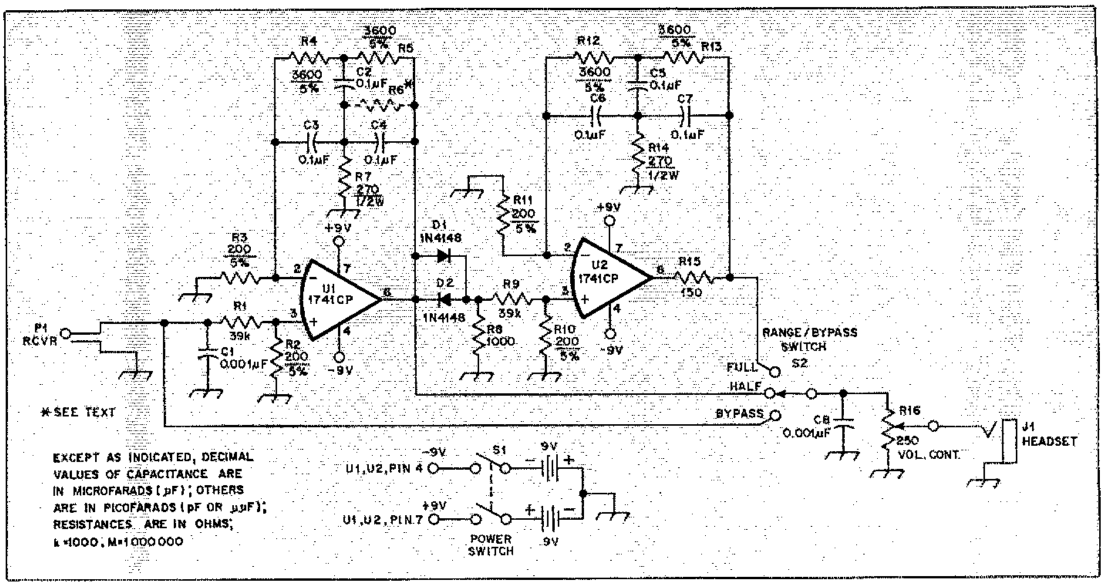


Fig. 1 — An audio-filter circuit for the cw operator. Capacitors are ceramic or Mylar. Fixed-value resistors are 1/4-W composition except as indicated. See text concerning R6, R7 and R14.

C1, C8 — 0.001 μF.
C2-C7, incl. — 0.1 μF.
D1, D2 — Silicon switching diode, type 1N4148 or equivalent.
J1 — 1/4-inch (6-mm) phone jack, Radio Shack no. 274-324 or equiv.
P1 — 1/4-inch (6-mm) phone plug, Radio Shack no. 274-1539.
R1, R9 — 39 kΩ.
R2, R3, R10, R11 — 200 ohms, 5 percent.
R4, R5, R12, R13 — 3600 ohms, 5 percent.
R6 — 50 kΩ (see text).
R7, R14 — 270 ohm, 1/2 watt (see text).
R8 — 1000 ohms.
R15 — 150 ohms.
R16 — 250-ohm linear-taper potentiometer, Allied Electronics no. 753-8329 or equiv.
S1 — Dpdt slide or toggle switch.
S2 — Three-position slide, push-button or rotary switch.
U1, U2 — Type 741 operational amplifier, Motorola MC1741CP or equiv.

operation of active-filter circuits. Some annoying squeaks, squawks and miscellaneous grunts occurred when I first tried the filter during transmissions. With higher transmitting power the filter even became silent. Simply by providing rf bypassing of the input and output circuits, these problems were eliminated.

Construction

The circuit layout is not critical and may be readily constructed on Vectorbord or in printed-circuit form. Type 741 operational amplifiers are available in several case designs. I selected the eight-pin type MC1741CP because of the smaller size and availability. If another version of the 741 operational amplifier is used, the builder should note that the pin designations may be different from those shown in Fig. 1.

Individual builders may prefer other ways of switching power and filter output than the method shown in Fig. 1 in order to take advantage of switches on hand. I selected miniature toggle switches for compactness and as a means of combining power and bypass functions, although slide or rotary switches would generally be more economical.

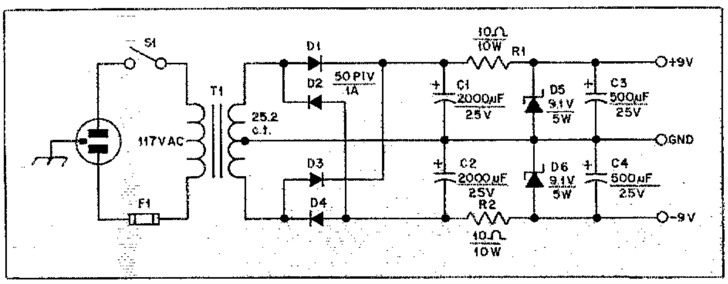
Batteries are used to power the filter, as the current requirement is less than 5 mA. A more affluent builder may want to consider the ac supply illustrated in Fig. 2. The 0.1-μF capacitors should be Mylar or ceramic. All resistors can be 1/4 watt except R7 and R14, which should be 1/2 watt. A 5-percent tolerance for resistors is specified.

Using the Filter

The filter is designed to have an input cable that is plugged into the headset jack on the receiver. The phones are then plugged into an output jack at the rear of the cw filter. To adjust the filter, set the filter volume control near maximum and, with the filter power off, turn on the receiver. If all is well, normal receiver operation should be observed. Next, tune the receiver to a portion of a band where no signals are heard. With the filter power turned on and the selector switch set at the FULL position, advance the receiver af gain control to a point where a pinging sound is heard. This is the 750-Hz component of the background noise. Lower the

Fig. 2 — Circuit diagram of the club filter power supply.

C1, C2 — 2000 μF, 25 V, electrolytic.
C3, C4 — 500 μF, 25 V, electrolytic.
D1-D4, incl. — Diode rectifier, 50 PIV, 1 A.
D5, D6 — Zener diode, 9.1 V, 5 watt.
F1 — 1/4 A.
R1, R2 — 10 ohms, 10 watt.
S1 — Spst switch, Radio Shack no. 275-602 or equiv.
T1 — Low-voltage rectifier transformer, 117-V primary, 25.2-V secondary. Radio Shack no. 273-1386 or equiv.



af gain until the pings are infrequent or just disappear. Set the filter selector to the HALF position and tune in a cw station. If necessary, use the filter volume control to set a comfortable listening level, but do not change the receiver af gain setting. As the receiver is tuned across the cw signal, the 750-Hz tone will be greatly amplified while other frequencies will remain rather low. After the signal has been properly tuned in, the FULL position may be selected to give maximum quieting outside the 750-Hz note. A slight receiver tuning adjustment may be necessary to maximize the signal in the narrower band-pass region.

Conclusion

I find that the HALF position of the selector switch is best for general receiving. When the QRM gets really rough, the FULL position works like a magic wand.

Most of the filters constructed by club members performed well once wiring errors and dead batteries were eliminated. Two problem areas did turn up. The first was with R7 and R14, the wattage values of which seem to be fairly critical. All the filters employing 1/2-watt resistors for R7 and R14 worked while those using 1/4-watt resistors failed. The solution was obvious. The other problem was the gain of the type 741 operational amplifiers. While all had good gain, some had exceptionally high gain, producing a ringing or echo effect on the cw note. To correct the problem a 50-kΩ resistor, R6, was placed in the first stage (see Fig. 1) which restored a natural cw note.

With appropriate instruments and operating under controlled conditions, all of the constructed units and a commercial unit were tested for band-pass sharpness and frequency, and gain. I mention this only to report that the commercial unit failed to match the others. Even with maximum filtering this particular commercial filter would have been considered defective had it been one of our constructed units operating in just the HALF position. QST

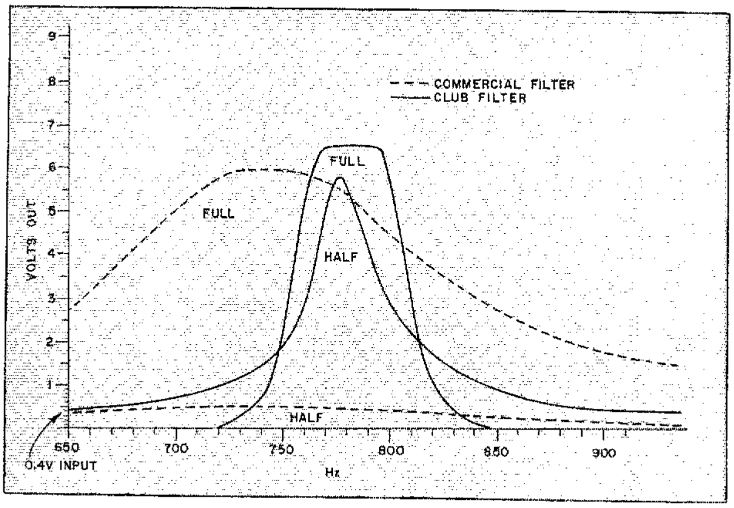


Fig. 3 — Response curves for the club filter. Broken lines represent the response of a commercial filter used for comparison. The effect of full filtering, employing both filter stages, is compared to half filtering, in which only one stage is engaged.

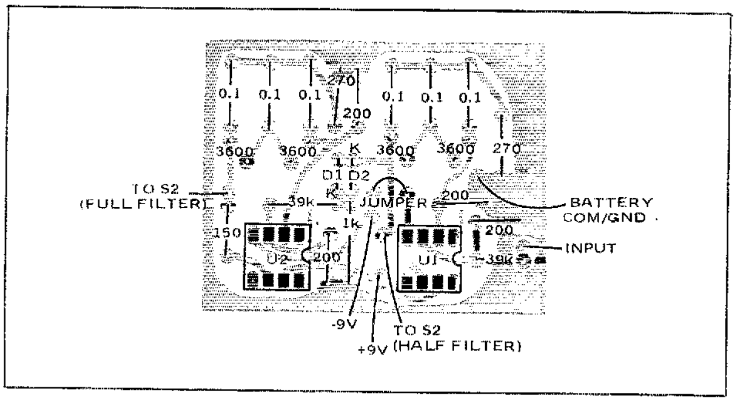


Fig. 4 — Parts placement guide for the club filter. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (The etching pattern appears in the "Hints and Kinks" section of this issue.) Whole-number values with no units represent resistances in ohms; k = 1000. Decimal-value numbers alone represent capacitance in microfarads. K indicates the cathode of a diode. C1 and C8, 0.001-μF bypass capacitors shown in Fig. 1, are mounted off the circuit board.

Strays

CIRCUIT BOARD SUPPLIERS

☐ Spectrum Research Laboratory, Inc., P. O. Box 5824, Tucson, AZ 85703, no longer supplies ready-made etched circuit boards for amateur projects. Their company is listed in the current (1972) edition of *FM and Repeaters for the Radio Amateur* and in earlier League technical publications such as the *Handbook*. A current list of board suppliers may be obtained by sending a stamped return envelope to ARRL Hq., 225 Main St., Newington, CT 06111.

Arizona Senator Barry Goldwater, K7UGA, is getting the feel of the bug belonging to Carl Glock, W3NFW, center, president of the Pennsylvania Bar Association. Peter Roper, W8YPJ, the Bar's new executive director looks on. Sen. Goldwater spoke at the annual meeting of the association in Pittsburgh recently.

THE BIG SCRUB

☐ Now the films you borrow from the ARRL training aids library are in good condition thanks to a superb cleaning job by Dick O'Keefe, WB1GDH. Dick did about 15 to 20 films each week. It took all summer, but after his tireless effort all our films are reconditioned and can look forward to a longer life! Thanks, Dick. — *AB1P*

I would like to get in touch with . . .

☐ Federal Reserve System hams interested in establishing an FRS net and newsletter. Jerry Anderson, WDØBJR, Federal Reserve Bank of Minneapolis, Minneapolis, MN 55480.

Hints and Kinks

OSCAR MOBILE WITH THE IC-245

My versatile ICOM IC-245 is a great performer for both mobile and portable use. One disadvantage, a lack of the lower-sideband function, almost meant "Goodbye OSCAR mobile!" To correct this limitation, I developed a simple, neat modification that does not upset the appearance or performance of the set.

The IC-245, with sideband adapter attached, consists of the two main frames. The smaller ssb unit is attached by four bolts to the larger transceiver frame. Removal of the two front bolts and loosening of the two in the rear will provide access to the necessary pads on the circuit board of the ssb adapter. Directly between the front panel and the circuit board there is space between the RIT and the CW-T controls to perform the simple changes.

First, one should carefully remove the 10.6985-MHz usb crystal and replace it with two 2-1/2-inch (64-mm) lengths of no. 22 insulated solid wire, leaving 1/4 inch (6 mm) of bare wire on each loose end. From the underside of the circuit board, solder a 3-1/2-inch (89-mm) piece of no. 22 insulated wire to the common junction of D1, R93, R94 and the tuning network C64, C65 and C66. Route this wire to the vacant area between the RIT and the CW-T controls, leaving a bare end for future use.

Next solder the 10.6985-MHz usb crystal to one of the outside pairs of the dpdt toggle switch. On the opposite side, solder one lead of the 10.7015-MHz lsb crystal to the switch. Slip a 1/2-inch (13-mm) length of spaghetti sleeving over the bare crystal lead.

Notice the wires from the former usb crystal position. Solder the lead from the base of Q20 to the switch wiper contacts common to both crystals. Solder the other lead to the other wiper contact on the toggle switch.

The remaining wire is connected to the tuning network consisting of a 0.7- to 0.9-pF ceramic trimmer padded by a 24-pF silver-mica capacitor. Solder the remaining lsb crystal lead to the other end of the tuning network. Except for drilling a small hole to accommodate the switch, this completes the modification.

Tuning is accomplished by connecting a frequency counter to CP-1 adjacent to Q21 and adjusting the appropriate trimmers to obtain correct frequencies. The 10.6985-MHz usb frequency and the 10.7015-MHz lsb frequency should be set and rechecked. Carefully reassemble the unit and use it for receiving OSCAR 7 on lsb. — *Bob Kile, WA7GCI*

ONWARD WITH RIT FOR THE HW-8

Receiver incremental tuning (RIT) might be the best cure for QRM, short of turning off the rig. A slight receiving-frequency shift often makes the difference between solid copy and going QRT in disgust. It helps, too, in digging weak signals out of QRN because fine tuning can make a big dB difference (audio peaking) with devices like the narrow HW-8 filter.

Some HW-8 owners had trouble finding the Sprague Q-line (QRT) parts specified in Ben Saylor's article "Full Break-in and RIT for the HW-8" appearing in July 1977 *QST* (see "Feedback," November 1977 *QST*). Alternatively, one can try substituting parts that may be readily available.

The af-amplifier silicon transistors, Q101 to 103 are used for low power dc switching and probably are not critical. I used Radio Shack 276-2014 transistors. One might expect more critical requirements for the varactor diode, CR1, which acts as part of the VFO. Remembering that Jay Rusgrove and Stan Brindle had used a pair of 1N914 diodes in a similar way in "The CB Slider" (March 1977 *QST*), I successfully substituted a 1N914 for the QRT-262 in the HW-8 RIT circuit. However, my transmitting frequency was affected by changes in the RIT adjustment. Therefore, I substituted a jumper for R108, bypassing the RIT potentiometer entirely during the transmit mode. Also, I omitted R109 with no sacrifice in performance of the RIT, while providing a maximum frequency shift of ±5 kHz. The purpose of R108 and R109 was apparently to minimize the effects of temperature variations on the RIT divider. I find little disadvantage in the omission of these resistors. I am pleased with the assurance of a fixed transmitting frequency while adjusting the RIT control to the extremes.

As Andy Thall ("Hints and Kinks," January 1978 *QST*) pointed out, the wide-selectivity switch on the HW-8 is useful for copying ssb. Instead of removing it altogether, I relocated it on the rear panel. The long run of cable from the rear of the circuit board is tied at an inaccessible place under the main VFO tuning assembly. I cut off all that was not needed to reach the rear panel. For sideband listening with the HW-8, the RIT control acts as a fine-tuning clarifier. — *Phil Emerson, WD8IZA*

REGENCY HR-2B MODIFICATION

This simple two-hour modification will improve the strong-signal characteristics of the Regency HR-2B receiver without harming the sensitivity. Prior to the change, I had considered purchasing a new 2-meter rig, but now I find the set quite satisfactory.

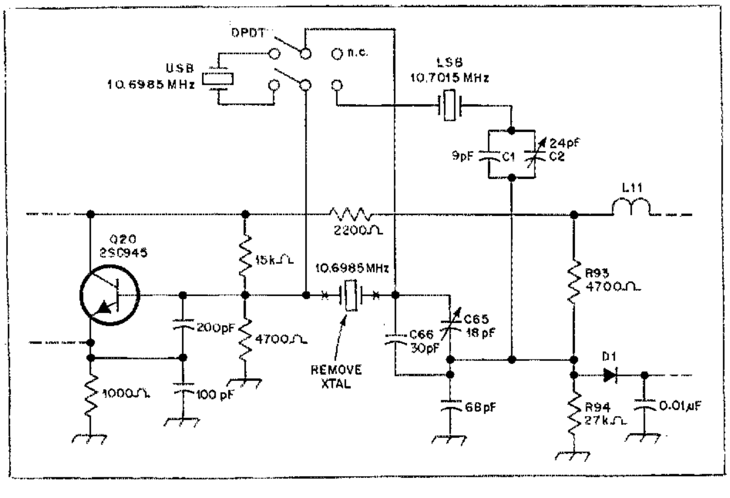
The modification requires removal of C204 (3.9 pF), R204 (1000 ohms), R202 (4700 ohms) and Q201 (rf amplifier). Use a small pencil iron and solder wick. A solder wick substitute can be improvised by using fresh, stripped, small-diameter stranded wire.

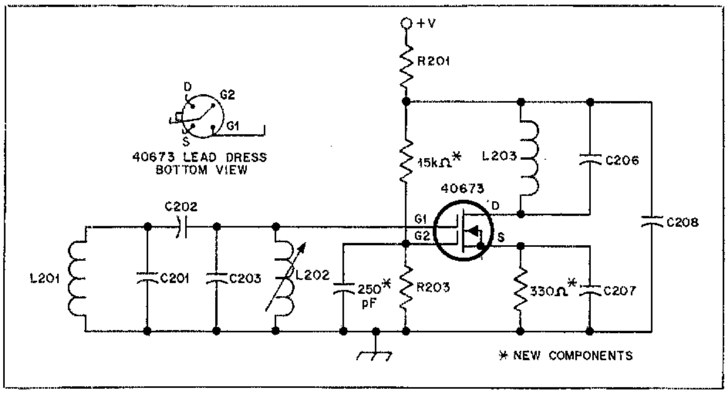
Next, cut the circuit element which connects the collector of Q201 to the tap on L203. Make the opening as close to the L203 connection pad as possible. Then drill a small-diameter hole in the circuit board for the ground connection of the 250-pF capacitor to be added. Refer to the diagram. This hole is drilled beside the ground connection for R203 (a 10-kΩ resistor).

Jumper the "hot" end of L203 to the original collector pc strip for Q201, which was cut as instructed above. Use a scrap of bare, tinned, copper wire. Proceed with the installation of the following components: a 330-ohm resistor in place of R204; a 15-kΩ resistor in place of R202; a 250-pF capacitor from the original base connection of C204 to the ground hole drilled in an earlier step.

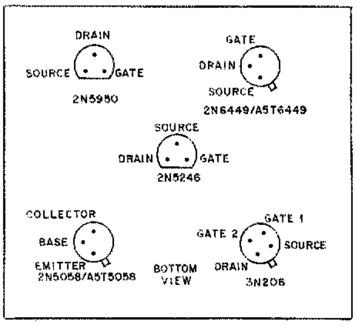
At this point, form the 40673 leads as shown in the illustration. Extend the G1 lead with small-diameter bare wire if necessary. To install the 40673, the drain is connected to the

Modification of the ICOM IC-245 transceiver for receiving the lsb transmissions from OSCAR 7. Required parts include a dpdt miniature toggle switch, a 0.7- to 0.9-pF ceramic trimmer capacitor (C1), a 24-pF silver-mica capacitor (C2), and a 10.7015-MHz series-resonant crystal in an HC-25/U holder for a 30-pF load (available from crystal suppliers advertised in *QST*).





Performance of the Regency HR-2B is improved by this circuit modification.



These pin diagrams, furnished by AA6PY, will be helpful to those who wish to make semiconductor replacements for vacuum tubes based on W5DA's "Solid Tube" article in the April 1977 *QST*.

original Q201 collector. Then make these connections: the source to the original Q201 emitter; G2 to the original Q201 base; G1 to the original C204 pad connected to L202. Next, realign the receiver front end. To prevent the front end from oscillating, the 40673 drain must be wired to the hot end of L203 and not to the original tap. — *Bob Novas, W3DK*

SALVAGING COAXIAL FITTINGS

Salvaging PL-259 coaxial cable fittings can be frustrating when using a soldering gun or heavy copper iron. W1VON and I agree that much of the frustration can be avoided by drilling the solder out of the holes of the connector with a drill that is the same size or slightly larger in diameter than the openings to be cleared. Carefully drill just through the coaxial cable braid: Seldom does the solder run under the thimble. Next, hold the fitting with pliers and give the cable a short twist, loosening the connector. The center conductor is then unsoldered and the cable may be pulled free. Excess solder should be cleaned off with a hot iron and a small brush, following which the coaxial connector should be in almost new condition. — *"Twisty" Ljongquist, W1CQS/W4DWK*

VARIABLE VOX-DELAY CURE FOR 32S-3

The VOX-delay time constant of my Collins 32S-3 seemed long when the transmitter was first turned on; it only became normal after a 45-minute warm-up period. The original time-constant capacitor, C119, was apparently a low-cost ceramic unit. I replaced this 0.02-µF (0.05 µF on later models) capacitor with an Elmenco dipped type. A new diode for CR8 (1N458A) was installed at the extremity of the diode leads to remove it from heat-producing R89 and R112.

This change, an improvement, fell short of being entirely satisfactory. My next move was to remove the two hot 68-kΩ, 2-watt resistors (R89 and R112) connected to the cathode of V11A-T8. Two .7-watt paralleled 68-kΩ resistors were used as replacements. Both were placed vertically on the chassis and on the outboard side of the V11 socket. The VOX delay now functions normally under all operating conditions. Incidentally, these resistors in the later 32S-3A have been replaced with a single 34-kΩ, 5-watt wire-wound resistor, which I'm informed also runs very warm. — *J. H. Buck, W6TCO*

QST PATTERNS

I am glad to see etching patterns printed in *QST* with black ink rather than gray or some other color. This way, the pattern may be lifted directly from the magazine using an acrylic-polymer medium. I use the product called Liquitex no. 5016. It is available at many art supply stores. After coating the circuit layout in the magazine with four or five coats of polymer and allowing it to dry between coats, one will obtain a very fine negative of the pc board after soaking the dried polymer in warm water to remove the paper.

I've used this sytem often; it allows me to get projects under way quickly without having to order the needed boards from a supplier. — *Robert J. Gumm, W9RG*

HINT FOR MAKING SOLID-STATE TUBES

W5DA's article in April 1977 *QST* on the design of solid-state devices to replace vacuum tubes was very informative. It should enable the average experimenter to make replacements with little difficulty. The pin designations which were not shown in the article are not readily available. Therefore, guessing at the correct hookup can lead to destruction of the devices.

I am furnishing the missing information, as provided in the Texas Instrument *Transistor and Diode Data Book*. The TIS131, however, was not shown in that publication, but is electrically equivalent to the 2N5058/A5T5058 in the accompanying illustration.

Another problem for the experimenter is locating the seven- and nine-pin plugs to fit into the existing tube sockets. Those plugs seem nearly impossible to find. But a good way to circumvent this problem is to make the plugs. This is done easily by obtaining printed circuit seven- and nine-pin tube sockets, then soldering short pieces of no. 18 solid wire in the tube side of the socket. This upside-down tube socket can then be used like a plug. One should not forget that the upside-down socket, in effect, reverses the pin order so that pin no. 1 becomes pin no. 7 on the plug. — *J. Craig Caston, AA6PY (ex-WA6PXY)*

EXPANDED-SCALE AC-LINE MONITOR

My intention was to build a simple ac-line monitor for use at my workbench and with portable generators during Field Day activities. I realized that the usual simple system has a voltmeter scale with much space devoted to the low-end voltages while the voltages of interest are crammed into a small segment of the scale, as shown at A in my illustration (next page). My first proposed solution to this problem resulted in the incineration of a fine old junk-box meter movement. This led to the following idea.

A Variac with a 0- to 132-volt output was connected to the primary of a filament transformer and the voltage set at 80, as shown at B. The rectified output of the transformer was measured at this voltage setting and a Zener diode which matched that dc value was acquired. The idea is that the Zener diode can be put in series with the meter so that no current will flow until the Zener breakdown voltage is reached. (See part C of the drawing.)

The minimum ac reading desired was 80 volts, and 130 was chosen as the maximum. These figures were selected because I had a meter with 50 divisions on the scale, the equivalent of one volt per division. (See illustration D.)

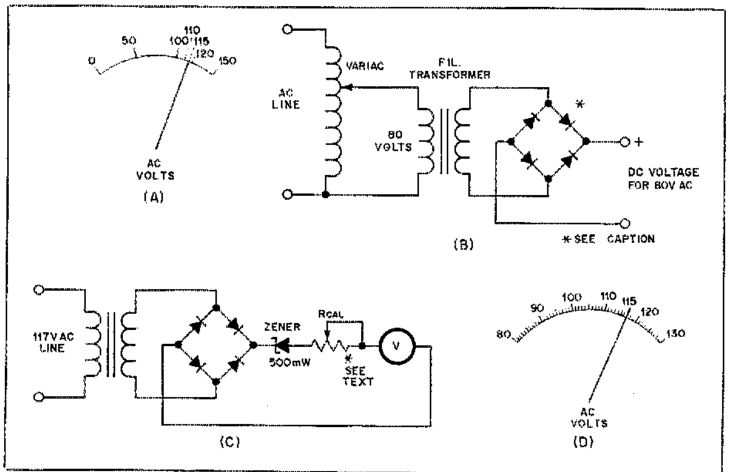
A current-limiting calibration resistor was placed in series with the meter and the value was computed by the formula

$$R = \frac{V_{DC\ MAX} - V_{ZENER}}{\text{Meter Current}}$$

For instance, if the maximum dc output of the secondary is 13.2 volts, the Zener diode output is 8.2 volts, and the meter has a 1-mA movement, then the resistor would be determined as follows

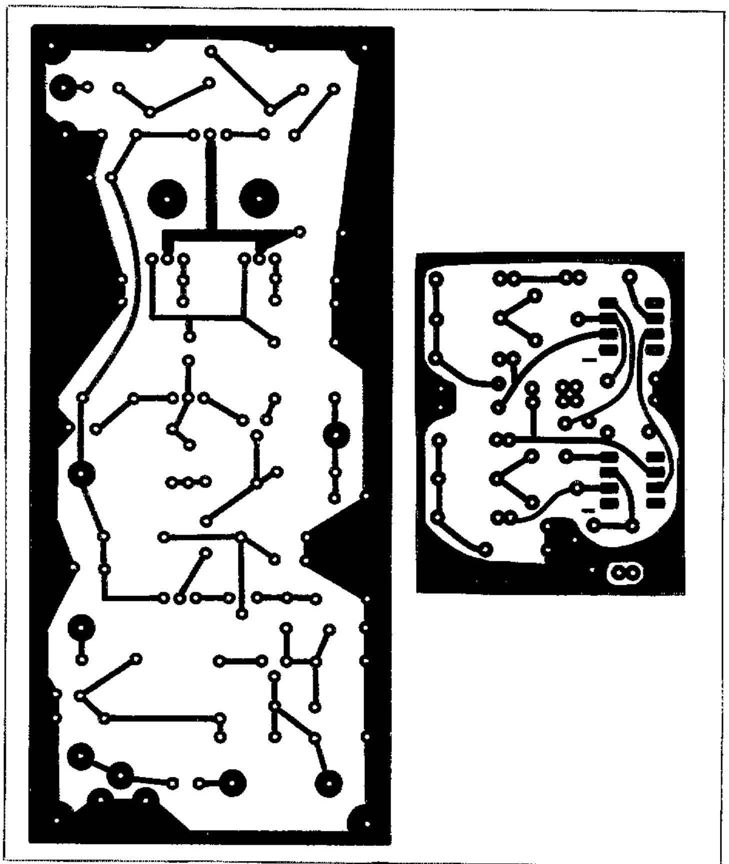
$$R = \frac{13.2\ V - 8.2\ V}{0.001\ A} = 5000\ \text{ohms}$$

I used a Bourns 10-turn potentiometer which works well. The meter is calibrated by adjusting the potentiometer for maximum resistance, then setting the Variac for 130 volts of output. The potentiometer is then adjusted for 100-percent deflection of the meter movement. Next, check different voltage settings of



These illustrations show how N7JJ reworked his line-voltage meter to better display the range of commonly used voltages. See text for details. Diodes should be selected according to the voltage and current chosen. In drawing C, the Zener diode must be reverse biased. Observe polarity!

Circuit-board etching patterns for construction projects contained in this issue of *QST*. The boards are single-sided. They are shown here at actual size, from the foil side. Black represents copper. At the left is the pattern for the 6-watt VXO-controlled transmitter (see Fig. 2, page 13). At the right is the pattern for the active club filter (see Fig. 4, page 37).



the Variac and note the corresponding meter readings. A slight adjustment of the calibration resistor might be desired in order to have the 115-volt reading line up with a major scale marking. Once calibration is accomplished, the Variac can be removed.

My monitor is accurate to within 1 volt. As for the Zener diode, if it is an 8.2-volt device with 1 mA flowing through it, the power dissipated by it is only 8.2 mW. For this application a 400-mW Zener diode is quite adequate. — *John Lapham, N7JJ (ex-WA7LUJ)*

DIGITAL SPEED READOUT IDEAS

☐ The article, "A Digital Speed Readout for the Electronic Keyer," in July 1978 *QST* was interesting. I'm sure a lot of amateurs are collecting parts and building the unit now. Here's a tidbit of information that may help them until they have their units completed. To clock the speed of an electronic keyer, close the dash side of the keyer and count the number of dashes sent in a five-second period. This number is approximately equal to the speed in words per minute. — *Al Brogdon, K3KMO/N3AL*

☐ I'd like to suggest an alternative time base for the "Digital Speed Readout for the Electronic Keyer." No additional ICs would be required to count down the 60 Hz available through the power source. Two programmable dividers such as 8281s or 74191s could be used so that the time base of 1.2 seconds would always be determined by the line frequency. By using 6 × 6 × 2 or 9 × 4 × 2 arrangements, the final 2, in each case, could serve with one of the spare sections of the 7400 to obtain the 180° outputs needed for the counting section. Also, in case of 50-Hz line frequency being available, a 6 × 5 × 2 division could be employed. — *Vern Parks, K4IGO*

NPN OR PNP

For those who can't remember npn from pnp try this simple recall method: pnp — *points in* proudly; npn — *not* pointing *in*. — *Jim Bartlett, K1TX*

HINTS

☐ Keeping spare fuses in a plastic 35 mm film container that is taped to the power cord is a good idea for Field Day operators. — *Kenneth Nollet, KØEN*

☐ Applying liberal amounts of water to the ground where a ground rod is being installed can make the work easier. — *Margaret Noblet, WB8CLG*

☐ I resolved an unwanted frequency shift in my old Viking II VFO through removal of the dark deposit on the bandswitch by carefully applying a silver dip liquid to the contacts. The residue should be rinsed away with alcohol or warm water. — *Paul Atkins, K2OZ*

☐ Prevent nearby business or Amateur Radio stations from interfering with HW-7 or HW-8 transceivers by inserting a 1- to 2-mH choke between the switch terminal and the + terminal of the Heath power connector. — *John H. Czap, WB2LGS*

☐ Want to quiet a 14-watt Muffin Fan to the level of a 7-watt whisper fan? Then series connect nine 50-ohm, 10-watt resistors (Radio Shack no. 271-133 or equivalent) in one of the ac leads. A light dimmer also works, providing a variable fan speed. — *Charles E. Ficklin, WB3LBW*

Give Your Repeater Some Identity

Let your repeater have a chance to tell people about itself instead of merely saying who it is.

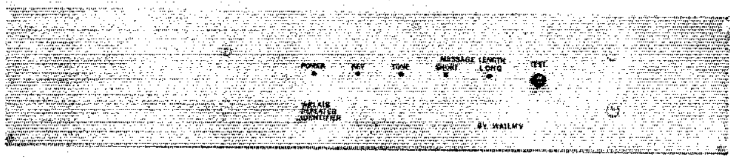
By Rick Swenton,* WA1LMV

If you think this is just another diode matrix identifier article, don't stop reading yet. Most i-d units function well in the station identification mode, but very few i-d units tell a story! Did you ever have a repeater function that you wished to be indicated on the air as to its status . . . is it on . . . or off? The old trick was to change the pitch of the i-d tone to signal the function status. An example of this is the method of indicating a commercial power failure at WR1ABM in Bristol, CT. When the repeater is operating on emergency power, the i-d tone changes from its usual low pitch to a higher pitch. This signals the users to conserve battery power. But wouldn't it be nice to have the cw i-d send a message indicating such a status? Here is such a circuit.

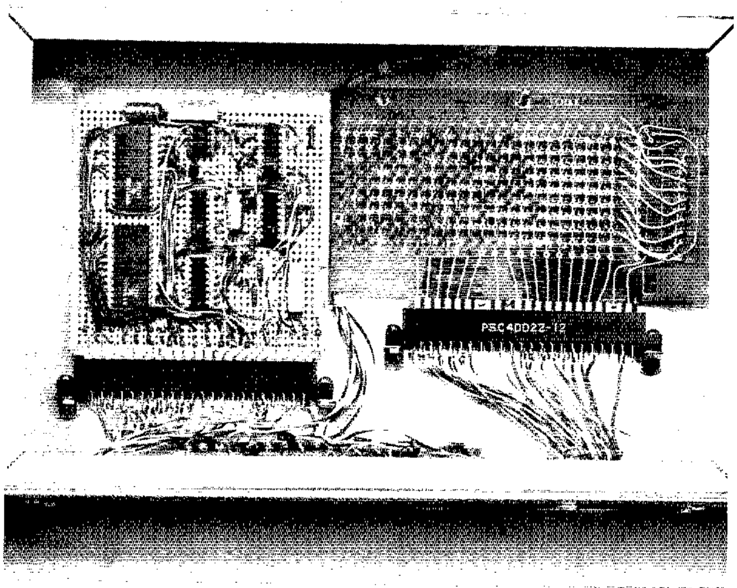
This i-d unit performs the usual station identification. It is user programmable with diodes in a read-only memory (ROM) matrix. There are 256 positions (or bits) in the memory. Most repeater identifiers (such as DE WR1AAA) will occupy less than 100 memory locations. This leaves about 150 memory locations for the special message. Such a message might be EME PWR indicating emergency power operation, or LINK indicating a cross-band link is activated. The difference between this i-d unit and other units is the presence of a control input which selects either the station i-d only or the station i-d plus the message. The circuit uses inexpensive, reliable TTL ICs which are readily available at most outlets such as Radio Shack.

The circuit diagram of the identifier is shown in Fig. 1. U1 is a 555 timer IC used as an astable multivibrator. This provides pulses to the counters, U2 and U3. The code speed of the identification is adjusted by the 10-kΩ pot connected to pin 6

*19 Allen Street, Bristol, CT 06010



Front panel of the dual-purpose identifier from the WR1AIB 450-MHz repeater. It is built on a standard rack panel and has LED indicators to display the status of the various functions.



The control logic for the identifier is located on the board at the left. The board on the right contains the diode matrix, and was obtained from surplus (original manufacturer was Cubic Corp.). Both boards can be unplugged to simplify servicing or modification of the units.

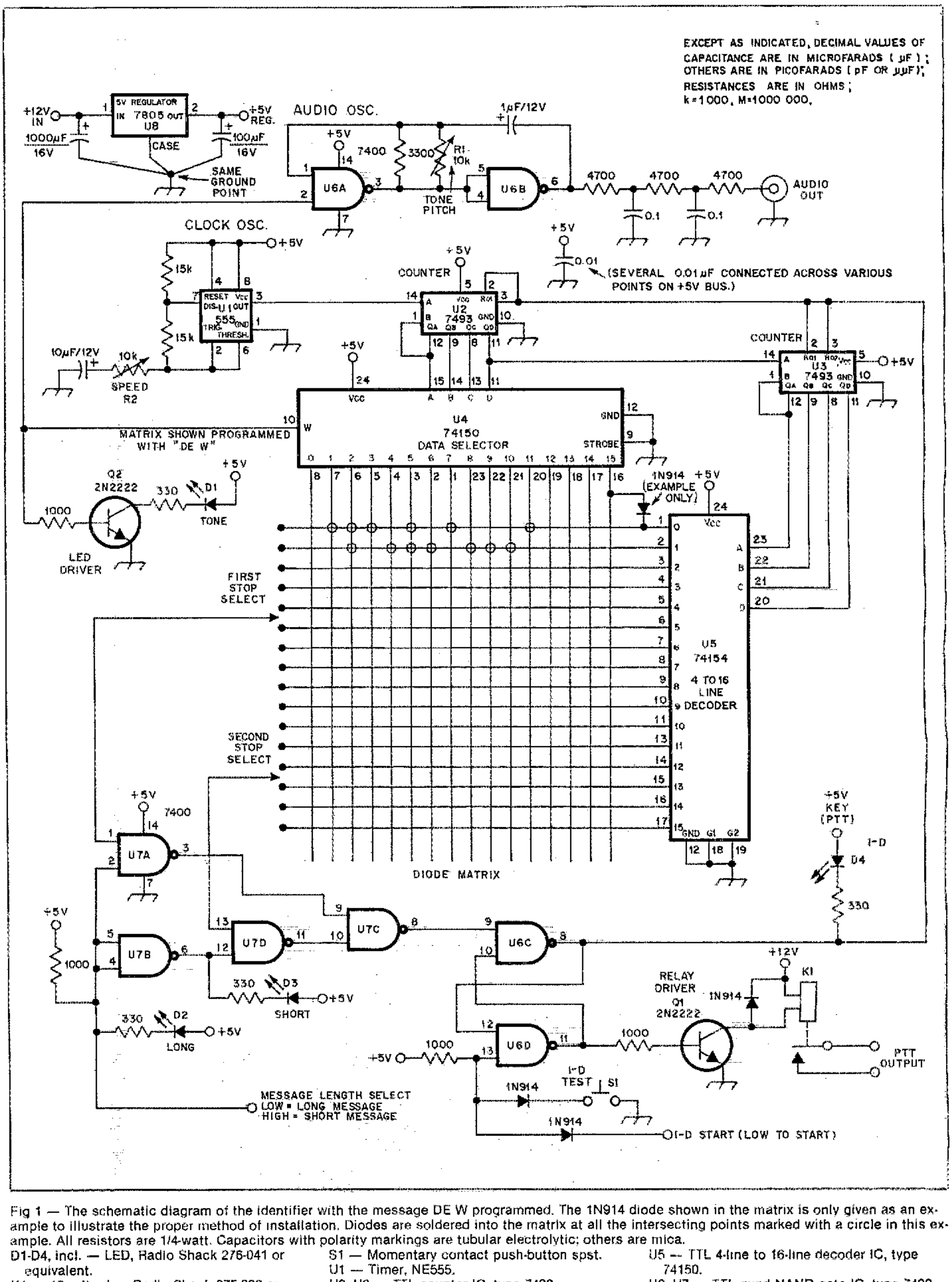


Fig 1 — The schematic diagram of the identifier with the message DE W programmed. The 1N914 diode shown in the matrix is only given as an example to illustrate the proper method of installation. Diodes are soldered into the matrix at all the intersecting points marked with a circle in this example. All resistors are 1/4-watt. Capacitors with polarity markings are tubular electrolytic; others are mica.

D1-D4, incl. — LED, Radio Shack 276-041 or equivalent.
K1 — 12-volt relay, Radio Shack 275-003 or equiv.
R1, R2 — Trimpots.
S1 — Momentary contact push-button spst.
U1 — Timer, NE555.
U2, U3 — TTL counter IC, type 7493.
U4 — TTL multiplexer IC, type 74150.
U5 — TTL 4-line to 16-line decoder IC, type 74150.
U6, U7 — TTL quad NAND gate IC, type 7400.
U8 — 5-volt regulator, type 7805.

on U1. Speeds from a slow crawl to an almost impossible rate can be achieved. The counter ICs U2 and U3 provide the 256-bit count. The binary count from the outputs of the ICs U2 and U3 (7493) are converted from binary to two separate groups of 16 lines. These two groups of lines perform the diode matrix "scanning." The 74150 IC, U4, is a data selector. Its function is to select and thereby scan the matrix columns. The 74154, U5, is a four- to 16-line decoder. It enables the matrix rows. While U4 is scanning the columns, U5 is enabling the rows by pulling each low, one row at a time. (The other 15 rows remain high.) The output of U4, pin 10, feeds U6A, a 7400 IC used as a tone oscillator. The 10-kΩ pot connected between pins 1 and 5 on U6 A and B adjusts the pitch of the i-d tone. Q2 is a driver for D1 which flashes along with the i-d tone (this circuit is optional). An RC low-pass filter eliminates the harmonics of the square wave produced by U6 A and B to provide a clean sine wave at the output of the i-d unit. U6 C and D and all of U7 provide the start/stop and message-length select control. The i-d is started by either grounding the i-d start line or pressing the test switch. The i-d stop signal will come from either the first or second stop-select lines. The connection of the stop-select lines is described below in the matrix programming instructions. U7, a 7400, performs the stop-signal selection. Depending on the logic level present on the message-select line, the i-d will be either a long message or a short message. Grounding the line will provide the total message. Allowing the line to float or go to +5 V will provide a short message. U7 selects which stop-select line will reset the i-d. The PTT relay in the collector circuit of Q1 should be any small, general-purpose 12-V dc relay. The relay is energized when the unit is identifying. The 7805 IC, U8, provides regulated 5 V from a 12-V dc source.

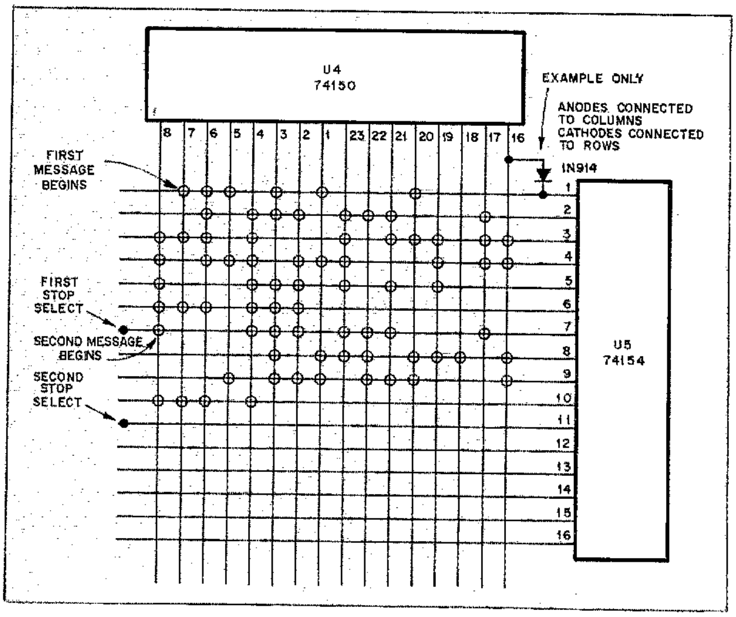


Fig. 2 — The diode matrix is shown with the message DE WR1ABM EME PWR programmed. A diode is installed at each circled position. For normal operation, only DE WR1ABM will be sent. For the first stop select, start the second message on a new line. Connect the first stop select to the line which begins the second message. For the second stop select, connect the second stop select to the next line after the second message ends.

Programming the Matrix

Type 1N914 silicon diodes are used in the matrix. Do not place the first diode in location "00"! When the i-d is in the reset mode, the first memory location is addressed. If you place a diode in the first location, there will always be a tone present on the output when in the reset mode.

Three diodes in a row constitute a dash, one diode constitutes a dot. Three spaces in a row constitute a space between letters. One space constitutes a space between code elements. I used six spaces to constitute a space between words. (Although "perfect machine-sent code" calls for seven spaces, the difference between 6- and 7-unit spacing is hardly noticeable by ear, and the saving in matrix bits may be significant on long messages.) The diodes are placed in the matrix just as the code appears on paper in a dot-dash format as shown in the example in Fig. 2.

To wire the stop-select lines, connect the first stop-select line to the row line which contains the beginning of the second message. Note that you should not begin the second message on the same row where the first message ends. The i-d will reset itself to zero on the signal which begins to read the row containing the start of the second message.

The same is true for the end of the matrix. Don't place any diodes in the last row. This line is reserved for the second stop-select signal if the matrix is fully loaded to the second-to-last row. The example in Fig. 1 shows how the stop-select lines are implemented.

Your repeater can now tell the users about itself. This feature can pay for itself by helping to extend operating time when the repeater is on emergency power. Also it can help keep autopatch testers in the woodwork when the patch isn't working.

Strays

OSCAR 8 GOES TO SCHOOL

OSCAR 8 went to class in more than 30,000 junior high schools this fall, in the form of an article and a 45-rpm record included in the October issue of *Current Science* magazine. Editor Vincent Marteka and Science Editor Charles Piddock contacted ARRL headquarters for assistance in preparing the piece.

Steve Place, WB1EYI; Jeanie Zaimes, AB1P and Bernie Glassmeyer, W9KDR, put together a tape of OSCAR sounds and supplied background information to Xerox Educational Publications, which puts out *Current Science*. Published as the feature article, the piece was entitled "OSCAR 8 Is Number One With Student Hams." Also included was a two-page science quiz sheet. The whole production was a first-class effort, and our hats are off to Xerox for a job well done.

We are told that 500,000 copies were printed and distributed. The article will reach at least 2,000,000 students. Copies are available from Xerox Education Publications, Middletown, CT 06457. No copies are available from ARRL hq. — *Bernie Glassmeyer, W9KDR*

GEORGIA TRAINING NET

Georgia hams can now learn how to handle traffic, improve their code speed or just have a change of pace by checking into the Georgia Training Net. GTN meets daily on 3.718 MHz at 2230 UTC. More information available from Tim Lennon, WA4OMQ, 5599 Coronation Ct., Atlanta, GA 30338.

Aerial Performers of the Radio Circuits

Basic Amateur Radio. Part 2: Why do some antennas get out better than others? Here are some practical answers plus all you need to know for building a simple coax-fed, half-wave dipole.†

By Margaret Koerner,* KØIQ (ex-WBØBEM)

A few miles west of this writer's amateur station, many of the mountain sides are dotted with gold mines, most of them long since abandoned. Out of those mines came ore — tons of ore from which a comparatively few ounces of coveted gold were laboriously obtained.

Producing a radio signal can be compared to a gold-mining operation, even though the coveted "gold" is not measured in ounces but in *watts* — units which indicate power. As in the mining of metallic gold, a great deal of labor is involved, a great deal of refining is necessary, and the amount of power which makes up the finished product may be small compared to the amount needed to produce it.

With a poor antenna installation, evidence of this last fact can be dramatic. To illustrate: Let's assume we have a transmitter which draws about 400 watts of alternating-current power from a wall outlet in order to generate 200 watts of radio-frequency power. This loss of 50 percent within the transmitter is basically beyond our control since it is dependent on equipment design. The 200 watts of rf power must then be sent through a feed line and antenna (which together make up the antenna system) before a signal can be radiated into space. The efficiency of the antenna system will determine whether the 200 watts will be utilized to the fullest advantage or be further reduced in strength. If our hypothetical antenna system is a "lossy" one, as much as three-fourths of that 200-watt output strength can be dissipated as heat, leaving as little as 50 watts of actual power to be radiated from the antenna. This means that of the 400 watts we started with, only 50 watts remain — a total power loss of 87.5 percent!

*2133 9th St., Boulder, CO 80302

†Part 1 apeared in November 1978 *QST*.

The left side of Fig. 6 shows the losses in the lossy feed line and antenna just described. In contrast, the right side shows the same transmitter, a low-loss feed line, and a well-constructed, 3-element beam antenna — a system which shows "gain" rather than loss. If you compare the illustrations, you can see where losses and gains occur. Now it's time to take a closer look at what we mean by decibels and gain.

Decibels

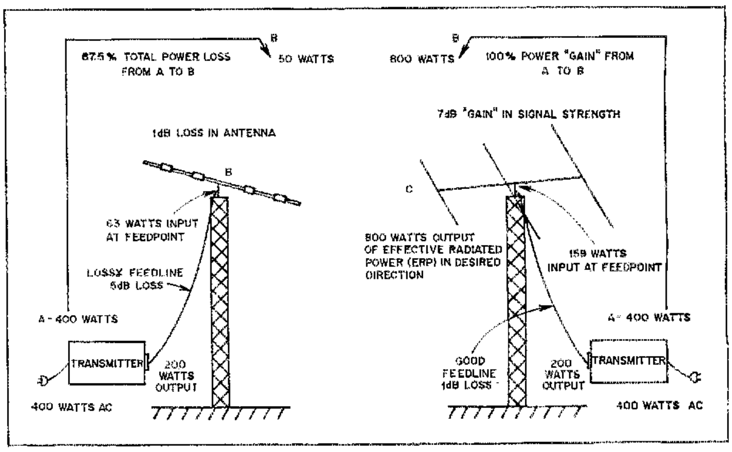
The actual output power of a radio signal is measured in watts. In Amateur Radio discussions and in the exchange of signal reports on the air, however, we usually hear signals compared in terms of *decibels.*[1]

Decibels are units of comparison between two power levels. Used initially in audio engineering, a decibel (dB) is a just-detectable change in sound level under ideal conditions. Table 2 is a tabulation of some useful dB comparisons.

The power of an Amateur Radio signal as it leaves the transmitter and travels through the feed line to the antenna can be measured at the transmitter output in units of *actual* power — watts. After the signal has been radiated from the

[1]The bel was named in honor of Alexander Graham Bell. A decibel equals 1/10 of a bel.

Fig. 6 — The antenna system at the left is lossy, resulting in an 87.5 percent loss of power from transmitter input to antenna erp (effective radiated power). Total loss is 6 dB due to power dissipation in the transmitter, poor connectors at the transmitter output and antenna feed point, lossy feed line, and poorly constructed and installed antenna. At the right, there is an overall power "gain," despite the same 3-dB power loss in the transmitter. A good-quality feed line has brought only 1 dB of loss, while a beam antenna has added 7 dB of "gain." Total erp from this antenna system is 800 watts.



antenna, its strength is usually expressed in decibels of *relative* power, as shown on a receiver's *S meter* (signal strength meter). S meters are marked in divisions which indicate decibels and groups of decibels. The groups are known as *S units;* the number of decibels in each S unit (usually 5 or 6) depends on receiver design. The meters themselves vary as far as design, readability and reliability are concerned, and unless they are calibrated against a signal of known accuracy, they do not, as a rule, indicate the actual strength of a signal. Instead, they show each signal's relative strength compared to (1) other signals, (2) the noise level, or (3) a change in strength of that same signal.

Comments concerning the strength of signals may indicate that one station is 6 dB louder than another, that a signal lost 2 S units when the transmitting station switched from one antenna to a different one, or that a signal increased 10 dB when an amplifier was turned on. You may be told that your signal is the strongest one on the band, that it is way down in the noise, or that it is anywhere in between. Many things affect the strength of a signal, but the antenna system, composed of feed line and antenna, always plays a major part.

In addition to *seeing* relative strength responses on a meter, we can often *hear* relative strengths of signals as they emerge from a speaker or headphones; our ears have the ability to respond to relative loudness, just as the meter responds to relative power. These responses are logarithmic (see Table 2), which means (1) it takes a really substantial increase in actual power to make any noticeable difference in signal strength, and (2) doubling the power increases a signal's relative strength by 3 dB. This holds true no matter what amount of power is being increased by a factor of two — 10 watts to 20 watts, 500 to 1000, or 1000 to 2000. Each of these increases raises the relative power by 3 dB.

If power is *decreased,* the same thing happens in the opposite direction: When power is cut from 1000 to 500 watts, the strength of a signal is reduced by 3 dB.

Table 2
Useful dB Comparisons

Gain in dB	*Increase in Relative Power**
0	1.0
1	1.3
2	1.6
3	2.0
4	2.5
5	3.2
6	4.0
7	5.0
8	6.3
9	8.0
10	10.0
20	100.0
30	1,000.0
40	10,000.0
50	100,000.0

*0 through 9 dB power increases are approximate; others are exact.

Gain Questions

The assigned work of any transmitting antenna system is to radiate as much of the energy sent to it from the transmitter as possible. An antenna cannot, and therefore does not, *generate* any energy. All it can do is *radiate.* Question 1, then, is this: Why do we refer to antenna "gain"? Gain over what? (Question 2) And why is it that some antennas put out much stronger signals than others receiving the same amount of power from a transmitter? (Question 3)

Questions 1 and 2 can be answered together. Whenever we discuss any type of gain, we are comparing one thing with something else. A train, for example, gains speed — its speed increases over what it was; there are gains in the stock market today, compared to yesterday's listings. Gain indicates a *comparison,* and a signal's gain in power is also a comparison — a comparison against a standard, or point of reference. The standard may be a certain type of *practical* antenna, usually a half-wave dipole, or the standard can be a *theoretical* antenna called an *isotropic radiator.* The isotropic antenna can (in theory) radiate equally in all directions. Practical antennas, on the other hand, always radiate more energy in some directions than in others. If you read an antenna advertisement that says a certain type of antenna has dBi gain, the i indicates that the comparison reference is an isotropic antenna. If it says dBd gain, the second d means that the gain is calculated by using a half-wave dipole as a standard. (Incidentally, a half-wave dipole shows a 2.1-dBi gain.) If the ad merely states that the antenna has "gain," it's anybody's guess what it refers to.

Now for Question 3, concerning how gain is achieved. In Part 1 of this antenna article (November *QST*) we discussed beam antennas — directive types such as Yagis and quads, which, if properly constructed, radiate stronger signals than less-directive types such as commonly used dipoles and verticals. They achieve this extra strength (the so-called gain) not by generating additional energy but by concentrating the energy they receive from the transmitter and radiating it in a chosen direction at the expense of other directions, much as a flashlight does. Certain antenna types, then, can produce what we call gain.

Some antenna systems show gain over others because they have a better location. An antenna system can also show gain by keeping losses to a minimum. By eliminating loss sources, thereby lowering the amount of total loss, an antenna system of any type can show signal gain over a more lossy antenna system. It can even show gain over its former self when improvements are made, such as replacing defective feed lines, tightening connections, increasing height above ground, and increasing the number of radials. The gain is usually expressed in decibels of relative power. Power *loss* (also expressed in decibels), which can occur in either feed line or antenna, is determined by the antenna system's efficiency — the ratio of its input power to its output or radiated power. In any type of antenna system, high efficiency is achieved by careful and proper construction and installation, including matching of feed line to antenna, particularly when coax is used.

Proper Construction and Installation

Those words represent our present-day responsibility in our radio mining operation. During the past hundred years or more, by ingenious labor, thousands of radio amateurs, as well as other engineers, scientists and experimenters, made our present amateur equipment and communication possible. Because of their efforts and experiments we can obtain alternating current (ac) at 60 hertz (cycles per second) from a simple wall outlet; can change that ac to direct current (dc) by rectification; can utilize the dc in transistors and tubes to again generate and amplify ac (this time at radio frequencies of millions of times per second), and can send that rf energy to an antenna system to be radiated into space. This last step is our responsibility; our job to see that the "gold" that has been produced in our transmitter gets shipped out efficiently and profitably to its various destinations. If we send our precious rf power to a lossy feed line, we have allowed our gold to be hijacked en route. If we send it to a poor antenna, we have for all practical purposes (though unintentionally) thrown most of it onto the mine dump.

Here, then, are three things to remember about antennas:

1) Antenna work involves *work.* Extra work on feed lines as well as on antennas can yield extra watts and extra decibels of precious rf power.

2) A well-constructed beam antenna, by concentrating most of its energy in one direction, can produce a signal 10 to 20 times (or in very large installations, even more than 20 times) greater than that of an equally well-constructed but nondirectional antenna. But (and this is good news for everyone) it is also true that an antenna *of any type* that performs well by keeping its losses to a minimum can also radiate a far stronger signal than that of an antenna system with low efficiency. And all this relative increase is without the use of a separate power amplifier.

3) A good small — even simple — antenna, such as a dipole or a vertical, can produce a better signal than a lossy big installation, no matter how impressive the latter may look.

So as you put up your first antenna (and later ones, too), set your sights and your antennas high, and the "gold in them thar hills" can then be yours.

So Which Will It Be?

One of the questions beginners always ask is this: *Which kind of antenna is best?* And it is no wonder they wonder. All about them, in commercial ads, on roofs and on towers, in conversations on and off the air, they see or hear about all sorts and species of antennas: the most common ones — dipoles, verticals, Yagis, quads and longwires; the less-common windoms, rhombics and Zepps (that last kind so-called because they were first used on the Zeppelin dirigible); and a few antennas with such strange and wonderful names as six-shooter, bobtailed curtain, Beverage and fishbone — the last two receiving antennas only. All of these are billed as skilled aerial performers in the radio circuits. Each, too, is a deciding factor (possibly *the* deciding factor) between a signal that really "gets out" and one that really doesn't.

The answer to the question of which one is best is simple: There is no such thing as one best antenna for everyone, but there *is* a best antenna for *you*, depending on your own special situation. Answering the following questions should help you evaluate your situation:

1) How much room do you have for your antenna installation? It's amazing how small a space can, if necessary, be enough.

2) How much money can you afford to spend for this part of your amateur station? You can get by on only a few dollars, or on what we will simply call "more."

3) Do you intend to build your first antenna or buy a commercial one? Materials for the construction of a simple wire dipole are easily available to almost everyone.

4) Are there neighborhood (or domestic) problems to be worked out?

Look at antennas and talk about them with others. Read about them in books and periodicals (five common types were described briefly in Part 1 of this article). Look again at your own situation. If, after that, you decide to put up a coax-fed, half-wave dipole that is inexpensive and relatively easy to build, the accompanying information should be of practical help. For that matter, even if your choice is different, you might read the section anyway and perhaps "mine" something of interest from it.

Constructing and Installing a Simple, Coax-fed, Half-wave Dipole

This section[2] will provide a step-by-step guide to building your own one- or two-band (see text), half-wave dipole antenna. It's the type most Novices (and some higher class licensees) use, and it just may be the right one for you.

Materials Needed

1) *Wire.* For a dipole antenna, both the wire size (gauge) and length are important. For a straight dipole supported at the ends, the wire must be strong enough to mechanically support both the dipole and the weight of its coax feed line. Wire sizes no. 12 to 18 are recommended, the smaller number indicating the larger size. The wire should preferably be of the copper-weld type, which has a steel center to give it strength and prevent it from stretching, and a copper outer layer bonded to the steel center to make it a good conductor. Electric fence wire, either copper-covered or galvanized, can also be used effectively.

If you are putting up a space-saving, drooping dipole (also known as an inverted V), you can use any of the above-mentioned kinds of wire or the softer all-copper wire, since this type of dipole has the coax and antenna weight supported at the middle by a mast.

The amount of wire needed for either type of dipole will depend on the band or bands for which the antenna is being constructed. The total length of wire will be approximately one-half wavelength long for the desired band; measuring from the center, each side of the dipole will be about one-quarter wavelength long plus a little extra for making connections. (See Table 3.)

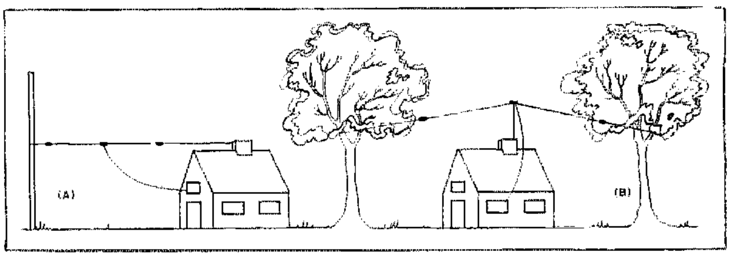
2) *Insulators.* Insulators are used at the center of the dipole and at the far ends of the two dipole wires. A center insulator is needed to keep the two halves of the dipole electrically separated and to provide an anchor for the two dipole wires and the feed line. This center insulator can be a commercial one or it can be made from a piece of acrylic or phenol-type plastic, such as the type shown in Fig. 8A, or it can even be made of wood. If it is made of wood, the wood should be saturated with hot paraffin or treated with varnish or some other coating to make it weatherproof.

Other insulators, usually made of porcelain, ceramic or glass, will be needed for the far ends of the dipole wires. The so-called egg insulator (Fig. 8B) or some other type of compression insulator, as well as "dog bone" type insulators (Fig. 8C) are in common use. Wood is not satisfactory for insulation at the ends of the dipole, as the rf voltage is much higher there than in the middle; if wood is used you may end up with high energy losses.

3) *Coax.* Get a good grade of 50-ohm coax for your dipole feed line. (See Fig. 1, November *QST*, page 43). If you can see through the braid to the insulation underneath, the braid's copper coverage (called "shield continuity") is probably inadequate. When you have installed the coax, be sure that none of the braid is left exposed, since exposed braid can soak up water like a wick. Use a silicone rubber compound (such as GE RTV) to weatherproof all connectors. You can also wrap connectors with electrical tape, cover them with a battery clamp "rubber boot," or use a combination of all three methods.

The antenna is fed directly from the transmitter, via the coax, at the center insulator, using a connector socket and plug (Fig. 8A). Use an SO-239 socket or its equivalent for the center connector and a PL-259 plug for the antenna end of the

Fig. 7 — At A, a typical half-wave dipole installation. Sturdy rope is used to connect the ends of the antenna to trees or other supports. At B is an inverted V, a half-wave dipole with the center part of the antenna raised. The ends should be as far apart as possible, for best results. Be sure to leave the ends of this type of antenna high enough above the ground so they can't be touched; someone could get an rf burn by touching the wire while the station is operating.



[2] Credit for the practical information in this construction section (as well as for many helpful suggestions and important items of information in previous sections) must go to Jim Snyder, WØUR/KØZCM.

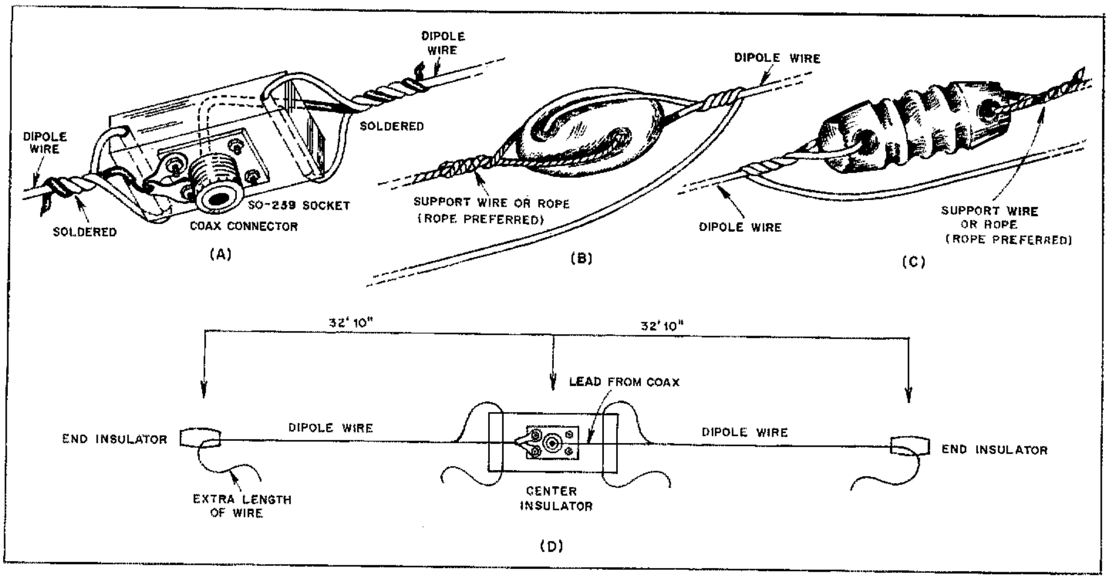


Fig. 8 — At A is a homebrew center insulator. This type is also available commercially. The "egg" type compression insulator (B) and the "dog bone" type (C) are common end insulators. A diagram of a 40-meter half-wave dipole is at D. All wire connections should be soldered. Trim the extra length of wire in (B) and (C) for minimum SWR. *(drawings based on originals by G. Ladwig)*

coax. The other end of the coax must have a connector that fits your rig. Using a properly installed connector at the feed point of the antenna, rather than splitting the coax (as is sometimes done), prevents water from getting into the coax.

4) *Supports.* For an inverted V, you will probably need a center support to get the high (middle) portion of the antenna up in the clear. This center support, called a mast, may be a metal pipe, a TV push-up mast, a 2 × 4 or some other type of center support strong enough to stand up against wind, ice and the antenna's weight.

For either the inverted-V or straight dipole, you will need to fasten the far ends of the dipole wires to sturdy objects. Plan ahead to determine what these objects will be — a roof, tree, pole or anything else convenient for the purpose. Have the antenna ends as far apart as possible.

Assuming that you or someone else in your family has a tool box with screwdrivers, pliers, wire-cutters and other essentials, the only expenses for your first antenna will be coax, wire and perhaps a few insulators and connectors. You may know an amateur who will bring some of his own equipment and perhaps contribute needed materials to the cause. Most amateurs have overflowing junk boxes and, since they are probably traders and scroungers themselves, will be happy to help other scroungers, particularly beginning ones, any way they can.

Preliminary Construction (things to do on the ground)

1) Measure the wire according to the following table, but *before cutting* it be sure you have included an additional length needed to go through the insulators and secure them, and another bit extra if you are putting up a drooping dipole instead of a straight one.

2) If you are using bare copper wire that has become tarnished, clean off the ends for several inches with steel wool so that it will be possible to make good solder connections. If insulated wire is used, remove the insulation at both ends with wire strippers or a knife.

3) Always use *rosin-core solder* on all connections. Acid-core solder will cause the wires to corrode.

4) Put the coax connector on the center insulator block and attach the dipole wires to the coax leads from the connector, as shown in Fig. 4.

5) Measure the two dipole wires again (now that they are attached to the center insulator), and mark the points which indicate the length needed for each side, using the band measurements listed in Table 2. Attach the end insulators, as shown in Fig. 8. Be sure to note the wiring illustration for the egg insulator. Wired as shown in the illustration, the dipole will not come apart, even if the insulator breaks.

6) Cut the length of 50-ohm coax you will need, allowing for some slack, and put on the two connectors. Put the connector sleeves on the coax before soldering the main part of each connector. *The Radio Amateur's Handbook*[1] contains complete information on installing coaxial connectors.

7) If you have access to an ohmmeter, test the coax for continuity and shorts after putting on the connectors. Place one probe on the *center conductor* at one end of the coax and the other probe on the *center conductor* of the other end. The ohmmeter should indicate less than 1 ohm of resistance — a virtual dead short. Again using the ohmmeter, touch the probes to the *braid* at both ends. Again, the result should be a virtual dead short. Finally, touch one probe to a center conductor and one probe to the braid (either at the same end of the coax or at the two ends) and you should get an infinity reading — infinite resistance. Failure to show these readings indicates a break in the coax or bad solder connections for the first two tests, and a short in the coax or connectors for the last one.

8) For your safety and for best operation of the antenna system, a ground

Table 3

Wire Lengths* for a Straight Half-Wave Dipole

Novice Band	*Length Each Side (1/4 λ)****	*Full Length (1/2 λ)*
80 meter	62' 10"	125' 8"
40 meter**	32' 10"	65' 8"
15 meter	11' 1-1/2"	22' 3"
10 meter	8' 3-1/2"	16' 7"

*Before cutting the wires for either a straight or drooping dipole, be sure to add extra lengths of wire to go through the insulators and secure them. See Fig. 8. For a drooping dipole, also add about 2 percent extra to the lengths shown in the table, provided the antenna is up high enough so that the ends of the dipole wires are not close to the ground or to other objects.

**A 40-meter dipole can generally be used effectively on 15 meters, without change.

***Feet × 0.3048 = m; inches × 25.4 = mm.

[1] *The Radio Amateur's Handbook*, ARRL, 56th Ed., 1979, pp. 17-5, 17-6.

connection is necessary. Run a metal rod (4-8 feet/1.2-2.4-m long) into the ground outside the shack. Attach a piece of heavy bare or insulated copper wire (12 gauge or larger) or a strap of copper or galvanized metal to this rod and attach the other end to the chassis of the rig.

9) A Blitzbug or some other kind of lightning arrestor should also be properly installed in the coax line.

Installing the Dipole

Only general directions can be given for this process since each situation is different and your resourcefulness will be needed to determine where and how. Certain suggestions may nevertheless prove helpful.

1) Get your antenna as high as the given situation will permit.

2) Keep your antenna wires away from power lines; *never* go over or under them. If you fail to follow these precautions you may not even live to regret it.

3) Treat your coax with great care. Don't walk on it and don't put mechanical stress or strain on it.

4) As you pull the antenna into position, watch that the wires do not kink. Our apologies for not telling you *how* to pull it into position or how to fasten it to the mast; you'll have to figure out how to do this for your own situation.

5) For either the drooping or straight dipole, bring the coax down vertically as far as possible.

6) If your antenna end support is a living tree, put a piece of rubber hose around the tree (for the tree's protection) and run the support wire or rope through the hose. There should be an additional length of cord or wire, after the end insulator, to secure it in place via the rubber tubing.

7) Be sure to solder and, where necessary, weatherproof all connections carefully. The antenna and upper part of your coax will not be readily accessible like other parts of your station. Eventually any weak spot is sure to be damaged by the wind and other elements, and will have to be repaired. Ultraviolet light from the sun can weaken guy ropes, so use strong cord such as plastic clothesline with a polyethylene center for your supports. *Never* use rope with a wire center as a support for any type of antenna.

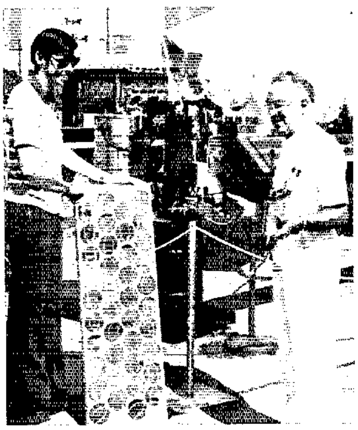
8) Even though there is a legitimate use for a piece of equipment called a *balun* (rhymes with gallon and is derived from the combination of balanced and unbalanced), it is usually not needed as an electrical balancing device for this type of simple, coax-fed antenna. Feeding the coax directly to the antenna and using the connectors as described cuts down the cost and makes the entire installation simpler.

9) You may hear someone talking about an antenna matching or tuning unit, such as a match box or Transmatch. These are useful or even required in some situations, but since most modern rigs are made to operate into a nominal 50-ohm load, a matching unit for this coax-fed dipole should not be necessary. You can learn more about matching (and baluns) in *The Radio Amateur's Handbook*.

10) You will also hear people talking about SWR meters or the SWR (standing wave ratio) of their antenna systems. They may report SWRs of 1:1 (known as 1 to 1), 1.7:1 or 3:1. SWR could take up an entire article, but we will limit our discussion of it to one brief statement. Antennas are supposed to be tuned to a desired resonant frequency (usually a frequency at about the middle of a desired band). The use of an *SWR meter* or *SWR bridge* is one way of finding out whether the tuning of a coax-fed antenna has been properly achieved. A *change in length* is usually the means by which simple antennas are adjusted to take care of the tuning. If it is determined from an SWR meter reading that the resonant frequency of your antenna is lower than you desire, you can *raise* the resonant frequency by *shortening* both sides of the dipole, equally. If the resonant frequency is *higher* than desired, you can *lower* the resonant frequency by *lengthening* both sides of the dipole equally. See Fig. 8.

But don't worry too much about the SWR of your simple, coax-fed half-wave dipole. If you use good 50-ohm coax, cut your dipole wires the proper length, make sure all connections are tight, and put your antenna up as high and in the clear as possible, you should be able to "mine" your share of the radio spectrum for years to come.

Strays

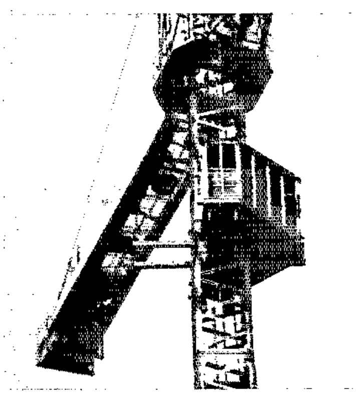


At the Los Angeles Energy Fair '78 Pete Matthews, W6UIA (left), holds a 25-watt solar-panel array toward the sun while Dr. Norm Chalfin, K6PGX, operates on 2-meter fm. During the late September event, the solar array was used "raw," except for a series regulator to maintain 11.56 V out. The cells have an open circuit output of 20 volts.

These four teachers found that they could get in-service credits and a new hobby all at once. The Washington, DC, schools offered two hours of credit for completion of a Novice level Amateur Radio course. Its purpose was to create a pool of qualified people to operate and maintain the school system's amateur equipment. The teachers are (l-r) Oliver Ellis, KA3BBF; Cliff Harewood, KA3AUK; Brazzilia Nowlin, KA3AUV; Charles Leonard, KA3BBG and their instructor, John Thayer, K3DDS.

CQ, SEKIU

☐ Out near the tip of the Olympic Peninsula in the state of Washington, lies a small fishing village named Sekiu. It's pronounced precisely the same as CQ. — *W7YF*



Dale Williams, WD5AJC, of Sugarland, TX, doesn't use a typical ham station. His shack is a wooden structure built on the side of a construction crane 200 feet in the air above Houston. His antenna is a sloper stretching from the top of the crane down to the counter jib where the electric motors are mounted. The crane rotates 360 degrees and is the most extravagant rotor we've heard of, costing $200,000.