Electronics World

SEPTEMBER, 1967
60 CENTS

TEMPERATURE-DEPTH MEASUREMENTS IN THE OCEAN

NEW AVALANCHE TRANSISTOR CIRCUITS

LOW-COST SEMICONDUCTORS FOR THE CONSUMER MARKET

DIRECTORY OF THE MOST POPULAR LOW-PRICED VIDEO TAPE RECORDERS

MEASURING MISSILE EXPLOSIONS

A ZIFF-DAVIS PUBLICATION

Nowhere is the soundness of the component approach to home music better demonstrated than with the new Electro-Voice Starter Set.

The unique value of this system lies—in large part—in the modestly-priced E-V ELEVEN speaker systems. These compact basic starter units offer a most pleasant appearance and surprisingly robust performance . . . conclusive proof that the advantages of component reproduction need not be expensive.

But the principal unit of the Starter Set is the E-V 1177* FM Stereo receiver . . . and rightly so. For the future of your stereo system rests on the ability of this receiver to meet tomorrow's needs. Right from the start you enjoy FM stereo with remarkable clarity. Yet you can expand your musical horizons as you wish, adding any component stereo record player or tape recorder at any time.

But the Starter Set goes further, providing all the power and quality needed to accommodate the very largest—and smallest—component speakers available. If you eventually desire even finer speaker systems, they're easily added. Your E-V ELEVEN's may then be moved to a second listening location where requirements are perhaps less critical. Nothing has been lost—nothing made obsolete.

In essence, the E-V Starter Set offers you more than the initial pleasure of fine high fidelity. It is designed to grow and change with your personal needs—and without compromising your standards of musical reproduction.

You'll be surprised at the modest initial cost of the E-V Starter Set— and at how much it offers. Take the first step toward a lifetime of musical pleasure. Write today for full details, or listen to the Starter Set at fine high fidelity showrooms everywhere.

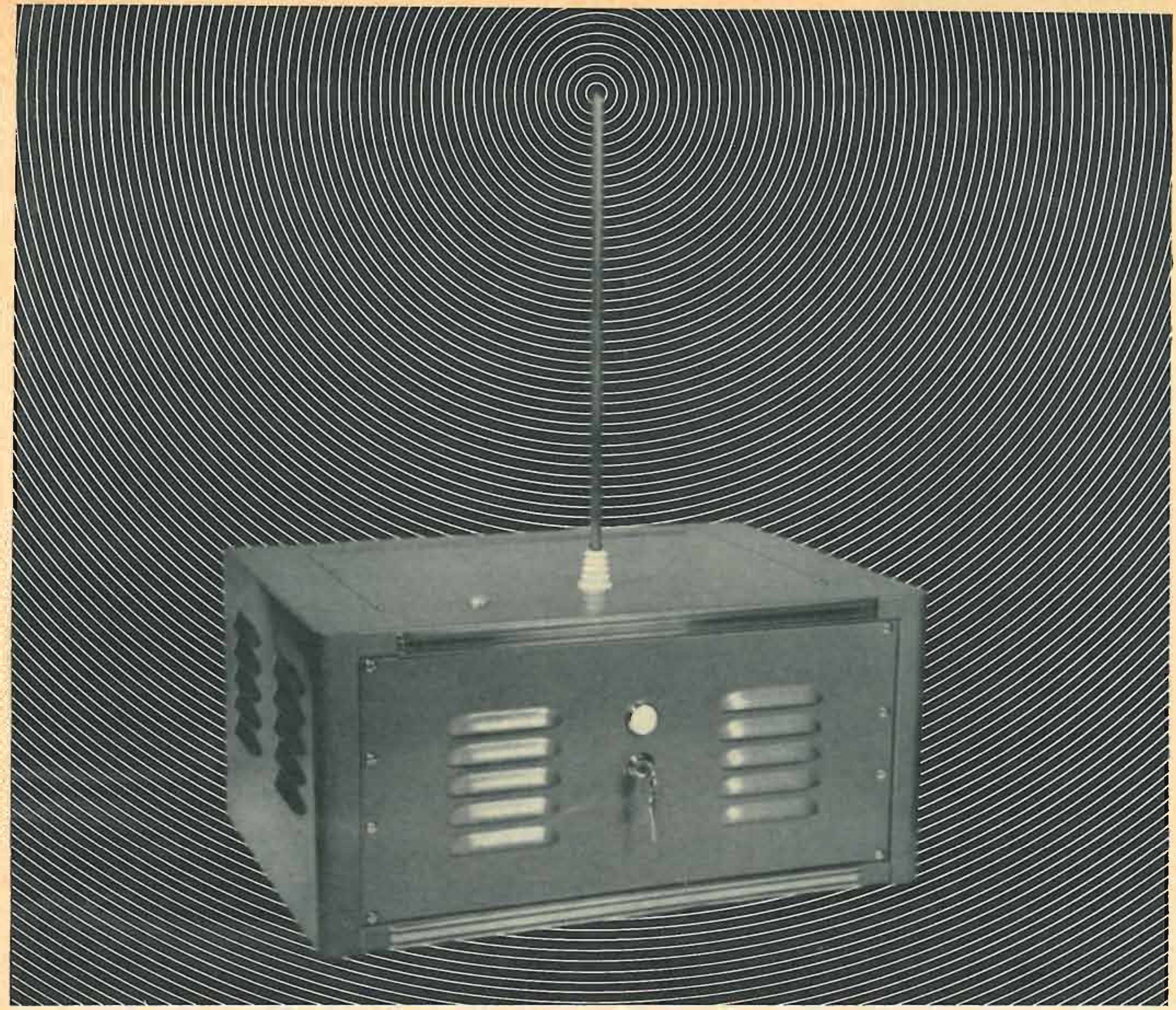
**Also available with E-V 1178 AM/FM Stereo Receiver*

high fidelity speakers and systems • tuners, amplifiers, receivers • public address loudspeakers • microphones • phonograph needles and cartridges • organs • space and defense electronics

ELECTRO-VOICE, INC., Dept. 974N, 629 Cecil Street, Buchanan, Michigan 49107

CIRCLE NO. 116 ON READER SERVICE CARD

Electro-Voice®



You are now in Radar Sentry Alarm's r.f. microwave field. Don't move a muscle!

This security system is so sensitive, it can be adjusted to detect the motion of your arm turning this page.

And if this Portable Model Unit were within 35 feet of you and you moved... people up to a half-mile away could hear the siren. Plus with optional equipment, it can detect fire... turn on lights... even notify police.

What does a burglar alarm have to do with you?

Just this: Radar Sentry is no ordinary alarm. It is the most modern and effective security system available. And it's also electronic.

That's why we need you. We need Dealers with technical knowledge. For the most successful Dealers for Radar Sentry Alarm are men who know electronics. This is a product that sells itself when demonstrated properly.

It's been proven time after time. In fact, many of the more than one thousand readers of electronics magazines who became Dealers in the past year—sold a system on their *first* demonstration.

And that's why we need men with technical knowledge and experience.

Men like *you.*

How about it?

Do you want to start a business of your own... or expand your present business with a product that in 8 years has become the world-wide leader in its field?

Do you want to earn up to $5,000 a year in your spare time?

Do you want to earn $20,000 and more full time?

We'll show you how.

O.K., now you can move.

Fill out the coupon and get complete Dealer/Distributor information... free.

Mail to: RADAR DEVICES MANUFACTURING CORP.
22003 Harper Ave., St. Clair Shores, Michigan 48080

Please tell me how I can have a business of my own distributing Radar Sentry Alarm Systems. I understand there is no obligation.

Name__________

Address__________

EW-9

City______ **State & Code**______

CIRCLE NO. 98 ON READER SERVICE CARD

 Tips for Technicians

Using silicon rectifiers in horizontal AFC circuits

FIG. 1. 6AL5 AFC CIRCUITS

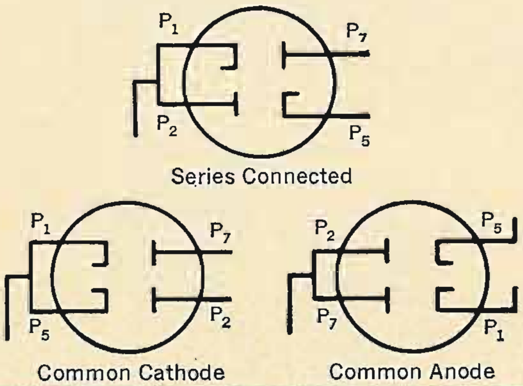


FIG. 2. SELENIUM RECTIFIER AFC CIRCUITS

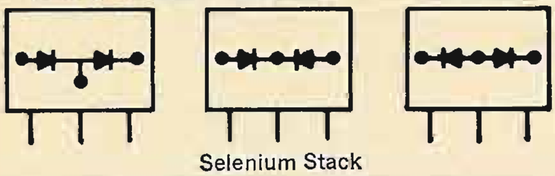
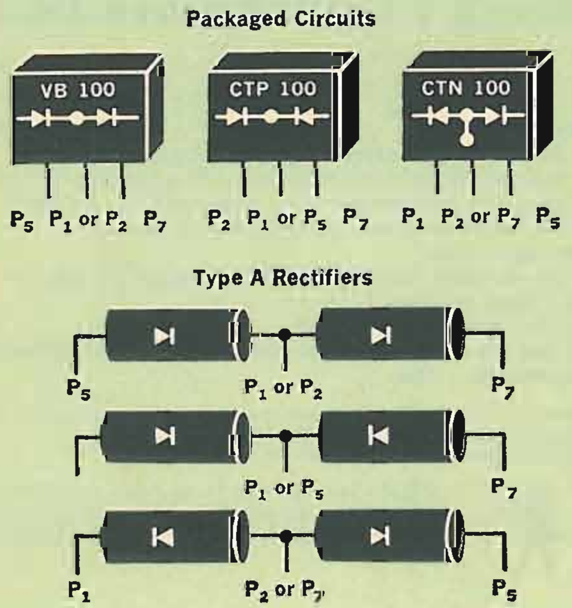


FIG. 3. MALLORY SILICON RECTIFIER REPLACEMENTS



Many of the older TV sets you'll run into have a 6AL5 dual rectifier tube in the horizontal automatic frequency control circuit. Its function is to insure a stable horizontal frequency, by comparing the input signal from the sync separator with a feedback signal from the horizontal output. Three different circuits were used for this job, as shown in Figure 1.

In some later sets, selenium rectifiers took over the 6AL5 job for AFC. These were connected as shown in Figure 2.

When you run into one of these AFC circuits that needs fixing, you can do your customer a favor by switching to Mallory silicon rectifiers. You'll give him a repair job that will shape up this part of the set for all time, at no extra cost. You won't have to chase around finding a selenium stack with exactly the rating you need. And you're sure you won't ever have a call-back on the job.

You can go either of two ways with Mallory silicon replacements. Simplest is to use a Mallory packaged rectifier circuit—a pair of factory-connected rectifiers in a single compact plastic case. Cost is slightly less than two separate rectifiers, and installed reliability is better because you have fewer solder connections to make. The VB doubler is ideal for the series-connected AFC circuit; just get a Mallory VB100 and hook it to the tube socket. For the common cathode AFC circuit, use a Mallory CTP100 (full wave, center tap positive). And for the common anode circuit, use a Mallory CTN100 (full wave center tap negative).

Or if you prefer to work with separate rectifiers, get yourself a pair of Mallory Type A's. The A100 will work fine. Either way, just make your connections as shown in Figure 3.

For this service, 100 volt ratings are ample to give you full protection against transient "spikes" and assure long life. For other applications in TV sets, stereo, radios and industrial equipment, take a look at the complete line of Mallory power rectifiers, zener diodes and other semiconductors stocked by your Mallory Distributor. He's a good guy to know for everything you need for service, prototype building or experimental work. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM—*"What else needs fixing?"*

CIRCLE NO. 105 ON READER SERVICE CARD

THIS MONTH'S COVER shows an attempted launch of an Atlas-Centaur rocket in 1965. While these now rare explosions may seem wasteful, much needed information can be obtained from failures if proper instrumentation is on-site at the time. The Pad Abort Measuring System described in our lead article "Measuring Missile Explosions" received its first checkout at Cape Kennedy during this explosion. Information gathered by the system will enable aerospace engineers to reduce hazards to personnel and damage to structures from any future explosions................. Photo courtesy of NASA —Kennedy Space Center.

Publisher
PHILLIP T. HEFFERNAN
Editor
WM. A. STOCKLIN
Technical Editor
MILTON S. SNITZER
Associate Editor
P. B. HOEFER
Assistant Editor
MARSHA JACOBS
Contributing Editors
WALTER H. BUCHSBAUM
Prof. ARTHUR H. SEIDMAN
Art Editor
HERBERT L. SILBERMANN
Art and Drafting Dept.
J. A. GOLANEK
Advertising Sales Manager
LAWRENCE SPORN
Advertising Service Manager
ARDYS C. MORAN

Electronics World

SEPTEMBER 1967 VOL. 78, No. 3

CONTENTS

23 **Measuring Missile Explosions** *E.A. Lacy & C.N. Golub*
27 **Period-Frequency Graph** *R.W. Bailey*
28 **Recent Developments in Electronics**
30 **Avalanche Transistor Circuits** *Sidney L. Silver*
33 **Temperature-Depth Measurements in the Ocean** *John Althouse*
37 **Low-Cost Semiconductors for the Consumer Market** *John S. MacDougall*
40 **Directory of Most Popular, Low-Priced Video Tape Recorders**
42 **Gunn Oscillators** *David L. Heiserman*
44 **Electronics for Speech and Hearing Therapy** *L. George Lowrence*
46 **Report on Annual Assembly of RTCM** *Richard Humphrey*
47 **Switches: A Guide to Selection & Application** *Arthur F. Hackman*
60 **Permanent Tinning of Soldering Irons** *Peter J. Prolera*
71 **New Approach to Engine Tachometers** *Ronald L. Carroll*
84 **Solid-State Ring Counters & Chasers for Light Displays** *A.A. Adem*
87 **The Volume Unit**
88 **Tone-Selective Signaling: The New Look** *Leslie Solomon*
93 **The Common Slide Rule for Reactance Calculations** *Glodden B. Hauck, Jr.*
94 **Hi-Fi Show Seminars Program**

6 **For the Record (Editorial)**
N. Y. Hi-Fi Show
16 **EW Lab Tested**
"Knight-Kit" KG-790 AM-FM Stereo Tuner
PML EC-71 Capacitor Microphone
58 **Technical Writing** *John Frye*
66 **Test Equipment Product Report**
Seco Model 240 Thyristor (SCR) Analyzer
Hewlett-Packard Model 5221A Electronic Counter
Amphenol Model 670 Transistorized Volt-Ohmmeter

MONTHLY FEATURES

4 **Coming Next Month**
12 **Letters from Our Readers**
70 **Radio & TV News**
80 **Book Reviews**
81 **Electronic Crosswords**
96 **New Products & Literature**

Electronics World: Published monthly by Ziff-Davis Publishing Company at 307 North Michigan Ave., Chicago, Illinois 60601. One year subscription $6.00. Second Class Postage paid at Chicago, Illinois and at additional mailing offices. Subscription service: Portland Place, Boulder, Colorado 80302.

COMING NEXT MONTH

SPECIAL ISSUE: SWITCHES

A 24-page section devoted to all types of switches will include: **Open-Frame Rotary Switches** by William Sefton of Centralab; **Snap-Action Switches & Their Ganged Arrays** by Harry H. Meyer of Micro Switch; **Slide Switches & Their Ganged Arrays** by Bernard Golbeck of Oak; **Miniature Switches** by Al F. Contarino of Alcoswitch; **Toggle Switches** by Ronald G. Rezel of Cutler-Hammer; **Lighted Switching Devices** by Walker Smith of Micro Switch; and **Stacked Switches & Their Ganged Arrays** by James Bailey of Switchcraft. With the information provided, circuit designers and component engineers will have at their fingertips complete and up-to-the-minute data on all currently available types.

INFRARED RADIOMETRY
Since everything above Kelvin zero emits heat that can be converted into infrared photographs, by radiometers, industry is taking advantage of this technique to make mechanical inspections while the Armed Forces use it to locate camouflaged men and vehicles.

THE SUN AND SPACE SOLAR MEASUREMENTS
What types of radiation and what levels reach the earth from our sun? To answer these important questions, the OSO series of advanced space explorers are orbiting space and sending back much valuable data.

AUDIO INTEGRATED CIRCUITS—WHAT'S AVAILABLE?
A wide range of low-cost IC's is now available for use in low-power audio circuits. Donald E. Lancaster provides a rundown on what is on the market now and what you can expect to find in the next few months.

All these and many more interesting and informative articles will be yours in the October issue of ELECTRONICS WORLD . . . on sale September 19th.

ZIFF-DAVIS PUBLISHING COMPANY

William B. Ziff
Chairman of the Board (1946-1953)
William Ziff
President
W. Bradford Briggs
Executive Vice President
Hershel B. Sarbin
Senior Vice President
Philip Sine
Financial Vice President
Walter S. Mills, Jr.
Vice President, Circulation
Stanley R. Greenfield
Vice President, Marketing
Phillip T. Heffernan
Vice President, Electronics Division
Frank Pomerantz
Vice President, Creative Services
Arthur W. Butzow
Vice President, Production
Edward D. Muhlfeld
Vice President, Aviation Division
Irwin Robinson
Vice President, Travel Division

Editorial and Executive Offices
One Park Avenue
New York, New York 10016 212 679-7200

NEW YORK OFFICE 212 679-7200
James J. Sullivan
Joseph E. Halloran

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
Midwestern Advertising Manager, Royce Richard

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265; BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN
James Yagi
Ishikawa Mansion
#4, Sakuragaoka
Shibuya-ku, Tokyo
462-2911-3

CIRCULATION OFFICE
Portland Place, Boulder, Colorado 80302

Member Audit Bureau of Circulations

Radio & TV News • Radio News • Radio-Electronic Engineering Trademarks Reg. U.S. Pat. Off.

SUBSCRIPTION SERVICE: All subscription correspondence should be addressed to Electronics World, Circulation Department, Portland Place, Boulder, Colorado 80302. Please allow at least six weeks for change of address. Include your old address, as well as new—enclosing if possible an address label from a recent issue.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.

ELECTRONICS WORLD (September, 1967, Vol. 78, No. 3). Published monthly at 307 North Michigan Avenue, Chicago, Illinois 60601, by Ziff-Davis Publishing Company—also the publishers of Airline Management and Marketing, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Flying, HiFi/Stereo Review, Modern Bride, Popular Aviation, Popular Electronics, Popular Photography, Skiing, Skiing Area News, and Skiing Trade News. (Travel Weekly is published by Robinson Publications, Inc., a subsidiary of Ziff-Davis Publishing Company.) One year subscription rate for U.S., U.S. Possessions, and Canada, $6.00; all other countries, $7.00. Second Class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash.

Your Sylvania distributor can give you a technical library. For fast answers to difficult electronic problems.

Nobody beats Sylvania when it comes to up-to-date technical information—for *your* applications. And your Sylvania distributor has it all for you.

You can get data sheets and catalogs on industrial receiving tubes, transmitting tubes, industrial control tubes, counter tubes, cathode ray tubes, flash tubes, gauge tubes, photosensitive devices, microwave devices and all semiconductors.

Your Sylvania man also has inventory programming forms—and many types of application information. Plus other kinds of free technical materials.

And he's a tube expert. He can analyze your tube and semiconductor replacement needs. He can prevent emergencies, take an inventory and save you time and money.

Call him for these services—and for the best technical literature in the tube industry. And depend on him for fast delivery—in any quantity.

Sylvania Electronic Tube Division, Electronic Components Group, Seneca Falls, New York 13148.

SYLVANIA

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS GT&E

For the record

WM. A. STOCKLIN, EDITOR

N.Y. Hi-Fi Show*

As chairman of a committee of one, we have again been asked by the Institute of High Fidelity to plan the various seminars to be run concurrently with the New York Hi-Fi Show at the Statler Hilton (Sept. 21-24).

This will be the fourth consecutive year in which these seminars have been held and, if past experience is any criterion, this forthcoming program should attract considerable interest. In fact, the Hi-Fi Show Committee, under the direction of its president, Walter Stanton, has been so encouraged by past attendance that almost double the number of seminars will be held this year.

In addition to the technical and semi-technical sessions, we will add three separate programs on the subject of applications of hi-fi equipment as part of "Room Decor". These sessions will be conducted by members of the Association of Interior Decorators and the National Association of Interior Design.

There will also be four additional symposia on "Musicology". These sessions will explore the theory and background of the most popular musical art forms, including "Jazz", "Popular Music", "Classical Music", and a special session on "The Successful Recording".

This year's sessions should prove to be most exciting. While many of our "regulars" will be back, for the most part, there will be new faces—new people with new ideas—engineers and executives—and when we get to the symposia on musicology many of the "experts" will be well-known radio-TV stars. For complete program details, see page 94 of this issue.

Technical Symposia

"Tape and Tape Recorders"

Many of you will remember Joe Kempler of *Audio Devices* who has been with us for the past two years. He has given us such thought-provoking presentations in the past that we have asked him to return. In addition to discussing raw tape—what to buy, how to store it, and what to expect—Joe will expand his talk to include raw tape as used in our many new tape cartridge systems. This is a new field and should prove an interesting subject for exploration.

Paul Bunker, product manager of the *Magnecord Div., Telex Corp.* is a new guest panelist and he will discuss tape recorders—not only what you should expect for what you spend—but review many of the technical characteristics, their meaning, and importance. Paul comes to us highly recommended and we look forward to an interesting session.

"Cartridges, Turntables, and Changers"

We couldn't help but ask Jim Kogen, chief engineer, R&D, *Shure Brothers,* to return. Not only was his presentation enlightning, but Jim is the only one we know of who has a demonstration kit to illustrate the 45/45 degree operation of a disc recording. We are sure he will bring us up-to-date on the new developments in stereo cartridges, with particular emphasis on the elliptical stylus and the 15° tracking angle.

As a co-panelist, we have selected a newcomer to our group of guest speakers—a man well-known in our industry for many years. Bud Childs, president of *Elpa Marketing Industries* (*Thorens*), is technically qualified to answer all questions about automatic turntables and changers.

"Amplifiers and Tuners"

This is a new program this year and our guest speakers, since their specialty is solid-state design, are relatively new to our industry. We will have with us George Meyer who is product manager of *Fisher Radio,* and Larry Fish, chief engineer of *H.H. Scott.* Both of these men will bring us up-to-date on solid-state applications to hi-fi equipment. They will go beyond the present and describe future trends in applying integrated circuits and pulse-counting detectors.

"Stereo and The Listener"

Abe Cohen, formerly with *University Sound* and now manager of acoustics at *Instrument Systems Corp.,* and Vic Brociner, assistant to the president of *H. H. Scott,* have been called back to repeat their performances of last year. Their presentations, and particularly their live demonstrations of the stereo effect, proved of such interest that we felt many of those who attended last year's program would repeat this year.

These are the four technical sessions and, of course, everyone is invited to attend. If anyone has any hi-fi questions, this is an ideal opportunity to come and ask the "pros".

It would be a grave error if we didn't mention the great presentations given the past three years by Len Feldman in a semi-technical talk covering all aspects of hi-fi. Leonard attracted capacity crowds at every session and we have asked him to be with us again this year. He will give four repeat performances during the Show.

My personal thanks, of course, to all of our old friends who are again devoting their time and effort to help make this year's program a success, and a hearty welcome to all of the newcomers who will assist us in broadening the scope of our coverage. ▲

*Plans are under way, but not finalized, for holding similar symposia at the Institute of High Fidelity's West Coast Show, Nov. 2-5, Ambassador Hotel, L.A.

GET A FASTER START IN THE COURSE YOU CHOOSE WITH NRI'S REMARKABLE ACHIEVEMENT KIT

When you enroll with NRI we deliver to your door everything you need to make a significant start in the Electronics field of your choice. This remarkable, new starter kit is worth many times the small down payment required to start your training. And it is only the start . . . only the first example of NRI's unique ability to apply 50 years of home-study experience to the challenges of this Electronics Age. Start your training this exciting, rewarding way. No other school has anything like it. What do you get? The NRI Achievement Kit includes: your first set of easy-to-understand "bite-size" texts; a rich, vinyl desk folder to hold your training material in orderly fashion; the valuable NRI Radio-TV Electronics Dictionary; important reference texts; classroom tools like pencils, a ball-point pen, an engineer's ruler; special printed sheets for your lesson answers—even a supply of pre-addressed envelopes and your first postage stamp.

Learning electronics at home is faster, easier, more interesting with new achievement kit

Only NRI offers you this pioneering method of "3 Dimensional" home-study training in Electronics, TV-Radio . . . a remarkable teaching idea unlike anything you have ever encountered. Founded more than half a century ago — in the days of wireless — NRI pioneered the "learn-by-doing" method of home-study. Today, NRI is the oldest, largest home-study Electronics school. The NRI staff of more than 150 dedicated people has made course material entertaining and easy to grasp. NRI has simplified, organized and dramatized subject matter so that any ambitious man — regardless of his education — can effectively learn the Electronics course of his choice.

DISCOVER THE EXCITEMENT OF NRI TRAINING

Whatever your reason for wanting knowledge of Electronics, you'll find the NRI "3 Dimensional" method makes learning exciting, fast. You build, test, experiment, explore. Investigate NRI training plans, find out about the NRI Achievement Kit. Fill in and mail the postage-free card. No salesman will call. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D. C. 20016

ELECTRONICS COMES ALIVE AS YOU LEARN BY DOING WITH CUSTOM TRAINING EQUIPMENT

Nothing is as effective as learning by doing. That's why NRI puts so much emphasis on equipment, and why NRI invites comparison with equipment offered by any other school, at any price. NRI pioneered and perfected the use of special training kits to aid learning at home. You get your hands on actual parts like resistors, capacitors, tubes, condensers, wire, transistors and diodes. You build, experiment, explore, discover. You start right out building your own professional vacuum tube voltmeter with which you learn to measure voltage and current. You learn how to mount and solder parts, how to read schematic diagrams. Then, you progress to other experimental equipment until you ultimately build a TV set, an actual transmitter or a functioning computer unit (depending on the course you select). It's the practical, easy way to learn at home—the priceless "third dimension" in NRI's exclusive Electronic TV-Radio training method.

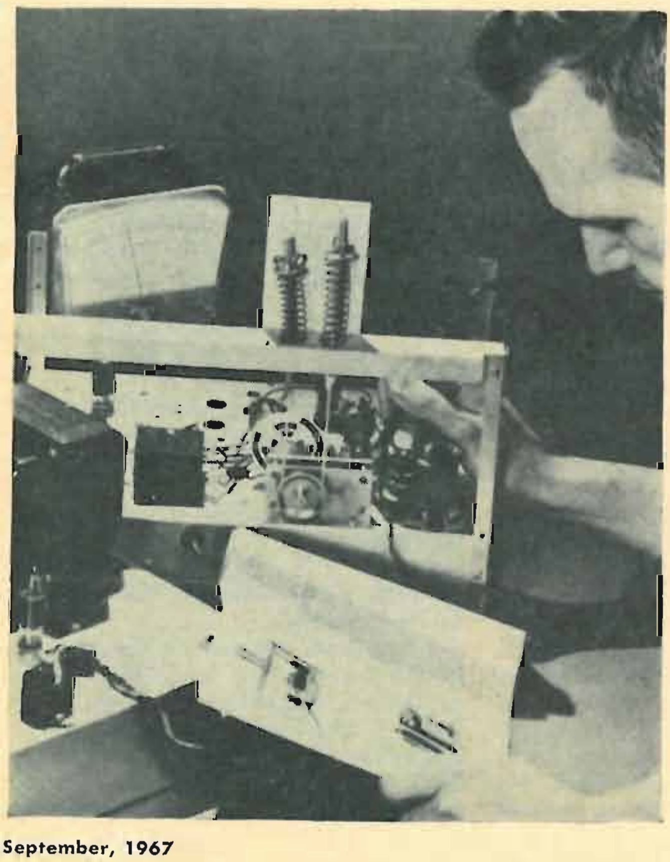
SIMPLIFIED, WELL-ILLUSTRATED "BITE-SIZE" LESSON TEXTS PROGRAM YOUR TRAINING

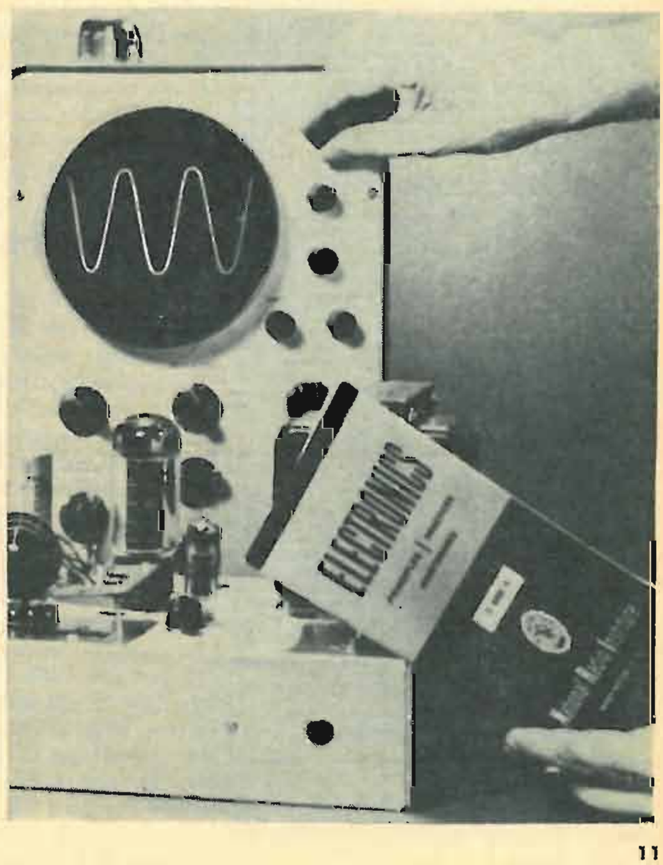
Lesson texts are a necessary part of training, but only a part. NRI's "bite-size" texts are as simplified, direct and well-illustrated as half a century of teaching experience can make them. The amount of material in each text, the length and design, is precisely right for home-study. NRI texts are programmed with NRI training kits to make things you read come alive. As you learn, you'll experience all the excitement of original discovery. Texts and equipment vary with the course. Choose from major training programs in TV-Radio Servicing, Industrial Electronics and Complete Communications. Or select one of seven special courses to meet specific needs. Check the courses of most interest to you on the postage-free card and mail it today for your free catalog.

Available Under
NEW
GI BILL

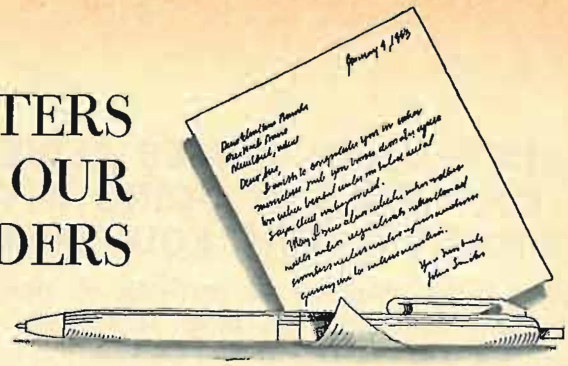
If you served since January 31, 1955, or are in service, check GI line in postage-free card.

custom training kits *"bite-size" texts*





LETTERS FROM OUR READERS



WEATHER SATELLITES GUIDE PILOTS

To the Editors:

Two of the photos in your May "Recent Developments" department show a new ESSA 4 weather satellite along with an optical reader used by the U.S. Weather Bureau to read weather data from the satellites. Well, our weather bureau is not the only one using data from these satellites. According to a recent Associated Press newspaper story, the weather satellites are being monitored by our Air Force in South Vietnam and Thailand. It was reported that cloud-cover photos of all Southeast Asia had become a very valuable guide to United States bombing. By spotting breaks in the clouds, planes can be promptly diverted to clear areas.

Bill Donahue
St. Louis, Mo.

Also, because the wavelengths are not secret and the required receiving equipment is so simple, it's a good guess that North Vietnam is using the same information for air-defense operations as well. As a matter of fact, it is possible to buy commercial equipment for receiving as many as 15 high-resolution cloud-cover photos a day from these weather satellites. Cost of all the equipment required except for the receiving antenna is between $3500 and $5000.—Editors

* * *

AUTOMOTIVE ELECTRONICS

To the Editors:

The articles on electronics in automobiles in the May issue were quite interesting, especially those about new developments. However, I found two slight inaccuracies, both of which involve one company, *American Motors.*

First, at the bottom of p. 23, concerning transistorized voltage regulators, it is stated, ". . . *Ford Motor Company* has announced that it will be using some solid-state regulators in many of their 1968 models." Since this is the only mention of an automobile manufacturer in this section, the implication is that the 1968 Fords will be among the first to use solid-state voltage regulators. This is about two years behind the actual use of solid-state regulators by an automobile manufacturer. My 1966 Rambler Classic has as standard factory equipment a *Motorola* alternator and *Motorola* solid-state voltage regulator. The regulator is in a sealed metal case about 1" x 1" x 2" in size. I understand that the solid-state regulators were adopted about the middle of the 1966 model year by *American Motors* for *all* Rambler models.

Second, on p. 28, you mention ". . . *American Motors'* announcement in February of its intention to market a small combustion-type passenger car which would openly compete with the Volkswagen." If I am not mistaken, the *American Motors* February announcement was not of a new model, but rather of a new pricing structure for the Rambler American, which has been in production for several years. This change involves the elimination of yearly model changes, with improvements in safety and other features being added as they are developed (as is done with Volkswagen). The elimination of yearly changes allowed a price reduction of about $200.

W. J. Stiles
Wentzville, Mo.

To the Editors:

I have just read the article called "Automotive Electronics" in the May issue. The article was great, as were the associated articles.

Naturally, it is impossible for you to cover every single development so this may be the reason why the item I enclose information on was not mentioned.

Tom Sanchez, Sr.
Albany, N.Y.

Thanks to Reader Sanchez for sending us a description of a solid-state device that automatically raises the roof of a convertible in the event of rain, even though the driver is not in the car.—Editors

* * *

PHONO CARTRIDGES VS RECORDS

To the Editors:

I have read with interest the article in your June issue by Mr. J. H. Kogen on the tracking ability of phono cartridges. Apparently Mr. Kogen has adopted an "If you can't lick 'em, join 'em" philosophy with respect to the ridiculously wild modulation on some of the current recordings. He even has the audacity to call them "high quality"! There can be no valid excuse for record manufacturers to produce recordings with such high modulation levels that many otherwise high-quality cartridges cannot track them. This sort of exercise evolves into a contest between the record manufacturers and the cartridge manufacturers, with the loser in this game being the poor consumer. It is high time that reasonable limits for peak modulation levels were established and adhered to.

Although he cited it as an example only, I don't believe that Mr. Kogen's selection of 10% distortion at the peak output of a cartridge is within reason. A better figure might be 1%, since the paper referred to by Mr. Kogen points out that a measured CCIF distortion of only 1% at 10 kHz becomes 7.5% after passage through the RIAA playback network.

J. E. Dupree
San Antonio, Texas

To the Editors:

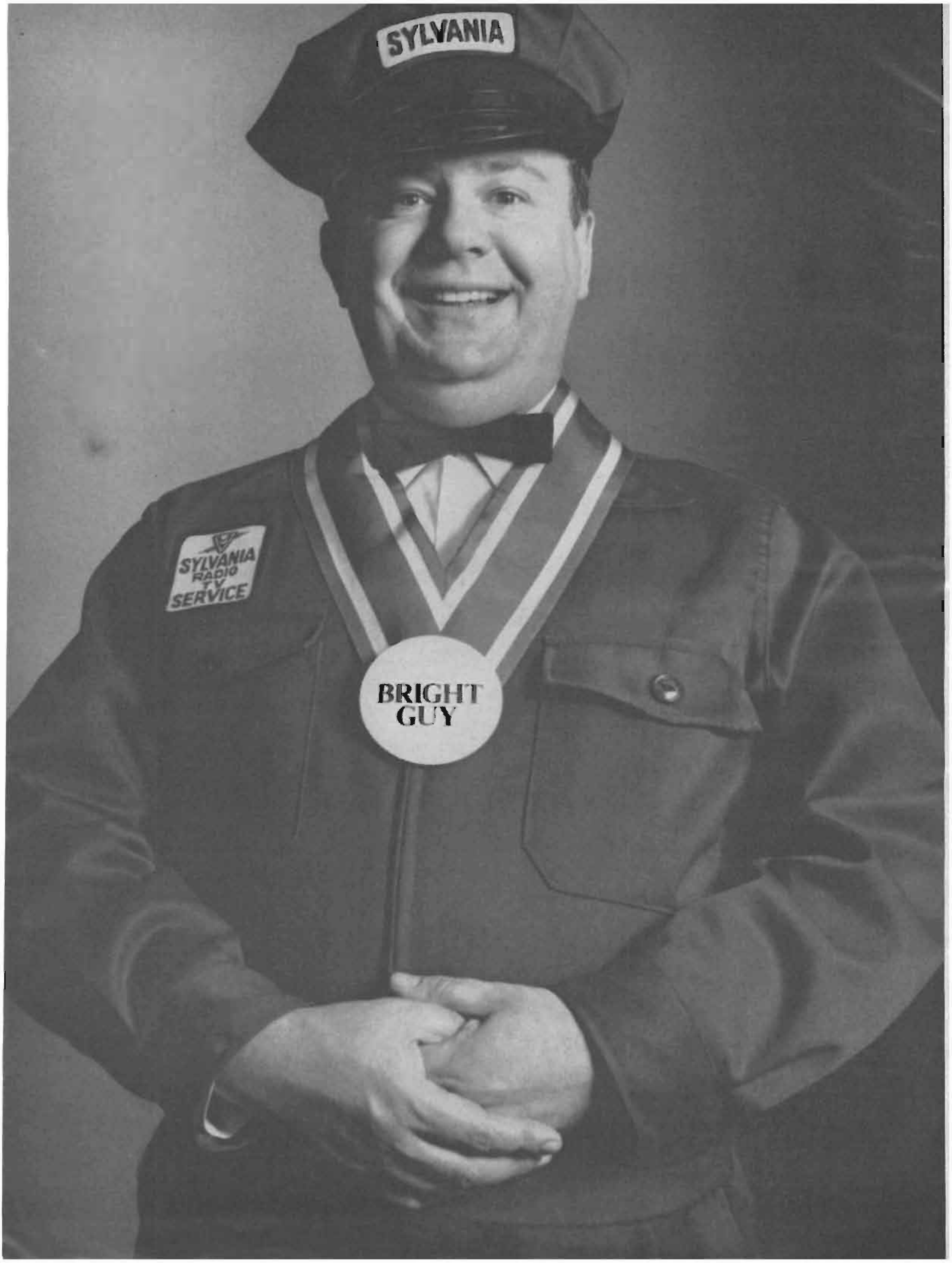
Mr. Dupree has misinterpreted our position on the subject of high recording levels. We are by no means trying to promote the concept of excessive modulation levels. We are simply recognizing the facts of life. We continually try to encourage the record companies to maintain reasonable levels, but we have a concurrent responsibility to our customers to provide a cartridge which will track existing records properly. Adequate tracking is essential not only to eliminate a source of severe distortion but also to protect records.

With regard to our calling records with high modulation levels "high quality," it should be emphasized that we are not referring to the program content or any esthetic aspect of the record. We refer only to the fact that these records do not have significant distortion when played with a suitable phonograph cartridge.

Mr. Dupree makes the statement that "There can be no valid excuse for record manufacturers to produce recordings with such high modulation levels that many otherwise high-quality cartridges cannot track them." Isn't there some question as to how one would then define a high-quality cartridge? We certainly wouldn't want to see a contest such as Mr. Dupree suggests, but, on the other hand, we would not want to see the progress of disk recording impeded by stagnation in the development of cartridges.

As to my selection of 10% distortion, this was chosen simply as a value for comparison. There was no intention of relating this to subjective reaction.

J. H. Kogen, Chief Engr.
Shure Bros. Inc.
Evanston, Ill. ▲


SYLVANIA
SYLVANIA RADIO TV SERVICE
BRIGHT GUY

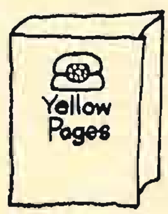
Are you eligible for the Bright Guy Awards?

It's easy to get them—and to get all the business they'll bring you. New customers. More sales. More money.

The Bright Guy Awards is the big program Sylvania's running this year to boost your sales.

Your Sylvania distributor can put your name and address in TV Guide in your own area. These Sylvania ads will call you "the brightest serviceman in town"—and tell people in your town why they should call you.

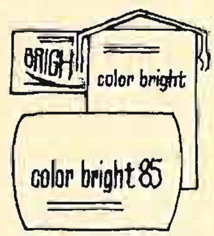
You'll get into the Yellow Pages, too, under the heading "TV Service and Repairs."



Once again this year you'll be eligible for over one hundred valuable, interesting SMB-Bright Guy gifts, just for buying the Sylvania TV replacement parts you normally buy anyway.

And you'll get window displays proclaiming you "the brightest"—the TV serviceman everyone's reading about.

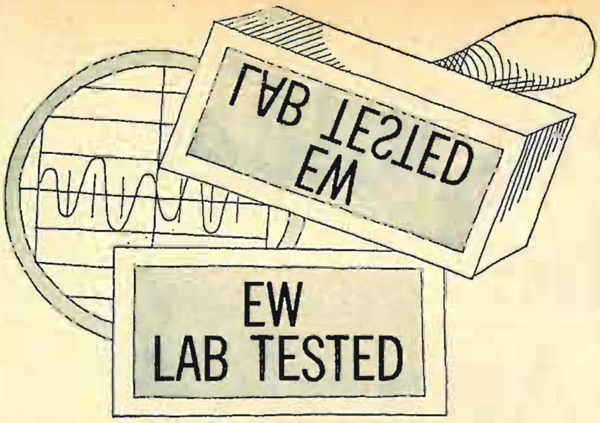
You're eligible for the Bright Guy Awards just by buying Sylvania's famous *color bright 85*® color picture tube. And our other picture tubes, and our receiving tubes. So see your Sylvania distributor.



Sylvania Electronic Tube Division, Electronic Components Group, Seneca Falls, New York 13148.

SYLVANIA
SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E

CIRCLE NO. 90 ON READER SERVICE CARD



HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

"Knight-Kit" KG-790 AM-FM Stereo Tuner
PML EC-71 Capacitor Microphone

"Knight-Kit" KG-790 AM-FM Stereo Tuner

For copy of manufacturer's brochure, circle No. 40 on Reader Service Card.

THE KG-790 ("Superba Series") stereo tuner is the finest tuner kit in the comprehensive line offered by *Allied Radio* under the "Knight-Kit" label. It is a companion, in style, size, and quality of performance, to the KG-895 amplifier reviewed in the August issue.

The panel of the tuner, handsomely finished in brushed gold, is 5" high and 16¾" wide, and it extends approximately 15" behind the panel. The multi-color edge-illuminated dial face has green calibrations for the FM band and orange for the AM band and the logging scale. The illuminated tuning meter is used for both AM and FM and a bright green light indicates FM-stereo reception.

The front panel contains three knobs and two rocker switches. The center knob, labeled "Selector", controls the power to the tuner and selects the mode of reception. Illuminated words appear on the dial face to indicate "AM", "FM", or "Stereo" reception, in colors to match the corresponding dial calibrations. In the "Stereo" position, the automatic mono/stereo switching of the tuner is effective, but in case a stereo signal is marginal in strength, the stereo circuits may be disabled by selecting the "FM" position.

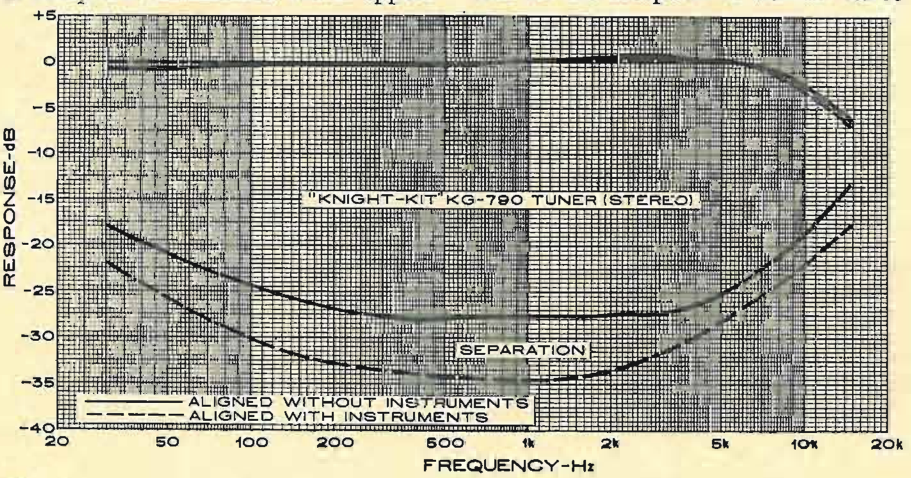
The left knob is the interstation muting control which is adjusted to suppress the hiss between FM stations. An "Off" position is provided on this control. The right knob is the tuning control. The tuning is very smooth, aided by a heavy flywheel. One rocker switch turns on the SCA filter which eliminates or greatly reduces the gargling or whistling sounds often heard when a station is simultaneously broadcasting stereo and commercial SCA transmissions. It has no appreciable effect on the reception of normal stereo broadcasts. The other rocker switch turns on the a.f.c. This is one of the few transistorized tuners we have seen with a.f.c., although it does not need this feature any more than most modern tuners do, having negligible drift.

In the rear of the chassis are the left and right channel outputs, with a second pair of output jacks in parallel for connecting a tape recorder. There are individual level adjustments for each channel to match the requirements of the associated amplifier, and one for the AM output which appears at both output jacks. There is a built-in ferrite AM antenna and a terminal for connecting an external AM antenna in weak-signal areas.

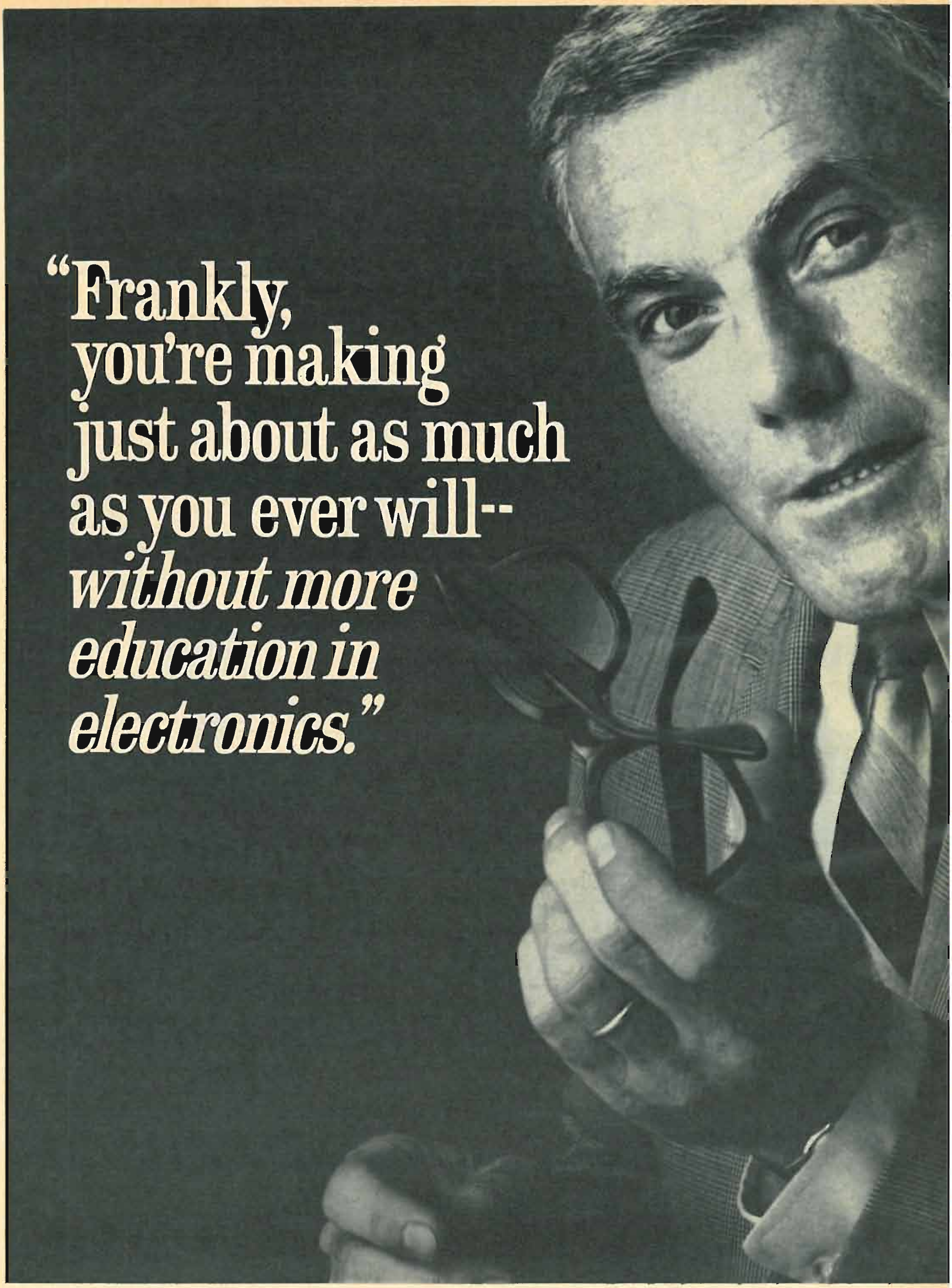
The "Knight-Kit" KG-790 circuits are assembled in several modules. The AM tuner is assembled on a printed board which is put together and aligned by the kit builder. The FM tuner is a pre-assembled and aligned unit, mounted on a metal plate sub-assembly with the i.f. circuit. The entire i.f. is pre-aligned and requires no touch-up by the builder. The multiplex printed board requires mounting of its parts but is pre-aligned and needs no more than a touch-up alignment without additional test equipment. The power supply, which has a zener-diode-regulated output for critical circuits, is assembled on the chassis.

The FM tuner section has a tuned r.f. stage, oscillator, and mixer. Four i.f. stages precede the ratio detector. The AM tuner also has a tuned r.f. stage and shares the first two i.f. amplifier stages with the FM tuner, using separate 455-kHz transformers in series with the 10.7-MHz FM i.f. transformers. The AM diode detector is followed by a 10-kHz whistle filter.

In the multiplex section, the 19-kHz pilot signal is amplified and doubled with a full-wave diode circuit to obtain the 38-kHz switching signal for the four-diode balanced modulator. The 19-kHz amplifier is controlled by the a.g.c. voltage developed from a diode at the output of the second i.f. stage. This



(*Continued on page* 76)


"Frankly,
you're making
just about as much
as you ever will--
without more
education in
electronics."

MEASURING MISSILE EXPLOSIONS

This early attempted Titan launch shows the need for explosion measurements to prevent future mishaps.

By EDWARD A. LACY and CYRIL N. GOLUB

Pan American World Airways, Inc., Guided Missiles Range Div., Patrick AFB, Florida

Using thermocouples, calorimeters, radiometers, pressure gauges, microphones, and tape recorders, engineers at Cape Kennedy stand ready to measure and to record a missile catastrophe. Armed with such knowledge, we should be able to prevent most future mishaps.

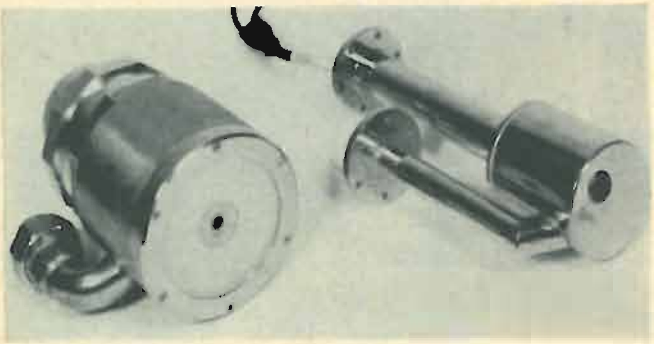
IT all starts with a malfunction in the missile or rocket—the result is an accidental abort or a deliberate destruct. In either case, within seconds the missile explodes, a gigantic ball of fire erupts, and shock waves bounce off nearby gantries.

With manned spacecraft or with nuclear payloads such disasters are not pleasant to contemplate. Can the escape system, for instance, outrun the fireball? Or can it withstand the tremendous heat and pressure if it does not outrun the fireball? Also, can the launch stands take this sort of punishment?

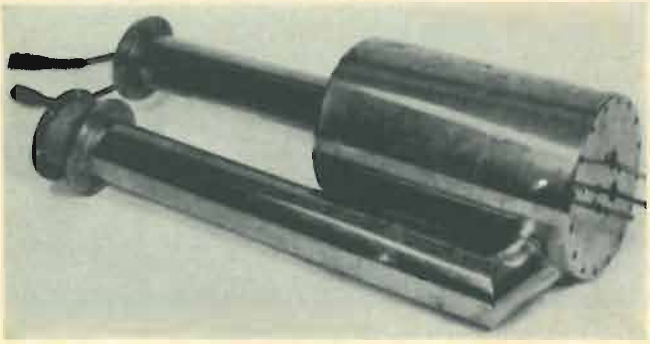
At Cape Kennedy the engineers have begun studying these problems in the most direct manner possible: by setting up their instruments and then waiting for an explosion to occur. With a group of thermocouples, calorimeters, radiometers, pressure gauges, and tape recorders they were ready to measure and record a missile catastrophe.

Then in March of 1965 came their big opportunity. At Complex 36 the countdown proceeded without interruption on a 2-stage liquid-propellant Atlas-Centaur rocket carrying a Surveyor for the moon. The rocket lifted off as scheduled but reached an altitude of only four feet when

Swing-out chassis on the PAMS console makes servicing easier.



Quartz window radiometer receiver (left) and calorimeter.



Close-up of one of the thermocouples used in the PAMS system.

the booster lost thrust. As it fell back and struck the launching stand, its thin metal skin ripped, spilling liquid oxygen, RP-1 fuel, and liquid hydrogen. Within seconds five explosions occurred, yielding a peak force equivalent to 25,000 pounds of TNT, and shattering glass 3000 feet away. The ellipsoidal fireball had a major axis of 800 feet; the temperature of the fireball was in excess of 5600° F, hot enough to melt tungsten.

Thus the Pad Abort Measuring System, PAMS for short, received its first checkout "under fire" and provided its designers much needed explosion measurements: temperatures inside and on the surface of the fireball, thermal energy generated by the fireball, blast pressures, and their history in time and space.

Although such parameters have generally been available for conventional and nuclear explosions, they have not been available for large chemical explosions. However, the need for such data becomes greater each day, not only for oil refiners and munitions manufacturers but particularly for the aerospace industry. For despite the fact that the abort rate has drastically decreased in 16 years of launches at the Cape, the danger from an abort has increased—today's rockets are much bigger since they are required to have much greater thrust.

Obviously the rocket engineers cannot take chances with such danger. But on the other hand, when the rocket launch complexes and their associated safety zones begin to take up large amounts of real estate, the designers become cost-conscious. Cost also becomes a big problem in the construction of ground-support structures such as blockhouses—to overdesign or provide too much protection may take away funds from much needed rocket design and development.

To determine the damaging effects of missile explosions, it is essential to determine how fast the shock waves and fireballs occur, how long they take to subside, and how they are distributed in space. In the Atlas-Centaur explosion, for instance, it was learned that they occur much too fast for comfort: the expansion rate of one of the fireballs was 1600 feet/second. Thus an escape system for outrunning this fireball would have had to have a velocity greater than 1000 mi/h. To make matters even worse, such a system would have to get up to speed in 3 seconds.

The Atlas-Centaur explosion showed too that overpressures due to shock waves can be distributed quite unevenly in space: while the peak pressure in one direction was equivalent to 25,000 pounds of TNT, in other directions the pressure was as low as that created by 1100 pounds of TNT. The explosion caused overpressures (increases in atmospheric pressure) as high as 101 psi at 37 feet away. Since an overpressure of only 2 psi can shatter a concrete block wall, it was fortunate indeed that the peak overpressure subsided to 1 psi within a few hundred feet. As it was, the umbilical tower and the gantry (which was 300 feet from the launch pad) were not damaged.

Since that first rugged checkout, PAMS pressure transducers and thermal sensors have been placed on all major launch complexes at the Cape, including Titan, Saturn, and the old Gemini complexes, thereby allowing engineers and scientists to gain vital information about normal and aborted launches. More recently microphones have been installed to measure acoustic waves.

PAMS was built for the Air Force's Range Safety Division by the *Sandia Corporation* under the direction of *Pan American World Airways'* Guided Missiles Range Division which now operates and maintains the system.

Pressure Transducers

Twelve pressure transducers or gauges are laid out in a spiral pattern around each major launch complex to measure the shock waves formed during an explosion. The spiral pattern is based on lack of symmetry in the explosion. Thus, three high-pressure units are mounted on the launch deck, a sensitive low-pressure unit is installed just outside the complex perimeter, and the remainder of the gauges are located in between.

Overpressures from 0.025 to 10,000 psi can be measured with these gauges, and pressure risetimes as short as 100 microseconds can be detected.

The pressure gauges are bridge-type variable-reluctance transducers installed in removable canisters which are inserted in concrete slabs buried flush with the ground. The face of the canister serves as a reference for the side-on pressure measurements. Each gauge circuit is excited by a 10-volt, 3-kHz carrier signal received by an underground cable from a transportable recording console. (The console is usually located hundreds of feet away in a blockhouse where it is safe from blast forces.)

Normally the bridge is balanced and no output signal is produced. When a shock wave strikes the sensor, it causes a small diaphragm to move which unbalances the bridge circuit, thereby producing a modulated a.c. voltage.

The signals from the twelve transducers are amplified by twelve amplifiers in the recording console and then recorded on 14-track magnetic tape at a speed of 3¾ ips.

Since surface wind direction and velocity, temperature, surface pressure, and relative humidity can affect blast wave propagation, *Pan American* weathermen record these weather factors at the launch blockhouse during all tests involving the use of PAMS. With such measurements they can perform more accurate data analysis.

Thermal Sensors

Two sets of six thermal sensors are mounted on the umbilical tower and the launch deck for measuring temperature and heat energy. Each set consists of four different thermocouples, a calorimeter, and a radiometer. The radiometer senses radiant energy only since the receiver, a blackened silver foil, is protected from heat convection by a quartz window. The calorimeter measures total heat energy (radiant and convective thermal energy) which may approach that of a kiloton nuclear device for some of the larger launch vehicles.

Both the radiometer and the calorimeter provide a low-level d.c. signal which is calibrated in terms of Btu per square foot-second. The radiometer senses thermal radiant energy up to 1000 Btu/sq ft-s while the calorimeter senses radiant and convective energy up to 500 Btu/sq ft-s. The output of the radiometer is 16-18 millivolts and the output of the calorimeter is 8-10 millivolts.

The thermocouples measure from 150° to 5600° F in four overlapping ranges. With such an overlap, continuous coverage is insured since some of the fastest reacting thermocouples cannot survive the highest heat encountered.

For example, the most sensitive of these thermocouples is a tungsten/tungsten-rhenium couple in a thin tantalum case. Its time constant is 1 millisecond which means that it is the first unit to generate a signal when an abort occurs. Although it did not fail during the Centaur explosion, it is expected to disintegrate on future aborts before it can measure the decreasing side of the temperature curve. A similar thermocouple heavily sheathed in siliconized molybdenum for greater protection has a slower response but can survive and measure much of the temperature decrease. The other thermocouples are slow response but high survivability platinum/platinum-rhodium and chromel-alumel thermocouples housed in stainless steel cases.

With this multiple-element technique an accurate coverage of the complete temperature/time profile of the Atlas-Centaur explosion was obtained, as shown in Fig. 1. The solid lines represent recorded temperatures from each of two thermocouples and the dotted line represents the predicted temperature.

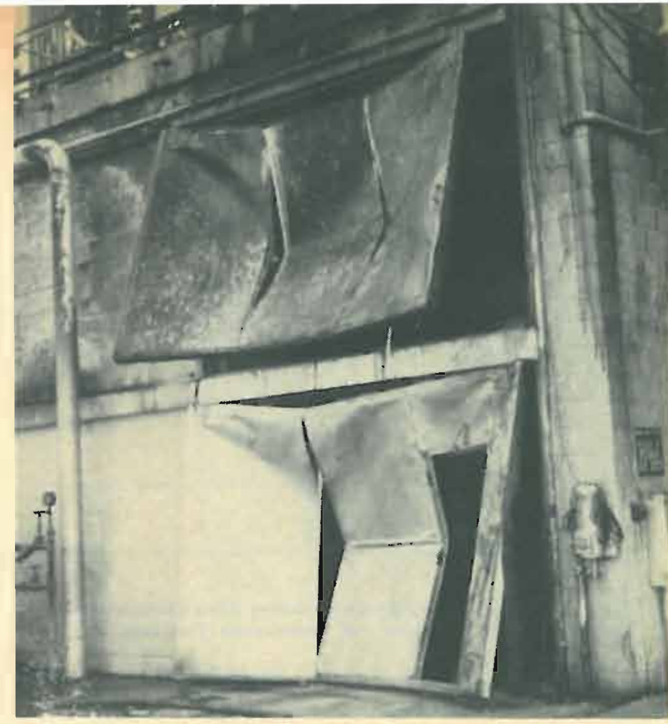
The signals from the thermocouples are amplified by a 12-channel d.c. amplifier located under the launch stand and then transmitted to the recording console.

Acoustic Measurements

At some of the largest launch complexes, such as for the Titan III, the noise generated during a normal launch is so great that it may set up undesirable vibrations in the ground-support structures and equipment, especially if the waves have a frequency near that of the resonant frequency of the structure.

Piezoelectric microphones and charge amplifiers which are part of the Launch Acoustic Measuring System (LAMS), are now being used to measure this acoustic noise. LAMS is an auxiliary unit to the Pad Abort Measuring System. LAMS can make sound power measurements from 80 to 200 dB (referred to 0.0002 dyne/cm^2) at distances from the rocket exhaust of a few feet up to 20 miles.

Because of the hostile environment during launch, it is not possible to place preamplifiers near these microphones, some of which are located near the rocket exhaust. Since preamplifiers cannot be located far from the microphones



The Atlas Centaur explosion (see color photograph on the cover) caused this amount of damage to the doors on the launching pad.

The over-all view of Launch Complex 36 at Cape Kennedy with the location of the pressure gauges and thermal sensors indicated.

Pan American engineers removing a pressure gauge from its earth well to check it out prior to launch. Author Golub is at left.

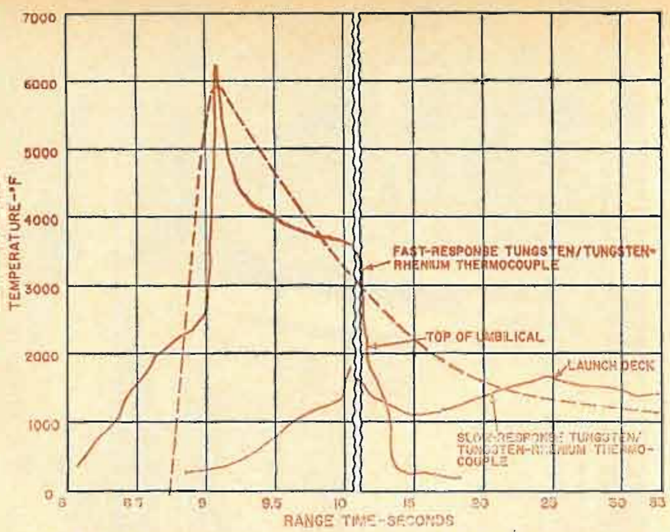


Fig. 1. Temperature measurements during Atlas Centaur explosion. The dotted line represents the temperature that was predicted.

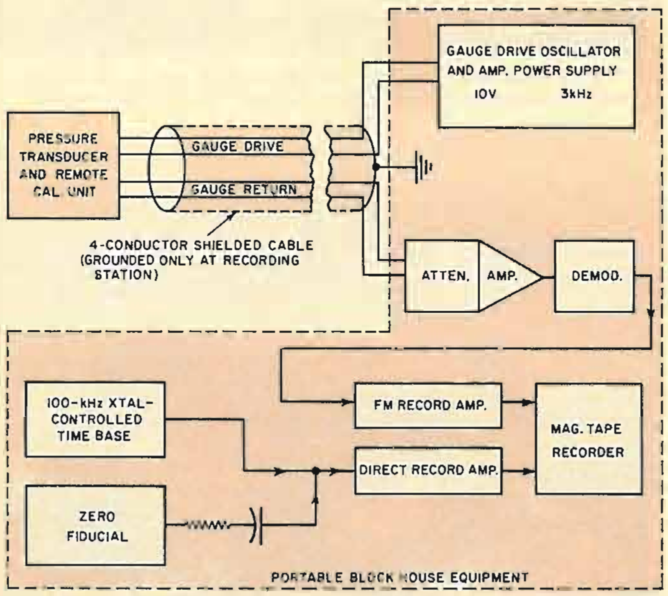


Fig. 2. Block diagram showing portable blockhouse equipment.

because of signal degradation due to long cable runs, charge amplification is used in preference to voltage amplification. In this method of signal conditioning, the charge from the microphone is sensed by an operational type amplifier and balanced by an equal charge of opposite sign provided by a feedback arrangement.

The controlling parameter is the total capacitance of the microphone and the feedback capacitor. Its value is much larger than the capacitance of the cable connecting the microphone to the charge amplifier. With this technique the microphone can be located up to 2 miles from the charge amplifier, and the charge amplifier can be located up to 5 miles from the recording equipment that is employed.

Once the output charge of the microphone has been converted into a voltage by the charge amplifier, it can be recorded directly on the magnetic tape or strip chart, or it can be multiplexed so that as many as ten data channels can be recorded on a single track of magnetic tape. The multiplexing process converts the analog voltage output that is produced into a frequency-modulated carrier which again lends itself to long-distance transmission that is carried over cable.

In a typical application where the tape recorder speed is 60 inches per second, the output of a charge amplifier can be directly recorded on tape with a frequency response from 0 to 10 kHz. A multiplexed signal can also be recorded with each channel having a frequency response from 0 to 2 kHz with constant-bandwidth multiplexing.

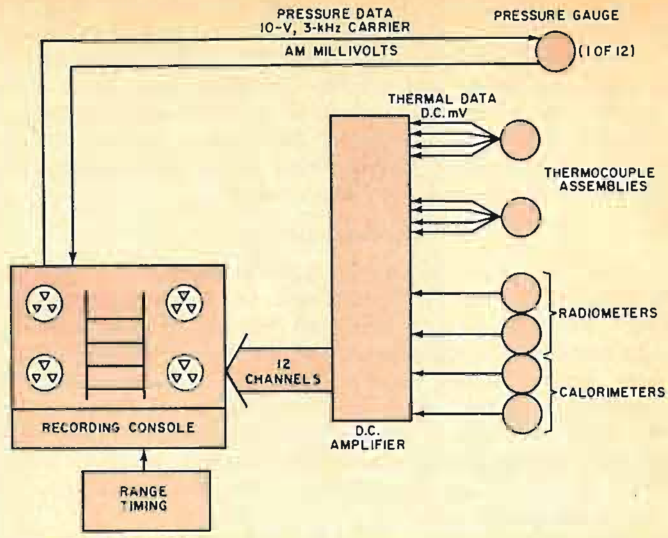


Fig. 3. Data flow in the PAMS system shown in block diagram.

Recording Consoles

Recording consoles for PAMS and LAMS are mobile. One PAMS console and one LAMS console are housed in a self-contained air-conditioned instrumentation van. PAMS consoles can also be moved from the Launch Hazards Laboratory to the blockhouse for each test which requires PAMS coverage. See Fig. 2.

The PAMS console consists essentially of two tape recorders (one for the pressure data, one for the thermal data) and amplifiers for the pressure data. An oscillograph is used to transcribe the magnetic-tape analog data onto a visual record (Fig. 3).

The LAMS console includes among its electronic equipment charge amplifiers, multiplex and test equipment, and a tape recorder.

Because of the unpredictable nature of an abort or explosion, PAMS equipment is turned on before a hazardous sequence is started and is left on as long as necessary. After three hours the tapes on the recorder must be changed to give an additional three hours of recording time. In addition to covering the launches, PAMS covers dual tanking tests involving liquid propellants and solid propellant dry runs which go as far as arming the first-stage ignition system or the vehicle's destruct system.

Remote Abort Measuring System

If a rocket explodes or is aborted after it leaves the launch stand, the damage may be far different than what it would have been with the rocket on the launch stand. Most aborts in flight occur within a slant range of six miles of the launch stand. Ideally it might be possible to place survivable sensors on the rocket, but this cannot be done because of the fact that space on the rocket is so very valuable.

For this reason engineers at the Cape are now investigating techniques for measuring explosions remotely by ground-based equipment. These techniques include laser and r.f. ranging methods for plotting shock-wave position in time and space, and infrared television, interferometric, and spectrometric means for measuring thermal properties. The electromagnetic phenomena generated by a fireball are also being studied.

Under these conditions, the day is not far off when we will be able to measure and analyze every facet of missile and rocket operation "from the ground up" with a view toward avoiding future mishaps. ▲

PERIOD-FREQUENCY GRAPH

By R. W. BAILEY

A chart that makes it easy to convert a large number of period measurements to frequency or frequency to period.

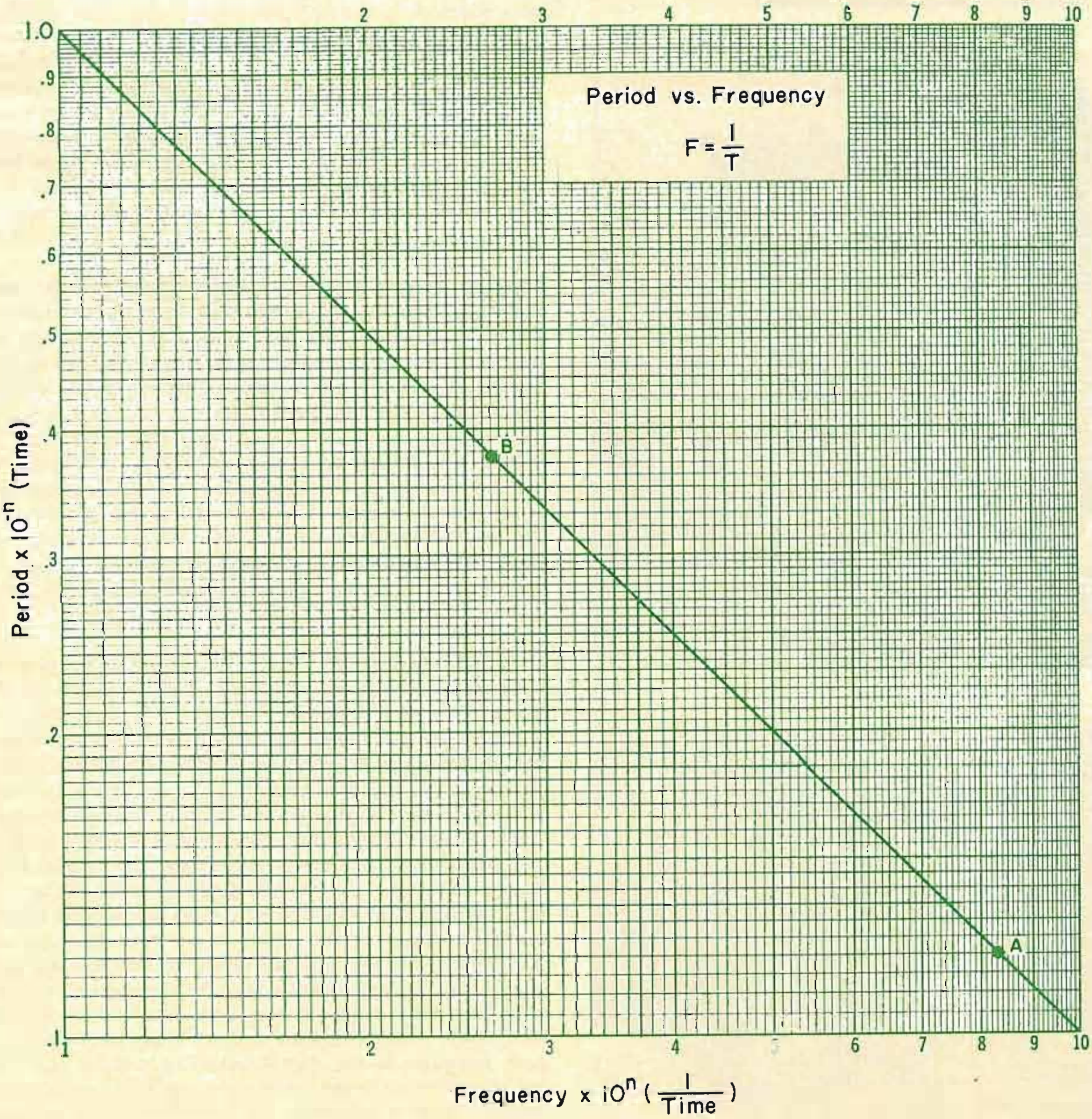
THE electronics technician or engineer is frequently confronted with the task of converting period to frequency and *vice versa*. Although the relationship between frequency and period is expressed simply as $F=1/T$, the graph below can be useful when a large number of conversions is required. This is often the case, for example, when an oscilloscope with a time-calibrated sweep is used to make frequency measurements.

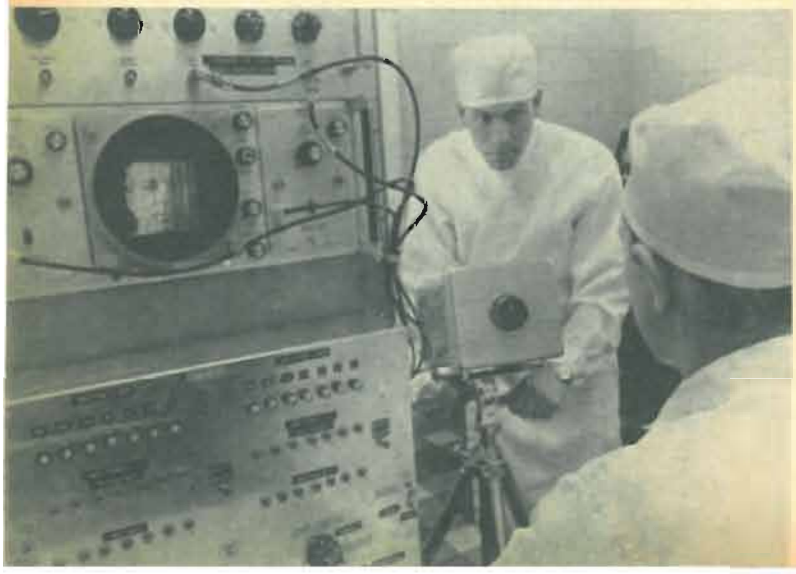
It should be noted that the graph is actually a log-log plot of the expression for an equilateral hyperbola ($XY=1$) with the restriction that (X) and (Y) must be positive or they must both be negative simultaneously. This graph, then, is nothing more than the reciprocal curve and thus can be used for a variety of parameters other than period and frequency.

Example No. 1: Suppose a period of 12 milliseconds is measured and the corresponding frequency is required. Note from the graph that the period must be written as a number between 0.1 and 1.0 multiplied by the quantity 10^{-n}. Since 12 milliseconds equal 0.12×10^{-1} second, n is equal to 1. Locate 0.12 on the Period axis and follow it across to the graph; read the number 8.35 on the Frequency axis directly below the intersection. The actual frequency is found by multiplying 8.35 by the expression 10^n where n is the number 1 established above. Since 10^1 is equal to 10, the frequency is $8.35 \times 10 = 83.5$ Hz. (See point A.)

Example No. 2: Suppose a frequency of 2650 Hz is measured and the corresponding period is required. Note from the graph that the frequency must be written as a number between 1.0 and 10.0 multiplied by the quantity 10^n. Since 2650 Hz = 2.65×10^3 Hz, the value of n is 3. Locate 2.65 on the Frequency axis and follow it up to the graph. Directly to the left of the intersection of the 2.65 line and the graph, read the number 0.377 on the Period axis. The period is found by multiplying 0.377 by the quantity 10^{-n} where n is 3, as was established above. The correct multiplier is then 10^{-3}. The period is 0.377×10^{-3} second, or 377 microseconds.

It should be noted that any units of time may be used with the graph as long as consistency is maintained. ▲





RECENT DEVELOPMENTS IN ELECTRONICS

Laser "Seeing-Eye" Cane. (Top left) An experimental laser cane for the blind is shown being demonstrated here. The dotted lines show the paths of the two invisible infrared injection laser beams that strike the surface three and six feet ahead of the cane. If there are no obstacles at these two points, the laser beams are reflected back to optical detectors, midway down the cane. Blunt pins in the handle of the cane vibrate to tell its user that no large depression or raised surface is in front of him. If an obstacle is illuminated by either beam, it is not reflected back to the cane and the corresponding pin stops vibrating. The experimental cane weighs less than five pounds and can be operated for 10 hours before its four small batteries must be recharged. The inventor, Wm. J. Hannan of RCA Laboratories, is investigating the use of an array of laser diodes to generate a number of laser beams for an advanced model. This contemplated model would be able to provide cane user a contour map, which he would be able to feel with his thumb, of the area that is directly in front of him.

Computer-Drawn Graphs (Center) The closing prices of three stocks over a five-month period have been plotted on the screen of a display unit by a computer. Information was previously fed to the computer by means of the light pen and two keyboards. This is an experimental program which eliminates the painstaking manual plotting of points and lines usually required to draw graphs. Any numerical field can be plotted against any other numerical field, making the number of graphs which can be generated from the various combinations almost infinite. Scaling—making the graphs the right size for the variables being plotted—is done automatically by the IBM computer. Several plots can also be shown simultaneously on one graph, using either solid or dotted lines on CRT.

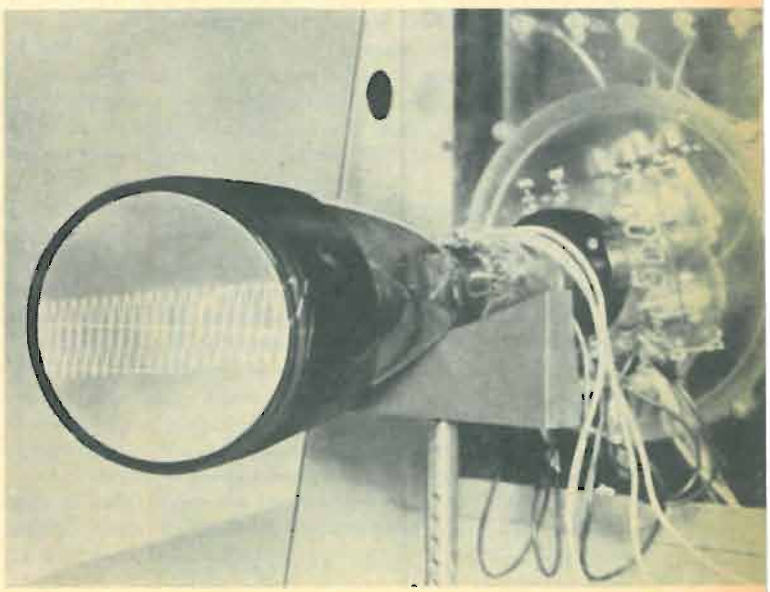
Solid-State TV Camera. (Left) The second in a family of solid-state image converters has been built for NASA by Westinghouse. The new converter is part of a long-range program to develop a solid-state TV camera with imaging characteristics equivalent to those of a conventional vidicon camera. Resolution of the new converter is 100 lines and it can "see" images in six shades of gray. The heart of the system is a monolithic 100-by-128 element array of phototransistors fabricated on a half-inch square silicon substrate. The 12,800 phototransistors of the mosaic are addressed sequentially in a row-column fashion at rates up to 60 frames per second to provide a standard TV-type raster. There is no need for high voltages, magnetic fields, vacuum envelopes, or filament power. Consequently, an imaging system using a solid-state sensor is smaller, lighter, and more rugged, uses less power, and is more compatible with integrated circuits than its vidicon counterpart. Because of the digital scanning, special scan processing for moving-target indication, pattern recognition, and random scan is obtained without digital-analog conversion.

Remote-Controlled Oceanographic Buoy. (Right) A large red 40-ft diameter steel sea buoy is scheduled to go on-station just outside the entrance to New York harbor for evaluation as a possible replacement for the Scotland lightship off Sandy Hook, N.J. Two 1-kW generators running on liquid propane supply charging current for a 21-cell nickel-cadmium battery comprising the power source for the 5000-candlepower light, foghorns, and on-board electronic equipment. The buoy can operate unattended for one year. On-board equipment is automatic but can be controlled by telemetry command from a shore station. Sensors on the buoy measure air speed and direction, temperature, barometric pressure, as well as sea-water temperature, pressure, salinity, speed, and direction. All data will be transmitted to shore. Antennas atop the buoy are for the v.l.f. radiobeacon and for v.h.f. command and telemetry.

Portable Thermoelectric Generator. (Center) A new portable thermoelectric generator, weighing only 35 lbs with fuel, has been developed which can be carried about by a soldier to provide immediate, silent, and long-term power for military field equipment. The generator, produced by 3M Co., delivers 300 watts of electrical power, has an 8-hr fuel supply, and can operate on kerosene, jet fuel, or diesel fuel. Generators of this type can convert heat into electrical energy using a series of pellets of semiconductor material arranged in junctions.

One-Gun, Two-Color CRT. (Below right) The availability of what is said to be the first commercial high-resolution single-gun, two-color display tube has been announced by Sylvania. Designed for non-entertainment type applications, the new tube can be read under high ambient light. The CRT uses a 5-in round faceplate coated with two layers of phosphor—red and green. The two layers are separated by a barrier layer. By switching the final anode voltage, the electron beam is made to excite the first phosphor layer only, creating one color, or to penetrate the barrier and excite both phosphor layers, creating a second color. By high-speed voltage switching, the tube produces a two-color display that appears to be continuous to the viewer. No shadow mask or dot pattern is employed.

Facsimile Via TV. (Below left) An experimental system that can broadcast printed copy into the home along with standard TV programming is shown here. The image of a girl appears on the TV screen while a printed weather map and forecast emerge from the facsimile equipment below. RCA has requested FCC permission to make on-the-air tests of the system between New York City and Princeton, N.J. The facsimile signals which can now transmit four different printed messages at the same time, are sent out during TV vertical blanking intervals. A page of copy can be reproduced every ten seconds.



AVALANCHE TRANSISTOR CIRCUITS

By SIDNEY L. SILVER

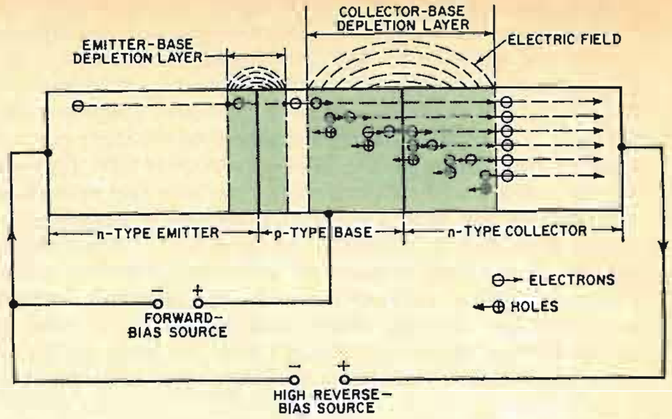


Fig. 1. Simplified current-flow diagram of an "n-p-n" transistor that is shown here operating in the avalanche mode.

These special switching transistors—made possible by improved fabricating techniques—can produce extremely fast pulses at high power output levels.

IN the early days of transistor development, avalanche breakdown was considered a troublesome phenomenon which imposed a limit on the useful life of a junction transistor. To offset this problem, collector voltages were restricted to values far below the actual breakdown rating in order to reduce surface leakage currents across the collector junction. Excessive leakage currents not only increased the power-dissipation level of the transistor, but also initiated thermal runaway and possible destruction of the device.

The avalanche effect was found to be nondestructive if the peak and average power dissipated at the collector junction were controlled by external circuitry. By operating ordinary high-frequency switching transistors in the avalanche mode, it was possible to generate extremely fast pulses (in the nanosecond range) in applications requiring high current outputs of short duration. Nevertheless, the avalanche process did not find wide acceptance since, in many cases, transistors of the same type did not always exhibit uniform avalanching properties. Consequently, it was necessary to carefully test and select these units for consistent breakdown characteristics, thus making it difficult to design stable, reliable pulse circuits.

As a result of recent improvements in fabrication technology (leading to, for example, the reduction of surface leakage currents), modern avalanche transistors are now capable of operating at relatively high collector voltages and of producing large current-voltage swings with subnanosecond rise times. Within the limits set by allowable power dissipation, pulse widths of 100 μs are easily attained with repetition rates in the MHz region. In simple circuits, peak swings of 75 volts and 10 amps in less than 0.5 ns are obtainable with ultra-high-speed transistors whose geometry is optimized for avalanche switching. In more complex circuits, rise times of less than one ns can be generated at peak powers in excess of 500 watts across very low impedance loads.

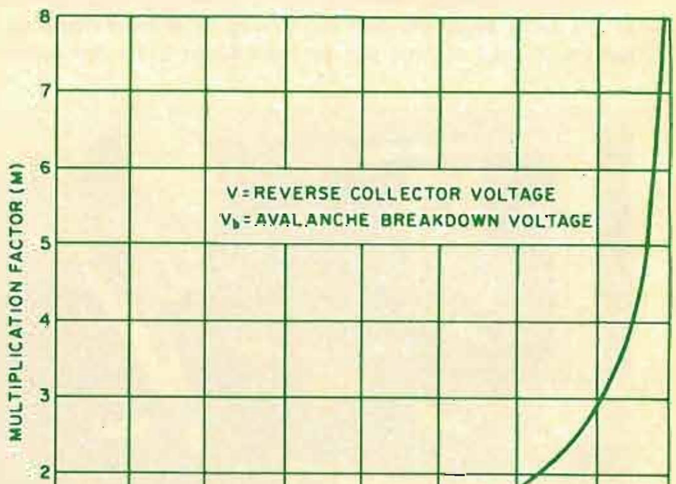
Some of the important applications of avalanche transistors include the generation of fast-rising pulses employed in sampling oscilloscopes, decade ring counters, and high-speed nuclear instruments. For pulse power requirements in the milliwatt range, suitable avalanche devices are now being developed for low-level computer logic circuits. For higher pulse handling capacity, avalanchers are finding increasing use in strobe-pulse generators, pulse amplitude detectors, memory-core drivers, and voltage-comparators. With proper impedance-matching, avalanche pulse generators can be used for pulse modulation of injection lasers.

In normal transistor operation, a reverse bias is applied to the base-collector junction so that an electric field is produced within a space charge region, or depletion layer, of the junction. In the avalanche process, however, the reverse collector voltage is raised substantially above the normal operating value so that the depletion layer is considerably widened, and a large electric field extends over most of the base region.

As shown in Fig. 1, the strong electric field approaches the small field associated with the narrow emitter-base depletion layer thereby reducing the effective base width. As a result electrons diffuse across the base from the emitter region and accelerate to high velocities toward the collector. Upon entering the collector-base depletion layer, the fast-moving electrons excite additional carriers (hole-electron pairs) by impact ionization with atoms in the semiconductor material. Owing to the high field, the free electrons move rapidly toward the collector and the associated holes drift in the opposite direction across the base region. The new carriers, in turn, acquire sufficient energy to cause further ionization by collision with the other atoms in the material. Since the atoms in the lattice structure are closely spaced, the ionization process occurs many times, particularly at the collector-base junction which corresponds to maximum-field intensity.

The cumulative process, referred to as avalanche multipli-

Fig. 2. Relation between avalanche breakdown voltage and M.



cation, results in a much larger number of electrons entering the collector region than cross the collector-base junction. When a critical point is reached, the current flowing across the collector-base junction rises abruptly as avalanche breakdown occurs and tremendously high values of reverse collector currents are attained. The breakdown condition is not a permanent effect since the junction will rapidly recover when the voltage is reduced again.

An important parameter used to designate the rise of collector current prior to breakdown is the multiplication factor (M), which is defined as the ratio of actual collector current to the current that would flow had there been no increase in current due to ionization. Fig. 2 shows a typical multiplication factor curve for an *n-p-n* silicon transistor in which M values are plotted against collector voltage.

At low collector voltages, M is close to unity and no apparent multiplication effect is present. In avalanche, however, the emitter-to-collector gain is increased to a magnitude many times greater than unity, so that M approaches an infinitely high value. In practice, the multiplication factor can never be infinite, since this would imply an unlimited current flow and unlimited heat generation. To obtain a high value of M, it is desirable that the collector current be as large as possible; but a limit is set by the maximum allowable power dissipation of the transistor, which is controlled by external circuitry.

The multiplication factor is found to be related to the reverse bias across the collector junction by the formula: $M = 1/[1-(V/V_b)^n]$ where V is the applied collector voltage, V_b is the avalanche breakdown voltage, and n is a parameter whose value depends upon the type and resistivity of the junction material, and ultimately determines the sharpness of the knee of the M curve. For silicon *n-p-n* transistors, $n = 4$ and for germanium *n-p-n* types, $n = 3$.

Basic Circuitry

The basic features of a single *n-p-n* transistor operating in the avalanche mode are shown in the emitter-follower configuration of Fig. 3A. In the quiescent state, capacitor $C1$ charges toward the collector supply voltage, V_{cc}, which is adjusted to a value slightly less than that required to initiate avalanche breakdown. When a positive-going trigger pulse is applied to the base, the emitter-base junction becomes forward-biased, and the breakdown potential is effectively lowered. The emitter begins to inject electrons into the base, which are multiplied at the collector junctions, causing a regenerative current build-up to occur.

At breakdown, the heavy current flowing through the collector-emitter junction path rapidly discharges $C1$ and produces the leading edge of a positive pulse across load resistor R_L. The breakdown condition exists as long as there is stored energy in $C1$ to sustain it, since the alternate path (from V_{cc} *via* $R1$) is unable to supply sufficient current. After $C1$ has discharged, a small transient current flows through $R1$, which maintains the collector at a lower voltage and allows the transistor an interval of time to recover and revert back to its original quiescent state. Finally, capacitor $C1$ slowly recharges toward the collector supply source through $R1$ and upon arrival of the next trigger pulse, and the cycle is repeated.

The pulse repetition rate of the monostable circuit in Fig. 3A is determined by the time constant of $R1$ and $C1$, while the pulse width depends upon the values of R_L and $C1$. Resistor $R1$ can be made adjustable (within small limits) so that increased repetition rates are obtainable by decreasing its value. $C1$, which determines the avalanche turn-on transient, is usually fixed by pulse-width requirements.

If a negative output pulse is required, the emitter terminal may be grounded and the load resistor, R_L, is placed in series with the $C1$-to-ground connection. To convert the generator into a self-running type, the collector supply voltage, V_{cc}, may be raised or the base resistor, $R2$, returned

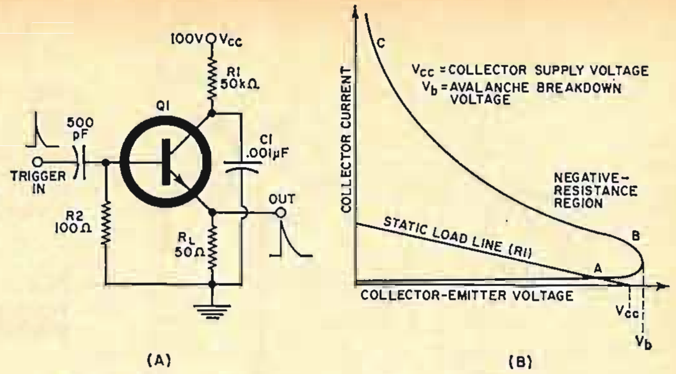


Fig. 3. (A) Avalanche switching circuit, and (B) the V-I curve.

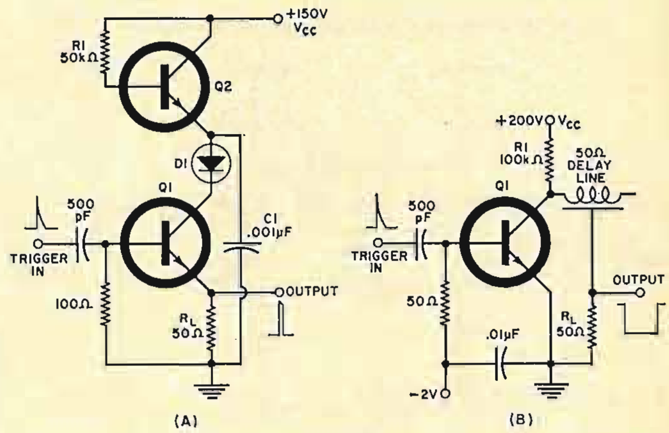


Fig. 4. (A) A narrow-pulse avalanche generator capable of high pulse repetition rates. (B) Delay-line avalanche-mode generator.

to a suitable bias voltage so that the avalanche breakdown is achieved without the need for an external trigger.

The sequence of events relating to the avalanche-switching mechanism is graphically illustrated by the volt-amp characteristic curve of Fig. 3B. Under quiescent conditions, a static load line is constructed to yield a single stable operating point (A), where it intersects the curve in the low-current region. When a trigger pulse appears, avalanching occurs between points A and B, where the transistor's operating point is shifted beyond its normal-region rating. Capacitor $C1$ supplies the surge of discharge current which builds up rapidly toward point C in the negative-resistance region. It is the low transit time with which the transistor switches from a low-current state to an avalanche discharge state in the negative-resistance area that leads to extremely fast rise times. When the trigger pulse has dissipated, the operating point moves back to point A as capacitor $C1$ recharges to the same point and the circuit is ready to accept another transient.

An important design consideration is that the load line must not intersect the transistor breakdown curve in the high-current region. This condition, referred to as "latch-up," would establish an undesirable stable operating point at the common intersection and prevent the normal shift to point A during the recovery period. If the product of current and voltage at the latching point were sufficiently high to exceed the maximum transistor power rating, circuit malfunction or thermal destruction would occur.

Narrow-Pulse Switching

The main disadvantage of the single-stage avalanche pulse generator is the relatively long recovery time after the avalanche transition period which sets a limit on the maximum pulse repetition rate. Fig. 4A shows an arrangement which incorporates a second transistor to dynamically reduce the charging time constant of the circuit without appreciably affecting the static load line during the pulse period. Initially, the base-emitter junction of transistor $Q2$ is forward-

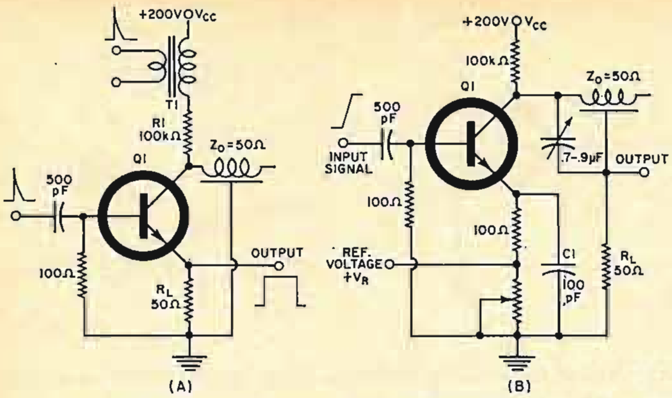


Fig. 5. (A) Pulse-coincidence detector. (B) Comparator circuit.

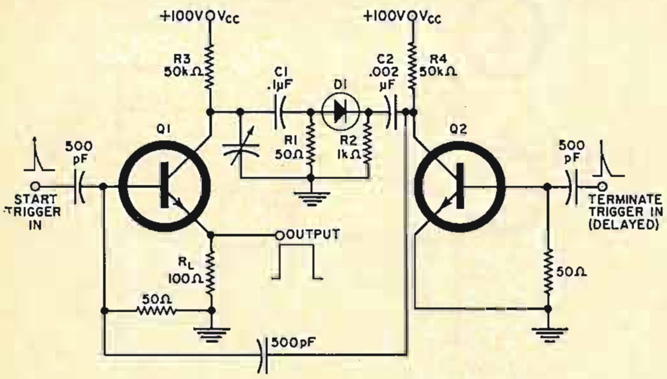


Fig. 6. Variable-width avalanche pulse generator circuit.

biased, and $C1$ is charged, *via* $Q2$, toward the collector supply voltage, V_{cc}. Transistor $Q1$ rests near its avalanche breakdown potential and V_{cc} is adjusted to a value slightly less than that which would start the $Q1$ circuit free-running.

When $Q1$ is triggered $C1$ discharges rapidly through the series path formed by load resistor R_L, transistor $Q1$, and diode $D1$. The resultant voltage drop across $D1$ reverse-biases the emitter-base junction of $Q2$, leaving only the limiting resistor $R1$ as the current path between V_{cc} and the collector of $Q1$. After $C1$ has discharged, $Q2$ turns "on" and $C1$ rapidly charges toward V_{cc} *via* the low-resistance path provided by $Q2$. By this means, very narrow pulses are easily generated which have fast fall times as well as fast rise times. Pulse repetition rates can thus be increased a hundredfold over the single-stage circuit, with obtainable repetition rates up to approximately 5 MHz.

Delay-Line Stabilization

In applications requiring flat-topped pulses, a transmission-line load provides greater control of pulse duration, amplitude, and phase of the output signal than does the use of a load capacitor. Fig. 4B shows a monostable pulse generator which employs an open-circuited delay line as a pulse-forming network in the collector circuit of transistor $Q1$. In this configuration, a hold-off bias is applied to the base to maintain $Q1$ in the nonconducting state. During the "off" cycle the delay line acts essentially as a capacitive load which is charged to the collector supply voltage, V_{cc} in conjunction with resistor $R1$. The application of a trigger pulse forward biases the base-emitter junction and produces a positive regenerative avalanche transient across the transmission line and load resistor R_L.

At this point, the switching transient travels along the delay line (approximately 2 ns/ft), which now behaves as a resistive element equal to its characteristic impedance ($Z_o =$ 50 ohms). When the pulse reaches the open end of the line it is reflected back to the source (in phase) since there is no resistive termination at the load end to absorb the energy. Upon returning to the collector, the pulse increases the voltage across the source end of the line and causes a reduction of the voltage across R_L. By this means the collector current is reduced to a sufficiently low value to turn off the transistor regeneratively, thus terminating the pulse.

In this circuit, the duration of the rectangular output pulse is equal to the two-way transit time of the delay line. Although small changes of pulse repetition rate can be produced by adjusting the values of V_{cc} and $R1$, the repetition rate is primarily determined by the value of the transmission-line capacitance. To prevent ringing and undesirable reflections, R_L must be equal to or slightly less than the characteristic impedance of the line.

Fig. 5A indicates how the avalanche process is applied to coincidence detection in high-speed nuclear instrumentation. In this arrangement, the two trigger pulses applied to the delay-line coincidence circuit are derived from a pair of nuclear scintillating counters. To detect the coincidence of both pulses, one half of the required pulse height is coupled to the collector of $Q1$ and the other half is fed to the base input circuit. The collector circuit parameters are selected so that the presence of both pulses is necessary in order to drive the transistor into avalanche and deliver an output.

In the voltage comparator circuit shown in Fig. 5B, the input level of a ramp signal is compared with an adjustable positive voltage reference source V_R, in the emitter circuit. When the applied voltage ramp exceeds the threshold trigger level, avalanche breakdown takes place and the collector-emitter path of $Q1$ conducts heavily. The delay line then discharges around the loop formed by load resistor R_L, emitter bypass capacitor $C1$, and $Q1$ so that a large nanosecond pulse is produced at the output.

Variable-Width Pulses

A convenient method of obtaining continuously variable pulse width is the complementary arrangement shown in Fig. 6. Here the fast rise time of avalanche transistor $Q1$ is utilized for the leading edge of the output pulse and that of $Q2$ for the trailing edge so that precise control of pulse duration is achieved. By varying the time delay between start and stop trigger signals, it is possible to continuously adjust the pulse width from a few nanoseconds to over one microsecond.

Initially, $C1$ and $C2$ are charged toward the V_{cc} source *via* resistors $R3$ and $R4$, respectively. To initiate the avalanche process, a start trigger pulse is applied to the base of $Q1$. A heavy current flows through the collector circuit which discharges $C1$ through the $R1$, R_L, and $Q1$ path so that the leading edge of the output pulse is formed. During this interval, diode $D1$ is reverse-biased to prevent interaction with the $Q2$ switching circuit.

After a predetermined period of time, a trigger pulse is applied to the base of $Q2$ in order to terminate the pulse. As $C2$ discharges through $R2$ and $Q2$ a large negative voltage is developed across $R2$ which overcomes the reverse bias on $D1$. As a result, the $R1$-$C1$ junction is driven more negative so that the algebraic sum of the voltages between the $Q1$ collector and ground approaches zero. This bucking effect cancels the power that keeps $Q1$ in avalanche, thereby turning off $Q1$ and terminating the pulse. At this point $C1$ and $C2$ recharge to complete the cycle as the $Q1$ circuit awaits the arrival of a new start pulse.

At the present state of the art, the avalanche mechanism adds a new dimension to solid-state switching design which has not yet been fully explored. To meet the increasing demands for ultra-high-speed, high-current switching applications, a number of high-frequency transistors are now commercially available, *e.g.*, 2N3033, 2N3034, 2N3035, which are specifically tailored for avalanche-mode operation. As more avalanching transistors become available, circuit designs will reach farther into the picosecond region to solve some of the problems related to operation at very high repetition rates. ▲

Temperature-Depth Measurements in the Ocean

By JOHN ALTHOUSE

A description of the electronic instruments used to make these important oceanographic measurements. Included here are the various types of electronic bathythermographs, infrared and quartz thermometers, recording thermographs.

DID Benjamin Franklin measure temperature more accurately than oceanographers do today? It is quite possible that he did and here lies a challenge to the electronics industry. It was almost 200 years ago that Franklin developed his "thermometrical navigation". He was able to guide a ship along favorable currents by measuring the temperature of the surface water. His measurement method was simple. He dipped a bucket into the water, hauled his water sample aboard, and measured its temperature with an ordinary thermometer.

Today, temperatures taken by this method are called "bucket temperatures" and the technique is still the prime method of obtaining the temperature of ocean surface water. But it is likely that Ben Franklin used wooden buckets. Today's metal buckets are poor insulators and can allow water temperature to change before measuring.

Reversing Thermometer

In 1874 the English instrument firm of *Negretti and Zambra* introduced the reversing thermometer, an instrument whose accuracy is a source of some embarrassment to the manufacturers of today's electronic instruments.

Ben Franklin's bucket was limited to measurements of surface temperature. The reversing thermometer can measure temperature from near the surface to as deep as 20,000 feet. It is a form of mercury-in-glass thermometer which is lowered to the depth at which a measurement is to be taken. A trigger mechanism then "locks" the thermometer reading so it can be brought back to the surface to be read. (See "Electronics in Oceanography" in the March, 1967 issue.)

The reversing thermometer is of particular interest because it uses techniques common to many oceanographic instrument designs:

1. It is pressure protected. An unprotected thermometer will change calibration at the high pressures of the deep ocean.

2. It measures pressure by use of an auxiliary thermometer. Pressure is not measured for its own sake but as a means

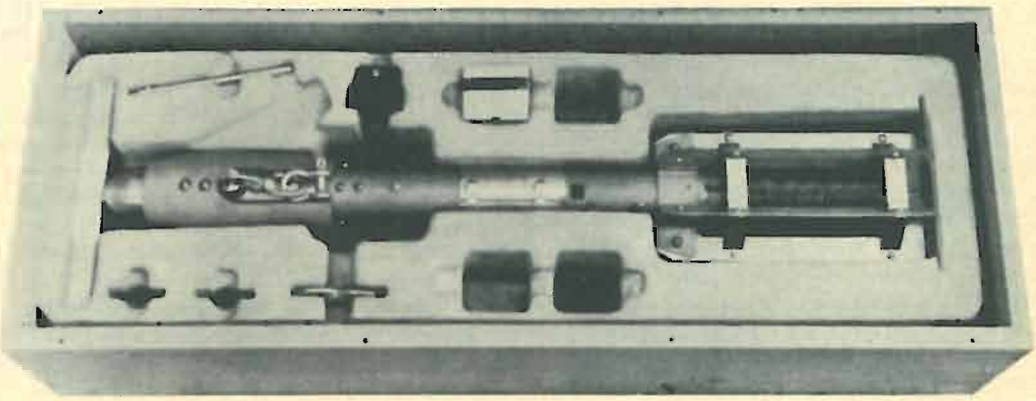


Fig. 1. The mechanical bathythermograph (shown here in its carrying case) makes a graph of temperature vs depth on a coated glass slide as it is lowered and raised in the water at end of wire rope. (Manufacturer: Kahl Scientific Instrument Corporation.)

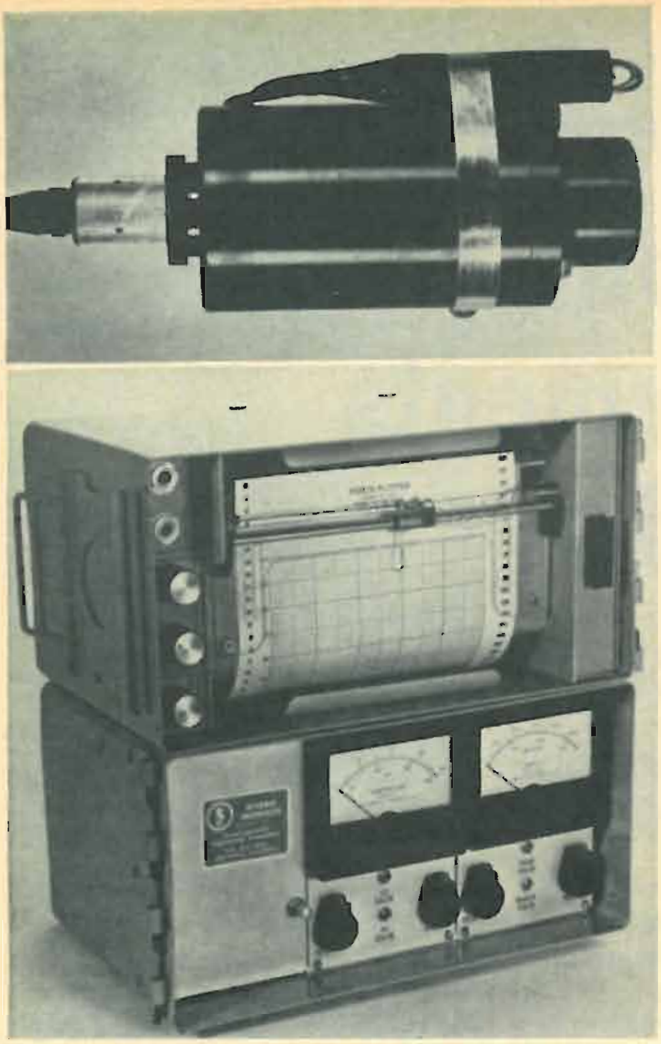


Fig. 2. Upper photo shows the underwater probe of the electronic B-T. It consists of a Bourdon tube potentiometer pressure transducer in an oil-filled aluminum housing and a neoprene-jacketed thermistor (top). The lower photo shows the deck unit, containing a power supply, a meter readout, along with a graphic recorder. (The manufacturer: Hydro Products)

of determining depth. To a good approximation, pressure in the ocean increases at the rate of 0.445 psi per foot of depth. Depth can be determined more accurately by pressure measurement than, for example, measuring the length of wire supporting the thermometer.

3. It is used with a water-sampling bottle so that chemical analysis of the water (at the place where temperature is measured) can be made. This is the "instrument-cluster" concept frequently used in oceanographic instrumentation.

Disadvantages of this instrument are:

1. It takes but one measurement per lowering.
2. Some time is required to make each measurement.

The Bathythermograph

In 1938 Prof. A. Spilhaus devised a mechanical temperature/depth instrument that probably has been used to take more oceanographic data than any other single device. A commercial version of this particular instrument is shown in Fig. 1.

Designed to be towed behind a ship, it contains a replaceable smoked glass slide. A temperature-sensitive element moves a stylus vertically across the slide. The slide itself is moved horizontally by a pressure-sensitive bellows assembly. As the instrument is lowered into the water and raised again, the stylus traces temperature *vs* pressure (depth).

The instrument is usable to a depth of about 1000 feet and gives an accuracy of approximately ±10 feet in depth

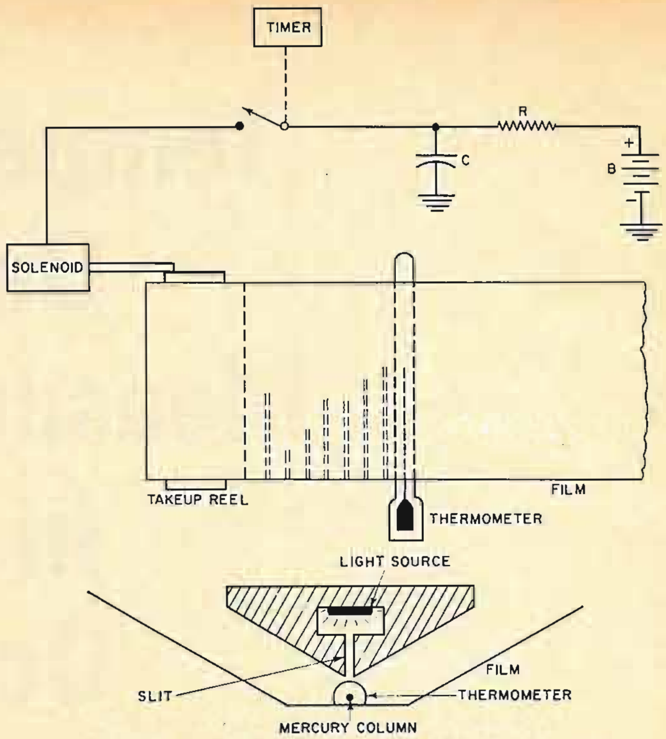


Fig. 3. Side and top views of the recording thermograph which makes hourly records of the temperature measured by a mercury thermometer. Photographic film is exposed by radioactive-phosphorescent light source. Film advance is controlled by clockwork timer and powered by capacitor discharge. (An instrument of this type is manufactured by Braincon Corp.)

and ±0.1 degree centigrade in measured temperature.

Electronic Bathythermograph

A simple and inexpensive electrical analog of the mechanical B-T is shown in Fig. 2. The underwater assembly contains a thermistor to measure temperature and a potentiometer-type pressure transducer to determine the ocean depth.

A multi-wire cable connects to a power supply, recording and signal-conditioning assembly on shipboard.

Its great advantage is that, unlike the mechanical B-T whose glass slide must be recovered before the data can be read, the temperature and depth measurements are displayed in real time on shipboard. If an interesting anomaly appears it can be closely investigated while the sensor is still in place. Also, the electrical data is amenable to electronic data processing techniques.

This simple electronic B-T is best suited for use near the surface of the ocean. At great depths more elaborate pressure protection is required. Also, as the lead wire becomes longer, its resistance becomes significant and it becomes desirable to place the signal conditioner underwater and, if possible, to use a single-conductor wire.

Recording Thermograph

The device shown in Fig. 3 is a unique combination of old and new techniques. It illustrates several facets of oceanographic instrumentation:

1. Ingenuity in design
2. Simplicity of design—a quality that has been found to be of importance in equipment used in the ocean
3. Low power consumption (Unattended instruments frequently must be located where sources of commercial power are not available.)

The temperature measurement is made with a mercury-in-glass thermometer. A zinc-sulfide phosphorescent material, excited by a radioactive source, provides light. This exposes a strip of film behind the thermometer except where the light is blocked by means of the thermometer's mercury column.

Fig. 4. The infrared thermometer consists of a hand-held or tripod-mounted sensing head (left) containing a thermistor bolometer detector, optical lenses and filters, controlled-temperature chamber, and mechanical chopper. The temperature of the ocean surface can be read directly on the meter located in the case of the instrument. (Barnes Engineering Co.)

The film advances periodically to give a record of temperature *vs* time. Power for the film advance comes from a battery that charges a capacitor through a large resistance. Once an hour a clock-controlled switch applies the capacitor charge to the solenoid-ratchet stepping mechanism.

The recording thermograph was designed to monitor temperature in harbors, bays, and estuaries where temperature changes are slow. Accuracy is on the order of ±0.1° C.

Infrared Thermometer

The concept of measuring temperature at a distance by observing infrared radiation has been put to practical use in oceanography in recent years. The instrument shown in Fig. 4 can be used on shipboard or, more commonly, in a low-flying airplane. The probe, which has 3° field of view, is pointed at the surface of the water. The infrared radiation received is compared to that of a standard-temperature source within the probe to determine the water temperature. The temperature that is measured is that of the top few millimeters of the ocean surface.

The probe contains optical filters to restrict its passband to 8-14 microns. In this wavelength band the sea appears black (non-reflecting) and the atmosphere is nearly transparent. Thus interference from sun reflection is minimal and attenuation through the sea-to-aircraft path is small.

The basic sensor is a thermistor which, with the aid of a gold-plated mechanical chopper, alternately sees the ocean surface and a chamber of known temperature. The resulting square wave is processed to provide a d.c. signal for meter display and recording.

The absolute accuracy of the infrared thermometer is about ±1.2° C. Most oceanographic temperature sensors are an order of magnitude better in this respect. But the ability of the infrared thermometer to operate from an airplane saves the high cost of a research ship and allows data to be collected over much larger areas of the sea.

The Deep-Sea Bathythermograph

Electronic methods have made practical continuous temperature-pressure (depth) measurements from the ocean surface to the deep sea.

Using the "instrument-cluster" concept, a typical system also measures sound velocity, conductivity, and other parameters. The instrument, supported by its electrical cable, is lowered over the side of a ship. Data is recorded on deck as the probe is lowered to 10,000 feet or more below the surface. Another record is made as the probe is pulled back to the surface.

The design of the deep-sea B-T differs in several respects from that of instruments used closer to the ocean surface.

Supporting Wire The deep-sea B-T may require a supporting wire that is four miles long. Such a wire needs considerable strength just to support its own weight. The mechanical design usually dictates that the electrical conductors of a multi-wire cable be small, #24 gauge for example.

The resistance of the wire is significant and, for measurements of good accuracy, the wire usually is not placed in series with a resistive transducer. Instead, the sensor bridge and output amplifiers are placed in the underwater probe. The deep-sea instrument is typically more complex than its near-surface counterpart for this reason.

The twisted-armor construction of multi-wire cable restricts the speed at which it can be towed. Thus many deep-sea designs favor single-wire plastic-insulated cable. The plastic insulation, buoyant in the water, reduces the total immersed cable weight and presents a smooth surface to the water The sea water serves as a return conductor.

Data signals, in this arrangement, must be multiplexed. Frequency multiplex is popular. Here, each measurement is converted to a frequency analog. The combined multi-frequency signal can then be sent up the single wire. At the same time d.c. to power the sensors can be sent down the wire.

Pressure Sensor. Pressure (depth) data from the bathythermograph varies slowly and the data-gathering time is long. The sensing system need not have wide data bandwidth. The prime requirement is for good long-term stability.

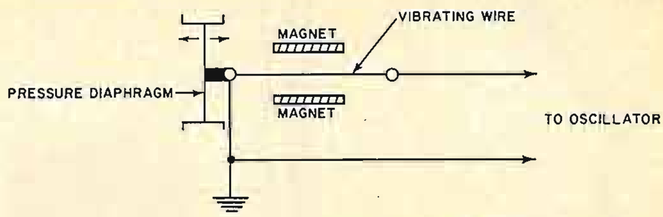


Fig. 5. The "Vibrotron" converts pressure into frequency through a vibrating wire When excited electrically, the oscillation frequency is pressure dependent. (United Control)

Thus, in preference to the v.c.o. approach widely used in missile telemetry, oceanographic frequency-multiplex systems favor more direct conversion from pressure to frequency.

A strain-gage-bridge transducer can be used directly as a feedback element to control an oscillator's frequency. Bridge-controlled oscillators (b.c.o.'s) using integrated-circuit amplifiers provide excellent long-term stability, are small in size, and use little d.c. power.

The "Vibrotron" is specifically designed to be used with a bridge oscillator. A tungsten wire (Fig. 5) in a magnetic field is stretched between a fixed anchor point and a pressure diaphragm. When the wire is connected in an oscillator circuit, it is excited to a sustained vibration at the natural frequency determined by the pressure on the diaphragm.

Accuracies on the order of ±0.3% of full scale are obtained with the sensor.

Temperature Sensor. The most popular temperature sensor is the thermistor. Platinum resistance sensors are also used for this application. Typically, they are connected as feedback elements to control the frequency of an oscillator.

For deep-sea use the probe must be protected from mechanical deformation by the high pressure environment. The metal sheath usually used for this purpose increases the time constant of the probe. It is difficult to obtain a thermal time constant less than ½ second in a pressure-protected probe.

The time constant limits the speed at which the probe can be lowered to obtain a temperature profile or, alternatively, it limits the accuracy and detail of the measurement.

Allyn Vine of *Woods Hole Oceanographic Institution* has described the time-constant problem in a pictorial manner with the "apparent probe size" concept.

Following a step change in temperature, a sensor approaches its final reading by 37% after one time constant, by 13% in two time constants, by 0.7% in five time constants.

If we want to read changes to 0.7% with a ½-second time-constant probe, a 2½-second wait is necessary. If the probe is moving at 5 feet/second it will move 12½ feet during this time.

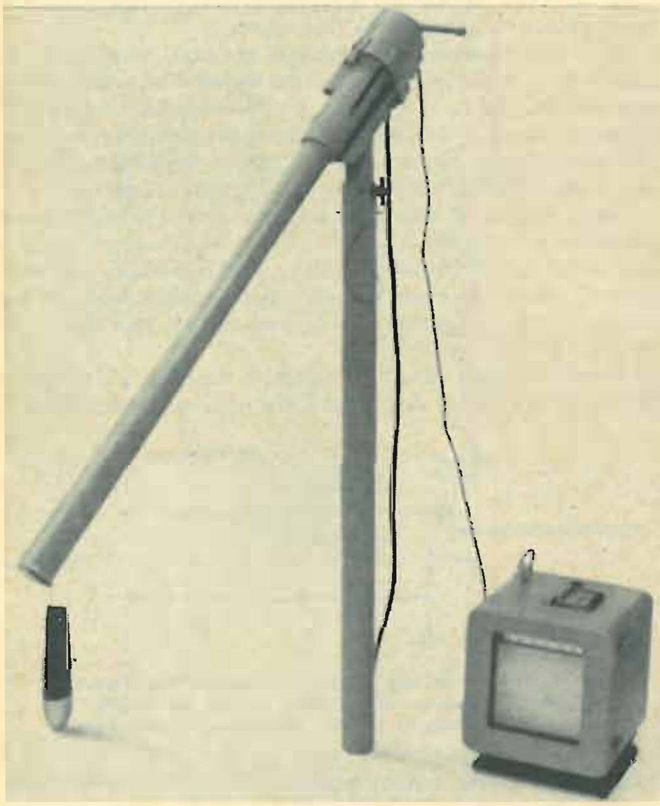
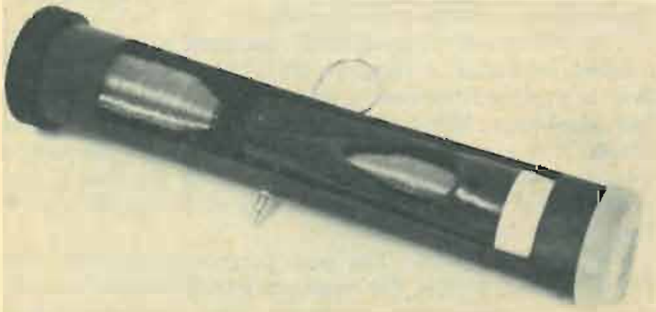


Fig. 6. The expendable B-T probe (lower left), its launcher, and recorder. The launcher, which extends over the side of the ship, ensures that the probe gets a good start on its journey to the bottom of the ocean. Temperature-depth recordings are made for the first 1500 feet. (Sippican Corp.)

Fig. 7. Cutaway view of expandable B-T probe and cannister. The wire coil at left remains in the launcher; its wire pays out as the ship moves. The wire coil in the probe (which is shown at the right in the photo) pays out as probe descends.



Thus, even though the probe may be small, it has an "apparent length" of 12½ feet for this measurement precision.

The Expendable Bathythermograph

It takes time to lower an instrument to 1000 feet or more and to haul it back up. During this time the ship's operation is restricted. If the instrument is heavy, a winch is needed to raise and lower it and in rough weather it may not be possible to use the instrument at all.

The expendable B-T is a new concept in temperature-depth instrumentation that eliminates these problems. It uses a thermistor temperature sensor mounted in a ballistically shaped housing. When dropped into the water it falls at a known rate. Thus, a record of its temperature readings *vs* time can be displayed as temperature *vs* depth.

The key to the successful operation of the probe lies in the ingenious use of two spools of fine insulated wire. One coil of wire is inside the probe. The other remains on shipboard. The coils are connected together to form one continuous length of wire that carries the temperature signal from the probe to a shipboard recorder.

As the probe falls through the water wire pays off its coil. Wire that is already outside the probe does not move and so does not hold back the probe.

As the ship moves wire pays off the shipboard coil. The wire laying along the surface of the water does not move. Nothing is towed behind the ship. Readings can be taken when the ship is moving as fast as 30 knots.

The system is shown in Fig. 6. It consists of the expendable probe, a launcher, and a recorder. Initially, the probe and the coil of wire that will pay out from shipboard are held in a canister (Fig. 7).

When the cannister is inserted into the launcher, electrical connection between probe and recorder is made. When the restraining pin is pulled the probe drops from the launcher. An electrical signal is generated when it hits the water and the recorder starts.

During the next 90 seconds the temperature-depth profile is recorded. When the probe reaches a depth of 1500 feet, it runs out of wire, the recorder stops, and the probe is expended.

The system gives accuracies of ±0.2° C in temperature and ±2% in depth. The expendable probe costs about $20.

The Quartz Thermometer

The quartz crystal resonator, which has seen wide use as a stable controller of radio-frequency oscillators, has recently been introduced as an oceanographic temperature sensor.

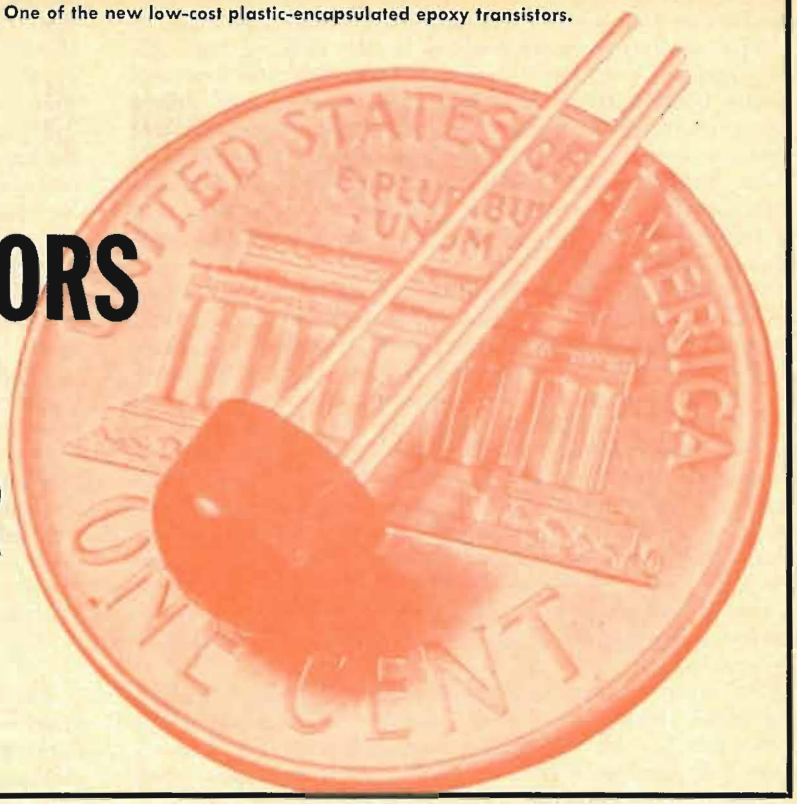
The quartz thermometer uses two crystals. One is an AT-cut which is temperature insensitive. It controls a "reference" oscillator. The other crystal is an LC (*L*inear *C*oefficient of frequency with temperature) cut which is sensitive to temperature in a linear manner. It controls a "temperature" oscillator. At its operating frequency of 28 MHz it changes 1000 Hz per °C.

The outputs of the two oscillators are mixed. The crystal frequencies are selected so that the resulting difference frequency is zero at 0° C. The beat frequency increases 1000 Hz/°C to 40 kHz at 40° C. This audio frequency signal is transmitted to an electronic counter that gives direct digital readout in °C.

The oceanographic temperature sensor was derived from the laboratory thermometer shown in Fig. 8. Here the reference oscillator and two temperature oscillators are built into the rack-mount assembly. The probes contain only the LC-cut crystals. Their cables are restricted to 12 feet in length. Probe diameter is ⅜ inch and the small probe is less than an inch long. Their time constants are less than one second.

By contrast, Fig. 9 shows the oceanographic temperature probe. It is 10 inches long and 1½ inches in diameter. Its time constant is three seconds. (*Continued on page* 95)

One of the new low-cost plastic-encapsulated epoxy transistors.



low-cost SEMICONDUCTORS FOR THE CONSUMER MARKET

By JOHN S. MacDOUGALL

Consumer Applications Department, Fairchild Semiconductor

The availability of new plastic-cased IC's, transistors, and diodes is now opening up vast new home and auto markets. Here is what's happening to the semiconductors involved in this revolution along with a look into the future.

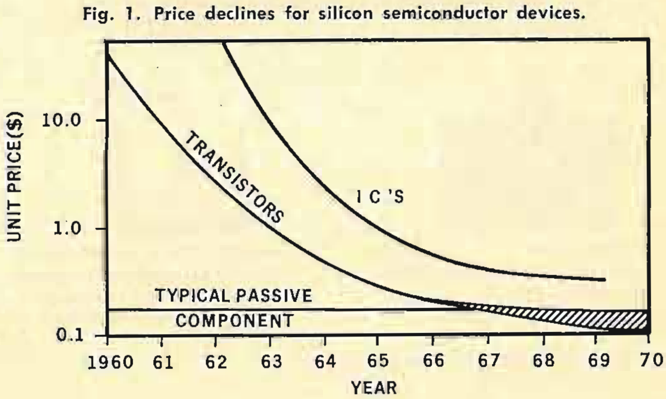
RECENT advances in semiconductor manufacturing technology have permitted drastic price reductions coupled with improved unit performance. These changes have alerted the consumer industry to the many advantages of using semiconductors. A quiet revolution is now taking place which will eventually trigger one of the greatest changes ever undergone by the consumer industry. In this age of space shots and moon landings the average housewife is probably unaware of the radical improvements which have been made in her household appliances. The purpose of this article is to examine what is happening to the components responsible for this revolution and from this to try and predict some of the future possibilities.

The Cost Picture

One of the primary reasons for the widespread acceptance of semiconductors in consumer products is price reduction. Transistors which once sold for $60 (Fig. 1) now cost less than 20 cents while integrated circuits which once carried a $200 price tag now sell for less than 60 cents. With these price reductions have come performance improvements so that in terms of price-performance the slope is really much steeper. When these changes are compared with the much smaller changes in the price of typical passive devices, such as resistors and capacitors, it is easy to see why manufacturers are interested. It should be noted that the prices shown for transistors are only for silicon devices since similar price reductions were made much earlier on germanium devices. However, it seems that silicon will dominate the market in the long run and will ultimately yield the lowest price and the best performance.

Why have these drastic price reductions occurred and what basis is there for predicting that they will continue? In the first place, the application of sophisticated manufacturing techniques makes it possible to "make the device for the socket". In the early days transistors were made for the military or computer market and after the best units were supplied to these high-priced areas, an outlet was sought for the "fallout". When the "fallout" business started to dominate the market, the manufacturer had to decide whether to sell prime material in the low-cost market or lose present and future business. The decision, which was made for the

Fig. 1. Price declines for silicon semiconductor devices.



silicon market about five years ago, was to enter the low-cost market with products designed for that market with production rates geared to predicted volumes and costs.

The resulting industry buildup is now yielding high volume and low cost. For instance, in 1966 *Fairchild Semiconductor* conservatively estimated sales of over 100 million epoxy transistors with an expectation that the market will continue to grow at a similarly high rate for many years to come. Estimates of the total world-wide industry volume of epoxy devices is also growing (Fig. 2). It can be seen that in 1970 world consumption of epoxy transistors should reach about 1.5 billion units.

Full development of the low-cost semiconductor devices should be credited to a unique manufacturing process and the epoxy package. The former permitted high-yield volume production while the latter reduced the cost of the most expensive component in the assembly. A third factor, testing, has not been fully automated as yet. The process for fabricating silicon transistors has already been described extensively in the literature and will not be covered here. The die that results from this process contains a highly protective surface covering of silicon dioxide and can thus be handled by relatively crude techniques. However, the epoxy environment is a nasty one and, in addition to the surface treatment, it may be necessary to provide additional protection to the device depending on its circuit application and method of encapsulation.

There are two principal encapsulation techniques involving plastic materials: *pressure molding* and *casting*. Each technique has its advantages and disadvantages from a technical standpoint which more or less offset each other but the principal argument in favor of the casting method is its suitability in low-cost-labor areas. (How these techniques work and their differences are shown in Fig. 3.)

Although design engineers usually try to avoid them, there are instances where metal or non-epoxy packages must be specified. Prices on some form of metal packages have been drastically reduced in the past few years but one must still pay a premium. Metal packages provide true hermetic seal, high dissipation, and low interlead capacitance.

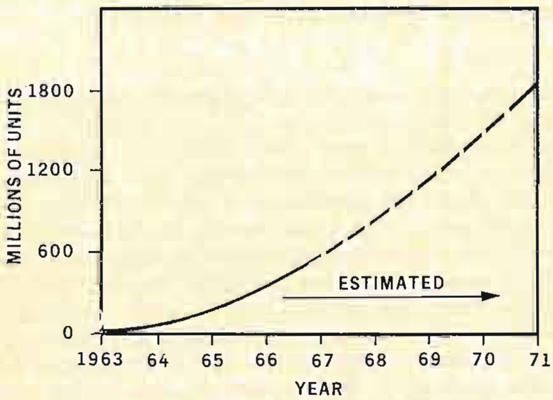
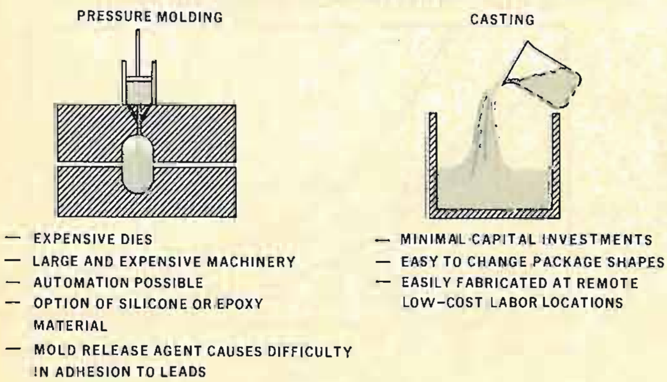


Fig. 2. Estimated world-wide usage of plastic transistors.

Fig. 3. Two main methods of encapsulation which are used.



If one assumes that the best device for a particular consumer application is one designed specifically for the socket, then it is obvious that the semiconductor manufacturer should be looking into all possible areas of semiconductor application to determine device requirements. Since the lead time from the conception of a new device specification to full production can be as long as two years, the semiconductor manufacturer must be at least two years ahead of his customers in order to be ready with the needed device. In looking for the technical and economic justification for making such a new device, he must consider the product for a particular application. It is only by operating in this way that a manufacturer can maintain his position in the market and continue to make a profit on high-volume, low-cost sales.

Another consideration that enters into the cost and price area is that of other possible methods of obtaining the same function. For instance, in the appliance field electromechanical switching functions can be taken over by equivalent SCR circuitry. However, relays, although inherently much less reliable, are still well entrenched in the industry and now sell at very low prices. In the radio and television industry, semiconductor components compete for the older vacuum-tube sockets on the basis of two factors—price of the total circuitry and performance.

What About Reliability?

The question most frequently asked by potential users of plastic-encapsulated devices concerns reliability. Reliability depends on the type of plastic used for encapsulation and on the environmental stresses.

In the early production runs of plastic devices reliability problems were encountered with both epoxy and silicone materials. At the present time technology has advanced to the point where both materials show exceptional resistance to environmental stresses.

The effects of environment are as follows:

1. *Humidity*: This great killer of all semiconductor devices can enter a plastic package *via* the lead-plastic interfaces, through the plastic interfaces, or *via* the absorption of the material itself. The interface route is by far the most common and problems in that area have now been eliminated. However, since the solution involves considerable plastic technology and know-how, it is still in the nature of a trade secret.

2. *Stray Ions*: The ion migration problem is of primary concern since undesirable ions are likely to be present in almost any environment under conditions of high-voltage back bias of the collector-base junction (a normal operating condition). These ions migrate to the semiconductor surface and form an electrostatic bias that tends to increase the leakage current of the device. The ions may be in the silicon dioxide itself or in the surrounding epoxy but wherever they occur the effect is readily apparent. Protection of the surface by metalization structures is almost essential for epoxy transistors operating above about 20 volts d.c.

3. *Shock*: Plastic-encapsulated transistors are especially resistant to mechanical shock.

Future of Integrated Circuits

In many digital applications in the industrial field, integrated circuits are now competitive with discrete devices in terms of total circuit cost. The systems designer gains a number of advantages by using integrated circuits:

1. If he has a minimum operating budget, he can avoid all of the design problems associated with the detailed circuit thus leaving his engineers free to concentrate on the system as a whole or additional performance features.

2. The system designer is buying a system component with guaranteed performance features.

3. Small size in large systems is of considerable help in terms of circuit boards to be assembled and handled.

4. Over-all cost of the product can be materially reduced.

In the consumer market, the use of integrated circuits is not as easy to justify since the systems are smaller yet still require the use of complex linear circuits. However, it seems that integrated circuits will ultimately enter the consumer area especially in radios, hi-fi equipment, TV sets, appliance controls, and automotive circuits. In all of these areas the circuit must offer equal or improved performance at an equal or better price as compared to discrete components in order to justify its use.

At present, it is technically feasible to make integrated circuits for the following portions of a color-TV receiver: the sound i.f., the video i.f., the sync-signal processing, the color amplification and processing, the color reference oscillator, vertical and horizontal scanning oscillators, the audio amplifier, and portions of the u.h.f. and v.h.f. tuners. If all of these circuits are integrated, the economics of IC manufacture will dictate that TV set makers have relatively little say in the design of the circuits or, on the other hand, the semiconductor manufacturer will function as a custom designer of IC's for the set maker. Obviously, some compromise between these two extremes will be required.

The Effect on the Consumer

The introduction of low-cost semiconductors will not offer the consumer any immediate price reduction in the equipment he is now buying. Rather, it is our feeling that the consumer will receive better performance from his present equipment and a chance to buy new kinds of equipment. For example, predictions of coming drops in the price of color-TV receivers are not based on the future trends of semiconductor pricing but on competitive factors. On the other hand it is certain that the consumer will be offered many extras which would not have been available to him except through the use of semiconductors.

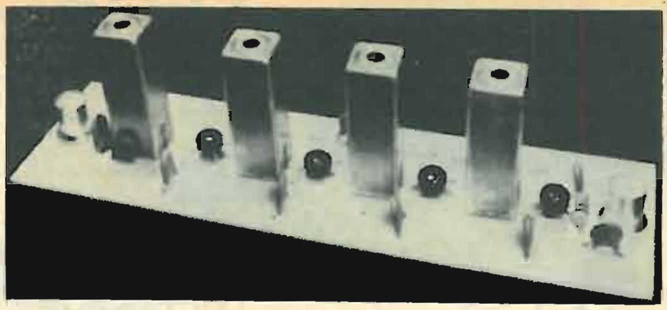
Among the general features which low-cost semiconductors can provide are:

1. *Flexibility*: Changes in operating parameters of the device can be easily altered in the design phase, in production, or by the user.
2. *Remote Operation*: A timer or speed control need not be at the point of operation—the attic fan can be easily controlled from the bedroom *via* low-voltage signal circuitry.
3. *New Control Features*: SCR speed control of mixers is one example.
4. *Reliability*.

There are many new things that can be done with semiconductors in household equipment. What are these new areas of application and what features do they offer the consumer?

1. *Continuous Speed Control*: Better and more reliable hand mixers, sewing machine which operate smoothly, and quieter fans and air conditioners will result. A current application of an SCR control to a washing machine permits control of the machine agitator for delicate fabrics without compromising its ability to handle heavy loads.
2. *Continuous Power Control*: A light dimmer is a relatively low-cost and unsophisticated example of this. In the future one might expect electric ranges with heating elements offering continuous control such as is now possible with gas stoves. Coffee machines with reliable contactless operation and space heaters with continuous proportional heat are other examples.
3. *Flexibility of Timing*: In the future we may have a timer for the whole house which could be programmed to ring the morning alarm, turn on the coffee maker, start the lawn sprinklers, turn off the lights (or turn them on sequentially during vacation periods), and start the oven. With a mechanical timer, providing these functions would be very complicated, but with a solid-state electronic unit, it would be a fairly simple matter and certainly much more reliable.

With this increased capability made possible by the use of semiconductors we can look forward to a host of new appliances and important changes made in older models.



Here are four plastic IC's used in FM tuner i.f. strip. Note the absence of a large number of separate R and C components.

The automotive field is another prime area for the application of low-cost semiconductor components. Two features can be offered which will make their use attractive to the car and truck buyer. The first of these is reliability. With the longer warranty periods and the new emphasis on safety, reliability is becoming both an economic and a performance sales tool. The second feature is added performance. The electronic ignition system is already available as an option for increased performance, however, it has not been widely accepted by the consumer since the improved performance is rarely obvious in everyday usage.

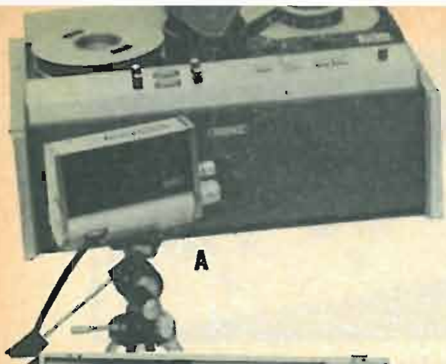
On the other hand, an electronic ignition system which would provide automatic timing adjustment would be very desirable and, at present, appears economically feasible.

In addition to improved radios, tape recorders, and back-seat TV receivers for the car, there are many areas where real performance features can be added. Some of these include anti-skid brake controls, computer-controlled automatic transmission systems, and automatic speed controls.

As to the future, production rates will continue to increase and epoxy devices will dominate the field. Integrated circuits will be introduced and used in conjunction with discrete circuits in the most economical arrangement. The appliance and automotive industries will certainly incorporate semiconductors in their products at an accelerated rate and this will create a booming new semiconductor market area. ▲

POSSIBLE USES FOR SEMICONDUCTORS IN THE HOME

- SCR control of electric range elements
- Capacitance burglar alarms or door openers
- Garage door openers using IC's
- SCR light dimmers
- IC temperature sensor for furnace control
- Digital electric clock using IC's
- A.c.-to-d.c. converter for electric razors to allow razor motor to deliver higher torque
- IC limit clocks for stop-start operation of electric ovens
- Ultrasonic power source for ultrasonic dishwasher and/or washing machine
- Solid conductivity detector to turn on sprinklers as the lawn dries out
- Water level cut-out switch for bath tubs and sinks to prevent overflow
- Automatic humidity control for dry air regions
- SCR control for electric blanket
- Electronic bathroom or food-weighing scale using strain gage coupled to counters
- Electronic metronomes for musical-instrument students
- Automatic electric timer-temperature computer for photography fans
- Timers for washers, dryers, ovens
- Speed controls for drills, saws, washers, furnace fans, air conditioners
- Digital coded or magnetically coded door locks
- Automatic focus control for projector
- Pollen/dust count detector and electronic filter control



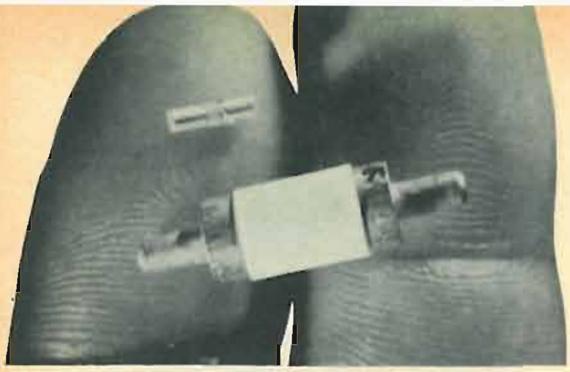
DIRECTORY OF MOST POPULAR, LOW-PRICED

PHOTO	Model	Number of Heads	Tape Size Used (in)	Reel Size (in)	Tape Speed (ips)	Record-Playback Time (min.)	VIDEO Input (V)	Level (Ω)	Output (V)	Level (Ω)	Response (MHz)	Horiz. Resolution (lines)
	AMPEX CORP., 401 Broadway, Redwood City, California 94063											
A	VR-6050	1	1	9¾	9.6	60	1	75	R.f.[a]	300	2.5	250
	VR-7000	1	1	9¾	9.6	60	1	75	{ R.f.[a] / 1	300 / 75	3.5	350
	VR-7500	1	1	9¾	9.6	60	1	75	{ R.f.[a] / 1	300 / 75	4.2	350
	CONCORD ELECTRONICS CORP., 1935 Armacost Ave., Los Angeles, Calif. 90025											
B	VTR-500	2	½	7	12	60	1	75	{ R.f.[a] / 1	300 / 75	2.5	250
	CRAIG PANORAMA INC., 2302 15th St., Los Angeles, Calif. 90021											
	6401	2	½	7 or 8¼	9½	63	.5	75	1	75	–	200
	GENERAL ELECTRIC CO., Audio Products Dept., Decatur, Illinois 62525											
C	VC-941	2	½	7	7½	90	1	75	1.4	75	–	200+
	GENERAL ELECTRIC CCTV Business Section, Syracuse, N. Y. 13201											
D	2-30	2	1	8	7.8	63	.5	75	1	75	3	300+
	PT-3A	2	½	7	7½	64	1	75	1.4	75	–	200+
	PT-2A	2	½	7	7½	64	1	75	1.4	75	–	200+
	MATSUSHITA ELECTRIC CORP. OF AMERICA, 200 Park Ave., N. Y., N. Y. 10017											
E	NV-8000	2	½	7	12	40	.4	75	1	75	2	200+
F	NV-204	2	1	8½	8.57	67	.5	75	2	75	3	340
	PHILIPS BROADCAST EQUIP. CORP., 900 South Columbus Ave., Mt. Vernon, N. Y. 10550											
G	EL3400	1	1	8	9	40	1	75	1 / R.f.[a]	75 / 300	3.2	285
	REVERE-MINCOM DIV., 3-M CO., 2501 Hudson Road, St. Paul, Minnesota 55119											
H	Wollensak VTR-150	1	½	8	7½	60	1	75	1	75	2	–
	SHIBADEN CORP. OF AMERICA, 58-25 Brooklyn-Queens Expressway, Woodside, N. Y. 11377											
I	SV-700U	2	½	7	7½	60	1	75	1	75	3.5	300
	SONY CORP. OF AMERICA, 47-47 Van Dam St., Long Island City, N. Y. 11101											
	CV-2000D	2	½	7	7½	60	1	75	1	75	2.5	200
J	CV-2000	2	½	7	7½	60	1	75	1	75	2.5	200
	TCV-2010	2	½	7	7½	60	1	75	1	75	2.5	200
K	TCV-2020	2	½	7	7½	60	1	75	1	75	2.5	200
L	DV-2400	1	½	5	7½	20	1	75	–		2.5	200

a—VHF channels 2 through 5; b—camera; c—monitor; d—tripod; e—microphone; f—mono version $3995; g—recorder, camera, monitor as package $1509.50; h—TV101 school trainer including VTR, receiver, viewfinder camera, tripod, console $5800; i—R.F. modulator; j—built-in monitor; k—built-in timer.

VIDEO TAPE RECORDERS

AUDIO Micro. (dB)	(Ω)	Line (dB)	(Ω)	Output (dB)	(Ω)	Response (Hz)	Dimensions (in) W	H	D	Weight (lbs)	Price ($)	Special Video	Notes
—	50K	—	100K	—	—	90–9,000	—	—	—	85	1195	—	b, c, d, e
.2 mV	200	.12 V	100K	{4 dBm {8Ω	600 6W	50–12,000	29¾	13¾	20¼	100	3450	—	b, c, d, e
.2 mV	200	.12 V	100K	{4 dBm {8Ω	600 6W	50–12,000	29¾	13¾	20¼	110	4495	color	b, c, d, e, f
1 mV	20K	1 V	1 meg.	1 V	600	60–12,000	17	10	16½	52	1050	—	b, c, d, e, g
−60	10K	−10	10K	0	2K	70–10,000	21¾	13¾	17¾	65	1035	—	Accessories: camera, monitor, tripod, mike
−60	600	−20	high	0	high	80–10,000	18½	10½	16⅝	—	1600	—	Includes camera, micro., monitor, cables
−70	600	−8	10K	+4 600/10K		—	26	11½	17⅞	88	3495	still, slow motion, color	two audio channels
0.775 mV	600	—		−2	10K	80–10,000	15½	9¾	16½	62	1695	—	consists of VTR, camera, monitor
0.775 mV	600	—		−2	10K	80–10,000	37½	34¾	26	75	1995	—	console—VTR, camera, monitor
−60	20K	0	1 meg.	−20	600	80–10,000	16⅝	9 7/16	16 3/16	54½	1050	—	b, c, d, e, i
−65	600	−10	600	0	600	50–12,000	24⅞	12½	16 5/16	97	3750	still, color	b, c, d, e, i
1 mV	1K	200 mV	500K	1 V	20K	120–12,000	24¾	16½	15¼	100	2495	—	h
.2 V	10K	—		.5 V	10K	50–10,000	20	9	14	50	1495	—	—
−60	10K	−14	10K	−14	Low	50–10,000	15¾	9½	15¾	53	1295	still	b, c, d, i
−60	600	−2	high	0	high	80–10,000	19¾	9⅞	15¼	42½	695	—	b, c, d, e
−60	600	−2	high	0	high	80–10,000	18½	11⅞	13¾	46	730	—	b, c, d, e
−60	600	−2	high	0	high	80–10,000	27½	11	16¼	66	995	—	b, c, d, e
−60	600	−2	high	0	high	80–10,000	29½	11⅞	11⅞	70	1150	—	b, c, d, e, j, k
−60	600	—		—		—	10½	9¾	12¼	12	1250	—	camera, viewfinder, micro. battery powered



The larger device is intended for the Gunn bulk oscillator, while the smaller device houses a Read-type junction diode.

GUNN OSCILLATORS

By DAVID L. HEISERMAN

A new type of microwave semiconductor that may one day replace present complex and expensive sources, and create new consumer microwave communications and radar devices.

THERE is little doubt in the minds of semiconductor scientists and engineers that microwave technology is on the threshold of a miniaturization and cost revolution. A new breed of simple microwave semiconductors may one day replace our present complex and expensive microwave sources and create a whole new line of consumer microwave communications and radar devices.

The makers of the revolution will be the new transit-time semiconductors best represented by the Read p-n junction diode and the Gunn bulk gallium arsenide oscillator. (See "New Frontiers in Semiconductors" on page 78 of the March, 1967 issue.) At this stage of development, however, no one can say which device will eventually set the microwave revolution into motion—both have advantages and disadvantages, and both are plagued by production reliability problems.

The theories of operation of both devices are rather new. The Read-type device operates on the well-known principles of the zener and tunnel diodes with the new idea of semiconductor electron transit time tying the two effects together. The operation of the Gunn device, however, represents a radical departure from conventional semiconductor thinking. In this respect, the Gunn device is worthy of closer study.

Gunn's Discovery

Those of us who have been working in electronics for more than a few years associate semiconductor devices with one or more p-n junctions. We think in terms of holes and electrons, minority and majority carriers, junction potentials—always in terms of at least one pair of p and n semiconductor materials within one device. To think of an operational semiconductor made up of only one type of semiconducting material (a bulk semiconductor) is, traditionally, to think of an impossibility. Despite conventional thinking, the "impossible" was accidentally discovered by Dr. J.B. Gunn at *IBM's* Watson Research Center.

In 1963, Gunn was running a series of routine experiments on a 0.005-inch thick slice of homogeneous n-type gallium arsenide when he noticed some unexpected coherent r.f. oscillations on his oscilloscope. Checking the set-up for possible stray reactance or faulty components, he discovered that the plain n-doped material was oscillating at slightly less than 1 GHz (1000 MHz) with nothing more than a 6-volt d.c. power supply connected to the terminals (Fig. 1).

What had been a purely theoretical possibility became a fact—Gunn found a semiconductor material that could oscillate in the microwave region without benefit of external tuned circuitry.

Gunn and his associates soon realized that they had uncovered a phenomenon that could not be explained in terms of the usual semiconductor theories, so they were forced to try new theories and experimental techniques. The theoretical model of the oscillator, as finally developed, represents one of the biggest sidesteps from the mainstream of semiconductor thinking since the introduction of the laser diode.

Negative Resistance in Bulk GaAs

Without the benefit of the usual p-n junction, the Gunn oscillator demonstrates negative resistance properties. The quantum energy diagram and corresponding I-V curve are shown in Fig. 2.

The diagram shows the usual forbidden gap between the valence and normal conduction bands. These regions in *GaAs* have the characteristics of any other n-type semicon-

Fig. 1. The current through bulk GaAs increases with an increasing amount of applied d.c. voltage until the conduction-band electrons gain enough energy to skip upward into high energy, low-mobility band. At this threshold voltage (about 3000 volts/cm or about 6 volts of applied voltage) the GaAs sample will oscillate without any external tuned circuitry.

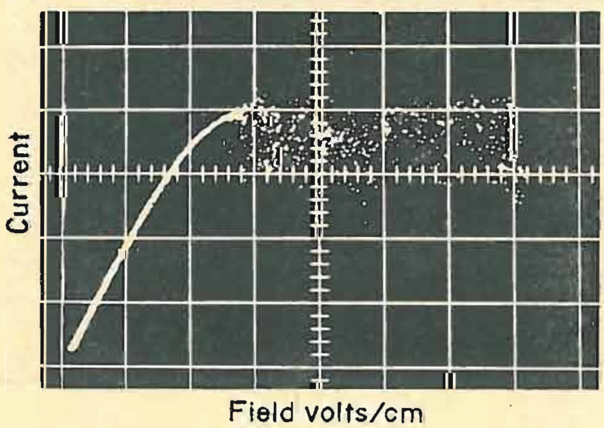
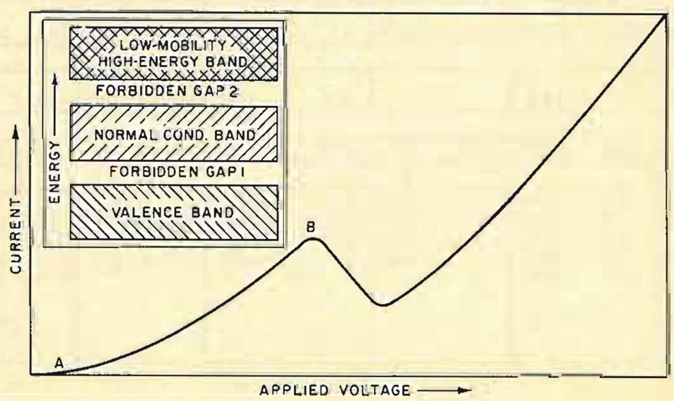


Fig. 2. The quantum-energy diagram (shown in the inset) along with a corresponding current-voltage curve for bulk gallium arsenide are illustrated below. The existence of the second forbidden gap and the low-mobility, high-energy conduction band gives GaAs quite different properties from the usual semiconductor, such as n-doped silicon, showing no negative R.



ductor such arsenic-doped silicon. The *GaAs*, however, has an additional forbidden gap and a special conduction band that differs from the first in two important respects. First, carriers (electrons in the case of *GaAs*) can cross the second forbidden gap only when the applied d.c. potential reaches an extraordinarily high value of 3000 volts per centimeter. Second, carriers that *do* gain enough energy to skip into the second conduction band effectively gain some mass and thus travel much more slowly through the semiconductor than their lower energy counterparts in the first conduction band.

The second conduction band is thus described as one containing only high-energy carriers which travel with unusual slowness through the semiconductor. It is this additional conduction band that makes it possible for an *n*-type bulk semiconductor to show negative resistance.

Referring to the *I-V* curve in Fig. 2, the non-linear slope between points A and B is due to the increasing fraction of valence electrons skipping upward into the high-mobility first (normal) conduction band under the influence of a small applied voltage.

As the applied e.m.f. is increased beyond point B, however, the current drops off sharply. It is at this point that some of the electrons in the low-energy, high-mobility first conduction band enter the high-energy, low-mobility second conduction band. If electrons move slower in the second conduction band than they can in the first, it follows that increasing the percentage of electrons in the second conduction band will cause a corresponding decrease in the net rate of electron flow through the material. As the applied voltage passes beyond point B, then, the current through the *GaAs* sample decreases. This, of course, is the general description of a negative-resistance effect.

The negative-resistance, junction-type semiconductors in use today require some capacitance or inductance to sustain oscillation while the Gunn device does not. So, negative resistance in bulk semiconductor theories are potentially useful, but cannot wholly account for the Gunn effect.

Electron Domain Transit Time

The theory that finally rounded out the explanation of the Gunn effect involves the new concept of slow-moving, high-energy packets or "domains" within a bulk semiconductor.

If a sufficient voltage (the threshold voltage) is applied to a thin slice of *n*-type *GaAs*, electrons skipping into the second conduction band tend to collect into discrete energy domains. Further, if the *GaAs* is of sufficient purity and the applied voltage is carefully regulated, one and only one domain can exist within the material at any one instant.

Since this one domain is made up of second conduction band electrons, the domain will behave exactly as the electrons described in connection with Fig. 2. The domain will drift with relative slowness from cathode to anode, holding the net current flow through the semiconductor to a minimum.

Once the domain reaches the anode, it disappears momentarily and current surges through the material *via* the first conduction band. This surge continues until another high-energy, low-mobility domain forms at the cathode. The current through the bulk semiconductor, then, is low during the electron domain transit time and relatively high during the brief period of time it takes to form another domain at the cathode. Thus, the Gunn device demonstrates current oscillations, the period of which depends on the rate of domain travel and the physical length of the bulk semiconductor material.

The oscillogram of Fig. 3 shows the high-energy domain passing through discrete points along the length of a thin slice of bulk *GaAs*. The trace at the top shows the domain leaving the cathode. In the following traces, the moving electron domain is shown at points progressively closer to the anode. If the frequency of oscillation is assumed to be about 1 GHz, the traces cover an interval of about 1 ns.

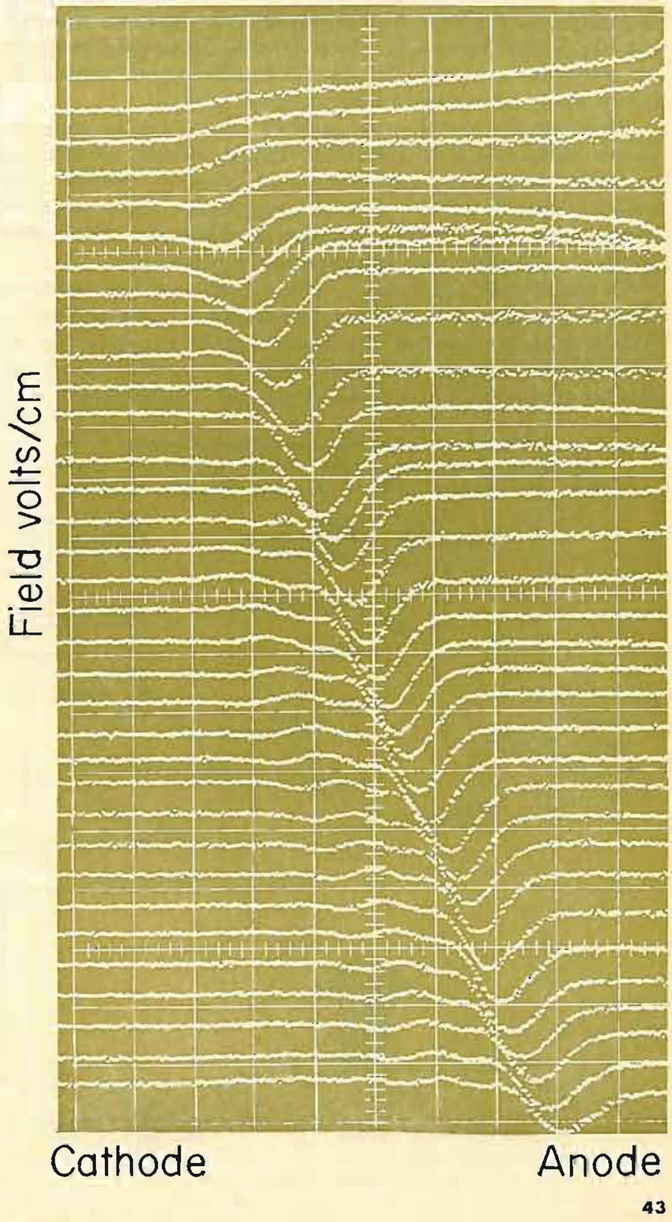
At the present stage of semiconductor technology, the Gunn device's advantages of small size, low cost, and simplicity must be weighed against the disadvantages of lower operating frequency and low c.w. output power. Placed beside the Read-type devices, the Gunn oscillator has about a 50 percent chance of becoming *the* microwave source of the future. See Table 1.

Regardless of the final outcome, the Gunn effect described in this article represents another opening to products and industrial equipment thought impossible a few years ago. ▲

Table 1. Performance of Gunn and other microwave devices.

DEVICE	FREQ. RANGE	POWER OUTPUT	EFFICIENCY
Gunn oscillator	2-3 GHz	0.060 W (c.w.) 200 W (pulsed)	5-6% 14%
Read diode	5 GHz	0.019 W (c.w.)	0.5%
Small klystron	10 GHz	0.100 W (c.w.)	2%

Fig. 3. The low-mobility, high-energy electron domain passing through the Gunn device. The domain builds up near the cathode and moves with relative slowness to the anode, holding the current through the semiconductor to a minimum. Although the ordinate of the oscillogram is in terms of field strength, the downward progression of traces has no physical meaning except to display the chronology of the shock wave that is produced.



Electronics For Speech and Hearing Therapy

By L. GEORGE LAWRENCE

Special techniques for detecting response to auditory stimuli, loop-type induction receivers, and unique neurological sound inducers are some of the many types of electronics used to help hearing-handicapped people.

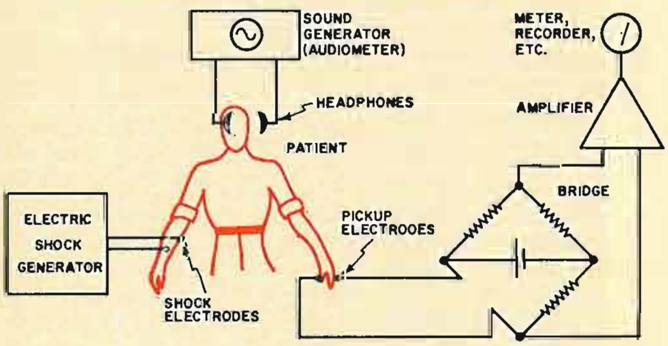
THE creation of a normal educational profile for hearing-handicapped persons, especially children, is of interest to society at large. Today, with otologists, audiologists, and educators being supported with purpose-tailored electronic systems, good progress is being made in nearly all teaching situations.

Unlike "normal" children, young students afflicted with a hearing impairment are exposed to electronic devices at an early age. This exposure begins when the child is taken to a clinic for audiometry, to be tested for threshold levels and fitted with a suitable hearing aid. In many cases, this piece of equipment will be an indispensable companion throughout life. Unlike those who use electronic devices for purposes of entertainment and the like, a handicapped person depends upon electronics for his personal welfare.

Although his vocal cords may be intact, the hearing-impaired child might be unable to speak. Speech requires an inventory of auditory-type references, a set of "models" after which a speech pattern can be formed. But since the child cannot hear, he is unable to collect and vocalize these references in a distinct and comprehensive manner.

In traditional audiometry, the clinical worker tends to define hearing in terms of a raised finger or a pressed signal button after the patient has been verbally or otherwise instructed to respond to sounds directed to him *via* headphones connected to an audio generator (audiometer). One might also say that a patient hears if his pupils contract or if his skin resistance decreases. And there also may be a "startle response" that follows a sudden intense stimulus. Unfortunately, the finger-raising and button-pressing type of auditory response indicators tend to fail if the patient is difficult to instruct or if he is unable to respond to verbal instructions due to too great a loss of hearing. It is under these and related conditions that quantitative information must be obtained by means of *galvanic skin response.*

Fig. 1. When measuring changes in skin resistance in response to shock and auditory stimuli, instruments rather than the patient indicate the true hearing threshold.



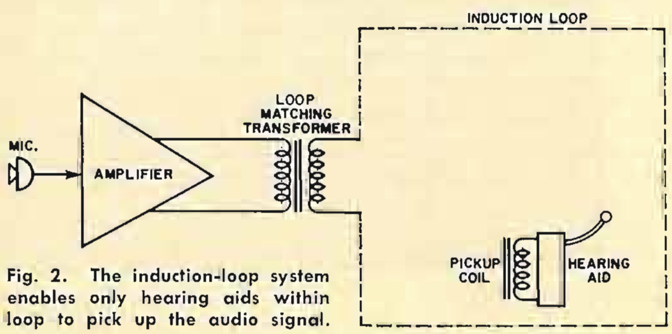


Fig. 2. The induction-loop system enables only hearing aids within loop to pick up the audio signal.

Galvanic Skin Response

Two kinds of response are of interest: the *Tarchanow effect* and the *Feré effect*. The former is a change in electrical *potential* that exists between two points on the surface of the skin, while the latter is a change in electrical *resistance* between two such points. The Tarchanow effect, or galvanic skin response, can be elicited both by intense sounds and electric shocks—the magnitude being directly related to the intensity of the stimulus.

Fig. 1 illustrates the equipment used for measuring changes in skin resistance (Feré effect) in response to applied electric shock and conditioned auditory stimuli. The shock electrodes may be connected to the arm or leg, and the resistance-measuring electrodes may be placed either on the top and sole of the foot, or on the back and palm of the hand. In practice, the first tones as supplied *via* headphones have a relatively high intensity. After an interval of 4 or 5 seconds, each tone is followed by a mild shock. The pause between tone and shock is long enough for separate response data to be gathered. As the intensity of the tone is gradually reduced, a point will be reached where the patient gives no response to the tone alone. The process, repeated several times, makes it possible to calculate a definite threshold of auditory acuity.

Historically, these and related methods are traceable to the Russian Nobel Laureate I. P. Pavlov (1849-1936) who pioneered studies in conditioned reflexes. The American scientists J. E. Bordley, W. G. Hardy, and C. P. Richter, as a result of experiments published in 1949, brought this art to a high degree of perfection. Other workers, active both here and abroad, are in the process of adapting and redefining these principles for the purpose of creating *tactile* communication systems. Tactile data communicators are a must if, for example, one wishes to transmit a set of emergency instructions to an astronaut whose hearing has been impaired due to brief, accidental decompression of a space suit or vehicular system.

In alignment with Pavlovian theory and concepts developed by American psychologist B.F. Skinner, speech pathologists have long recognized the need for speech to be recorded and played back to a hearing-loss-afflicted individual. The "phonic mirror" is a modern example of an instrument that lets the student speak whenever ready; then, after a few seconds' delay, he hears his speech played back automatically. Since he can listen to the playback several times, evaluation and correction processes become much more effective.

Most instruments of this type use a continuous-loop tape mechanism. Maximum sound-pressure levels are at 135 dB with a S/N ratio of 65 dB. The output amplifier develops 3 watts. In some designs, the student simultaneously hears the clinician's production in one ear and his own production in the other ear. By means of a binaural balance control, the clinician can vary sound intensities of the two stimuli, thereby creating a flutter effect that focuses attention. It is also possible to reverse the stimuli transmission between ears to emphasize speech discrimination and modification. The high sound pressure of 135 dB enhances the indication of sibilant disorders (lingual and lateral lisps) requiring correction.

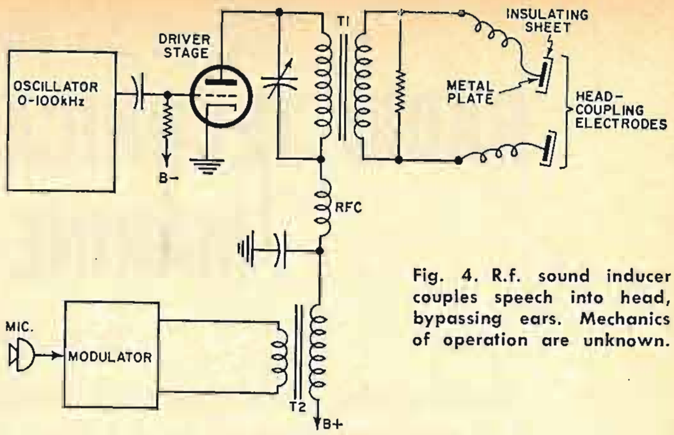


Fig. 4. R.f. sound inducer couples speech into head, bypassing ears. Mechanics of operation are unknown.

Induction Loops

For many years, the two standard methods of amplifying speech for the deaf and hard of hearing have been the conventional hearing aid and the group amplification system. Unfortunately, in the case of group amplifiers, the presence of connecting cables tends to place a severe restriction upon the movements of students. To mitigate these disadvantages, a new kind of wireless classroom hearing aid has been introduced. The composite system is known under the name of "loop-induction trainer" and is shown in Fig. 2.

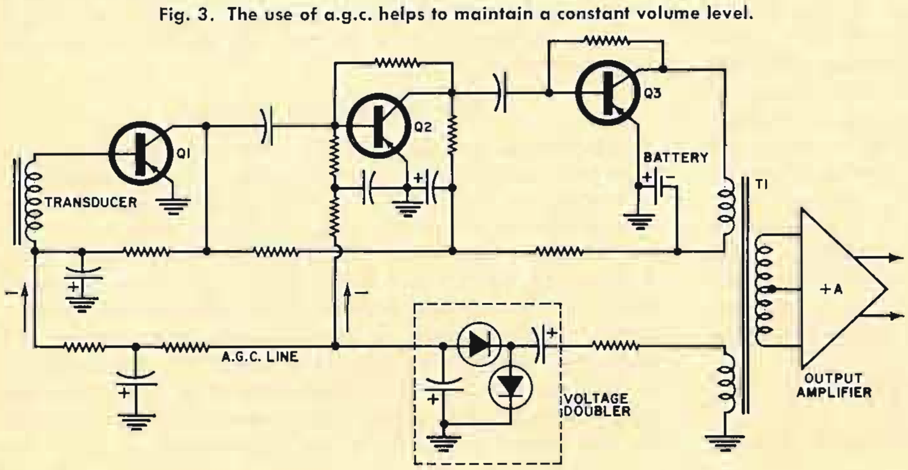
The generic term "induction" simply implies the transfer of electrical energy by wireless (non-galvanic) means. In the case at hand, loop-type communication systems were used during World War II aboard ship to enable the captain to speak to his crew while moving around. The present systems have been modified slightly, but the basic principle has been retained.

In operation, speech is picked up by the microphone. An amplifier magnifies the product and, *via* matching transformer, applies it to the loop. The loop itself consists of a thin wire strung around the interior of a given classroom. If a person having a hearing aid equipped with a telephone-type pickup coil moves within or close to the loop, he will hear the original audio information as picked up by the microphone feeding the power amplifier. Unfortunately, as experience has shown, the sound pattern often tends to be non-uniform at different places within the loop area. To mitigate this undesirable effect, efforts are being made to equip the receiving hearing aid with an a.g.c.-type amplifier such as shown schematically in Fig. 3. In this particular case, the a.g.c. voltage is derived from a voltage-doubler circuit having an a.c. supply winding of its own on the intermediate output transformer. The a.g.c.'s attack time is determined by the *RC* values in the a.g.c. line. The loop-feeding power amplifier might employ a similar form of volume gating to maintain the radiated electromagnetic loop energies at a predetermined level. Customarily, if sound pressure increases by 40 dB, the automatic gain control will hold the output stable within approximately 2 dB of the selected level.

A typical free-field speech trainer in the form of a standard hearing aid has a frequency response from 400 to 4000 Hz ±5 dB with three separate internal adjustments. It may operate from the induction loop or from an individual program source with control by the teacher or student. A convenient shoulder harness adds comfort.

Generally speaking, loop-type induction trainers appear to work very well in most situations. However, an interference problem occurs if there are too many fluorescent lights or certain other electrical fixtures operating in the classroom adding electrical noise to the program. Another drawback is electromagnetic spillover into adjacent classrooms, but cloverleaf loop patterns mitigate these effects.

Fig. 3. The use of a.g.c. helps to maintain a constant volume level.



New Concepts

While no drastic changes in traditional techniques and implements can be expected in the immediate future, the supreme position held by acoustical-type hearing aids will be challenged once the intrinsic auditory mechanisms have been defined more clearly. It appears that r.f.-type hearing aids offer new promise; but, unfortunately, their method of operation is such that manufacturers would be reluctant to let the public at large "play" with these relatively potent devices.

An r.f-type hearing aid is illustrated in Fig. 4. The apparatus takes the form of a Heising-modulated low-frequency transmitter operating at approximately 50 kHz. Insulated electrodes, connected to the output tank, are placed on facial areas (but not the region of the temples) and the system is then energized. The apparatus is unique in that in induces a clear, audible signal directly into the brain's neuron complex by bypassing the ears completely. The biological mechanism responsible for the phenomenon has not yet been defined, but it seems to lie *behind* the common auditory track. Since the effect does very much exist, scientists are forced to re-evaluate and, if possible, restate the classic laws dealing with stimuli and experienced sensation. Since the respective findings are of importance to the character of this article, some of the more pertinent points are outlined below.

In 1860, the German physicist G. T. Fechner (1801-87) published his widely acclaimed book *Elemente der Psychophysik*. In it, Fechner presented a scheme whereby the magnitude of a sensation could be computed from objective measurements of various physical stimuli and responses. He seemingly made clear once and for all that stimuli and responses could be measured directly, whereas sensations could

(*Continued on page* 69)

Report on Annual Assembly of

RADIO TECHNICAL COMMISSION for MARINE SERVICES

By RICHARD HUMPHREY

Most of this year's Washington RTCM meeting was devoted to the coming shift to single-sideband in the 2-3 MHz band and changes in new v.h.f. channels.

THE May 16-18 annual Assembly of the Radio Technical Commission for Marine Services in Washington, D.C. revolved around two centers: the coming shift from double-sideband to single-sideband emission in the 2-3-MHz marine band, and the extensive alterations in the new 18-channel v.h.f./FM marine frequencies.

The change in the v.h.f./FM band is in its final steps before becoming law. A Notice of Proposed Rule Making (issued March 15th) uses channel-splitting (going from 50-kHz to 25-kHz spacing) to create 38 transmit and receive channels and one receive-only "environmental" channel in the same spectrum spread presently occupied by 18.

Because of this doubling-up in the v.h.f./FM marine band, the first step under the FCC Notice (carrying an effective date of January 1, 1968) will be to go from wide-band FM (±15 kHz) to narrow-band FM (±5 kHz) to prevent adjacent-channel spill over. Our country's attitude, as expressed at the Assembly, is that the gain in the number of channels and new services included in the expansion plan (such as bringing the weather reports—now on 162.5 MHz—into the fold by including them in the 156.75-MHz "environmental" frequency) far outweigh the loss of capture effect and the possible incompatibility between foreign and U.S. ships.

J.C. Hillman of *RCA* cited the "good service provided at ±5 kHz FM in the land service" but went on to point out that there might be problems in trying to dovetail an international wide-band FM system with an American narrow-band FM system.

The international wide-band signal would be received with a high degree of distortion on an American narrow-band receiver. On the other hand, reception of narrow-band FM on a wide-band receiver results in no distortion but there *is* a definite loss of recovered audio. Most probably this could be compensated in the majority of cases by advancing the volume control.

The unofficial consensus was that v.h.f./FM equipment in the U.S. could best be "converted" by merely decreasing the transmitter deviation since, as Hillman put it, "tighter tolerance and roll-off filters are not required until 1971". This solution should certainly please owners of existing v.h.f./FM installations who have been worried about the expense of narrow-banding their equipment. For a towing or shallow-draft tanker company with a number of vessels this would represent quite an outlay. Recreational boatmen already committed to v.h.f./FM should be similarly relieved.

A good case for opposing views on the v.h.f./FM expansion was made by Colonel J.D. Parker (Secretary-General of the Committee-International Radio-Maritime) when he charged that the FCC's March 15 Notice "relies on the assumption that a large number of pleasure vessels are going to be forced to fit marine v.h.f.".

This hopeful assumption *has* been implicit in FCC (and U.S. Coast Guard) thinking from the outset.

Referring to the pleasure boater, Colonel Parker doubted that single-sideband equipment "need be so expensive as to preclude its use". A review of SSB marine radiotelephones presently on the market and small enough in size and voltage requirements, show the most inexpensive set to be well over $1000. On the other hand, *Heath Company's* C.A. Robertson said (in his paper) "our SSB marine radiotelephone" should "cost the boat owner about $720". The representative of another manufacturer suggested that his company is planning to sell an SSB marine radiotelephone in the $600 range.

Clearly the equipment choice available to both commercial and recreational marine interests is already expanding. The decision may not be so single-ended, *i.e.*, "to go to the v.h.f. band", as it was before.

But the problem still remains: which marine band will give the recreational boatman more of the services and type of communications he might feel he needs? If you think the interference and congestion on the 2-3-MHz band during the summer boating months is bad *now*, wait until all those thousands of pleasure-boat radio licensees begin falling over each other's transmissions with highly efficient, greater-distance-capability SSB emission.

The single-sideband question was in the future when Lt. Cmdr. Walter Hamilton (then Chief of Communications, 3rd U.S. C. G. District) in speaking for the 3rd District said, in effect, that the average recreational boater should get rid of his 2-3-MHz equipment because he didn't need it. Neither was SSB in Victor B. Robinett's (*AT&T* Engineering Staff) mind when he told the author v.h.f./FM should be used *instead* of 2-3 MHz by the bulk of pleasure boaters. This attitude (echoed by FCC officials, other Coast Guard officers) that the v.h.f./FM marine band is *the* place for the great majority of pleasure-boat stations has been reported many times in the past.

The author contends that to deliberately "sell" single sideband to those recreational boat owners whose interests would the best served by v.h.f./FM and make it possible for them to cause interference *thousands* of miles away instead of *hundreds* of miles away is a monumental disservice to marine communications as a whole.

The Interference Problem

Interference on the v.h.f./FM frequencies presently is almost non-existent. The minimal number of users contributes of course, but the fact that the bulk of the transmissions are by commercial users who keep their talk short and to the point is also a factor. But one characteristic of v.h.f. is going to *keep* the interference factor below that of the 2-3-MHz band: the line-of-sight feature. With a thousand vessel-stations, including yours, in a two-hundred-mile area on 2-3 MHz it is entirely clear that the potential interference factor is 999, the number of vessel-stations who could interfere with you and *vice versa.* This interference factor would be diminished on v.h.f. by the (*Continued on page* 86)

SWITCHES

A Guide to Selection & Application

By ARTHUR F. HACKMAN
Component Specialist, Standards Engineering Dept., McDonnell Douglas Corp.

Important factors for mechanically and manually actuated switches are presented as a practical aid in choosing the best switch for the job.

WHEN trying to decide what switch to use, your first questions must be "What function do I want the switch to perform? Will it be used to switch one circuit, two circuits; to switch electrical power to one load, two loads, or to one of several loads?" The answer must include the number of circuits and the number of loads, or the number of *poles* and the number of *throws* which make up part of the switch description. The word "throw" is not to be confused with the word "position" since "position" includes any "off" position that may exist. Hence a simple single-pole, double-throw switch can switch the power of one circuit to either of two loads and may be equipped with two, or with an "off," three positions. If a switch is to be kept in some particular position, this too is reflected in the description, such as single-pole, single-throw, normally open. Standard terminology and circuit arrangements are illustrated in Fig. 1. Those for rotary and other types of switches will be covered later in this article.

Voltage and current ratings must also be considered. The electrical ratings of the switch should not be exceeded if satisfactory operation is expected. It is not necessary to de-rate or use a percentage of the rated current of the switch of a reputable manufacturer. However, if greater electrical life is desired, the manufacturer can probably recommend a reduced current that will increase switch life. Current overloads decrease switch life: sufficiently high or consistent overloads cause early switch failure by welding the contacts. Over-voltage also decreases switch life. Ultimate switch failure from overvoltage results because the switch is unable to interrupt current flow after the contacts have separated. Voltage or dielectric failures are usually catastrophic, sometimes resulting in an explosion.

Often, minimim levels of voltage-current are overlooked but when values are expressed in millivolts and microamperes it is wise to determine and specify the maximum acceptable voltage drop at the rated load across the contacts. Usually gold contacts are specified for such applications, but this should be checked with the manufacturer or your company's switch specialist, if there is one.

There are many advantages in using off-the-shelf switches. The fact is that the vast majority of applications can be handled without the need for a specially designed switch. Admittedly, the state of the art would never advance without new designs, nevertheless an attempt should be made to use existing switch designs whenever and wherever possible.

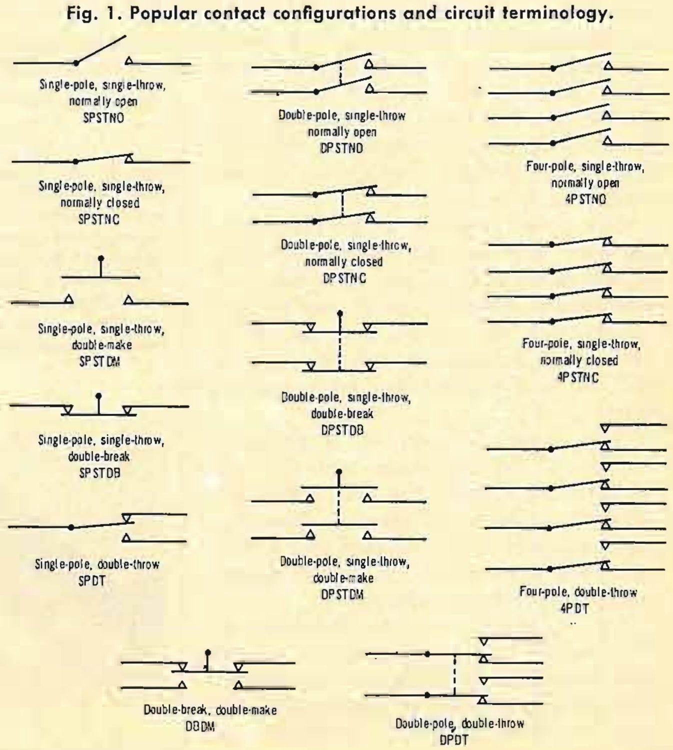
After determining what circuit configuration and electrical capacity is required, the next choice involves the method of actuation. This choice falls into two categories: 1. mechanically actuated, and 2. manually actuated switch.

Mechanically Actuated Switches

Very often an engineer will find that the mode of mechanical actuation is dictated by his design, that is, the medium sensed is also the actuating medium. The majority of these switches fit into the following catagories: pressure sensitive switches, temperature-sensitive switches, and position-sensitive or limit switches.

Pressure-sensitive switches are used when specifications require changes in fluid pressure to be monitored or controlled. Switches are available to cover a wide range of pressures—from those of over 25,000 psi to pressures expressed in fractions of an inch of mercury. Generally speaking, the actuating mechanism of pressure switches

Fig. 1. Popular contact configurations and circuit terminology.



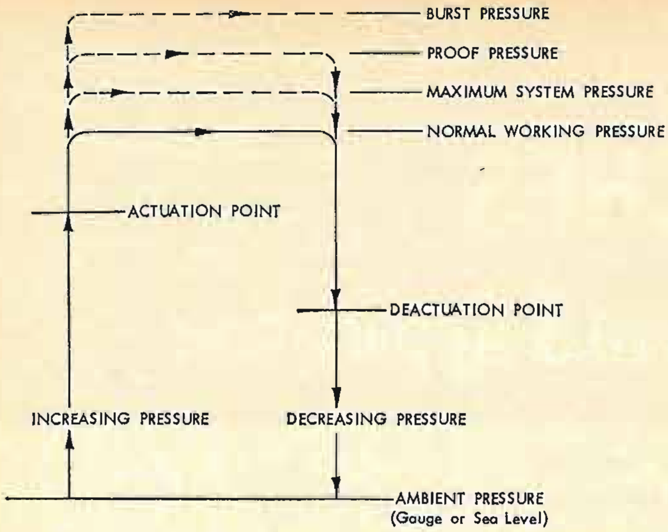


Fig. 2. Schematic operating cycle of a gauge pressure switch.

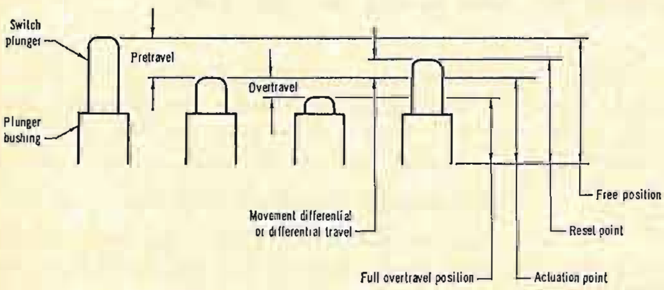


Fig. 3. Terms describing operation of limit switches are shown.

incorporates a pressure-sensitive diaphragm coupled to an electrical switch. Actuation of the switch occurs within a specified range of pressures. Similarly, deactuation occurs within a specified range of pressures. This range includes the actuation (or deactuation) point plus a tolerance which will vary widely, depending upon the accuracy required and the pressure range of the switch. Good engineering practice demands that only the required accuracy be specified as the tolerance, not the best available. The deactuation point is the pressure at which the switch mechanism resets and, as a general rule, occurs at a lower pressure than that which caused actuation. Sometimes, the terms of actuation and deactuation are interchanged, depending on the primary application of the switch in question.

The proof pressure is the maximum pressure that can be applied without a calibration shift in the actuation and deactuation points. Good design requires that the proof pressure of a switch be a minimum of one and a half times the maximum system pressure.

The burst pressure of a pressure switch is the maximum pressure to which the switch can be subjected without rupture or damage. Usually, burst pressure is two to two and a half times the pressure in the system under normal operating conditions.

Fig. 2 shows schematically an operating cycle of a gauge pressure switch and illustrates the terms just discussed. The different types of available pressure switches include: 1. altitude or absolute pressure switches, 2. differential pressure switches, 3. vacuum switches, 4. altitude switches, and 5. absolute pressure ratio switches.

Temperature-sensitive switches are used to protect against over-temperature, indicate an extreme temperature, or control at a specified temperature. The characteristics and behavior of thermal switches are similar to those of simple pressure-sensitive switches except that they are operated by changes in temperature. Actuation and deactuation occur in a similar manner. They are available with ranges from —100°F to +500°F. Switches with smaller ranges are also available with tolerances approaching ½°F. The range of the switch is a function of application, and tolerance or temperature differential will depend on the accuracy required.

Limit or position-sensitive switches are used to actuate or deactuate equipment relative to cam position or door location. Very often limit switches are multi-circuited to actuate signal lights to indicate the condition of the equipment. Types of limit switches vary according to the type of actuation, including lever, plunger, roller plunger, rotary roller-lever, and rotary linkage-lever, and non-contacting switches. Non-contacting or remote sensing switches perform the same function as other mechanically actuated switches but without physical contact. These include proximity, photovoltaic, photoelectric, or pneumatic devices acting as sensors coupled with amplifiers or relays to perform the switching functions. Since their use is largely confined to automated machinery, they will not be discussed here.

Plunger-actuated limit switches allow the greatest range of applications, but are restricted to in-line actuation with controlled overtravel. If the overtravel is not controlled, the switch may be damaged if the force is sufficient. (The actuation point of bushing-mounted plunger switches can be set by means of the two hex nuts supplied with the switch. Often, due to the normal build-up of tolerances, the exact position of actuation cannot be predetermined. It is then necessary to adjust the nuts by a cut-and-try technique to locate the exact actuation point of the switch.) Operating characteristics applying to limit switches are shown in Fig. 3.

The most popular mounting means are: 1. bolt or screw-mounted as in Fig. 4A or 2. bushing-mounted as in Fig. 4B through E. The bolt or screw-mounted limit switch is essentially restricted to basic switches, with most sealed limit switches being bushing-mounted.

Sealed limit switches can be designed to operate in almost

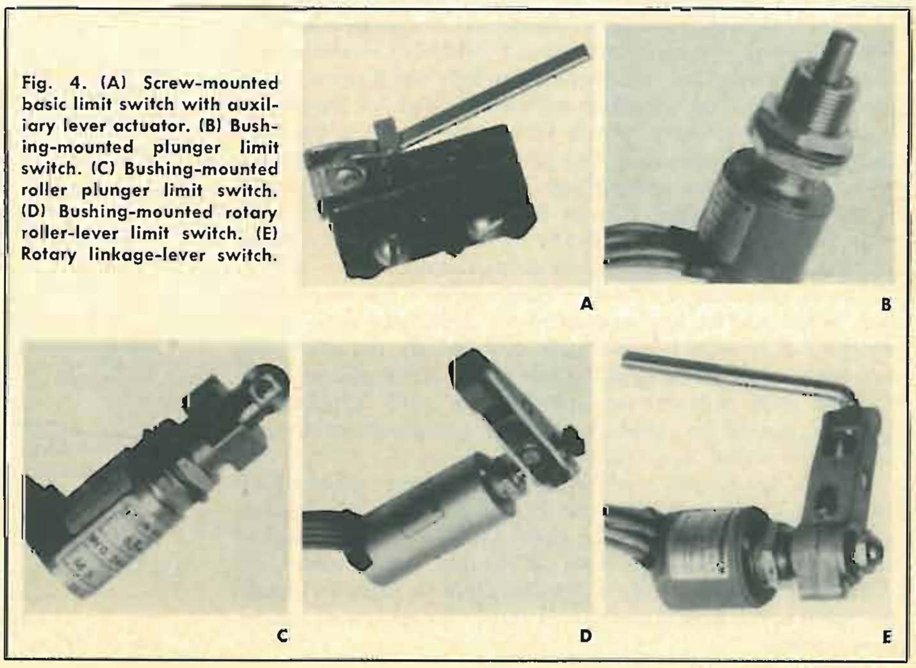


Fig. 4. (A) Screw-mounted basic limit switch with auxiliary lever actuator. (B) Bushing-mounted plunger limit switch. (C) Bushing-mounted roller plunger limit switch. (D) Bushing-mounted rotary roller-lever limit switch. (E) Rotary linkage-lever switch.

any environment. They are often watertight to the extent that moisture cannot be pumped into the switch through cycles of pressure or temperature with the resultant condensation. Some sealed switches, for example, are subjected to environments that build up ice on the actuating plunger. An integral part of the switch, called the "ice scraper," acts to clean the plunger upon actuation and free it of ice. If the switch has been held actuated and the actuating force is removed, the release force built into the switch acts to break the ice barrier.

Lever actuation is most often employed with a basic switch, as shown in Fig. 4A. Advantages include its compact size, ease of installation, general lack of tight tolerances, and its flexibility of application with additional actuators. Its main disadvantage is its vulnerability due to a lack of protection.

A roller-plunger limit switch is a slight modification of the plunger limit switch (Fig. 4B) for adaptation to cam or slide actuations which have an incline or rise of less than 30°. An example is shown in Fig. 4C. Often the roller plunger has an adjustment mechanism that allows locking the roller in 45° increments.

Cam or slide actuation with an incline of more than 30° requires a rotary roller-lever actuation, the type shown in Fig. 4D. This type of actuation usually operates in only one direction and is spring-loaded to return the lever to a neutral or deactuated position after the operating force is removed.

A modification of the rotary roller-lever switch is the rotary linkage-lever (Fig. 4E) which is used to physically connect the actuating device to the switch. This switch operates in both directions but has no return spring. The linkage-lever is threaded so it can be attached to the actuating device which must provide the deactuating as well as the actuating forces. The actuation point of both rotary lever

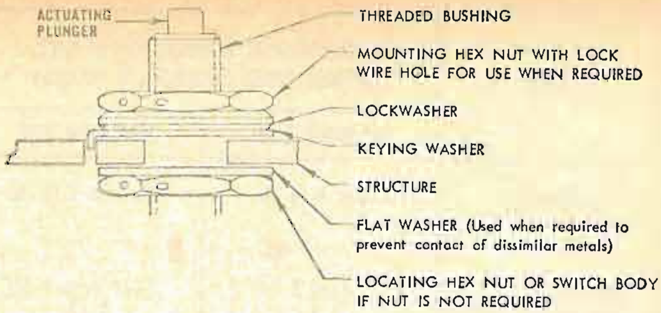


Fig. 5. Accepted installation of a bushing-mounted switch.

switches is positioned by a worm gear with a screw adjustment that locates the arm in any position through 360°.

Mounting of rotary-lever switches is often similar to that of plunger switches except the axial positioning of the switch is not as critical and, for this reason, only one hex nut is used. Fig. 5. shows an accepted method of installing a bushing-mounted switch. Note that the keying washer is placed on top of the structure to serve the dual purpose of keying the switch and protecting the structure from the lockwasher. An alternative to the keying washer, as used by some switch manufacturers, takes the form of two tabs projecting above the switch body which engage two mating holes in the mounting. In areas of extreme vibration, a lockwire is used to prevent loosening of the mounting nuts.

Manually Actuated Switches

A selection of manually actuated switches offers the designer a little more leeway in his circuit than mechanically actuated switches. Personal preferences may sometimes influence switch selection since a goodly number of applications can be handled by more than one type of switch. Table 1 compares applications while Table 2 compares parameters

Table 1. Comparison of manually actuated switches with their main advantages and limitations.

TYPE	ADVANTAGES	LIMITATIONS
Push-button	Short plunger travel and light actuating forces minimize operator fatigue when extended operation is required. Lighted switches add to the appearance of the panel and conserve panel space by combining switch and indicator. Lighted switches facilitate identification and provide rapid indication of switch or circuit condition.	Non-illuminated push-buttons often require an auxiliary indicator to signify actuation. The push-to-actuate motion can be conducive to accidental actuation. Care must be taken in their location. Often, guards that must be reached into or pushed aside must be used. Push-buttons are not readily adaptable to multi-position indication except when lighted.
Rotary	The most varied switching functions are available. Rotary switch knobs are very resistant to accidental actuation. The mode of actuation provides a natural habit reflex for "increase or decrease" functions.	Actuation of other circuits to reach the required position is often undesirable. The time required to find and select the desired position may cause considerable lost time
Thumbwheel	The operator is required to reach into a recess to cause actuation. Switch and circuit condition is indicated by the thumbwheel position.	Visual identification of switch position is difficult when viewed from a distance or at an angle. Actuation is difficult if the operator wears gloves. The limitations of rotary switches also apply.
Toggle	A great number of switching functions are available. Toggles are easily and speedily actuated. Two-position switches require no additional judgement once the decision to actuate has been made. Lever-lock toggles cannot be accidentally actuated. The installation may allow for habit reflex actuation or de-actuation.	Toggle levers are prone to accidental actuation when poorly located. Guards or lever locks must be used if no suitable location is available. When more than one switching position is available, some time may be lost if an operator's decision must be made prior to actuation. Actuation of unusual toggle designs rely on operator's memory.
Slide & Knife	Two-position switches require no additional judgement once the decision to actuate has been made. The installation may allow for habit reflex actuation or de-actuation.	Visual identification of the switch position is difficult when viewed "head on". Actuation may be difficult if operator wears gloves. Knife switches may present a shock hazard to operating personnel.

TYPE	DIMENSIONAL COMPARISON OF SIZE BEHIND PANEL SURFACE (IN INCHES)		CURRENT CAPACITY (IN AMPERES AT (28 V d.c./117 V a.c.)		COST[2] RANGE ($)
	MINIMUM SIZE[1]	MAXIMUM SIZE[1]	MINIMUM SIZE[1]	MAXIMUM SIZE[1]	
Push-Button (Integral), SPST, Sealed	1 deep X ⅝ dia.	1⅛ deep X ¾ dia.	10/10	35/35	4.00 to 6.94
Push-Button (Assembly), SPDT, Unsealed	21/32 deep X 25/32 X ⅜	15/16 deep X 1¼ X 1¾	4/5	40/40	4.45 to 9.90
Rotary, Single-Pole, Eight-Throw, Explosion-Proof	.62 deep X .62 dia.	1.43 deep X 2.125 dia.	.25/.25	15/15	10.00 to 22.00
Rotary, Single-Pole, Eight-Throw, Open	.4 deep X 1 dia.	.95 deep X 2 13/16 dia.	.55/.15	12/10	1.50 to 4.50
Toggle, Single-Pole, Toggle-Sealed	1.1 deep X 1.12 X .62	3 3/16 deep X 2⅛ X 1½	25/10	80/30	2.50 to 20.00
Toggle, Single-Pole, Sealed	1.2 deep X 1.16 X .62	-----	20/15	-----	5.00 & up
Slide, Single-Pole, Double-Throw	.7 deep X .9 X .6	-----	1/3	-----	.10 & up
Knife, Single-Pole, Double-Throw	-----	2⅝ X 1 (base dimensions)	-----	25/30	.25 & up

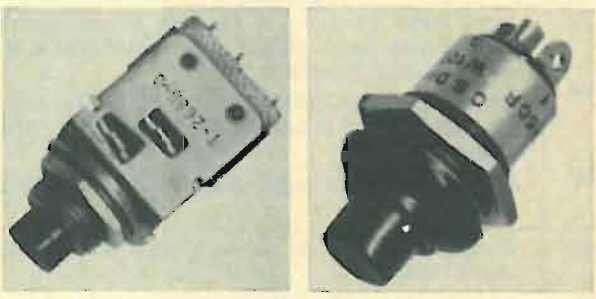
1. Some smaller minimums and larger maximums may be available. The switches chosen here were selected for their current capacity and size, consistent with high quality, competitive prices and is indicative of a cross-section of the industry.
2. The cost range is based on the purchase of a single unit qualified to Military Specifications. Procurements of large quantities often yield upward of a fifty-percent discount. Similar switches may carry smaller price tags; higher costs usually reflect an increased amount of testing and quality control.

Table 2. Characteristics of a cross-section of available manually actuated switches of various types.

of a number of different manually actuated switches.

The application of a manually actuated switch simply conveys a message from the man to the machine. The man/machine concept involves several considerations. Since the design of the machine interface is the more flexible, the switches involved must be selected and applied to fit the operator. The considerations involved are: 1. physical location, 2. mode of actuation, and 3. identification of the switch.

Actuating levers and knobs that are most often used should be in close proximity to the operator's normal position. The switch in the control panel should be positioned so that the operator's clothing won't accidentally cause actuation. The switch should also be located so that it is not inadvertently actuated. If this is not possible, protect the actuator with a guard. Ideally, if several switches are mounted on a single panel, they should be spaced far enough apart to avoid accidental actuation of a switch due to its proximity to another.



A B

Fig. 6. (A) Push-button assembly. (B) Integral push-button.

Consideration should also be given to the environment in which the switch will operate. Even though performance, life, and reliability can almost always be increased by improved sealing, this often carries a prohibitive price tag. For this reason, economics usually dictates selection of the least amount of sealing that can do the job. In addition to the obvious case of selecting a sealed switch if water may drip or splash on it, a sealed switch should also be selected if it will be exposed to extremes of temperature or some other environment that might cause moisture to penetrate the switch when the environment is a non-operating one. Flexible rubber seals or boots are available to aid in sealing a switch between the actuator and mounting bushing and/or mounting panel.

The mode of actuation should be consistent with habit reflexes, *e.g.*, actuate a toggle in the upward of forward direction to bring machinery up to full speed, or push a button to test for some condition. The effort required for actuation may sometimes be related to the switch application. For example, when switches will be actuated at high speeds and for long durations, a light actuating force is recommended. It is also desirable that some form a feedback, an indicating light for example, be designed into the circuit if the switch does not provide some audible or operational indication of actuation. Assuming the switch is in working order, the positive "snap" of actuation or sudden reduction of operating force will often be sufficient evidence of actuation.

fill the gaps... WITH A COMPLETE SELECTION OF ANNUALS, YEARBOOKS, DIRECTORIES AND HANDBOOKS

from the world's largest publisher of special interest magazines. Take a moment to review the titles and issues currently available. You're sure to find many of your favorites to help complete your library and fill those wide open spaces on your bookshelves.

PHOTOGRAPHY ANNUAL

A selection of the World's finest photographs compiled by the editors of Popular Photography. 212 pages—24 in full color.

1967 — $1.50 #38
1966 — $1.25 #1
1964 — $1.25 #3

ELECTRONIC EXPERIMENTER'S HANDBOOK

Many challenging projects for the electronics hobbyist.

1966–Fall Edition–$1.25 #39
1966–Spring Ed.–$1.25 #36
1965–Fall Edition–$1.25 #9
1965–Spring Ed.–$1.25 #14
1967–Spring Ed.–$1.25 #49

CAR & DRIVER YEARBOOK

A complete buyers guide covering virtually every car available in the United States . . . Road tests . . . Technical specifications . . . Accessories and performance equipment buying guide . . . Guide to racing with action-packed photos.

1967 — $1.50 #40
1966 — $1.25 #15
1965 — $1.25 #17

INVITATION TO PHOTOGRAPHY

A unique 116 page guide to better picture taking by the Editors of Popular Photography. Basic down-to-earth advice that helps you eliminate costly trial and error, time-consuming guess work. 20 complete, fact-and-photo packed articles in all.

1966 — $1.25 #35
1967 — $1.25 #50

CAR AND DRIVER RACING ANNUAL

An almanac of competition information covering the entire year of 1966. It's the finest, most complete manual of its kind—it brings every suspenseful heat back to life with lavish use of dramatic photos, and words that spell "speed" from start to finish!

1967 — $1.25 #51

PHOTOGRAPHY DIRECTORY

World's most complete photographic buying guide.

1967 — $1.25 #41
1966 — $1.25 #22

TAPE RECORDER ANNUAL

Everything you need to know about tape recording including a complete directory of mono and stereo recorders.

1967 — $1.25 #42
1966 — $1.25 #30
1965 — $1.00 #31

ELECTRONICS INSTALLATION AND SERVICING HANDBOOK

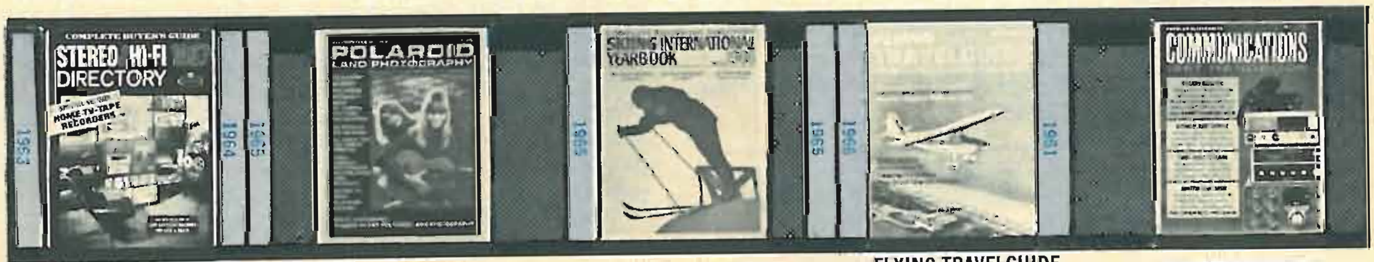
The only complete guide for servicemen and hobbyists to every major phase of consumer electronics servicing.

1967 — $1.25 #43
1966 — $1.25 #32

FLYING ANNUAL

The most valuable aviation yearbook ever compiled . . . Pilot reports . . . Aircraft directory . . . How to buy a used airplane . . . Navcom directory . . . Learn to fly section.

1967 — $1.50 #44
1966 — $1.25 #27
1965 — $1.25 #28



STEREO/Hi Fi DIRECTORY

Complete buyers guide for virtually every Hi Fi component manufactured.

1967 — $1.25 #45
1966 — $1.25 #29

POLAROID LAND PHOTOGRAPHY

Complete guide and only comprehensive and up-to-date handbook on Polaroid Land Photography.

1966 — $1.25 #24
1963 — $1.00 #25

SKIING INTERNATIONAL YEARBOOK

A luxuriously illustrated compendium of 1966's important events. . . . A timely forecast of the excitement-packed 1967 season—by the editors of Skiing Magazine.

1967 — $1.25 #48
1966 — $1.25 #26

FLYING TRAVELGUIDE

Here's the first really useful guide to flying vacations. Everything you need to know about: lodgings, restaurants, resorts, sightseeing, recreation, sports activities, airport facilities childrens fun, price information, special information for the gals—and much more.

1967 — $1.25 #46
1966 — $1.25 #34

COMMUNICATIONS HANDBOOK

The most complete and up-to-date guide to the exciting world of specialized radio communications.

1967 — $1.25 #47
1966 — $1.25 #18
1965 — $1.00 #19
1964 — $1.00 #20

TO PLACE YOUR ORDER, circle the numbers of the annuals you wish to receive on the coupon, clearly print your name and address and enclose your remittance. Please be sure to enclose an additional 15¢ shipping and handling for each copy ordered. Add 50¢ per copy for orders outside U.S.A.

Ziff-Davis Service Division—Department W 595 Broadway, New York, N. Y. 10012

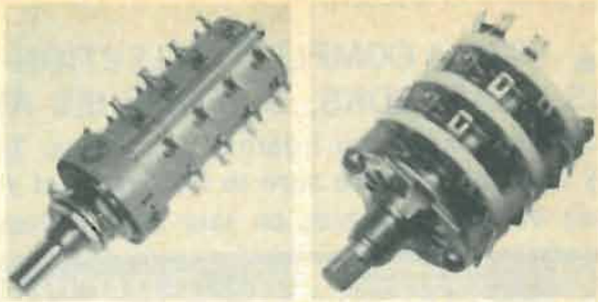
I am enclosing $________ for the annuals circled below. My remittance includes an additional 15¢ per copy for shipping and handling (50¢ for orders outside U.S.A.). I understand quantities are limited and orders will be filled on a first come-first served basis.

1 3 9 14 15 17 18 19 20 22 24 25 26 27 28 29 30 31 32
34 35 36 38 39 40 41 42 43 44 45 46 47 48 49 50 51

Name________
Address________
City________ State________ Zip Code________

EW-97

PAYMENT MUST BE ENCLOSED WITH ORDER



A B

Fig. 7. (A) A typical explosion-proof rotary switch is shown here. (B) More common open rotary switch.

Printed or lettered identification of the switch should be within reading distance and numbers or letters associated with the switch should be located in such a way as to allow reading when the operator is in his normal position. Sometimes an unusual shape of a knob or handle may be employed to help the operator make the proper selection quickly, but this type of design is generally not recommended as it relies on the operator's memory.

The majority of manually actuated switches fit into the following four catagories: push-button switches, rotary switches, toggle switches, and slide and knife switches.

Push-button switches are of two general designs: either a basic switch (or switches) mounted in a push-button housing, Fig. 6A, or an integral push-button switch, Fig. 6B. The switching chamber of the first design is simply that of the basic switch, often enclosed but unsealed. The integral push-button switch has a housing that is usually water-sealed at the plunger and environmentally sealed at the terminals. Both groups are further subdivided into lighted and unlighted push-buttons, with several possible identifying colors available. Unlighted push-buttons should be colored black. Lighted push-buttons should be red, green, amber, white, or blue. Requirements for the application of identifying colors as indicators are as follows:

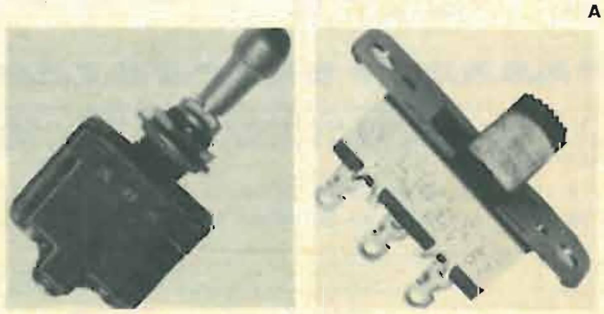
Red: The circuit controlled by the switch requires immediate attention, *e.g.*, a portion is inoperative or corrective action must be taken.

Green: The circuit controlled is in satisfactory condition, *e.g.*, the equipment is within operating tolerance.

Amber: The circuit controlled is in a marginal operating condition, caution may be required.

Fig. 8. (A) Sealed toggle switch. (B) Pull-to-unlock sealed toggle switch. (C) A typical slide switch.

A



B C

White: The circuit is operating satisfactorily with no "right" or "wrong" implications. White is often used to convey some additional information to the operator.

Blue: Blue is used to indicate radiation hazards but is generally accepted as an alternative to white. Blue should be used only when absolutely necessary since it doesn't show up well.

Push-buttons are available with maintained actions and momentary actions, the former requiring a second plunger operation to complete the cycle. Push-button switches should be used when a control or array of controls is needed for momentary contact or for test functions or when used frequently. The push-button surface should be concave or designed so as to prevent the fingers from slipping off the control.

Since there is no knob or lever position to indicate a maintained push-button's actuation, lighted push-buttons are usually preferred. Non-illuminated push-buttons may be used with an auxiliary pilot light but this decreases system reliability and may cause the operator to search for the proper indicator light.

Rotary switches can be classified according to the type of sealing—closed or open, with further sealing classifications in the sealed category. The most popular sealing of a closed switch is explosion-proof, that is, the rated load can be switched in an explosive atmosphere without causing the switch to explode. See Fig. 7A. This enclosure is not watertight to immersion, but is sufficiently tight to prevent water penetration in most applications. Often a rotary switch is made with a rubber "O" ring between the shaft and bushing to prevent moisture from entering the switch through the bushing. The advantage of a closed rotary switch, like that of other switches, is the protection afforded by its enclosure. However, open rotary switches offer an advantage, besides cost, that is very desirable in some applications. See Fig. 7B. The accessibility of the switching contacts allows visual inspection of their condition and even repair.

Rotary switches should be used when the circuitry involved requires more than three positions. They should not be used when only two positions are needed. Momentary actions are available in addition to maintained actions. Rotary switches can switch current to as many as 24 loads or with as many as 12 poles or circuits per deck. The number of poles can be increased by a factor of 3 or 4 by using several poles per deck at the expense of the number of loads. The common contacts (poles) of each circuit may be either shorting or non-shorting. A shorting contact activates the next circuit during each switching cycle before removing power from the last circuit. A non-shorting contact supplies power to only one circuit at a time.

Switches with concentric shafts are useful where a small package is essential. Two switches are combined into a single unit with two distinct shafts. Combinations of shorting and non-shorting contacts along with varied numbers of loads and poles are available. However, complex designs of this nature reduce system reliability, operator efficiency, and tend to degrade the over-all system effectiveness and should be avoided if possible.

Round black knobs are frequently specified. Consideration must also be given to the depth of the recess in the knob with the length of actuator shaft of the switch and any possible interference with the mounting panel (and face plate if one is used) or the switch identification.

Included in rotary switches are thumbwheel switches. These are rather specialized in their application and are usually used in conjunction with circuit boards. Most often the thumbwheel switch has ten position with the output digital or binary coded.

Toggle switches are classified according to their number of poles, with each group being further divided according to the sealing. Usually toggle switches have one, two, or four poles; three-pole switches are available but do not enjoy the same usage and popularity. The sealing is: 1. unsealed with varying amounts of enclosure; 2. toggle-sealed, that is, when submerged with water one-half inch above the bushing, water will not enter the switch through the toggle seal; or 3. environmentally sealed, that is when submerged completely and subjected to pressure equivalent to 56,000 feet altitude for several hours, depressurized, and allowed to remain under water for several more hours, water will not be pumped into the switch. An environmentally sealed toggle switch is shown in the photograph of Fig. 8A.

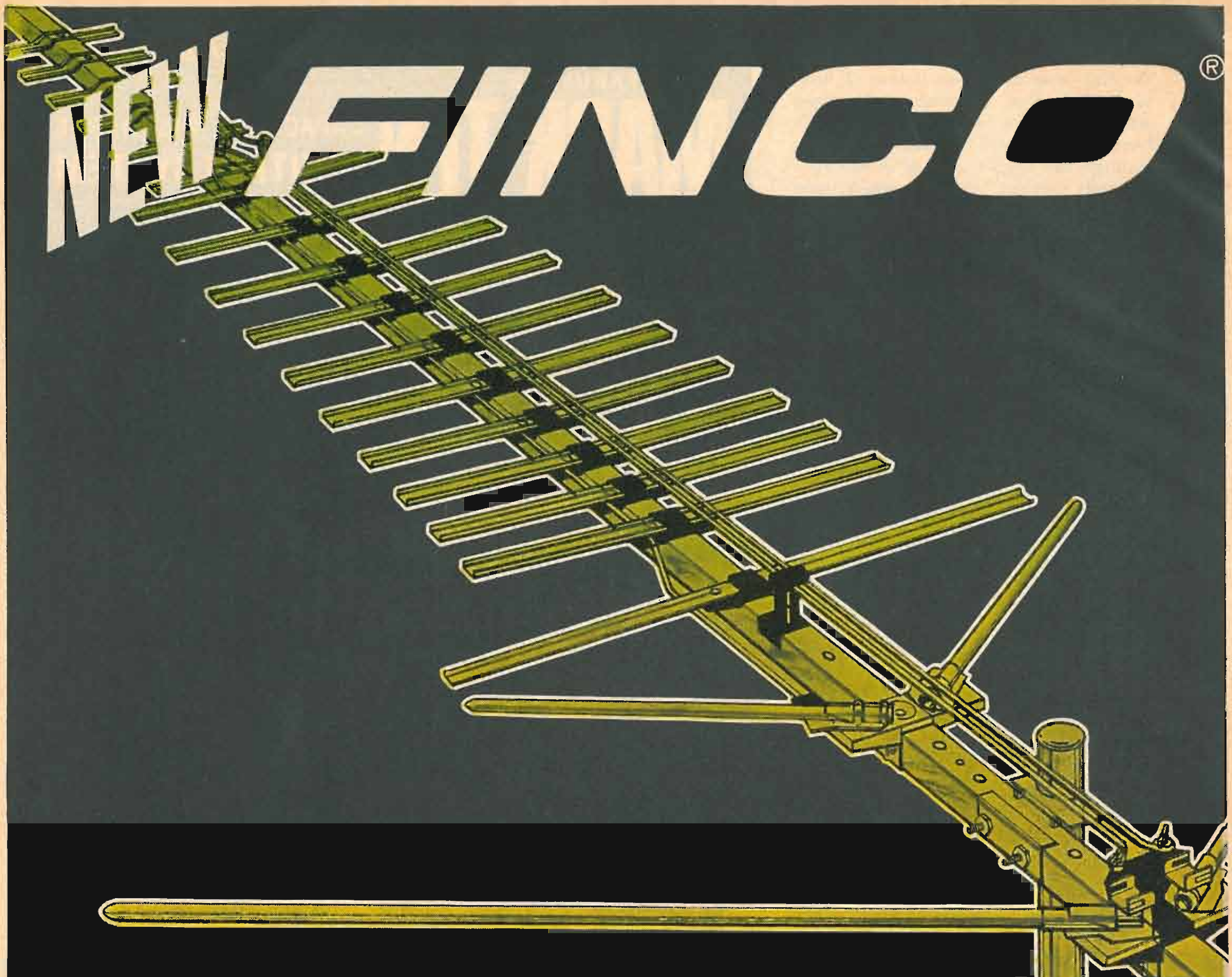
Toggle switches should be used in applications requiring two or three positions. Generally, in a three-position toggle switch the center is the "off" position with the extremes representing circuitry "on" conditions. These switches are also available with "momentary-on" positions. Toggles with more than three positions should not be used. When more than three positions are required, a rotary switch should be specified.

A very popular safety feature, often selected as an alternative to a switch guard, is the "pull-to-unlock" toggle lever, Fig. 8B. A spring-loaded cap or knob on top of the lever requires the operator to lift it manually to allow movement to another position. Guards are available ranging from complete enclosures of the toggle to channel-shaped guards that require the operator to reach into the channel and actuate the switch.

Slide and knife switches are the most basic, simple, and reliable of the manually actuated switches. A slide switch is shown in Fig. 8C. Almost without exception they are unsealed. They are usually enclosed or provided with some form of housing to protect the operator. As with any switch, special functions, hybrids, and accessories are available. The most popular slide and knife switches are used where economy is a major consideration. Their application is limited to environments that do not require sealing, except those knife switches used in outdoor fuse boxes which are usually classified as rain-tight. Their function is similar to that of toggle switches.

Standard Switches

Almost any number of variations on the switches discussed here are available—unusual or untested parts should be avoided. Such a selection most often contributes little or nothing to the system effectiveness. A hard and fast rule which will enable a designer to determine if a switch will function properly in his application usually does not exist. The only criterion is the establishment of the application requirements and then the selection of a suitable switch which will meet those requirements. ▲



"the ANTENNA that captures the RAINBOW"

No two reception areas are alike in the number of stations, UHF and VHF, station channel frequencies, and signal strengths.

FINCO has developed the Color Spectrum Series of antennas – "Signal Customized" – to exactly fit the requirements of any given area. There is a model scientifically designed and engineered for every area, even the most troublesome, and for all combinations of signal conditions.

Engineering studies show that a receiving antenna should have more gain as channel frequency is increased – that is, channel 6 more than channel 2, channel 13 more than channel 7, and UHF from channel 14 on up...

1 – to compensate for signal strength loss
2 – to compensate for down-lead loss
3 – to meet receiver requirements for more signal to operate properly

FINCO Color Spectrum Antennas obtain this frequency dependent characteristic through a newly developed principle of spacing between elements. Gain increases as frequency increases. This new FINCO engineering break-through, combined with superior flat response patterns and unusually high front-to-back ratios, assure the finest COLOR and B & W reception possible... everywhere.

MAKER OF THE WORLD FAMOUS COLOR FINCO BLACK / WHITE ANTENNA COMPONENTS AND ACCESSORIES

Write for full information on "Signal Customized" Antennas:

THE FINNEY COMPANY

34 West Interstate Street • Dept. 410 • Bedford, Ohio 44146

COLOR SPECTRUM T.M. ANTENNAS

are "signal customized" for better reception.

Check this chart for the FINCO "SIGNAL CUSTOMIZED" Antenna best suited for your area

STRENGTH OF UHF SIGNAL AT RECEIVING ANTENNA LOCATION	Strength of VHF Signal at Receiving Antenna Location: NO VHF	VHF SIGNAL STRONG	VHF SIGNAL MODERATE	VHF SIGNAL WEAK	VHF SIGNAL VERY WEAK
NO UHF		CS-V3 $10.95	CS-V5 $17.50 / CS-V7 $24.95	CS-V10 $35.95	CS-V15 $48.50 / CS-V18 $56.50
UHF SIGNAL STRONG	CS-U1 $9.95	CS-A1 $18.95	CS-B1 $29.95	CS-C1 $43.95	CS-C1 $43.95
UHF SIGNAL WEAK	CS-U2 $14.95	CS-A2 $22.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95
UHF SIGNAL VERY WEAK	CS-U3 $21.95	CS-A3 $30.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95

NOTE: In addition to the regular 300 ohm models (above), each model is available in a 75 ohm coaxial cable downlead where this type of installation is preferable. These models, designated "XCS", each come complete with a compact behind-the-set 75 ohm to 300 ohm balun-splitter to match the antenna system to the proper set terminals.

CIRCLE NO. 114 ON READER SERVICE CARD

JOHN FRYE

First-class technical journalism is a highly skilled art that effectively weds good writing and special knowledge.

TECHNICAL WRITING

EMITTING a sudden grunt of distaste, Barney hurled the electronics magazine he had been reading clear across the service shop. "I've had it with that so-called technical writer," he announced to Mac, his employer. "The joker is so busy demonstrating how devastatingly clever, witty, and cute he is that he has little time left for his subject. I couldn't care less about the car he drives or his opinion of miniskirts!"

Mac grinned sympathetically as he loaded his pipe, a sure sign he intended taking a break from the TV set he was aligning.

"He must belong to what my writing friend, Tom, calls 'the smart aleck cult,'" Mac observed. "These writers try to project an amusing, egocentric, mildly obnoxious personality as a substitute for hard work and research. They answer questions from readers flippantly, being more interested in securing laughs than in supplying useful information. These writers often make an amusing first impression on some readers, but they don't wear well with the majority.

"The sad thing is they have simply gone too far in trying to make their writing interesting for its own sake. Tom says all writing *should* be interesting in itself. He quotes: 'No man can read for profit what he cannot read for pleasure'. But good writing can be made highly readable and interesting through legitimate literary arts without becoming facetious, insulting, or downright silly. When a tech writer inserts his personality between the reader and the subject, he has gone too far in trying to hold the reader's interest. Means has become an end in itself."

"You seem to put considerable store by what Tom says."

"I do. He is a truly professional tech writer who makes a darned good living with his typewriter because he prepared himself to do just that. He made up his mind to write while still in high school and studied for his profession in the best university journalism schools in the country. He still reads constantly to improve his writing ability, and you will find almost as many books on English composition and effective writing on his shelves as you will technical electronics books. I know he has had several offers to write fiction and for TV, but he has stuck chiefly to electronics because of his long interest in this subject. He does occasionally do an article for a professional writer's magazine, though, and that in itself bears testimony to his recognized ability.

"For my part, I've been reading technical electronics articles and books for better than a third of a century, and I have pretty definite ideas about what does or does not constitute a good article.

"First, the subject matter should not be flyblown. It can present a new device, spotlight a novel application of an old device, or cast additional light into shadowed areas of electronics theory; but I don't want any tired old rehash of textbook material.

"Second, I expect the article to be well organized. I want a beginning that quickly outlines the subject to be covered and foreshadows the tone and depth of treatment so that I don't have to read the whole article to tell if I *want* to read it. The body of the article should develop the subject in an orderly easy-to-follow manner without any confusing necessity for backtracking. The majority of the text and illustrations should be concentrated in the areas of greatest need: on the most important and hard-to-understand parts of the discussion. When the subject has been thoroughly covered, the article should come to a prompt and definite end—not just peter out. If the final sentence appears at the bottom of the page, I should know it *is* the final sentence without having to turn the page to see.

"The article should not read as though written by a high-school sophomore. I expect it to be cast in clear, vigorous English devoid of clichés and verbosity. Marks of punctuation should be used with the precision of an engineer designating components of a prototype device. The punctuation should clearly and consistently indicate the relationship of the various sentence elements. There should be no room for suspicion that the author has punctuated 'by ear'.

"The article need not sound as though written by Shakespeare, but it should have a definite literary quality. Figures of speech, analogies, careful choice of words, variation in sentence length, proper paragraphing—all these should be used to insure clarity and enhance the readability. What's more, the article should be complete. By that I mean a construction article should include all the information necessary for the reader to duplicate the described device exactly from readily available resources. Every statement or theory open to question should be backed up by quoted authority or experimental data carefully described so that it may be duplicated.

"Finally, a good technical article should leave the reader with an urge to action. A construction article should make him want to duplicate the device described. A description of an exciting new device should make him want to obtain one for his own use. Even a theory article should awaken a desire to perform experiments to confirm the theory or to do more extensive reading along the same line. I consider this evoking of enthusiasm the most important test of a technical article because, if you stop to think about it, it embraces all the other requirements."

"You certainly have definite ideas about what a good technical article should be—and I can't argue with any of your points—" Barney admitted; "but what does Tom have to say about the making of a good technical writer? What preparation does a writer need to turn out the kind of articles you have just described?"

"Tom is most eloquent on that subject. He says good technical writing is first 'good' and then 'technical'. By that he means the possession of technical knowledge is not enough to turn out first-class technical articles. Technical writing, he says, is actually communication, and it is more closely related to teaching than it is to engineering. A tech writer doesn't 'just happen' any more than an engineer 'just happens'.

"It follows, then, that the first thing a tech writer must do is learn to write good, clear, simple prose. This ability, acquired only through diligent study and constant practice, is not easy to come by. Many men never acquire it. The turgid writing often seen in government releases bears proof. The authors of this tortured prose would do well to heed Hemingway's reminder: 'Good writing is architecture, not interior decorating'.

"Next the writer must acquire proficiency in handling the 'tools' of his profession. He must master not only the mechanical aids, such as the typewriter, tape recorder, and camera, but he must also learn to get the most out of an unabridged dictionary, a set of encyclopedias, a thesaurus, Fowler's *Modern English Usage*, and the public library. Knowing where and how to obtain needed information quickly and efficiently is absolutely essential.

"Tom says that ideally the tech writer's technical knowledge should be acquired through both study and experience. He must have—and use!—a good technical library and read most of the technical publications in his chosen field. Also, unless his writing is to take on a 'bookish' quality that will be immediately spotted and resented by a practicing technician, he must be constantly using and experimenting with actual equipment. Only this will give his writing that authentic 'this-guy-has-really-been-there' flavor.

"At the same time, he must have sufficient contact with various classes of readers to understand the technical limitations of each. Armed with this knowledge, he will be prepared to write articles that will successfully bridge from what those readers *do* know to what they *want* to know. In the writing trade, this matching of the writing of a magazine article to the sophistication of the magazine's average reader is called *slanting*, and it's done almost automatically by a good tech writer.

"Finally, the professional tech writer is a responsible person. He abhors publishing an error because he knows that the reputations of the editor who bought his article and the magazine that prints it are both being placed on the line right alongside his own reputation. That's why he checks and doublechecks every word he writes."

"Somehow I feel you don't think an engineer is a good technical writer."

"Not any more than I think a tech writer is a good engineer," Mac retorted with a grin. "Actually, both are professionals in different fields, and in this modern day of specialization it's rare to find a man who can master two professions. Some of the dullest technical writing I know is found in professional technical journals—the kind where the only reward received by the author is to see his article in print.

"On the other hand, some of the best-written technical articles published recently have appeared in such popular magazines as *Time* and *Life*. These articles, written by highly paid professional writers, often are more easily understood by technician as well as layman than are articles on the same subjects appearing in many technical journals. Articles on laser beams, holographic photography, and fluidics come to mind. The popular articles were better, not because of any basically superior content, but because of smooth professional writing."

"I think one reason there is such a demand for good technical writing is that the present generation has been accustomed to receiving information in attractive, interesting form. The editor who thinks he can get by publishing dull, unimaginative articles had better take a good long look at modern high-school math and physics textbooks. They are a far cry from the dull, forbidding texts of yesteryear. In these modern books every literary art is used to present knowledge in an attractive, palatable form."

"Right you are, Barney," Mac said, knocking the dottle from his pipe and switching on the sweep and marker generators. "Modern man's knowledge of himself, his environment, and the physical laws controlling his universe has taken a tremendous spurt in the past half century. In that brief span, his technical knowledge has far more than doubled all he learned in the preceding centuries. In fact, this knowledge pouring down from every side threatens to swamp him.

"But the professional technical writer voraciously attacks this flood of information channeled to him through carefully cultivated contacts with R&D laboratories, military research centers, and our great colleges and universities. He predigests a tremendous amount of this raw information and then regurgitates the essence of it in a form easily assimilated by those with less technical knowledge.

"Doing this well is a true profession; and I, for one, am glad to see these specialized writers beginning to receive the recognition and reward they richly deserve." ▲

"How could the Post Office have broken up your radio like that?"

PERMANENT TINNING OF SOLDERING IRONS

By PETER J. PROFERA

THE corrosive action of some soldering fluxes, and the solvent action of molten solder on copper soldering iron tips combine to eat away the working surface of the tip until it finally becomes useless for further work. When this occurs, the tip has to be retinned.

Silver solder has a far higher melting point than tin-lead solder and can be used to make a permanently tinned tip. This solder is the type used for brazing, not the type intended for use in printed-circuit board repair, and can be obtained from either plumbing or jewelry supply dealers, or ordered from a metal and alloy supply house.

This permanent tinning operation is based on the fact that conventional tin-lead solders (the so-called soft solders), melt at temperatures between 360 and 750°F (depending on the ratio of tin to lead), while silver solder melts at about 1300°F.

The first step is to remove the tip from the iron and file its working faces until they are bright and shiny and free from pit marks. Wrap the tip shank in a piece of asbestos cloth (available at electrical supply houses) and fasten the combination in a vise. The asbestos wrapping acts as a heat insulator to prevent rapid dissipation of the heat applied to the tip during the tinning process, and to keep the temper of the vise jaws from being destroyed by the high temperature attained by the tip during the tinning process.

The flux to be used with the silver solder is ordinary borax, available in powdered form at any drugstore. Mix a little of the powder with water until it acquires the consistency of a paste, then brush some of the paste on the surfaces of the tip which are to be tinned.

Heat the tip with a blow torch until it becomes hot enough to melt the silver solder. Dip one end of a silver solder rod into the borax paste and then melt the solder onto the tip until a good coating covers the desired areas. After cooling, a few strokes of a file will render the coating smooth and uniform. Be careful that you don't file through the coating and expose any of the copper underneath. If you do, you will have to reheat the tip and recoat the exposed area.

To complete the job, replace the tip in the soldering iron, plug in the iron and when it has come up to operating temperature, tin the tip with conventional tin-lead solder. The tip is now permanently tinned and a wipe with a clean cloth is all that will ever be needed to make the tip ready for use. ▲

How to get into

One of the hottest money-making fields in electronics today–servicing two-way radios!

HE'S FLYING HIGH. Before he got his CIE training and FCC License, Ed Dulaney's only professional skill was as a commercial pilot engaged in crop dusting. Today he has his own two-way radio company, with seven full-time employees. "I am much better off financially, and really enjoy my work," he says. Read here how you can break into this profitable field.

More than 5 million two-way transmitters have skyrocketed the demand for service men and field, system, and R&D engineers. Topnotch licensed experts can earn $12,000 a year or more. You can be your own boss, build your own company. And you don't need a college education to break in.

HOW WOULD YOU LIKE to start collecting your share of the big money being made in electronics today? To start earning $5 to $7 an hour... $200 to $300 a week... $10,000 to $15,000 a year?

Your best bet today, especially if you don't have a college education, is probably in the field of two-way radio.

Two-way radio is booming. Today there are more than *five million* two-way transmitters for police cars, fire department vehicles, taxis, trucks, boats, planes, etc. and Citizen's Band uses—and the number is still growing at the rate of 80,000 new transmitters per month.

This wildfire boom presents a solid gold opportunity for trained two-way radio service experts. Many of them are earning $5,000 to $10,000 a year *more* than the average radio-TV repair man.

Why You'll Earn Top Pay

One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he is *licensed* by the Federal Communications Commission. And there simply aren't enough licensed electronics experts to go around.

THIS COULD BE YOUR "TICKET" TO A GOOD LIVING. You must have a Commercial FCC License to service two-way radios. Two out of three men who take the FCC exam flunk it... but nine out of ten CIE graduates pass it the first time they try!

Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating at all times, and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

Be Your Own Boss

There are other advantages too. You can become your own boss—work entirely by yourself or gradually build your own fully staffed service company. Instead of being chained to a workbench, machine, or desk all day, you'll move around, see lots of action, rub shoulders with important police and fire officials and business executives who depend on two-way radio for their daily operations. You may even be tapped for a big job working for one of the two-way radio manufacturers in field service, factory quality control, or laboratory research and development.

How To Get Started

How do you break into the ranks of the big-money earners in two-way radio? This is probably the best way:

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC Exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales, where one sales contract might net you $5,000. Or you may even be invited to move *up* into a high-prestige salaried job with one of the major manufacturers either in the plant or out in the field.

The first step—mastering the fundamentals of Electronics in your spare time and getting your FCC License—can be easier than you think.

Cleveland Institute of Electronics has been successfully teaching electronics by mail for over thirty years. Right at home, in your spare time, you learn electronics step by step. Our AUTO-PROGRAMMED™ lessons and coaching by expert instructors make everything clear and easy, even for men who thought they were "poor learners." You'll learn not only the fundamentals that apply to all electronics design and servicing, but also the specific procedures for installing, troubleshooting, and maintaining two-way mobile equipment.

Get Your FCC License... or Your Money Back!

By the time you've finished your CIE course, you'll be able to pass the FCC License Exam with ease. Better than nine out of ten CIE-trained men pass the FCC Exam the first time they try, even though two out of three non-CIE men fail. This startling record of achievement makes possible the famous CIE warranty: you'll pass the FCC Exam upon completion of your course or your tuition will be refunded in full.

Ed Dulaney is an outstanding example of the success possible through CIE training. Before he studied with CIE, Dulaney was a crop duster. Today he owns the Dulaney Communications Service, with seven people working for him repairing and manufacturing two-way equipment. Says Dulaney: "I found the CIE training thorough and the lessons easy to understand. No question about it—the CIE course was the best investment I ever made."

Find out more about how to get ahead in all fields of electronics, including two-way radio. Mail the bound-in postpaid reply card for two FREE books, "How To Get A Commercial FCC License" and "How To Succeed In Electronics." If card has been removed, just send us your name and address on a postcard.

ENROLL UNDER NEW G.I. BILL

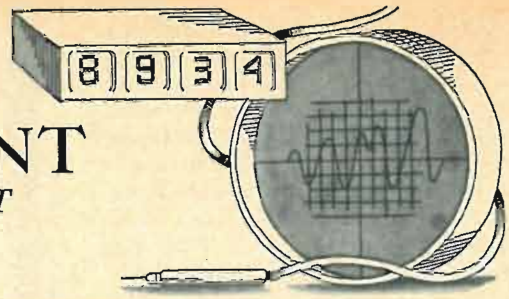
All CIE courses are available under the new G.I. Bill. If you served on active duty since January 31, 1955, OR are in service now, check box on reply card for G.I. Bill information.

CIE Cleveland Institute of Electronics
1776 E. 17th St., Dept. EW-36, Cleveland, Ohio 44114

A Leader in Electronics Training... Since 1934 • Accredited Member National Home Study Council

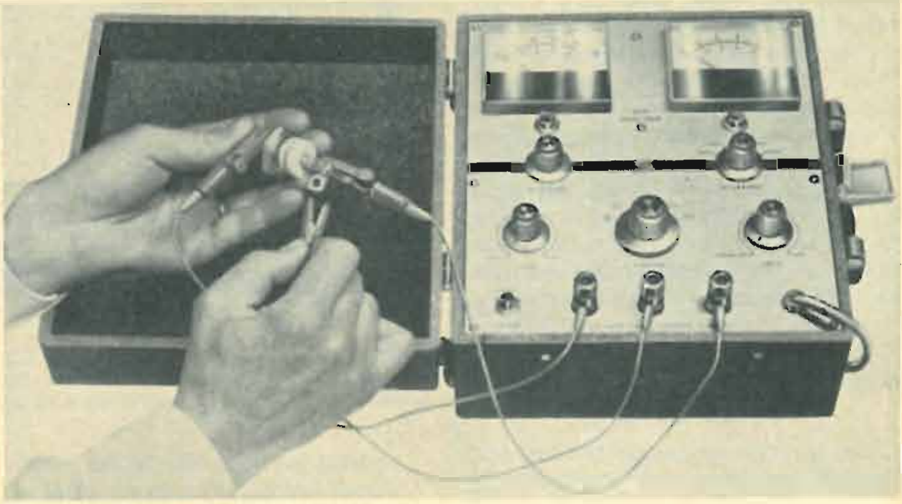
CIRCLE NO. 122 ON READER SERVICE CARD

TEST EQUIPMENT
PRODUCT REPORT



Seco Model 240 Thyristor (SCR) Analyzer

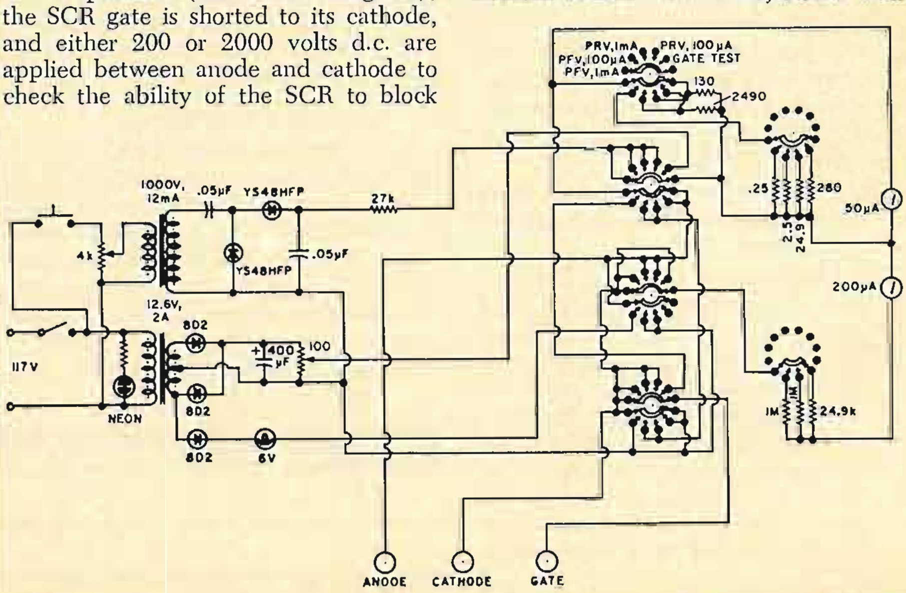
For copy of manufacturer's brochure, circle No. 153 on Reader Service Card.



As SCR's, triacs, breakdown diodes, and gate-controlled switches continue to gain in popularity in industrial equipment and home appliances, technicians have become aware of the need for a fast, accurate, modest-cost test unit for these thyristors. The *Seco* Model 240 was designed to meet this need. The instrument checks gate firing voltage and current as well as peak forward and peak reverse voltage and current. These parameters are indicated on two separate meters on the front panel of the tester.

When the function control is in the "PFV" position (see circuit diagram), the SCR gate is shorted to its cathode, and either 200 or 2000 volts d.c. are applied between anode and cathode to check the ability of the SCR to block forward voltages with zero gate current. Two ranges of full-scale sensitivity are provided: 100 μA and 1 mA. For the "PRV" test, the polarity of the anode-to-cathode voltage is reversed and the current is again measured on the two-scale current meter.

For the "Gate Test" position of the function switch, a 5-volt peak source (half-wave rectified a.c.) is connected to the SCR anode through an indicator lamp. With the SCR conducting an average current of 40 mA, the lamp is turned on. A 5-volt d.c. source is then connected between gate and cathode, and this source is made adjustable with



a front-panel control. As the voltage is varied, its value being monitored on the voltmeter, a point is reached when the SCR fires as indicated by the lamp. The values of gate current and voltage required are then indicated.

Because the tester is fast and easy to operate, it is useful in matching SCR's to particular voltage and current parameters, or for sorting SCR's into matched pairs or threes to share loads evenly in full-wave or three-phase circuits.

The instrument is housed in a durable vinyl-covered carrying case measuring 10½" x 9" x 5" deep. The Model 240 is priced at $144.50. ▲

Hewlett-Packard Model 5221A Electronic Counter

For copy of manufacturer's brochure, circle No. 154 on Reader Service Card.

SMALL size and low cost combined with high performance and ruggedness—this has been the promise of integrated circuits. We have already seen IC's used in a low-cost digital voltmeter, and now we have a new electronic counter from *Hewlett-Packard* which uses IC's.

The counter (Model 5221A) has a maximum counting rate of 10 MHz,

higher than any previous counter selling for less than $1000. This one sells for only $350.

Besides a significant reduction in price, a reduction in size was made possible by the use of integrated circuits. The instrument case is only one-third of a standard 19-inch rack module in width, a convenient size for carrying or for bench use. Case dimensions are 5⅛" wide by 6⅛" high by 11" deep. And the instrument weighs only 5 pounds.

The counter has a 4-digit readout using new miniature side-viewing Nixie tubes developed especially for *H-P* by the *Burroughs Corp.* The readout retains the most recent count until a new count is completed; then it changes to the new count, thereby providing a continuous, non-blinking display. A new blanking feature suppresses display of unneeded zeros to the left of the most significant digit, simplifying readout interpretation.

Counter functions are similar to previous basic counters. Frequency and rate measurements are made with either of two count times (gate times): 0.1 and 1 second. The time between counts is adjustable between 50 milliseconds and 5 seconds by a front-panel control, or a count may be retained indefinitely with the control in the "Hold" position. The counter also totalizes input pulses during the time that the "Gate Selector" switch is in the "Open" position. The gate can be controlled manually with the switch or remotely by a simple contact closure to ground.

Input impedance is 1 megohm shunted by 30 pF. Input sensitivity is 0.1 volt r.m.s. between 5 Hz and 10 MHz. An internal control allows either positive or negative pulses to be counted. The time base is derived from the power line, typically accurate within 0.1%. ▲

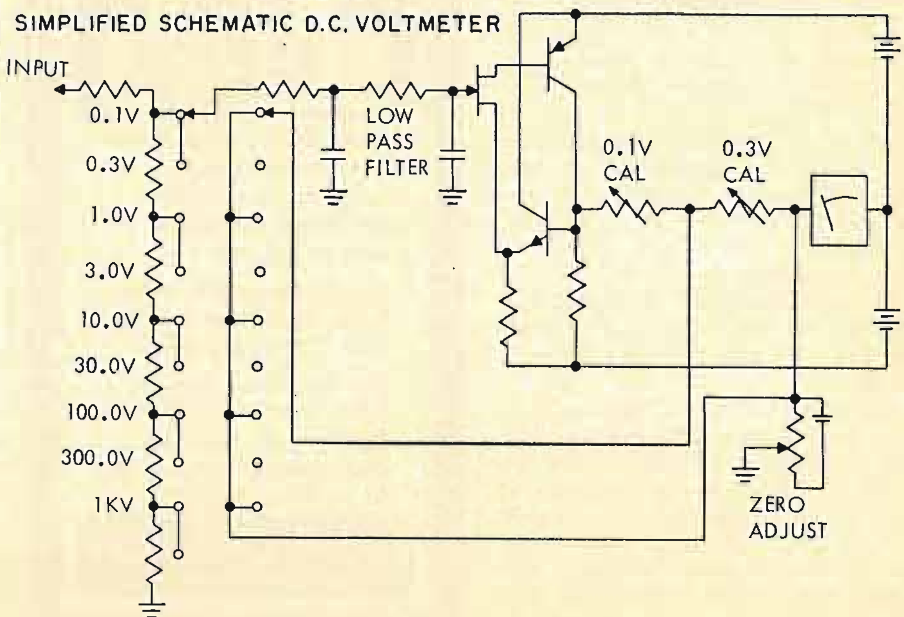
Amphenol Model 670 Transistorized Volt-Ohmmeter

For copy of manufacturer's brochure, circle No. 42 on Reader Service Card.

FIELD-EFFECT transistors, already widely used in hi-fi tuners and receiver front-ends, are now beginning to appear in modestly priced test equipment for the service technician. The latest such instrument to come to our attention is *Amphenol's* Model 870, called the "Millivolt Commander." By using an FET as the front-end for volt-ohmmeter circuitry, we can have the advantages of a v.t.v.m. with its very high input impedance along with the portability of a v.o.m., since the FET and other circuits within the instrument are completely battery-operated.

One other important feature of the new tester is its very low voltage d.c. and a.c. ranges. For example, it can measure voltages as low as one-tenth volt d.c. full scale and one-hundredth volt a.c. full scale. The measurement of such low voltages is very important to the technician who must work on new transistorized TV sets, radios, and audio equipment.

Nine d.c. ranges are provided, from



100 mV to 1000 V, along with ten a.c. ranges from 10 mV to 300 V. Input resistance of the unit is 11 megohms on d.c. and 10 megohms on a.c. In addition to voltage measurements, the instrument also has the usual resistance and decibel scales. Accuracy is somewhat better than the usual v.t.v.m., being ±2% of full scale on all d.c. ranges and ±3% of full scale on all a.c. and dB ranges. A single probe is used for all d.c. and a.c. measurements.

Power is supplied by two 1.4-volt mercury cells and eight 1.5-volt AA zinc-carbon cells, available in most stores. Because of the very low current drain from these batteries, life under normal eight-hour-per-day working conditions is expected to be the same as shelf life.

The meter is housed in a compact, luggage-like case with a pouch inside the cover for the probe. The instrument measures 9¼" wide, 6⅜" high, and 5¾" deep and it weighs about 4 pounds with batteries. The price of the v.o.m. is $99.95. ▲

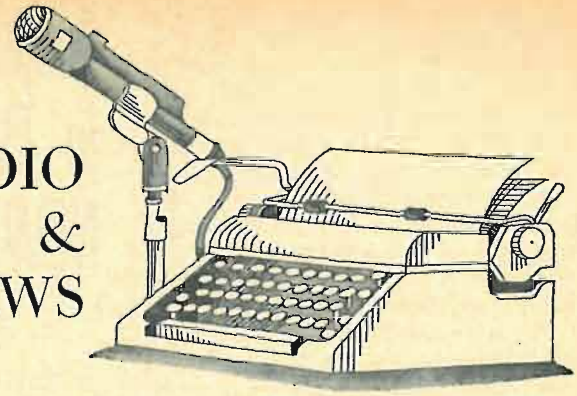
Electronics for Therapy

(*Continued from page* 45)

not. However, the foundation of Fechner's postulations was what is now known as Weber's Law. In 1834, E. H. Weber (1795-1878) had found that in order for a given stimulus to appear just noticeably different from a preceding stimulus, the necessary increment always had to be a constant fraction of the original stimulus. After some verifications, Fechner's Law started to emerge: $S = K \log I$, where S is the magnitude of sensation, I is a dimension of the stimulus, and K is a constant of proportionality that varies with sense modality. The *log* is there since the responses of human organisms to stimuli vary as the logarithms of those stimuli. Fechner therefore proposed that we accumulate such "just noticeable differences" (jnd) to calculate a sensory magnitude. Today, one finds that this early work matches our decibels rather well.

But—and this is where the trouble starts—the mathematical tenets do not hold true when it comes to microphysical-type processes electromagnetically triggered within the neuron complex of the brain. In the case of r.f.-type audio inductions into the brain, the observer has the novel experience of "hearing a *thought*" rather than a sound, and current research tends to bog down on this because the phenomenon cannot be defined biophysically or mathematically. In spite of these current drawbacks, however, there can be no doubt that a new family of superior auditory implements will emerge once the attendant problems of clinical safety and packaging have been solved. ▲

RADIO & TV NEWS



WHEN you subscribe to several technical magazines a month and you see things in some that you want to save, it often leads to voluminous files of odds and ends of information. Some people take to saving magazine indices just to find out what's where.

Take heart, all you paper savers, the U.S. Army Electronics Command has recently announced a new program in which a computer "browses" through the new technical literature of 7144 areas of interest (including technical reports, magazine articles, and translations) and prepares an individual listing of all pertinent material in accordance with the interests of each particular "subscriber."

The purpose of the new automated system, called Selective Dissemination of Information (SDI), is to ensure that each scientist is continuously aware of the latest technical publications in his field without having to spend many hours each week searching for it.

TV Planet Patrol

Long before man sets foot on other planets, robots with TV "eyes" far sharper than man's will have gone over almost all of the ground.

According to a spokesman from *RCA's* Astro-Electronics Division, these robot-like explorers of the 1980 to 2000 year period will have sensors far more advanced than those available today. Resolution of 20,000 to 30,000 lines is being discussed. Current space TV uses 600 to 800 line resolution, although *RCA* is presently working on systems using between 2000 and 8000 lines. As a reference, present commercial TV uses only 525 lines.

The significance of the 20,000 to 30,000 line systems is that they will be capable of producing visual data equivalent in quality to that offered by the finest photographic film. It is also expected that the robot TV system will also operate in color, although the technical operation may differ from today's version.

IR I See

It is an old adage in the military that you have to see the target before you can take a shot at it. But what do you do in the dark? Up until now, we have been using an infrared Snooperscope mounted on a rifle, a method which has been successfully used for many years by the military.

ITT now checks in with the Metascope, a binocular-like instrument for use by the troops. Essentially, it is intended for use by tank drivers, and the devices are mounted to the periscopes of their tanks.

The case of the Metascope contains a light source that resembles a flashlight with an infrared filter which only passes the light that is invisible to the human eye. The tank-mounted version uses an infrared searchlight.

An object hidden by darkness is illuminated by the invisible infrared beam. The night-vision equipment's infrared detection unit perceives the infrared images of the targets and converts them to visible images.

Reliability Personified

When we look at a large, complex electronic system having a vast number of transistors and other semiconductors, a large group of relays, switches, and power supplies, an optical system, a complex TV system, and a stack of other highly complex gear and then ponder over just what would happen to this mass of equipment if it were subjected to extremes of heat and cold, micrometeorite abrasion, and other assorted assaults that exist in outer space, we are right in wondering just how long it will work.

NASA, obviously proud, has just released some figures on Tiros VII, now in its fourth year in space (launched June 19, 1963). Although designed with an operational goal of three to six months, this weather satellite has completed 21,600 revolutions of the earth, travelling 594,000,000 miles in the process. It has also snapped over 124,500 pictures of the earth and its weather patterns. Areas covered by these pictures total over 50 billion square miles.

Although still capable of transmitting excellent weather pictures, Tiros VII is seldom used since it was joined in space by eight, more advanced Tiros and TOS weather satellites. Tiros VII is one of fifteen weather satellites. ▲

NEW APPROACH TO ENGINE TACHOMETERS

By RONALD L. CARROLL / Texas Instruments

AUTOMOTIVE engine tachometers for both conventional and transistor ignition systems use the waveform at the distributor points for triggering. From an engineering point of view, this is the worst place to use.

Consider the entire ignition system as a pulse generator having a constant duty cycle and a mechanically determined frequency of operation. The properties of a good pulse generator are basically low output impedance and clean waveform: *i.e.*, an absence of transients superimposed on the desired output waveform. By taking the counting pulses from the distributor points, both these aforementioned points are directly violated. First, we are now harnessed to a pulse generator having a 12-volt output waveform plagued with voltage spikes that can reach 1 kV; and second, the impedance of the circuit ranges from 100 to 1000 megohms.

Every 12-volt ignition system uses a ballast resistor of about one-ohm resistance. On late model cars, this takes the form of a piece of resistance wire between the ignition switch and the positive terminal of the ignition coil. Depending on the type of ignition circuit, between 4 and 12 amperes can flow through this wire. This current gives rise to a fairly clean voltage pulse (4 to 12 volts) across an ideally low one-ohm resistance.

The circuit to the right of the ballast resistor (R) shown in Fig. 1 has been thoroughly tested and its linearity in all cases was limited only by the linearity of the meter movement itself. Calibration potentiometer $R2$ must be selected for the meter used.

Calibration may be either with a known accurate engine tachometer or a good high-current pulse generator converting frequency to r/min as shown in Fig. 2. ▲

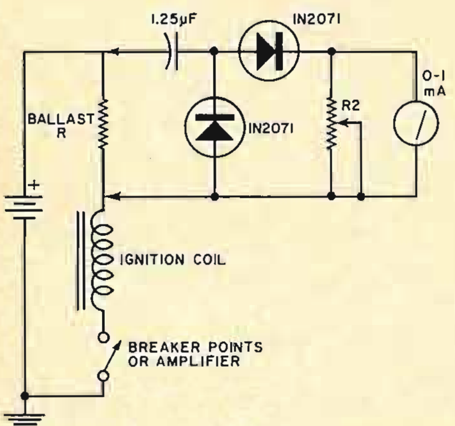
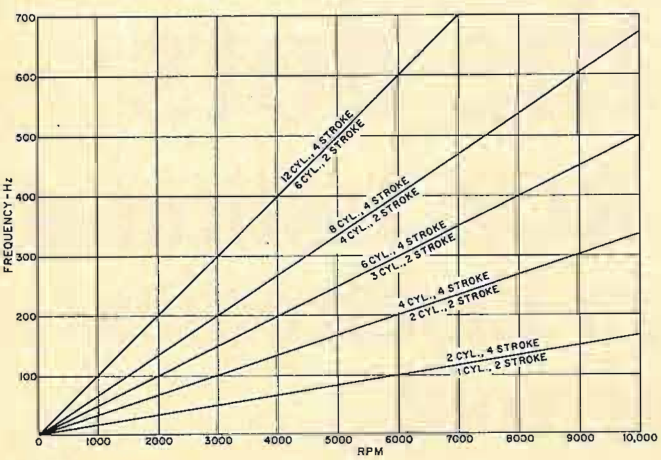
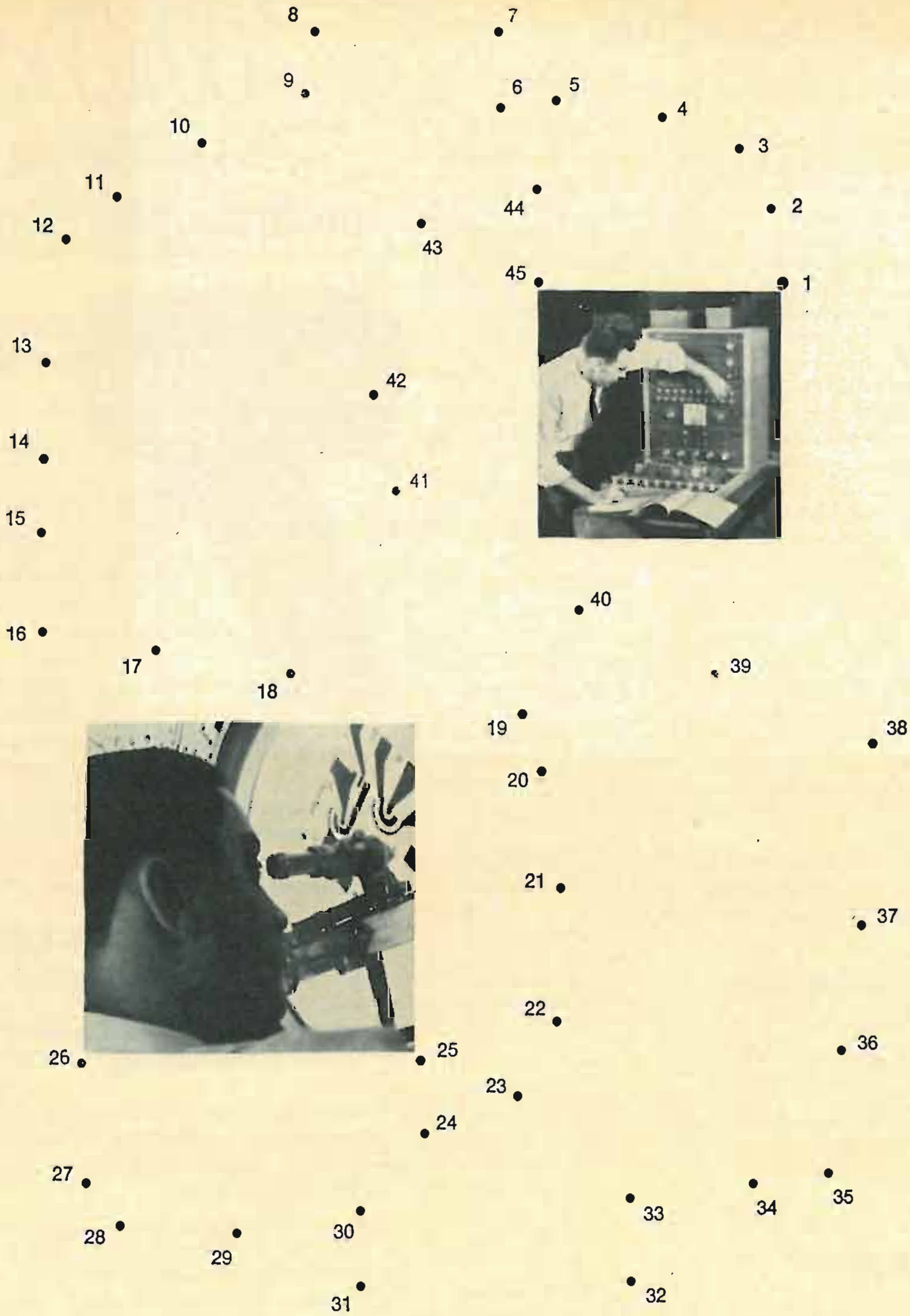


Fig. 1. Pulses are taken across ballast resistor.

Fig. 2. Converting frequency to engine r/min.





Connect the dots

and find out what RCA Institutes Home Training in Electronics can do for you!

Learn electronics at home faster, easier, almost automatically— with RCA AUTOTEXT

Are you just a beginner with an interest in the exciting field of electronics? Or, are you already earning a living in electronics and want to brush-up or expand your knowledge in a more rewarding field of electronics? In either case, AUTOTEXT, RCA Institutes' own method of Home Training will help you learn electronics more quickly and with less effort, even if you've had trouble with conventional learning methods in the past.

THOUSANDS OF WELL PAID JOBS ARE OPEN NOW TO MEN SKILLED IN ELECTRONICS!

Thousands of well paid jobs in electronics go unfilled every year because not enough men have taken the opportunity to train themselves for these openings. RCA Institutes has done something positive to help men with an aptitude and interest in electronics to qualify for these jobs.

HOME STUDY CAN TRAIN YOU FOR REWARDING CAREER OPPORTUNITIES

To help fill the "manpower gap" in the electronics field, RCA Institutes has developed a broad scope of Home Training courses, all designed to lead to a well paying career in electronics in the least possible time. You also have the opportunity to enroll in an RCA "Career Program" exclusively created to train you quickly for the job you want! Each "Career Program" starts with the amazing AUTOTEXT Programmed Instruction Method. And, all along the way, your program is supervised by RCA Institutes experts who become personally involved in your training and help you over any "rough spots" that may develop.

VARIETY OF KITS ARE YOURS TO KEEP

To give practical application to your studies, a variety of valuable RCA Institutes engineered kits are included in your program. Each kit is complete in itself, and yours to keep at no extra cost. You get the new Programmed Electronics Breadboard for limitless experiments, including building a working signal generator, multimeter, and a fully transistorized superheterodyne AM receiver.

ONLY FROM RCA INSTITUTES— TRANSISTORIZED TV KIT— VALUABLE OSCILLOSCOPE

All students receive a valuable oscilloscope. Those enrolled in the Television program receive the all-new transistorized TV Kit. Both at no extra cost and only from RCA Institutes.

CHOOSE THE "CAREER PROGRAM" THAT APPEALS MOST TO YOU

Start today on the electronics career of your choice. Pick the one that suits you best and mark it off on the attached card.

- Television Servicing
- Telecommunications
- FCC License Preparation
- Automation Electronics
- Automatic Controls
- Digital Techniques
- Industrial Electronics
- Nuclear Instrumentation
- Solid State Electronics
- Electronics Drafting

ADVANCED TRAINING

For those already working in electronics, RCA Institutes offers advanced courses. You can start on a higher level without wasting time on work you already know.

UNIQUE TUITION PLAN

With RCA Institutes Training, you progress at your own pace. You only pay for lessons as you order them. You don't sign a long-term contract. There's no large down-payment to lose if you decide not to continue. You're never badgered for monthly payments. Even if you decide to interrupt your training at any time, you don't pay a single cent more.

CLASSROOM TRAINING ALSO AVAILABLE

If you prefer, you can attend classes at RCA Institutes Resident School, one of the largest of its kind in New York City. Coeducational classroom and laboratory training, day and evening sessions, start four times a year. Simply check "Classroom Training" on the attached card for full information.

FREE PLACEMENT SERVICE, TOO

In recent years, 9 out of 10 Resident School students who used the Free Placement Service have been placed before or shortly after graduation. This Service is available to Home Study students.

SEND ATTACHED POSTAGE PAID CARD TODAY. FREE DESCRIPTIVE BOOK YOURS WITHOUT OBLIGATION. NO SALESMAN WILL CALL.

All RCA Institutes courses and programs are approved for veterans under the New G.I. Bill.

RCA INSTITUTES, INC. Dept. EW-97
350 West 4th Street
New York, N.Y. 10014

RCA® **The Most Trusted Name In Electronics**

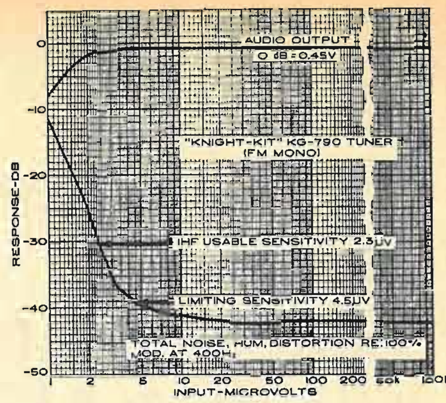
EW Lab Tested

(Continued from page 16)

prevents triggering of the multiplex circuit and the indicator light by weak signals or interstation noise. The a.g.c. voltage controls the gain of the first i.f. stage which also acts as a d.c. a.g.c. amplifier to control the FM r.f. stage and mixer. Another diode supplies a control voltage from the third i.f. stage to operate the muting circuits.

In our laboratory measurements, the tuner met or exceeded its salient specifications, within the limits of normal measurement error. The IHF usable sensitivity was 2.3 microvolts (rated 2.5 μV), with virtually complete limiting by 4.5 microvolts. The distortion at 100% modulation was 0.8% (rated 0.75%). The frequency response of the FM tuner was within ±1 dB from 30 to 8000 Hz, sloping off to —2.5 dB at 10,000 Hz, and —6.5 dB at 15,000 Hz. This was apparently the result of the filtering built into the deemphasis networks which are designed to eliminate 19-kHz and 38-kHz components from the tuner output where they might interfere with making tape recordings of stereo broadcasts. This filtering is quite effective and we were unable to hear any loss of highs resulting from the roll-off. In our view, this was a worthwhile exchange of performance parameters.

The stereo channel separation was about 27 dB at middle frequencies, reducing to 18 dB at 30 Hz and to 13 dB at 15,000 Hz. We attempted to improve the performance by instrument alignment, but were largely unsuccessful. The sensitivity and distortion, already equal to or better than rated values in the "as received" alignment condition, could not be improved at all. The multiplex circuits had been originally tested with no alignment since the coils are supplied pre-aligned. Using



our multiplex signal generator we optimized the alignment and gained an improvement of 3 to 7 dB in stereo separation across the frequency range of 30 to 15,000 Hz. This is a negligible improvement, hardly worth the effort, so that we have no hesitation in recommending to the builder that he follow the instruction manual advice and not disturb the adjustments of the pre-aligned coils.

The AM tuner alignment is simple, using received signals. When this had been done, we found it to be one of the better AM tuners we have used in recent years. It is free from "birdies" and the 10-kHz whistle filter works well. The sensitivity and selectivity were more than adequate for our suburban location, using the built-in ferrite antenna. The quality, while perhaps not high fidelity, was clean and undistorted and probably the best that could be obtained from a relatively simple tuner.

The "Knight-Kit" KG-790 is clearly one of the better kit-type tuners to be had and its performance easily matches that of many more expensive factory-wired units. Anyone who wishes to include AM capability in his high-fidelity system could hardly do better than to build the KG-790 which sells for $149.95. An oiled-walnut cabinet is available for $19.95. ▲

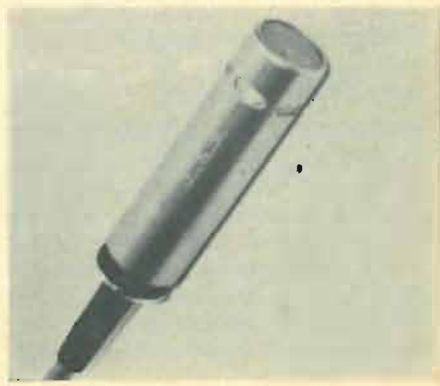
PML EC-71 Capacitor Microphone

For copy of manufacturer's brochure, circle No. 41 on Reader Service Card.

In January, 1965 we reported on the *PML* EK-61 capacitor microphone, which brought professional sound quality within the reach of the serious home recordist. *PML* (a Swedish manufacturer) has brought out a new version of this microphone, quite similar in its electro-acoustic design, but with its vacuum tube and power supply replaced by a field-effect transistor and a new, highly compact power-supply.

The capacitor microphone, although capable of the highest quality, requires an extremely high load impedance for the tiny transducer element. Previous designs normally used a subminiature vacuum tube as a cathode follower to match the high microphone impedance to the common load impedances of 200 ohms or less. The tube was housed in the body of the microphone and tube replacement was usually difficult.

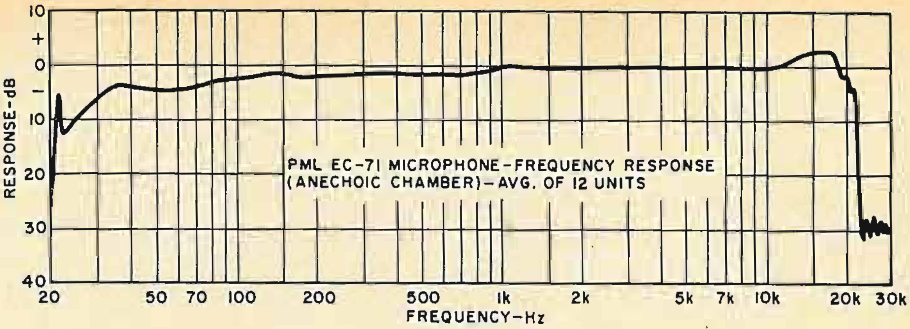
The FET, whose impedance is high-



er than most vacuum tubes, is ideally suited for this application. It should have an indefinitely long life and total freedom from hum and microphonics. In addition, the power-supply requirements are minimal. *PML* has an a.c. supply, measuring about 3" x 5" x 1½", which will accomodate two microphones. A similar battery-operated supply is available as well, with a 67.5-volt battery having a life of about 500 hours.

The microphone itself is housed in a small cylindrical case, 11/16" in diameter and 2 11/16" long, weighing only 1¼ oz.

The microphone comes in two versions, the omnidirectional EK-71 and cardioid EC-71. We tested the latter model by plotting the response of a speaker system with the EC-71 and with our calibrated capacitor microphone mounted in the same position relative to the speaker. When the two microphones have similar polar-response patterns, this permits an accurate measurement to be made, as we proved with the earlier model tested. However, the difference between the cardioid pattern of the EC-71 and the comparison microphone made this close correlation impossible. This is particularly true in view of the fact that our tests are done in a normal listening room rather than an anechoic chamber. Even so, it was obvious from the curve that the EC-71 has a smooth, uniform response over the full audio range, and we see no reason to question the manufacturer's published response curve, included here, which shows a very flat response from 30 to 20,000 Hz.



The EC-71 has a rather high output, about 25 dB higher than the comparison microphone. Evidently the electronic circuits of the EC-71 include amplification as well as impedance transformation. We made tape recordings with it and found it to have a smooth and natural sound consistent with its claimed response. We did, however, find a tendency to "blast" with close talking and found it necessary to stay at least 8 inches from the microphone. An accessory windscreen is available and might be helpful for close talking.

The power-supply unit contains impedance-matching transformers providing output impedances of 30-50 ohms, 200 ohms, 600 ohms (balanced), and a high-impedance unbalanced output. The output cable connection determines the impedance. Low-impedance cables are available in lengths of 25, 50, and 100 feet as well as the standard 12 feet.

We made a tape-recorded comparison between the *PML* EC-71 and a good-quality cardioid dynamic microphone. The EC-71 had a noticeably smoother and more natural sound on male voice, as well as far better highs.

The *PML* solid-state capacitor microphones continue to bring the finest sound quality into a price bracket within reach of many non-professional users. The EC-71, distributed in the U.S. by *Ercona Corp.*, sells for $109.50 and the omnidirectional EK-71 is $99.50. The power supplies for the microphone are $69.50 for the a.c. and $49.50 for battery-operated models. ▲

here's the missing link in color

Belden's Color Twins deliver full color power all the way to the set. Eliminate many causes of lead-in signal loss. Deliver a ghost-free picture. ■ Belden's COLOR TWINS are: 8290†† Shielded Permohm with Beldfoil* for congested or high interference areas; and 8285† Unshielded Permohm for rural, low-signal-strength areas. ■ 8290 with patented Beldfoil shielding prevents line pick up of interference signals that produce ghosts and electrical interference. 8285 Permohm's conductors are encapsulated in low-loss cellular polyethylene to maintain a strong signal in all weather conditions, especially in fringe reception areas. ■ 8290 Shielded Permohm is designed so that you can install it without expensive transformers, connectors, and "stand offs." You can even tape it to a mast or run it through a rain gutter. ■ With Permohm lead-ins, the set gets the full color power of the signal (full power for UHF or VHF, too.) Now owners can get the kind of picture they bought a color set for. You get the laurels.

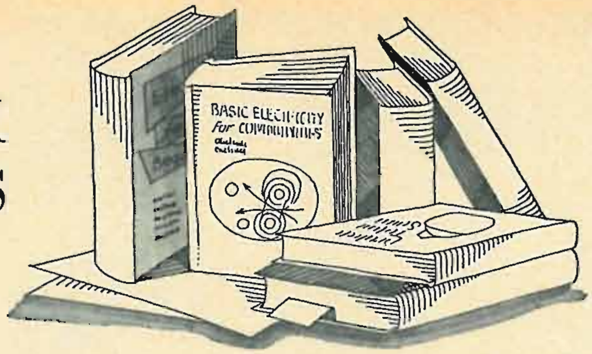
BELDEN CORPORATION
P.O. Box 5070-A • Chicago, Illinois 60680

8-3-7AA

*Belden Trademark Reg. U.S. Patent Office †Belden Patent No. 2,782,251 ††Belden Patent No. 2,782,251 and Pat. Pending

CIRCLE NO. 124 ON READER SERVICE CARD

BOOK REVIEWS



"SWITCHING CIRCUITS FOR ENGINEERS" by Mitchell P. Marcus. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 332 pages. Price $12.00.

This is a second edition of a book which originally appeared in 1962. It has been expanded considerably and updated throughout. The emphasis on the practical rather than the abstract has been retained. The author, who is with the Systems Development Division of *IBM's* Endicott Laboratory, has worked with his subject, taught his subject, and written about it and what he has to say about switching circuits commands attention. He contends that while switching circuits can be designed intuitively, because of the tremendous growth of automatic digital computers and complex business machines, logic design requires a discipline in order to reduce designing time and the number of components needed.

The book is addressed to both the logic design engineer and the engineering student of switching circuits and presupposes an engineering background and a familiarity with the requisite mathematical procedures.

The text is divided into 19 chapters covering Boolean algebra; special forms of Boolean expressions; logic circuits; electronic logic blocks; contact networks; tabular method of simplification; map method of simplification; trees—relay and electronic; symmetric functions, reiterative networks; number systems, adders; codes, error detection, error correction; sequential circuits; and pulse-input sequential circuits. Answers and solutions to the problems appearing in the text are provided in the back of the book for self-checking or classroom assignment.

* * *

"TRANSISTOR CIRCUIT ENGINEERING" by Basil L. Cochrun. Published by *The Macmillan Company*, New York. 437 pages. Price $13.95.

This volume is designed as a textbook for undergraduates in electrical engineering courses who have had some previous experience with the physics of semiconductors and a knowledge of mathematical procedures.

The text is divided into eleven chapters covering semiconductor concepts, semiconductor junctions, transistor behavior and equivalent models, low-frequency characteristics of the basic configurations, biasing, low-frequency amplifiers and active filters, high-frequency amplifiers (wide-band and narrow-band), noise, feedback and stability, and FET's. Five appendices cover the black-box approach to equivalent circuits, the superposition concept of gain and impedance, signal flow graphs, useful physical constants, and the frequency characteristics from log-modulus plots.

Each chapter carries a series of problems, a list of references, and a bibliography for further study. The text is adequately illustrated.

* * *

"CIRCUIT PROBLEMS AND SOLUTIONS" by Gerald Lippin. Published by *Hayden Book Company, Inc.*, New York. 188 pages. Price $3.95. Soft cover.

This is the first volume in a projected two-volume series and is subtitled "Elementary Methods". This book is a problem-oriented text which is designed to be used in conjunction with an a.c. and/or d.c. text.

Starting with Ohm's Law, progressing through meters, resistance, vectors, *RL* circuits, time constants, *RLC* circuits, and filter circuits, the author has first presented some circuit theory and then followed this with step-by-step problem solutions.

Written at the technical school or junior college level, the author has provided four appendices covering conversion factors, wire gauge tables, trigonometric tables, and log tables for the convenience of the student.

* * *

"INTRODUCTION TO RADIO ASTRONOMY" by Roger C. Jennison. Published by *Philosophical Library Inc.*, 15 East 40th St., New York, N.Y. 10016. 155 pages. Price $4.75.

This book by a former Senior Lecturer in Radio Astronomy at Jodrell Bank in England falls somewhere between an engineering treatise and a popular exposé. It would be helpful if the reader had some familiarity with electronics even if he knows nothing of radio astronomy.

The text is divided into eight chapters covering an introduction to astronomy, the basic tools of the trade (the equipment), the radio sun, the moon and planets, galactic radio emissions and the first radio stars, spectral measurements, the extra-galactic radio sources, and tricks of the trade. This final chapter covers the sophisticated techniques involved in radio astronomy and here the author has resorted to mathematical treatment which may be a little over the head of the average layman. The rest of the text is fairly easy to assimilate.

* * *

"APPLIED MATHEMATICS FOR ELECTRONICS" by L.J. Adams & R. Journigan. Published by *Holt, Rinehart and Winston, Inc.*, New York. 692 pages. Price $10.95.

Although addressed specifically to the post-high-school technical institute student, this volume is equally well suited to engineering students and practicing engineering technicians who want to upgrade thei- everyday mathematical skills.

The text covers arithmetic, algebra, trigonometry, analytic geometry, and elementary calculus, with emphasis on areas of special interest—such as Boolean algebra.

After an introductory chapter, the book goes on to cover basic arithmetical techniques, fundamental algebraic operations, the metric system, basic concepts of electric circuits, systems of linear equations, quadratic equations, trigonometry, the slide rule, alternating current, analytic geometry, calculus, Boolean algebra, and matrices. The authors have provided 13 appendices to give the user access to all of the reference data he will require to work with the text material.

Problems are provided throughout the text with the answers given for the odd-numbered problems. The text is attractively presented in two colors, with items for particular emphasis printed in brown.

* * *

"POWER SUPPLIES FOR ELECTRONIC EQUIPMENT" by Leo G. Sands. Published by *John F. Rider Publisher, Inc.*, New York. 184 pages. Price $6.25 (cloth) or $4.25 (paperbound).

This book is addressed to engineers, technicians, and experimenters who are involved in buying, applying, or maintaining power supplies used with electronic equipment. It covers batteries as well as generators.

Divided into ten chapters, the author first discusses the power requirements of electronic equipment, then batteries, electromechanical generators, utility power, transformers, rectifiers, filters, regulators, converters and inverters, and power-supply specifications. Since commercial as well as theoretical circuits are presented, this volume can serve as a "buying guide" as well as a reference source. ▲

ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

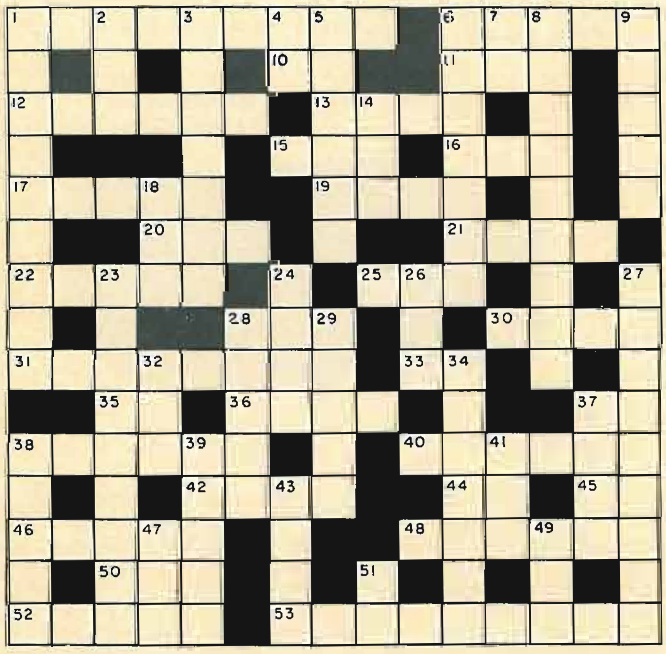
(Answer on page 102)

ACROSS

1. Process by which an object is electrified or magnetized by exposure to a magnetic field.
6. An electro-acoustic unit of power ratio.
10. Type of current (abbr.).
11. Fuss.
12. Variation of a wave with time, serving to convey information in communications.
13. Skill in dealing with delicate situations.
15. Communications record of a station.
16. Consume.
17. Connecting wires.
19. Entrance.
20. Lubricate.
21. Stake.
22. Large plants.
25. Unit of relative power.
28. Distress signal.
30. Recording medium.
31. Resistor whose value may be changed by means of a control knob.
33. Designation for a widely used circuit.
35. Designating an oscilloscope (abbr.).
36. First man.
37. Negative.
38. Mechanism used on indexed rotary switches to hold switch firmly in position.
40. Part of a cylinder mechanism.
42. Long period of time.
44. A small current (abbr.).
45. Russian affirmative.
46. Electromagnetic unit of resistance.
48. A body that will attract iron and steel.
50. "For that reason".
52. Requires.
53. In a directional antenna system, the rear portion or element (usually not connected to the remainder of the antenna).

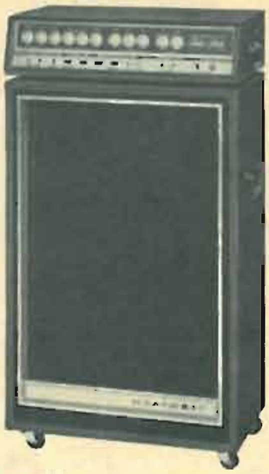
DOWN

1. An object that offers opposition to the movements of electrons: used for supporting or separating conductors.
2. Excavate.
3. Metal frame or base supporting an electronic circuit.
4. Ego.
5. Eight-element vacuum tube.
6. Lowest resonant frequency of an antenna or circuit.
7. Man with a blue pencil (colloq.).
8. Voltage.
9. Electromagnetic switch employing an armature to open or close the contacts.
14. Time past.
18. Female deer.
23. One of the plates of an electrolytic capacitor.
24. The power that a device delivers.
26. Organ of hearing.
27. Circuit that responds in accordance with oscillations produced in another circuit.
28. Commonwealth.
29. Discolor.
32. Unrefined metal.
34. Milieu.
37. Any point, line, or surface in a stationary wave system at which the amplitude of the waveshaping variable is zero.
38. Term used to indicate current being taken from a voltage source.
39. Titles.
41. Droop.
43. Finished.
47. Movie starring Paul Newman.
49. Remains after deductions.
51. In a superhet, a "combined" frequency (abbr.).



Look What's NEW In The

NEW! Deluxe Solid-State Combo Amplifier & Speaker System!



Kit TA-17 Amplifier
$175^00

Kit TA-17-1 Speaker System
$120^00

Special Combo Offer!
Kit TAS-17-2 Amplifier & 2 Speaker Systems
Save $20.00
$395^00
240 lbs.

All the "big sound" features every combo wants . . . tremolo, built-in "fuzz", brightness, reverb plus a shattering 120 watts of EIA music power. Has 3 independent input channels each with 2 input jacks. Handles lead or bass guitars, combo organ, singer's mike, even a record changer. Speaker system features two special 12" woofers, special horndriver and matching black vinyl-covered wood cabinet.

NEW LOW PRICE On Heathkit "180" Deluxe Color TV

Kit GR-180
Was $379.95
Now Only
$349^95
(less cab.)

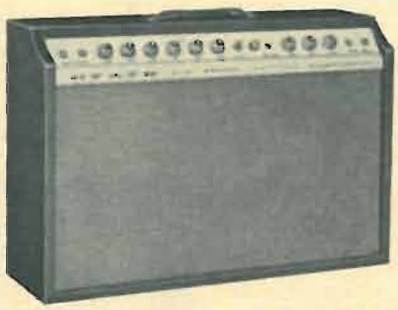
Now Save $30 on this superb set. Features 180 sq. in. rectangular viewing area, plus exclusive built-in servicing facilities so you can converge and maintain the best color pictures at all times. Also has 24,000 volt picture power, automatic degaussing, rare earth phosphors for livelier colors, 3-stage IF, plus many more advanced features. Choice of installation . . . in a wall, your custom cabinet or an old black & white set cabinet, Heath assembled contemporary (Illust. $49.95) or Early American ($75.00) floor cabinets, or new Heath table model ($24.95) cabinet. Build in 25 hours. 102 lbs.

NEW! Low Cost Single-Channel Solid-State Guitar Amplifier

Kit TA-27
$89^95

Boasts 20 watts EIA music power, 40 watts peak power; variable tremolo & reverb; two inputs that handle lead guitars; singer's mike; special heavy-duty 12" speaker; line bypass reversing switch that reduces hum; transformer-operated power supply; and handsome leather-textured, black vinyl covered wood cabinet with extruded aluminum front panel and chrome knobs. 35 lbs.

NOW Available Fully Assembled . . . Heathkit "Starmaker" Dual-Channel Guitar Amplifier



Assembled TAW-16
$199^95
(Kit TA-16 $134.95)

Features all solid-state circuit; 25 watts EIA, 60 watts peak power; two channels, one for accompaniment, accordion or mike, the other for variable tremolo & reverb; two inputs each channel; two 12" heavy-duty speakers; line bypass reversing switch for hum reduction; leather-textured black vinyl covered wood cabinet with extruded aluminum front panel & chrome knobs. For extra savings, build the kit version in just 15 hours. 52 lbs.

NEW! Heathkit Soldering Iron

Kit GH-17
$14^95

Ideal for kit-building or other electronic soldering jobs. Safe 6 volt, 25 watt GE midget iron with non-corroding tip. 3 heat ranges. Excellent heat recovery time. Quick warm-up . . . iron ready in 2 minutes. Protective metal cage. Build in an hour. 5 lbs.

NOW Available Fully Assembled . . . World's Most Advanced Stereo Receiver!

Assembled ARW-15
$499^95
(less cab.)
Kit AR-15, $329.95

Acclaimed by owners & audio experts for its advanced features like integrated circuits and crystal filters in the IF amplifier section; ultra-sensitive FET FM tuner; 150 watts dynamic music power; complete AM, FM and FM stereo listening; positive circuit protection; all-silicon transistors; "black magic" panel lighting; stereo only switch; adjustable phase control for best stereo and many more. 34 lbs. Optional wrap-around walnut cabinet $19.95

NEW! Professional 10-Band Shortwave Listener's Receiver

Kit SB-310
$249^00

Covers 6 shortwave bands (49, 41, 31, 25, 19 & 16 meters) . . . 80, 40 & 20 meter ham bands . . . 11 meter CB. Includes 5 kHz crystal filter for AM, SSB and CW listening. Features selectivity that slices stations down to last kHz . . . no more guessing station identities; 11-tube circuit; crystal-controlled front-end for same rate tuning on all bands; prebuilt & aligned LMO; tuning dial to knob ratio 4 to 1; and many more deluxe SWL features. 2-tone green metal cabinet included. Optional crystal filters for optimum CW & SSB available. 20 lbs.

'68 HEATHKIT® Catalog!

Introducing The Exciting New Look Of Heathkit Solid-State Instruments!

Now from Heath . . . the most exciting innovation in electronic instrumentation . . . new ultra-functional cabinet styling. These new Heathkit instruments feature a cabinet frame consisting of front and rear panels with side rails that completely support the component chassis independent of the top and bottom cabinet shells . . . allows complete freedom for assembly, checkout and calibration. You'll like the clean bold panel & meter markings for easier reading . . . the easier-to-grasp knobs . . . the compact size . . . and the retractable carrying handles that are concealed in the side rails. The die-cast front panel bezel styled in chrome and black, the black side rails, and the special two-tone beige front panels and cabinet shells give these new instruments an appearance as up-to-date as their performance.

NEW! Deluxe Solid-State Volt-Ohm Meter . . . Battery Plus Built-In AC Power

Features 8 DC and 8 AC voltage ranges from 0.5v to 1500 v. full scale; 7 ohmmeter ranges x1 (10 ohms center scale), x10, x100, xlk, x10k, x100k and x1 megohm; 11 megohm input resistance on DC ranges; 1 megohm on AC ranges; internal battery or 120/240 v., 50/60 Hz AC power for portable or "in-shop" operation; large, easy-to-read 6″ 100 uA meter; separate switches for individual functions; single test probe with finger-tip flip switch for all measurements; simple circuit board construction.

Kit IM-16 **$44.95**

Solid-State High Impedance Volt-Ohm-Milliammeter

All silicon transistors plus FET's. Features 9 AC and 9 DC voltage full scale ranges down to 150 mv; 11 current ranges from 15 uA to 1.5A full scale; 7 resistance ranges (10 ohms center scale) measure one ohm to 1000 megohms; AC plus battery power for portability; 6″ 200 uA meter with zero center scale for + & — voltage measurements without switching; accuracy of ± 3% full scale on DC volts, ± 5% on AC volts; separate range switches for each function; 1% precision resistors; 10-turn thumbwheel zero adjustment; fast circuit board construction. 10 lbs.

Kit IM-25 **$80.00**
Wired IMW-25 $115.00

New FM Stereo Generator For RF, IF and FM Stereo Alignment

Produces virtually all signals for trouble-shooting & aligning multiplex adapters, FM tuners and receivers. Generates mono FM or composite stereo FM signals. Crystal-controlled 19 kHz (± 2 Hz) pilot signal, adjustable from 0 to 10% for checking tuner lock-in range. Switch-selection of 400 Hz, 1000 Hz, 5000 Hz, 19 kHz, and 65 kHz or 67 kHz SCA signals for complete alignment capability. 100 MHz sweep signal (adjustable ±2 MHz) for overall RF and IF alignment. Built-in crystal controlled marker oscillator for IF and dial tracking checks. Phase test capability. No balance adjustment needed for equal right and left channel modulation levels.

Kit IG-37 **$79.95**

New Variable Regulated High Voltage Power Supply

Features 6v. and 12 v. AC filament voltages; also furnishes B+ from 0 to 400 volts DC, bias from 0 to —100 volts DC; separate panel meters monitor B+ output voltage & current; voltmeter switched to read C— volts; output terminals isolated for safety; high voltage and bias may be switched "off" with filaments still "on" for maximum testing efficiency and safety.

Kit IP-17 **$59.95**

New Solid-State Regulated Low Voltage Power Supply

New Zener reference-voltage power supply. New up-dated circuit that is virtually immune to overload from exotic transients. Relay-protected against short circuit & overload. Provides 0.5 to 50 volts DC with better than ± 15 millivolts regulation. 4 current ranges: 50 mA, 150 mA, 500 mA & 1.5 A. Adjustable current limiter: 30 to 100% on all ranges. Panel meter shows output voltage or current. Choice of kit or assembled versions.

Kit IP-27 **$76.95**
Wired IPW-27 $119.95

NEW

FREE 1968 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, electric guitar & amplifier, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022

HEATHKIT®

HEATH COMPANY, Dept. 15-9
Benton Harbor, Michigan 49022
In Canada, Daystrom Ltd.

☐ Enclosed is $__________, including shipping.
Please send model (s)__________
☐ Please send FREE Heathkit Catalog.

Name__________
Address__________
City__________ State__________ Zip__________

Prices & specifications subject to change without notice. CL-301

CIRCLE NO. 111 ON READER SERVICE CARD

SOLID-STATE RING COUNTERS AND CHASERS FOR LIGHT DISPLAYS

By A. A. ADEM / Semiconductor Products Dept., General Electric Co.*

Basic semiconductor circuits for incandescent light displays, warning and traffic lights, and illuminated advertising signs.

THIS article describes some basic semiconductor circuits for incandescent light displays, warning and traffic lights, and illuminated advertising signs. The SCR and the Triac are ideal for this type of application to switch heavy loads on and off. These solid-state switches have no contacts to bounce, stick, or wear out; they are economical, explosion-proof, and reliable.

Ring counters are used for display purposes where, out of a string of several lights, only one light (sometimes more) is kept on at any one time. There is, however, a continuous and sequential transfer from the light that is on to the next one. This can be visualized by imagining a sixty-stage ring counter where sixty lights are arranged in a circle, six degrees apart. In such a ring counter, if the trigger pulses are maintained one second or one minute apart, the movement of the light would correspond to the numeral to which the second or minute arm, respectively, points.

Chasers are similar to ring counters except that, once a light is turned on, it stays on until the rest of the lights are on, and then they all turn off and start with the first light again. In our imaginary clock, this type of operation would correspond to the hands "chasing" something, always beginning at one minute and losing it on the sixty-minute mark.

Ring Counters

A three-stage ring counter is shown in Fig. 1. More stages can be added to this circuit, as required, between the dotted lines. The components values as shown are for a load of 100 watts or less for each SCR. For heavier loads, diodes *D*1 through *D*4 would have to be changed to higher current diodes, such as the *G-E* A40B, and the value of the filter capacitor *C*1 and the commutating capacitors *C*2, *C*3, and *C*4 would have to be increased. The value of the commutating capacitors can be determined in the manner explained in the author's previous article on solid-state flashers (August issue).

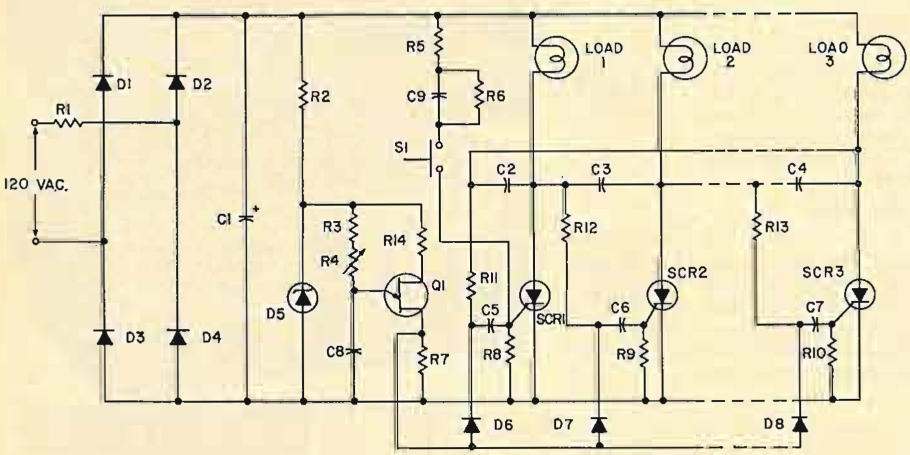
When power is first applied to the circuit, diodes *D*1-*D*4 and capacitor *C*1 supply 120 volts d.c. to the anodes of the SCR's through the loads, causing diodes *D*6, *D*7, and *D*8 to be reverse-biased. Out of this d.c. supply, zener diode *D*5 provides 18 volts to the free-running unijunction oscillator circuit. The trigger pulses from the UJT cannot turn any SCR on due to the reverse bias on the gate diodes.

To start the circuit, switch *S*1 must be closed momentarily to provide a pulse to the gate of *SCR*1 to turn it on. When *SCR*1 turns on, the reverse bias on *D*7 is removed and the next time the UJT supplies a pulse, *SCR*2 turns on causing *SCR*1 to turn off because of the commutating capacitor *C*3. Similarly, when *SCR*2 turns on, the reverse bias on *D*8 is removed and the next time the UJT fires, *SCR*3 turns on, causing *SCR*2 to turn off. Thus, every time a pulse appears at the common shift line, the power to the load transfers sequentially from one stage to the next, always in the same direction.

As the load of a ring counter is increased, the value of the commutating capacitors, (which incidentally are of the non-polarized type), the filter capacitor, and the current rating of the supply diodes must be increased. After a certain power output level, this circuit becomes impractical and uneconomical. If this is the case, a ring counter can be used to trigger Triacs much in the same way as described in the next section.

Fig. 2 shows a chaser circuit with three stages. Just like the circuit of Fig. 1, more stages may be added between the dotted lines. If in Fig. 1, the commutating capacitors were left out and some means were provided to turn all the SCR's off after *SCR*3 had been turned on, the circuit would function as a chaser.

Fig. 1. Ring counter in which each SCR is triggered in turn to operate its load.



R1—Adjust to give 120 volts across C1 (depends on load)
R2—4700 ohm, 2 W res.
R3—10,000 ohm, 1/2 W res.
R4—500,000 ohm linear pot
R5—100 ohm, 1/2 W res.
R6—1 megohm, 1/2 W res.
R7—47 ohm, 1/2 W res.
R8,R9,R10—1000 ohm, 1/2 W res.
R11,R12,R13,—33,000 ohm, 1/2 W res.
R14—330 ohm, 1/2 W res.
C1—100 μF, 200 V capacitor
C2,C3,C4—0.5 μF, 200 V capacitor
C5,C6,C7—0.01 μF, 200 V capacitor
C8—1 μF, 25 V capacitor
C9—0.1 μF, 200 V capacitor
D1,D2,D3,D4—A10B diode (G-E)
D5—Z4XL18 zener diode (G-E)
D6,D7,D8—A13F diode (G-E)
SCR1,SCR2,SCR3—Silicon controlled rectifier (G-E C20B)
Q1—2N2646 unijunction transistor (G-E)
Loads—100 W

Note: Additional stages may be inserted between dashed lines

*Now employed by Fairchild Semiconductor in Mountain View, Calif.

Chasers are primarily used in advertising signs where a string of lights is turned on sequentially to produce the effect of a "moving sign". Presently, this function is performed by a motor-driven cam, actuating heavy silver contacts, with its attendant drawbacks.

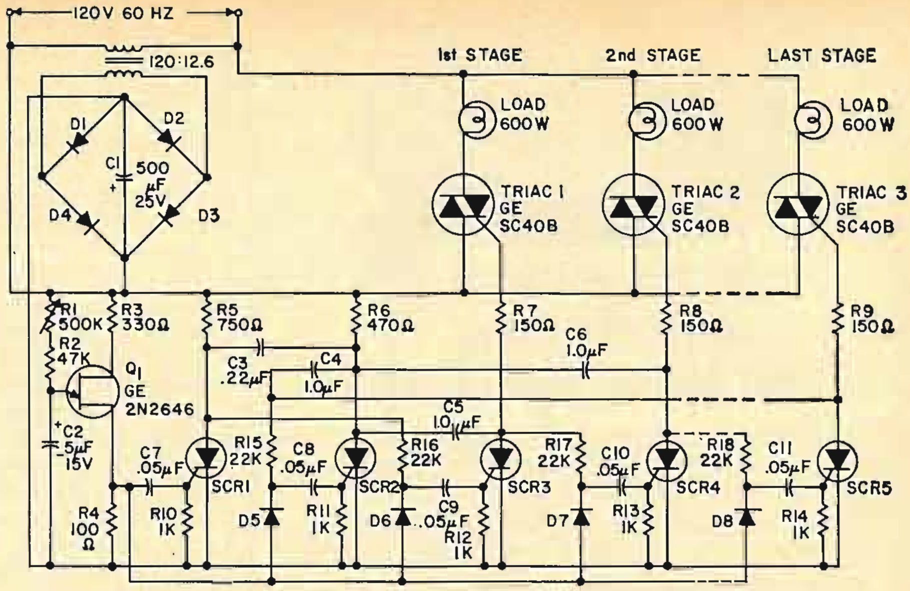
When power is turned on initially, all the SCR's will be in the "off" state. The free-running unijunction oscillator receives its power from the bridge rectifiers, *D*1-*D*4, and filter capacitor *C*1. At the end of the time delay, determined by the setting of *R*1, the UJT will fire and the pulse at base 1 will only turn on *SCR*1 (*D*5-*D*8 are reversed-biased). When the UJT fires again, *SCR*3 will turn on, thus firing Triac 1. The two new pulses will turn on *SCR*4 and *SCR*5, in that order, firing Triacs 2 and 3. The following pulse will fire *SCR*2 which will commutate off *SCR*1, *SCR*3, *SCR*4, and *SCR*5, removing the gate drive to all the Triacs. The next pulse will start the cycle again, turning *SCR*1 "on" and *SCR*2 "off."

With this arrangement, the "off" time takes two pulses; in other words, if the UJT pulses are spaced one second apart, the "off" time takes two seconds, whereas there is only one second between the time Triac 1 and Triac 2 come on. This is due to the additional stage introduced because of *SCR*2. Increasing the "off" time makes the function of the circuit more appealing to the eye. If this additional stage is not required, *SCR*1 and its associated components can be left out of the circuit to provide a starting pulse to *SCR*3. It will be noted that the circuit of Fig. 2 as shown can also be used as a 4-stage chaser by merely adding a 150-ohm resistor from the anode of *SCR*1 to the gate of another Triac. Under these conditions the "off" time will be reduced and the added Triac will turn on first, followed by Triacs 1, 2, and 3.

The circuit of Fig. 3 is an extension of the circuit shown in Fig. 2. In addition, it provides a separate timing adjustment for each stage of the chaser. Here, instead of Triacs, SCR's are used to drive the loads. When power is applied to the circuit, all the SCR's are in non-conducting state. *Q*1 starts timing and, at the end of the time delay set by *R*1, fires *SCR*4 which energizes the reed-switch coil.

The reed-switch contact then connects the d.c. supply to the remaining portion of the circuit and at the same time applies a d.c. drive to the gate of *SCR*1, turning it on. The closure of the reed contact starts *Q*2 timing which, at the end of its time delay, as set by *R*2, fires *SCR*6 which, in turn, fires *SCR*2. This sequential firing continues down the line until *Q*4 fires which causes *SCR*5 to turn on and *SCR*4 to turn off. The reed-switch coil de-energizes causing all the SCR's (except *SCR*5) to turn off thus resetting the circuit. At the same time that *SCR*4 is turned off, *Q*1 starts timing and the cycle repeats.

The 1-megohm resistor (*R*13) across the reed-switch contact is to prevent *SCR*6 and *SCR*7 from triggering because of the rate of rise of voltage when the contact closes. The anodes of these two SCR's essentially see the d.c. supply voltage even when the reed switch opens but these SCR's turn off because the SCR current does go below the holding current level. It is interesting to note that the reed switch draws very little current (less than 20 mA per stage) and yet is capable of turning on and off several hundred watts of power. This, of course, is possible because of the capability of the semiconductor switches in turning on with a small signal at their gates. ▲

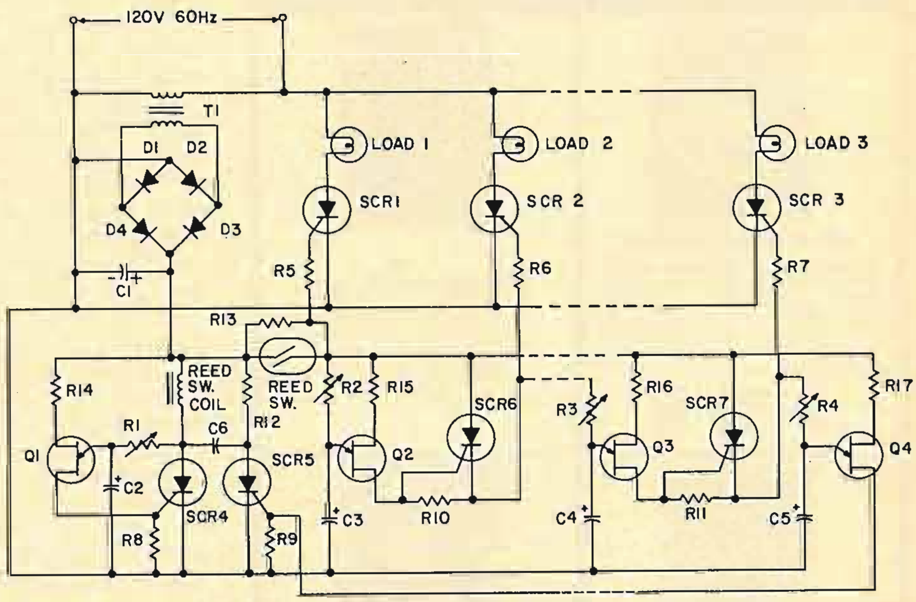


ALL SCR'S GE C106Y
ALL DIODES GE A13 F
FOR 1000-WATT LOAD USE GE SC45B TRIACS.

ALL RESISTORS 1/2 W
ADDITIONAL STAGES MAY BE INSERTED BETWEEN DOTTED LINES.

Fig. 2. A solid-state chaser circuit with only three stages is shown in diagram.

Fig. 3. A chaser circuit providing separate timing adjustment for each stage.



R1,R2,R3,R4—500,000 ohm pot
R5,R6,R7—750 ohm, ½ W res.
R8,R9—1000 ohm, ½ W res.
R10,R11—33 ohm, ½ W res.
R12—470 ohm, ½ W res.
R13—1 megohm, ½ W res.
R14,R15,R16,R17—330 ohm, ½ W res.
C1—500 μF, 25 V elec. capacitor
C2, C3, C4, C5—2 μF, 10 V elec. capacitor
C6—0.22 μF, 100 V capacitor
Reed Sw.—Use G-E 2DR15 (1 amp) or G-E 2DR30 (3 amp)

Reed Sw. Coil—10,000 t. #39 wire (825 ohms)
D1, D2, D3, D4—A13A diode (G-E)
SCR1, SCR2, SCR3—C20B silicon controlled rectifier (G-E)
SCR4, SCR5, SCR6, SCR7—C106Y silicon controlled rectifier (G-E)
Q1, Q2, Q3, Q4—2N2646 unijunction transistor (G-E)
Loads—550 W each
Note: Additional stages may be inserted between dashed lines.

Report on RTCMS

(*Continued from page 46*)

number of vessel-stations *outside* the range of your vessel-station.

But four papers presented at the RTCM Assembly concerned themselves directly with a concept which, if implemented, might possibly destroy this unique ability of the v.h.f./FM marine band to keep each area's signals where they belong and not cause interference hundreds of miles away in the manner of 2-3-MHz communications. These presentations, without exception, were well researched, intelligently conceived, and excellently written *and all dedicated to the concept of dramatically extending the range of v.h.f. marine communications by the use of satellites.*

This philosophy, if enlarged to include the whole of the v.h.f./FM maritime service, could end this band's usefulness as a highly efficient, *local-range* communications tool.

Medium-range and long-range marine communications are adequately served already. Single sideband will stretch these capabilities even farther. There is no need to hitch v.h.f.'s wagon to an electronic star.

Single-Sideband Proposals

Of a total of 34 papers delivered before the RTCM assembly, 25 were concerned with some phase of the projected (FCC docket #17295) expansion of the v.h.f./FM marine band. Four were devoted to comments on the various proposals to introduce single-sideband emission to the 2-3-MHz marine frequencies. This band is the one used by the majority of pleasure boaters. In the high-frequency marine band, the use of double sideband (AM) on the bulk of these "above 4 MHz" frequencies is already prohibited after January 1, 1974 in FCC R&R 83.132(a)(2). Here is the American SSB proposal which we will present at Geneva:

It is proposed:

1. To discontinue the installation of double-sideband equipment on ship stations by January 1, 1970.

2. Discontinue the use by coast stations of double-sideband emission by January 1, 1970.

3. Discontinue use by ship stations of double-sideband emission and by coast stations of full carrier (A3H) emission on January 1, 1975, except that coast stations shall retain the capability of operating with class A3H emission on 2182 kHz. (Item 3 bears the footnote that the date of January 1, 1975 may be extended to January 1, 1977.)

4. During the period of transition from double sideband to single sideband, coast stations and single-sideband ship stations shall have the capability of using full carrier (A3H) emission to permit communications with both double-sideband and single-sideband radiotelephone stations.

In the comments and proposals by Canada, the United Kingdom, Denmark, France, and Italy the dates for "discontinuance of installation" ranges from "already implemented" (by Canada) to 1973. The discontinuance of double-sideband (AM) emission bore dates from 1974 to 1980.

One thing should be pointed out, however: in the past the United States has not always followed point-by-point what has been set forth in International Conferences. In the v.h.f./FM marine band, for instance, we have gone ahead with our plans to expand the channels and services of this 156-162 MHz band without waiting for the rest of the world. In a conversation with a high-ranking FCC official, the author was told that the Notice of Proposed Rule Making for this single-sideband proposal was "already drawn up and will possibly be released *in a few weeks.*"

The emphasis on v.h.f/FM and single sideband at the Washington Assembly of the RTCM gives a very accurate idea of what the major portion of the World Administrative Radio Conference of the International Telecommunications Union will be discussing. ▲

THE VOLUME UNIT

MANY audio engineers do not understand the volume unit (vu), for it is a difficult unit to describe in words Perhaps it would help to state what the vu is *not*.

The vu is *not* a unit of measurement for power or power level as are the watt and dBm. The vu is *not* a unit of measurement of loudness as is the phon. In fact, the vu has no relationship to any other unit of measurement encountered in electrical communications.

Nevertheless, it is one of the most useful tools of the audio engineer, as it is used in the stating of the level of complex, non-recurrent, and non-periodic waves (music and speech) of electricity.

The vu should not be used for steady-state waves, just as the dBm must not be used for complex material. The vu and the dBm are highly different units and must be treated so.

Volume in vu is numerically equal to the highest scale reading observed on a standard vu meter during a short period of time, added to the dB attenuation of the attenuator network that precedes the meter. Occasionally meter deflections of unusually high level may be ignored.

From the above strict definition, several things may be deduced. First, since the meter reading is constantly changing, the ballistic characteristics of the meter are of great importance. Second, the vu is far from being a precise unit of measurement because it depends on human interpretation of a constantly changing condition.

A "standard vu meter" has a reference point (marked "0") near the upper end of its scale. The ballistic characteristic must be such that if a sinusoidal voltage of such amplitude as to give reference deflection under steady-state conditions is suddenly applied, the meter pointer must reach 99% deflection in 0.3 second. The pointer must then overswing the reference point by at least 1.0% but not more than 1.5%. When the signal is removed, the pointer must fall with approximately the same characteristic that it had when it was rising.

Unless a meter has the above dynamic behavior, it cannot be used to determine volume in vu.

Many meter manufacturers mark common a.c. voltmeters in vu and then call them "vu" meters. The use of such instruments should be discouraged.

The attenuator preceding a vu meter is calibrated in dB and marked in vu. It must be designed specifically for use with the impedances stated by the meter manufacturer. All American firms are standardized on one set of impedances and parameters.

This information appeared in the first issue of *Langevin Engineering Letter*. ▲

TONE-SELECTIVE SIGNALING The New Look

By LESLIE SOLOMON

This new generation of frequency selective devices has high "Q" enabling a considerable number of control tones to be passed over an audio link.

WHEN it is desired to control several functions at a distance but the intervening wiring or other transmission medium is restricted in bandwidth, then selective-tone signaling is usually used. Typical applications include selective CB or business radio transmissions where a base station wishes to alert only one of several remote stations, radio control of model planes or boats, "turn on/turn off" of remote electrically controlled equipment, or personnel alert where each person has a particular frequency-sensitive signaling device. In essence, the technique can be used in any application where a station at one point wishes to selective-call or actuate a particular device at some remote point using some form of narrow-band link capable of passing the conventional audio spectrum.

In such a signaling system, the sending end (encoder) uses some form of audio tone generator which can be placed in operation by a simple "on/off" switch. The tone is then passed to the communications medium for transmission to the remote receiver.

The receiver decoder consists of some form of frequency-selective circuit that is activated (delivers some form of output) when it receives a tone signal corresponding to the decoder's preset frequency. It is of prime importance that the decoder not activate when it receives tones of frequencies other than the one to which it is preset. In some cases where a single, false, accidental tone may trigger premature or unwanted response, the decoder may be arranged to require two or more tones, in some form of sequence, before it activates.

At present there are three basic methods of selective-tone signaling reception. The first consists of a resonant-reed relay that is mechanically "tuned" to respond to only one selected audio frequency. However, because of the necessarily lightweight mechanical reed required, the electrical contacts must also be very light, thus severely limiting the amount of current permitted to flow between these contacts. Because of these limitations, resonant-reed relay circuits usually use the reed contacts to activate a larger, power-handling relay that does the actual external power switching.

The second system uses some form of feedback oscillator, kept just under the point of oscillation, which can be triggered on by application of the correct audio tone. This oscillator, when it operates, activates another electronic circuit which in turn supplies the necessary switching power. However, the bulk of these all-electronic circuits are subject to frequency drift with aging of components and changes in applied voltage.

The third approach uses some form of passive *LC* filter, tuned to a particular audio frequency, that activates a device such as a transistor or vacuum tube, which in turn controls some external function. Typical examples of this latter approach can be found in the remote-control systems used in some TV sets. The major drawback of this system is that the low "*Q*" of such circuits requires a large frequency spacing between the tones to prevent mutual interference. Unless the connecting link frequency is raised far above the audio range, only a couple of tones can be used. For example, the TV control uses ultrasonic frequencies to transmit only a half a dozen control signals.

Within the past year, two new frequency-selective devices have been introduced to simplify selective-tone signaling systems. Neither of these devices uses any form of mechanical contacts, both are inherently stable, and only simple electronic circuitry is required to put them to work.

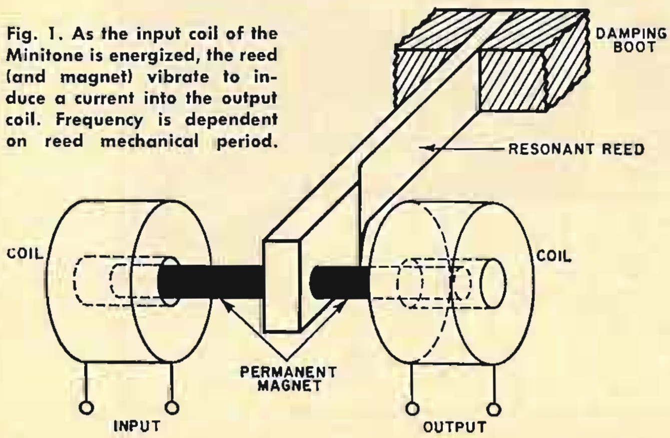


Fig. 1. As the input coil of the Minitone is energized, the reed (and magnet) vibrate to induce a current into the output coil. Frequency is dependent on reed mechanical period.

The "Minitone"

Developed and patented by *Motorola*, the "Minitone" is a miniature, lightweight, resonant-reed device capable of operation at any one of 200 preselected frequencies between 67 and 3150 Hz. Tolerance is 0.1% between 57 and 230 Hz, and 0.05% between 230 and 3150 Hz. Bandwidth ranges from 1 Hz at 67 Hz to 3 Hz at 3150 Hz, while input and output impedance is 400 ohms.

Operation, as shown in Fig. 1, appears similar to the tuning fork oscillator commonly used to generate stable audio frequencies. The resonant reed has one end mounted to a vibration-damping boot, which in turn is affixed to the chassis.

The reed is mechanically resonant to the predetermined frequency. A rod-shaped permanent magnet is mounted through and mechanically attached to the free end of the reed with each end of the magnet protruding into a coil on each side. When the input coil is supplied with an audio current of the same frequency as the mechanical resonance of the reed, the reed begins to vibrate in sympathy with the excitation frequency. This action is similar to the operation of a loudspeaker.

As the reed vibrates, the magnet also vibrates in and out of the output coil. A voltage of exactly the same frequency as the reed vibration is then induced into this coil. By electrically connecting the coils properly, the input and output signals will always be in-phase.

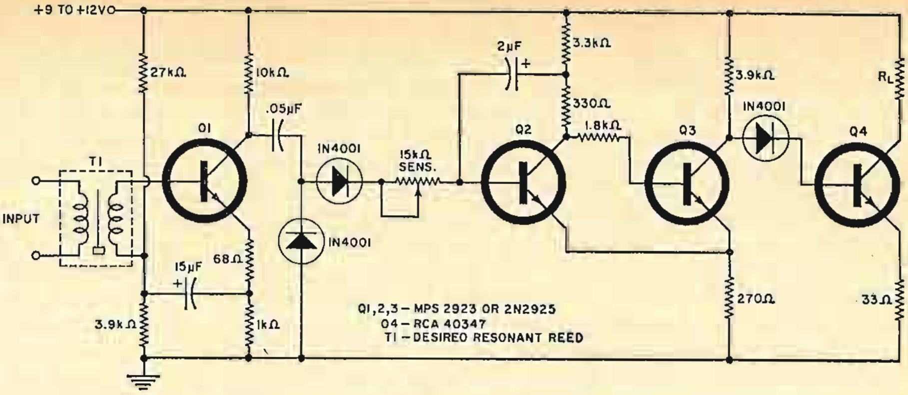


Fig. 2. A typical frequency selective receiver using a Minitone.

An application is shown in Fig. 2. The incoming audio line can be the terminals of the wire line, or the audio output of the radio receiver used. This signal is applied to the resonant-reed device (*T1*) where the audio frequency is selected. The tone signal is amplified by *Q1*, detected, and used to activate Schmitt trigger *Q2-Q3*. When the Schmitt operates, transistor *Q4* is turned on and current flows through the load R_L. Load R_L can be some combination of lights for use as a visual signaler, or a latching relay to maintain a continuous output once the tone has been received. This output relay can be used to operate a bell or buzzer for alerting purposes, or activate some other form of electrical device as required for a particular application.

A companion transmitter using a "Minitone" is shown in Fig. 3. Here, the resonant-reed device is connected in a feedback oscillator consisting of *Q1* and *Q2*, with the tone frequency dependent on the particular reed device used. Transistor *Q3* is used as an emitter-follower to match the relatively high output impedance of the oscillator to the load (telephone line or modulator of an r.f. transmitter).

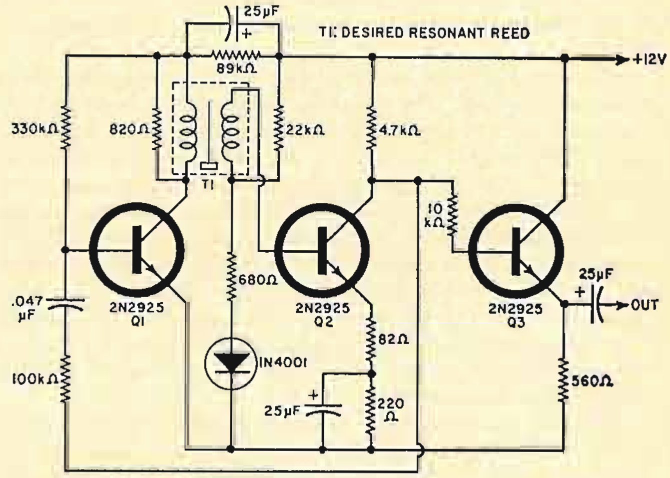


Fig. 3. Here, a Minitone is used as the frequency determining element of the audio oscillator used as the transmitter.

The "Twintron"

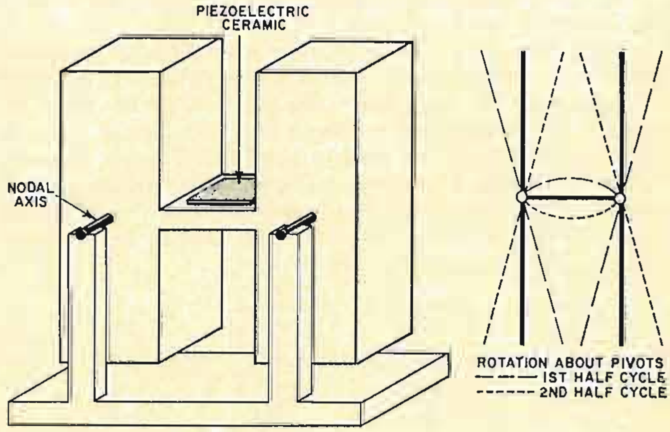
This second frequency-selective element came about because some engineers felt that the "Q" of the resonant-reed relay was being seriously affected because the vibrating reed was damped by its necessary physical attachment to the mounting base and damping material. One answer to this problem is the "Twintron" developed by the *H.B. Engineering Corp.* This electromechanical resonator claims a "Q" of up to 8000 and can be used to select, reject, or generate audio frequencies from a frequency as low as a fraction of a hertz up to 20 kHz.

As shown in Fig. 4A, this device is an H-shaped metal structure with the two larger vertical sections connected by a slender horizontal web. The structure is supported by a pair of axles located at the two large structure nodal points. The two parallel H-sections are balanced, each about its own nodal point, and therefore the motion of each about its own pivot produces no lateral motion on that pivot. The web that interconnects the two large masses locks the pair together so that any motion of the web causes an out-of-phase motion of the two masses.

This electromechanical resonator can be physically excited by any means that imparts a rotational movement about either axis. In this case, a piezoelectric ceramic wafer is bonded to one surface of the horizontal web and, when voltage is applied to this wafer (with the metal mass acting as the ground lead), it causes the web to elongate during one half cycle and compress during the other half cycle. See Fig. 4B for operation of the device.

This arrangement causes the web to flex up and down with the applied audio electrical signal to the piezoelectric wafer, thus causing the two large masses to try to rotate about their

Fig. 4. Basic operation of Twintron. A signal applied to the piezoelectric wafer causes the two large arms to flex. The resonant frequency is determined by the mass of the arms.



(A)

nodal axes. This moment of rotation occurs only when the electrical signal frequency corresponds exactly to the natural mechanical resonant frequency of the masses. Since the system is completely symmetrical and in balance at all times (but in opposite phase), no mechanical reaction exists outside of the system.

If another piezoelectric wafer is bonded to the other surface of the web, it will generate an electrical output signal at the frequency of the natural resonance of the H-shaped masses.

Since the electrical input and output are piezoelectric crystals, both the input and output impedance is high, typically 200,000 ohms.

Some applications are shown in Fig. 5. A simple series-pass filter is shown in Fig. 5A. This circuit can be connected between a pair of amplifiers and will pass only the filter frequency, rejecting all others. By connecting a resistor across the device (Fig. 5B), it then becomes a reject filter passing all frequencies except that of the device. By replacing the single output piezoelectric wafer with a pair of wafers, each isolated from the other, it is then possible to create a combined reject and pass filter such as shown in Fig. 5C.

Since the piezoelectric wafer is bonded directly to the flexing web of the device, it becomes part of the spring characteristics of the web. It is a characteristic of the piezoelectric material that its compliance, or spring stiffness, varies as the electrical load across the voltage generator. Therefore, if one portion of the dual wafer (either in the primary or secondary circuit) is connected to ground *via* a variable resistor, variations in the resistance will cause a change in the mechanical resonance of the system, in some cases controllable up to 50% of the fundamental frequency. Such a circuit is shown in Fig. 5D.

A very stable audio oscillator can be made using the circuit shown in Fig. 5E. The amplifier output has a −45° phase-shift network (at the operating frequency) in its input and a +45° phase-shift network at its output. When combined with the "Twintron", the frequency of oscillation and stability are determined only by the "Twintron" and not on any external circuit element parameter variation. If the oscillator shown in Fig. 5E is changed to that of Fig. 5F, then the output frequency will be a function of the value of the resistor used across one of the wafers in the device. This variable resistor can be a thermistor, or any resistor that varies in value with the desired function. This particular application will find many uses in telemetry.

By using the "Twintron" in an arrangement that results in a differential output, an ultra-narrow FM discriminator can be created (see Fig. 5G). The linear portion of the S-shaped FM discriminator curve can be as narrow as one to two Hz between peaks. Such circuits will find wide application in both medical electronics and servomechanism areas.

Intrusion Alarm

Suppose that you want to know the condition of a number of remote monitoring devices (a large number of windows, doors, gates, etc., in a large plant for example), and you want to know instantly when one of these devices is activated (meaning in this case that a window or door has been opened). By conventional means, a large number of interconnecting cables must be used to isolate each sensor from the others and, also, a relatively complex switching circuit will have to be used to rapidly determine the state of each remote sensor. Fig. 5H shows a typical application of an extremely simple system using these new devices.

The outputs of a number of tone generators (continuously operating) are connected in parallel and supply one side of a transmit-receive switch. An equivalent number of decoders (matching the encoders in frequency) are connected in parallel to form the receive portion of the same switch. Each decoder supplies a signal to some form of external signaling device.

From the rotor portion of the transmit-receive switch, a single cable is stretched around the premises to be protected. At intervals along this cable, a "Twintron" is connected, in series with a simple "on-off" switch, activated by opening a door or window, etc. When the switch is closed, that particular "Twintron" is connected to the cable. When the transmit-receive switch is placed in the transmit position, the multitone signals from the tone generators are passed down the cable. The switch is then immediately placed in the receive position. The audio tones rapidly traverse the cable, and if they encounter a closed switch, the pertinent tone excites its remote "Twintron". As the "Twintron" continues to oscillate for a considerable part of a second after removal of the audio stimuli, the signal generated by it will pass back up the cable and excite its companion "Twintron" at the monitoring console. As the monitor device is excited it, in turn, causes its signaling device to operate. Because of the high "Q" of the "Twintron", any number of devices can be attached to the cable and one, or all, can be operative at the same time.

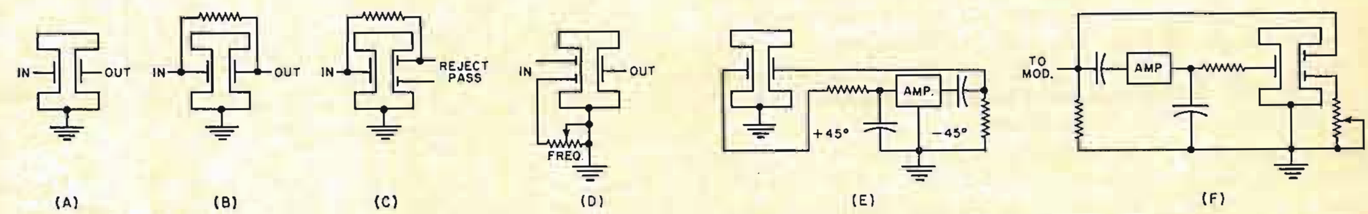
Summary

When the engineer starts thinking about filters for the audio frequency spectrum, he knows that he will be faced with either poor selectivity, unwieldy sizes, and possibly high cost. In general, if low selectivity (the ability to react to one specific frequency and not to other frequencies close by) is acceptable, electronic filters of either the *RC* or *LC* type, with or without active elements, are satisfactory. However, because the period of time constants at the low frequencies must, of necessity, be large, so must component values. In many cases, tolerance levels are excessive.

If the application requires good selectivity, the problem may be compounded due to the relationship between physical size and component value and, often, tolerance range.

Mechanical filters such as the tuning fork, have been used for many years—in fact since they were invented in 1711. However, at the low audio frequencies required, these forks become unwieldly in size.

Now, with the advent of the new generation of electromechanical filters covered in this article, engineers can design frequency-selective networks that are physically small, use very little power, have a broad range of applications, while their high "Q" enables them to use many audio frequencies over one link without any noticeable interaction. ▲



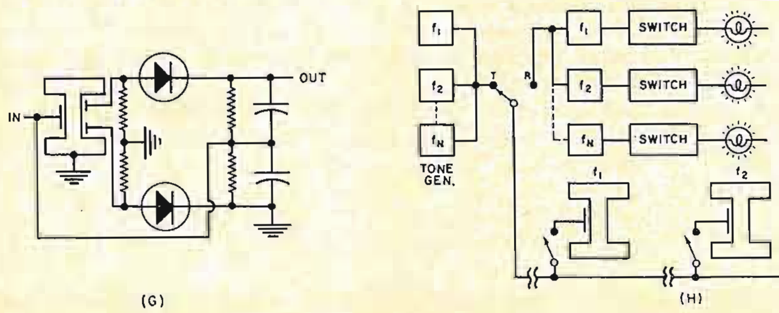


Fig. 5. Some basic Twintron applications. (A) Series-pass filter. (B) Reject filter. (C) Combined pass and reject filter. (D) Tunable filter. (E) Audio oscillator. (F) Telemetry transmitter. (G) Narrow-band FM detector. (H) Intrusion alarm.

CIRCLE NO. 108 ON READER SERVICE CARD→

THE COMMON SLIDE RULE FOR REACTANCE CALCULATIONS

By GLADDEN B. HOUCK, Jr.
Hirsch-Houck Laboratories

THERE are many engineers who use special slide rules for calculating inductive and capacitive reactance. Such rules as those from *Boonton Radio* and *Shure* are easy to use, but their accuracy is limited. A few marks added to the common slide-rule scales can make this operation easier to perform on these rules.

An index mark at 1.5915 ($1/2\pi$) is used to obtain the $2\pi F$ factor common to both the inductive and capacitive reactance formulas. The mark can be scribed on the D scale (and DF scale). The scale labels "L or C" can be added to the D scale. The "F" label as well as the "X_L" label should be added to the C scale. The CI scale is labeled "X_C". These few marks will make the operations quite obvious after solving a few problems.

To obtain capacitive reactance, the frequency on the "F" (C) scale is set opposite the $1/2\pi$ index mark on the D scale. The reactance is read on the "X_C" (CI) scale opposite the capacitance on the "L or C" scale (D). Inductive reactance is also a simple procedure. The only difference is that the reactance is read on the "X_L" (C) scale.

The system can be varied somewhat if the slide rule has other scales that are similar in operation. For example, the folded scales can save the off-the-end operation that the simpler rules require. An additional mark should be added to the DF scale for this purpose.

The mark for the $1/2\pi$ index can be scribed on the plastic type rules and filled with a contrasting ink from a Magic Marker. To fill a line, one marks the surface and erases the excess from the surface around the mark. A stiff eraser will work. Try it on the edge to practice the technique.

Some slide rules lack space near the scales for the label of the index marks added by the engineer. Often the edge of the rule can be used for this purpose if the mark is deeply engraved so the slider does not wear off the ink.

Example: What is the inductive reactance of a 0.3-mH coil at 1.27 MHz? First, set the frequency on the C scale opposite the $1/2\pi$ index mark on the D scale. Then, move the hairline indicator to the inductance value on the D scale. The reactance can now be read directly on the C scale as 2390 ohms.

A little practice with a few problems will demonstrate how time-saving this technique is. ▲

HI-FI SHOW SEMINARS PROGRAM

September 21-24, 1967

Statler Hilton Hotel, 7th Ave. & 32nd St., New York, N.Y.

IN view of the unusual interest in last year's technical seminars held during the New York Hi-Fi Show, Walter Stanton (President of the Institute of High Fidelity) has announced that this year's theme would be directed toward broadening consumer understanding through an increased number of seminars.

In addition to the eight sessions held in 1964, 1965 and 1966 on the technical and semi-technical aspects of hi-fi reproduction, there will be separate sessions on "Decor" and "Musicology". Three outstanding authorities will discuss the use of components in decorating with sound, and NARAS (National Academy of Recording Arts & Sciences), under the direction of George Simon, Secretary, will present four sessions on the theory behind the most popular musical art forms. Listed below are complete program details covering the entire period of the Show. ▲

THURSDAY, SEPTEMBER 21, 1967

6:30-7:30 p.m. Novice Symposium: "Introduction to Hi-Fi Components"
Leonard Feldman, Engineering Vice-President, Crestmark Electronics

7:30-8:30 p.m. "Tape and Tape Recorders"
Moderator: Milt Snitzer, Technical Editor, Electronics World
Panelists: Joe Kempler, Technical Services Dept. Manager, Audio Devices
Paul Bunker, Magnecord Division Product Mgr., Telex Corp.

8:30-9:30 p.m. "The Classical Recording Scene"
Moderator: David Hall, Director, Library of Performing Arts at Lincoln Center; former Music Editor, HiFi/Stereo Review; 1st Vice-President, (N.Y. Chapter) and National Trustee, (NARAS)
Panelists: Martin Bookspan, former Program Director, WQXR
Other panelists to be announced

FRIDAY, SEPTEMBER 22, 1967

6:30-7:30 p.m. Novice Symposium (as above)

7:30-8:30 p.m. "Cartridges, Turntables and Changers"
Moderator: Bill Stocklin, Editor, Electronics World
Panelists: Jim Kogen, Chief Engineer, R&D, Shure Brothers
Bud Childs, President, Elpa Marketing Industries (Thorens)

8:30-9:30 p.m. Decor Group
Albert Herbert, President, Albert Herbert Design

SATURDAY, SEPTEMBER 23, 1967

2:00-3:00 p.m. "The Pop Scene"
Moderator: George Avakian, former Supervisor, Album Production, Columbia and Victor Records; National President of NARAS
Panelists: David Kapp, President, Kapp Records
Bob Crewe, Bob Crewe Productions
Tom Dowd, Chief Engineer, Atlantic Records

3:00-4:00 p.m. "Amplifiers and Tuners"
Moderator: To be announced
Panelists: George Meyer, Product Manager, Fisher Radio Corp.
Larry Fish, Chief Engineer, H.H. Scott Inc.

4:00-5:00 p.m. Decor Group
Bill Leonard, President, William L Associates (designers)

6:30-7:30 p.m. Novice Symposium (as above)

7:30-8:30 p.m. "Stereo and the Listener"
Moderator: To be announced
Panelists: Abe Cohen, Manager, Acoustics, Instrument Systems Corp.
Vic Brociner, Asst. to the President, H.H. Scott Inc.

8:30-9:30 p.m. "The Successful Recordings (Let's Look at The Record)"
Moderator: Goddard Lieberson
Panelists: Ernie Atschuler, V.P. and A & R Director, RCA Victor
Phil Ramone, Vice President, A & R Recording Studios
(recording artist to be announced)

SUNDAY, SEPTEMBER 24, 1967

2:30-3:00 p.m. Decor Group
Vladimir Kagan, President, Kagan Dryfuss (designers)

3:00-4:00 p.m. Novice Symposium (as above)

4:00-5:00 p.m. "The Jazz Recording Scene"
Moderator: Father Norman J. O'Connor, author, radio-TV personality; has own TV show "Dial M for Music" (Channel 2); President (N.Y. Chapter) NARAS
Panelists: John Hammond, Director of Talent Acquisition, Columbia Records; and National Trustee of NARAS
Bob Thiele, Art/Repertoire Director, ABC Paramount and Impulse Records
Billy Taylor, jazz pianist, disc jockey (WLIB); head of Jazz Interaction; Treasurer (N.Y. Chapter) NARAS

Temp.-Depth Measurements

(*Continued from page* 36)

The increase in time constant results from the additional pressure protection required. The 10,000 psi aluminum housing increases size and weight as does the addition of the oscillators and mixer to the probe.

The fact is that, as oceanographic sensors go, this probe is quite small and light (1½ pounds). Since the probe output is from 0-40 kHz instead of at 28 MHz, the cable connecting it to the electronic counter can be as much as 5 miles long.

The quartz thermometer has an absolute accuracy on the order of ±0.01° C and a usable resolution of ± 0.0001° C. Neither the reversing thermometer nor Ben Franklin's bucket can match this. ▲

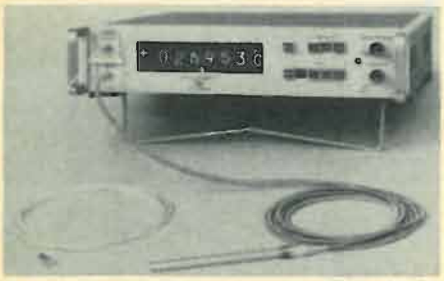


Fig. 8. The probes of this quartz thermometer each contain an LC-cut type crystal. They are connected by coaxial cable to the electronic chassis. The cables carry 28-MHz signals. (Dymec Div., Hewlett-Packard)

Fig. 9. The oceanographic quartz thermometer probe contains an AT-cut crystal, LC-cut crystal, reference oscillator, temperature oscillator, and mixer. The pressure case at left withstands 10,000 psi.

"No, this is the assembler—that's the marking station."

NEW PRODUCTS & LITERATURE

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

POWER SWEEP GENERATOR

The Model 6550-1 power sweep generator produces triangular, square, and sine waves at 100-watt levels with selectable sweep rates or manual control for use in performing conducted audio frequency susceptibility tests per MIL-1-26600,

MIL-1-6181D, MIL-STD-826A, etc. The generator is useful in making transient studies of passive networks, square-wave testing of amplifier systems, and as a source of 400 Hz or other power frequency supply to test samples.

Frequency range is 15 Hz to 150 kHz. Sweep rates are one per minute, ten per minute, or manual dial. The output is adjustable up to 100 watts into a 2-ohm load. The generator is $8\frac{1}{8}$" x 9" x $14\frac{5}{8}$".

Complete specifications and prices will be supplied on request. Solar

Circle No. 126 on Reader Service Card

HYBRID IC's FOR TV

Five new hybrid integrated circuits for TV, radio, and phonograph applications have just been introduced.

The HC1001 is an FM sound-system module which combines a wide-band i.f. amplifier, an FM detector, and an audio preamp in a 0.5 x 0.5 x 0.2-inch package. This complete sound system meets all current TV design requirements whether tube, solid-state, or hybrid combinations, black-and-white or color, line-operated or portable.

The series of audio hybrid IC's, HC1003, HC1004, HC1005, and HC1006, include both low-input-impedance circuits for AM radios and high-input-impedance units for FM radios and phonographs.

These new hybrid IC's combine discrete semiconductors with thick-film resistor-fabrication techniques. A thermally conductive ceramic substrate serves as the base for screened-on, thick-film resistors and conductors. The semiconductor chips are coated with glass, providing an effective moisture barrier.

Specs sheets on these new hybrid IC's will be supplied on request. Texas Instruments

Circle No. 127 on Reader Service Card

TEN-TURN POTENTIOMETERS

Multi-turn potentiometers providing less than one second resolution with output smoothness levels to 0.01% and useful operating lives up to 200 million revolutions are now available.

The Model 7813 with rear terminals and the Model 7814 with radial terminals incorporate in a $\frac{7}{8}$" diameter aluminum case a true helical resistive element of smooth plastic film, multiple-fingered precious metal wipers, gold-plated slip rings, and precision ball bearings at both ends. Resistance range is 5000 ohms to 1.5 megohms with a best linearity of 0.05%.

Complete specifications and additional information on these pots will be forwarded on request. Computer Instruments

Circle No. 128 on Reader Service Card

PHOTOELECTRIC CONTROL

A sensitive photoelectric control unit which turns lights on at sunset and off at sunrise is being marketed as the "Lampliter".

Completely automatic, the unit is secured to the windowsill by means of its suction cup and then plugged into any a.c. outlet. The lamp to be controlled is plugged into the socket on the "Lampliter". The unit is guaranteed for three years and carries the UL seal. Four T's Co.

Circle No. 1 on Reader Service Card

1000-WATT DIMMER

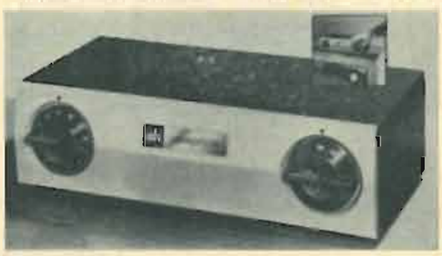
A three-way, 1000-watt dimmer with "push-on/push off" switch to control 1000 watts of incandescent lighting from two different control locations is now available. The unit easily fits a single-gang wall box and has a 5" x 5" double-gang faceplate. The new unit is the Model D-103P. Lutron

Circle No. 2 on Reader Service Card

TV CONVERTER

A new converter designed to eliminate double-image pickup in strong TV areas has been introduced as the "Imagicon".

The new unit converts CATV, MATV, and off-



the-air v.h.f. signals to an unused channel on the TV receiver to provide clear color or black-and-white TV picture reception. The basic unit consists of a transistorized TV tuner, a fixed-frequency converter, and a power supply. The tuner selects and converts any of the standard v.h.f. channels to 40 MHz. The fixed-frequency converter converts the 40-MHz signal to one unused channel, 12 or 13, through the output connection to the TV receiver. The TV receiver is left permanently tuned to one channel and channel selection is made at the Imagicon unit. Unwanted station signals, no matter how strong, cannot interfere with the picture reception. Standard Kollsman

Circle No. 3 on Reader Service Card

HANDY COLOR-TV SERVICE AID

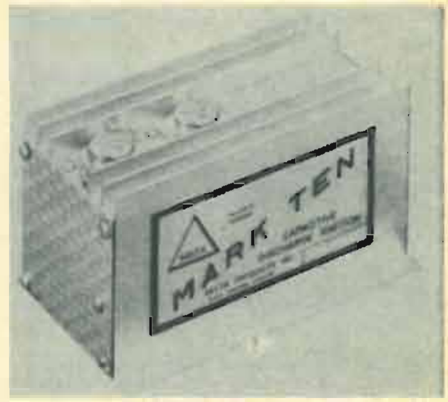
A "Color Viewer" that separates the three primary colors in a color-TV tube and magnifies them for easy analysis has been introduced as an aid to TV technicians. Measuring approximately 2" x 2" and equipped with a small handle, it is constructed from a portion of a picture tube shadow mask.

In use, the technician places the viewer on the picture tube face plate and rotates it until the dot pattern achieves the desired magnification of individual colors. The "Color Viewer" is especially useful in visually demonstrating the need for repair or adjustment to the color-TV set owner. Sylvania

Circle No. 4 on Reader Service Card

CD IGNITION SYSTEM

A new capacitive-discharge ignition system which is designed to increase mileage, cut point



and plug wear, and provide improved engine performance and acceleration, is now available in both kit and assembled versions.

The "Mark Ten" installs in minutes on any car, jeep, truck, camper, farm vehicle, or competition racer by attaching to coil terminals without any change in wiring or components.

In operation, voltage is stored in a capacitor until needed. Applied battery voltage converts from 12 volts to 400 volts by means of the converter circuitry. This power supply delivers full energy to the capacitor at engine speeds over 8000 r/min.

Full details on both versions of the CD ignition system will be forwarded upon request. Delta Products

Circle No. 5 on Reader Service Card

INDUSTRIAL INSPECTION KIT

The "Major Kit" is a new, wide-range industrial inspection kit used for close examination of equipment not normally accessible to the naked eye. The kit consists of an assortment of varying length probes into which are fitted miniature electric lamps and lenses. When used in conjunction with the kit's adjustable mirrors and magnifying fittings, illumination and inspection of the most inaccessible spots through the smallest apertures becomes possible.

The kit can be used for the inspection of waveguides, cavities, pumps, dies, valves, printed-circuits, small motors, relays, and other electronic components. All 21 working elements in the kit are interchangeable and interlocking. All are housed in a fitted, black hardwood case.

Further information and a spec sheet will be forwarded on request. Jensen Tools

Circle No. 6 on Reader Service Card

HUMIDITY-PROOF TRIMMER

A humidity-proof $\frac{3}{8}$" square trimmer which performs to the requirements of MIL-STD-202B is now available as the Model 3610.

The square design of the trimmer permits a longer mandrel than is used in a rectangular trimmer with up to 131% better resolution, according to the company. The unit can be specified for any circuit requiring a maximum temperature of 125° C and a power rating of 0.5 watt at 40°C. The PC pins of the 3610 fit the cards of any standard 3/8" or 1/2" square trimmer. It is only 0.200" high for low card space applications. Resistances are available from 100 to 20,000 ohms.

A slide-rule type selection guide covering the company's line of wirewound and metal-film trimmers and a data sheet on the 3610 are available. Amphenol Controls

Circle No. 129 on Reader Service Card

REGULATED D.C. SUPPLY

A compact, three-in-one supply, the Model KG-664, is now available in either kit or assembled form.

The unit serves as a "B+", filament, and d.c. supply to meet the need for the multiple voltages required in circuit development, test, and repair. It delivers 0-400 volts of regulated d.c. power at up to 200 mA continuously; 0-100 volts d.c. at 1 mA regulated for line variation, plus 6.3 volts a.c. at 6 A and 12.6 volts a.c. at 3 A for filament supply voltages. Two front-panel meters continuously monitor voltage and current.

The circuit combines tubes and semiconductors and quality components are used throughout. The specially designed voltage regulation circuitry permits less than 1% variation in output voltage from no load to full rated load. Input regulation allows less than 1% variation for ±10 volts variation at 120-volt a.c. input. High voltage output provides 8-watt capacity. There are ten isolated 5-way binding posts on the front panel to provide maximum flexibility in ground polarity connections.

The unit measures 7 3/4" x 14 3/4" x 9 3/4" and is designed for 110-130 volts, 50-60 Hz. Allied Radio

Circle No. 7 on Reader Service Card

SHIELDED MATCHING TRANSFORMERS

A new line of low-level shielded matching transformers, designated as the M-S series, has just been announced.

These transformers are of double high-nickel alloy shielded to provide approximately 65 dB of shielding to minimize stray magnetic pickup. They are available in a wide range of impedances for applications such as chopper, microphone, and line-matching.

Designed for miniaturized equipment, the transformers are 1 17/32" high x 1 1/16" in diameter and weigh only 3 ounces. Although developed primarily for industrial applications, they meet MIL-T-27B Grade 6 Class R requirements. Microtran

Circle No. 130 on Reader Service Card

ALPHA-NUMERIC READOUT

The "Alpha-Lite" is a microminiature, modular, multi-filament, alpha-numeric readout display with added features for greater versatility. In addition to the initially developed units with pigtail leads, the "Alpha-Lite" is now being produced with a microminiature plug-in termination allowing for mixed use with modular "Midgi-Lites". Separate plug-in decimal point units are available in all "Midgi-Lite" sizes.

Character height is only 1/4", over-all depth is 5/16", and over-all height is 3/8". Width of the Model 43 "Alpha-Lite" is 0.335" while the Model 04-30 "Midgi-Lite" is only 0.275". Each "Alpha-Lite" contains a complete alphabet, complete digit, and numerous symbols.

Further information on both standard and custom models in the line is obtainable on request. Pinlites

Circle No. 131 on Reader Service Card

RECHARGEABLE "D" CELL

A "D" size rechargeable sealed silver-zinc cell for use in industrial and consumer products has just been developed.

The SPD-5 "Spiracel" has a wide range of applications because of its higher ampere-hour capacity and energy than any other type of rechargeable "D" cell and because it maintains its capacity over a long cycle life, according to the company. The cell is capable of hundreds of discharge—recharge cycles when charged at an overnight rate, with each charge yielding more than two and a half times the energy density of an ordinary nickel-cadmium "D" cell. Yardney

Circle No. 8 on Reader Service Card

SILICON POWER TRANSISTORS

The 2N4348 "n-p-n" silicon power transistor is now available in production quantities. Essentially a high-voltage version of the 2N3772, the 2N4348 meets all JEDEC registered parameters and, in addition, is given a free-air power test of 150 watt-seconds as a production test. The pulse power test insures full power capabilities without secondary breakdown throughout the active region.

Housed in the TO-3 package, the transistor is suitable for use in computers, power supplies, audio systems (mono and stereo), and wherever reliable high power characteristics are required. A spec sheet giving full characteristics will be forwarded on request. Solitron

Circle No. 132 on Reader Service Card

POWER SUPPLIES FOR IC's

A response to overvoltage of less than 10 μs is featured in a new series of power supplies for integrated circuits recently introduced.

Features of the new WRE Series include adjustable overvoltage protection, output resolution as

low as 1.4 millivolts, and the absence of "on-off" overshoot. The supplies are highly regulated.

Five models are available. Two are 10-volt modular units with amperage of either 0-2.2 or 0-3.7. The others are 7.5-volt bench or rack units with amperage of 0-10, 0-20, or 0-50. Voltage regulation (line and load combined) is $\pm 0.005\%$ or ± 0.2 millivolts for the modular models and $\pm 0.01\%$ or ± 0.4 millivolts for the bench or rack models. Output resolution is typically 28 millivolts for the modular units and 1.4 millivolts for the bench units. Raytheon/Sorensen

Circle No. 133 on Reader Service Card

DIGIT DISPLAY MODULE

The new Model D-100 low-cost digit display module is designed for use in high-speed electronic counters and readouts. The unit accepts four-line BCD input code for single digit display on a neon glow tube. The module comes complete with rectangular end-view tube.

The compact design of the D-100 makes it readily adaptable as a building block for computer input/output, numerical control displays, and a wide range of digital instrumentation requirements. Offering monolithic integrated circuitry, an encapsulated package, and printed wiring with etched connections, the units are physically and electronically interchangeable with competitive models. They operate on a supply of 4.75 to 7 volts and 200 volts for tube anodes. Integrated Circuit Electronics

Circle No. 134 on Reader Service Card

INDUSTRIAL TRIMMER

A new commercial/industrial wirewound trimmer which stands less than a quarter-inch above the PC board is now available. A special cover equips these single-turn devices for either instant fingertip or screwdriver control.

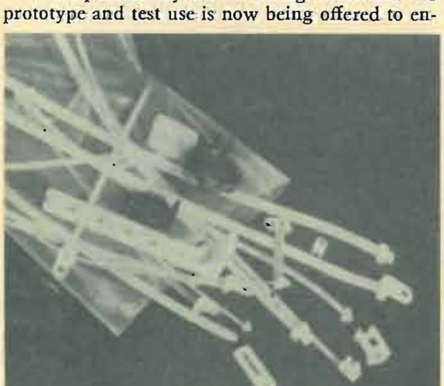
Lightweight phenolic cases with molded-in terminal pins resist adverse effects of automatic soldering and subsequent board cleaning. Standard printed-circuit spacing is used for the terminals.

Designated Type 500, the new trimmers are rated 0.5 watt at 25°C and are available in all standard intermediate resistance values from 10 ohms to 50,000 ohms $\pm 10\%$. IRC

Circle No. 135 on Reader Service Card

WIRING ACCESSORY KIT

A complementary kit of wiring accessories for prototype and test use is now being offered to en-



gineers. The kit contains samples of the six sizes of self-locking "Sta-Strap" cable ties, including the new intermediate unit for diameters up to 1¼" and the new extra-long, heavy-duty strap for diameters to 8". Also in the kit are "Pan-Rings" for automatically threading the straps into their self-locking heads.

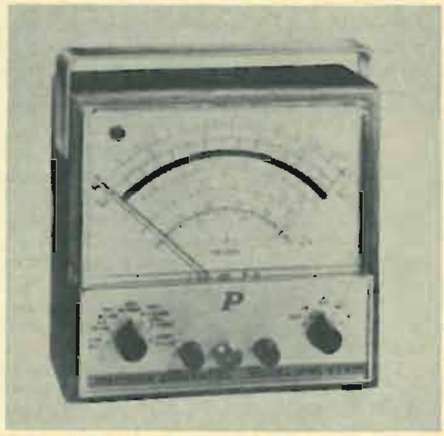
Other products in the kit are "Pan-Poles" for stand-off wiring, adhesive mounts, clamps, identification markers, and connector rings. Panduit

Circle No. 136 on Reader Service Card

PROFESSIONAL V.T.V.M.

The new professional v.t.v.m., Model V-95, incorporates an exclusive solid-state power supply replacing the batteries normally required in a v.t.v.m.'s ohmmeter section.

Features include a rugged 7" meter movement with mirrored scales to eliminate parallax; specially calibrated scales for reading low-voltage



measurements during transistor analysis in the 0.5, 1, 1.5 and 5-volt ranges; and simplified peak-to-peak and dB scales.

Complete specifications on the V-95 will be forwarded on request. Precision Apparatus

Circle No. 9 on Reader Service Card

HI-FI—AUDIO PRODUCTS

TURNTABLE PACKAGE

The McDonald 500 automatic turntable is now being offered in combination with an Empire 808 cartridge and a walnut finished base/plastic dust cover as the 500/808 package.

Not only is the cartridge fitted and tested but the turntable is mounted on the base ready for immediate use. The new package offering is designed to save time and trouble for audiophile and dealer alike. BSR

Circle No. 10 on Reader Service Card

SLOW-SPEED TAPE

A new slow-speed, low-noise, audio-range magnetic tape featuring the "Crystalined" process is being marketed as the "Star Series".

The new tape has been especially designed for stereo tape recorders by providing extended frequency response and dynamic range, improved signal-to-noise ratio, and high fidelity. It is being offered on 1.5-mil acetate, 1.5-mil Mylar, and 1-mil Mylar base materials on 5" and 7" reels. The tape has a colored leader and trailer on each reel. Greentree

Circle No. 11 on Reader Service Card

80-WATT AM-FM RECEIVER

A new all-silicon, 80-watt AM-FM receiver is now on the market as the Model S-7600-FET.

Among the features of this new receiver is a low-distortion linear FM detector which was especially designed for the set; selected field-effect transistors in the r.f. and mixer stages to provide —95 dB of cross-modulation rejection; and 1.8-μV FM sensitivity.

The Model S-7600-FET will deliver 80 watts of IHF dynamic power to two pairs of 8-ohm speakers. Front-panel rocker-action switches permit the two pairs to be played independently or simultaneously. Dynamic power is 80 watts at 4 ohms and 50 watts at 8 ohms. Power bandwidth is 12-35,000 Hz.

Available for custom mounting, or in a walnut-grained leatherette case, the receiver measures 15½" x 12" x 4½" high. Full technical specs are available on request. Sherwood

Circle No. 12 on Reader Service Card

PORTABLE 4-TRACK STEREO UNIT

The Sony Model 230 "Stereo Compact" is a completely portable 4-track stereo record and playback system featuring a built-in solid-state stereo control center, with amplification providing 20 watts of total dynamic power.

The stereo control center has complete input and switching facilities for the connection of external hi-fi components to play through the 230's amplifier and speaker system. The unit has split speakers which form the carrying case lid. Each speaker is self-contained, having a tweeter and woofer in each unit. The speakers may be placed up to 15 feet apart.

The recorder provides three tape speeds, 7½, 3¾, and 1⅞ in/s; has a retractomatic pinch roller for threading ease; automatic end-of-reel shut off; and a digital tape counter. It also has two vu meters; a stereo headset jack; and includes two cardioid dynamic microphones. Superscope

Circle No. 13 on Reader Service Card

CASSETTE PLAYERS & RECORDERS

A new line of tape players/recorders for home and portable use has been introduced as the "Micro Series".

The new line includes stereo systems for the home and a battery-powered model for portable listening or recording—all employing cassettes. The "Micro 20" is a combination a.c.-d.c./battery-powered portable mono recorder in a case measuring 12½" x 8" x 2¾" and weighing 6 pounds. The "Micro 50" is a walnut encased stereo player/recorder deck designed for use with any stereo system. It has preamps and a power supply. All solid-state, it measures 14½" x 8¾" x 3½" and weighs 8 pounds.

The "Micro 85" is a complete system including a walnut encased player/recorder with dual power

amplifiers, preamplifiers, matching walnut speakers, and two omnidirectional microphones.

The cassettes measure only 4" x 2½" x ½" and record or play back for up to 90 minutes at 1⅞ in/s. The company is developing a recorded cassette line of more than 500 albums from 17 different labels which will be available by the end of the year. Ampex

Circle No. 14 on Reader Service Card

STEREO CARTRIDGE

The new 999VE professional stereo cartridge is capable of tracking 30 cm/s at less than 1 gram, according to its maker.

The cartridge features a 4-pole, 4-coil, 3-magnet design for maximum efficiency. Stereo separation is 30 dB at 1000 Hz and as much as 20 dB at 20,000 Hz. Compliance is 30 x 10^{-6} cm/dyne for wide excursion bass notes.

The cartridge has an all-diamond stylus which is ground, lapped, polished, then inspected 14 times. Empire

Circle No. 15 on Reader Service Card

REEL-CHANGING RECORDER

A new tape recorder with an automatic reel changing mechanism that allows up to five reels of pre-recorded tape to be stacked on a spindle and played in automatic sequence has just been announced as the Sony Model 760.

In addition to the reel changing mechanism, the new recorder features automatic reel threading, automatic reel reversing, and the ejection of the completed reel after hoth sides have been played. The new unit will handle reels from 3" to 7" in diameter which may be intermixed. There are also solenoid push-button controls for manual operation.

The solid-state 760 is a deck model operating at $7\frac{1}{2}$, $3\frac{3}{4}$, and $1\frac{7}{8}$ in/s. It will be marketed in two

versions: one for playback only and the other for recording and playback. Superscope

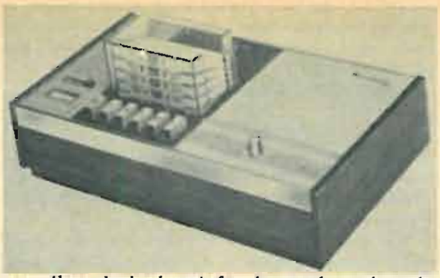
Circle No. 16 on Reader Service Card

CASSETTE CHANGER

Among the new items which have been recently announced is an automatic cassette changer, the Model 2502.

An a.c. stereo playback unit, the 2502 provides up to $4\frac{1}{2}$ hours of continuous music and is designed to be used in conjunction with existing hi-fi systems. It permits loading up to six cassettes for playback. Eech is successively dropped into playing position and, when completed, automatically moves into a storage compartment within the teak cabinet. The low-profile unit has push-button controls, a pilot light, and digital counter.

Other items in the new line are the Model 2500, a single-play a.c. stereo playback unit; the 2200,



a cordless playback unit for the youth market; the 2600, a stereo cassette player for cars; the "Continental 175", a battery-operated portable mono cassette recorder; and the Model 4408, a three-speed, four-track stereo recorder. Norelco

Circle No. 17 on Reader Service Card

FLUTTER METER

An all-solid-state flutter meter which makes precision r.m.s. measurements on any magnetic tape recorder has been announced as the Model 398.

The internal oscillator develops a 3-kHz refer-

ence tone which is recorded on tape. Speed variations (flutter) in the recorder's drive mechanism is then sensed during playback by the unit's high-sensitivity pulse averaging discriminator and displayed on a large dual-range panel meter. A pre-calibrated scope output permits viewing the flutter waveform directly. Video Research

Circle No. 18 on Reader Service Card

90-MINUTE TAPE CASSETTE

The new C-90 tape cassette contains 450 feet of BASF recording tape and can be played for a full hour and a half (45 minutes in each direction). The cassette is designed to be used with General Electric, Norelco, Wollensak, and all other compatible cassette recorders. Computron

Circle No. 19 on Reader Service Card

AMPLIFIED HEADPHONES

Two new amplified headphones have just been introduced as the "Amplitwin" and the "Amplitone."

The high-fidelity "Amplitwin" is a stereo headphone with separate amplifiers in each ear cup. Each amplifier features a volume control and has a low-level and a high-level input. Two shielded cords with phono jacks are included. The amplifiers operate on 9-volt transistor radio batteries. The "off" switch preserves battery life and converts the unit to a conventional headphone.

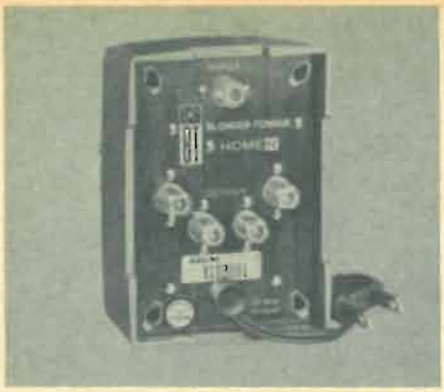
The "Amplitone" is a guitar headset which is offered in either mono or stereo versions and provides private listening for the teen set. Telex

Circle No. 20 on Reader Service Card

POWERED SPLITTER

A new solid-state amplified splitter, called the "Homer", is designed to improve FM or TV reception on up to four sets operating from a single antenna. The new unit incorporates a unique inductively coupled emitter feedback circuit on which a patent is pending.

The new circuit delivers the maximum dynamic



range from the transistor used and is said to be effective in defeating cross-modulation, harmonic interference, windshield-wiper effect, hash, herringbone, and beat patterns. Interset isolation is 14 dB.

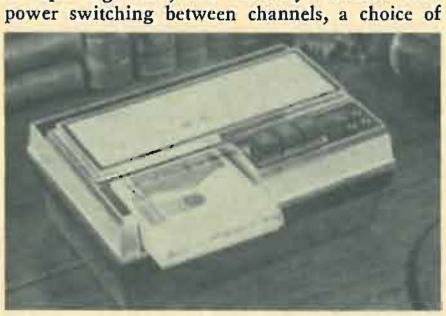
According to the company, the amplified splitter nearly triples TV or FM signals (9 dB) when operating two sets from a single antenna and doubles the signal (6 dB) gain with four sets. Blonder-Tongue

Circle No. 21 on Reader Service Card

CARTRIDGE TAPE PLAYER

A stereophonic cartridge tape player which incorporates six exclusive features has just been introduced as the TP-8.

The new features include an automatic tape insertion and locking device, straight-line vertical movement of the tape head, dual guides for proper tape alignment, and virtually noiseless low-power switching between channels, a choice of



continuous play or automatic shut-off after the fourth channel, and an unlocking device which prevents cartridge damage by automatically releasing pressure when the player is not operating.

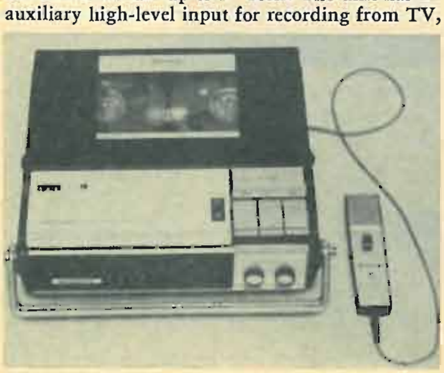
The solid-state cartridge player weighs 7 pounds and measures 10" x 7" x $4\frac{1}{2}$". It is designed to play 8-track stereo cartridges through external speaker systems. Sylvania

Circle No. 22 on Reader Service Card

BATTERY/A.C. TAPE RECORDER

The Sony "ServoControl 860" is a solid-state battery/a.c. portable recorder which incorporates a special motor that electronically corrects for speed variations and maintains precise timing accuracy.

The dual-track 860 works on household a.c. current or flashlight batteries, without the need for an adapter. It operates at $3\frac{3}{4}$ and $1\frac{7}{8}$ in/s and can accommodate up to 5" reels. The unit has an auxiliary high-level input for recording from TV,



telephone, radio, or other high level sources, as well as a digital tape counter, push-button controls, and a remote stop/start microphone. Superscope

Circle No. 23 on Reader Service Card

TAPE-RECORDER LINE

Five new reel-to-reel tape recorders, two cassette models, plus compatible 4 & 8 track and straight-8 car stereo tape players have been recently introduced.

The portable cassette tape recorder, the Model 2602, features keyboard controls, automatic level control, provision for voice actuation, pop-up button for easy cassette ejection, and a no-erase safety lock for pre-recorded cassettes. The unit is battery operated and is equipped with a battery life indicator and a.c. adapter jack. Craig Panorama

Circle No. 24 on Reader Service Card

CB-HAM-COMMUNICATIONS

MOBILE/PERSONAL CB UNIT

An all-solid-state CB transceiver, designed to be used in all types of mobile and personal applications, is being marketed as the "Pace-Mate".

This 3-channel, 2-watt transceiver features a double-conversion superhet receiver teamed with a rugged all-silicon transistor transmitter. There is a six-section tuned i.f. filter for maximum adjacent-channel rejection, shaped push-pull audio design for sharp voice reproduction, automatic noise limiting and tapered squelch control for quiet operation, and a full stage automatic gain control.

The unit comes equipped with a detachable helical coil antenna, a "snap-back" power pack for operation on penlight cells, or rechargeable "Nicad" pack. The transceiver measures $2\frac{3}{4}$" x $1\frac{3}{4}$" x $7\frac{3}{4}$" and weighs $1\frac{1}{4}$ pounds. Pace

Circle No. 25 on Reader Service Card

MARINE CB ANTENNA

A new high-performance, omnidirectional marine CB two-way antenna with an exceptionally low angle of radiation for maximum over-water range is now being marketed as the ASM-23 "Sea-Hook".

The 27-MHz antenna is a full electrical half-wave radiator with an over-all length of 97 inches. It has a cycolac base with a built-in foldover feature which allows instant retraction of the antenna when negotiating bridges or other low obstacles.

No ground plate is required since link-coupling is employed, thus simplifying installation. All critical parts are solid brass with chrome plating for additional protection. The loading coil is precision wound and enclosed in white weatherproof plastic with chrome-plated end caps. Impedance is 50 ohms and v.s.w.r. is said to be better than 1.5:1. Antenna Specialists

Circle No. 26 on Reader Service Card

MOBILE TRANSCEIVER WITH IC's

The new 23-channel Model HB-525C mobile transceiver features integrated circuits for high sensitivity and low power drain. A frequency synthesizer includes crystals for all 23 CB channels. The dual-conversion receiver has a 455-kHz mechanical filter, 3-position delta tuning, series-gate noise limiting, and variable squelch circuits.

The full 5-watt-input transmitter uses range-boost modulating stages to increase effective talk power and offers full public address provisions with input and output jacks. A built-in 3" x 5" speaker with directive louvered grille provides clean, clear sound reproduction.

The transceiver operates on 12 volts d.c., negative or positive ground. Three optional power supplies permit operation on 117 volts a.c., 6 volts d.c., or as a portable battery-operated unit. The unit measures $2\frac{3}{8}$" x $6\frac{1}{2}$" x 8" and comes with a mounting bracket, fused power cable, and push-to-talk microphone. Lafayette

Circle No. 27 on Reader Service Card

ANTENNA MATCHING NETWORK

The new "CB Matcher" provides a v.s.w.r. of

1.1:1 when inserted between the antenna and a CB transmitter. For calibration, a bridge or meter can be inserted between the transmitter and matching network and can be left in the line if desired.

Finished in black and gold, the "CB Matcher" measures $1\frac{3}{4}$" x $2\frac{1}{4}$" x $3\frac{3}{4}$" over-all. Gold Line

Circle No. 28 on Reader Service Card

25-50 MHz TRANSCEIVER

The "Broadcaster I" is a completely solid-state transceiver for the 25-50 MHz land mobile radio service for either mobile or base station use.

The transceiver measures $5\frac{3}{4}$" wide x 2" high x $7\frac{3}{4}$" deep. Current drain from a 12-volt d.c. power source ranges from 30 mA to $\frac{1}{2}$ A when receiving and only 1 A when transmitting.

The receiver employs a four-element crystal filter in a double-conversion superhet circuit. Sensitivity is better than 1 μV for 12 dB S+N/N;

the 6-dB bandwidth is 6 kHz and selectivity is better than 50 dB down at $\pm$8 kHz of center frequency. Image and spurious rejection is greater than 70 dB. Audio output is 3 watts.

Full technical specifications will be provided on request. Unimetrics

Circle No. 29 on Reader Service Card

COMPACT CB RIG

A new 5-channel solid-state CB transceiver has just been introduced as the TR-5. Measuring a compact $5\frac{3}{4}$" x $6\frac{1}{4}$" x $1\frac{7}{8}$", the transmitter uses silicon transistors which have been especially manufactured to a higher peak voltage than before. The TR-5 features zener diode protection, 100% modulation, an illuminated channel selector, transmit indicator, auxiliary speaker jack, single-knob tuning, a modulation indicator, and a special "safety circuit" to protect against mismatched antenna, incorrect polarity, and overload. Courier

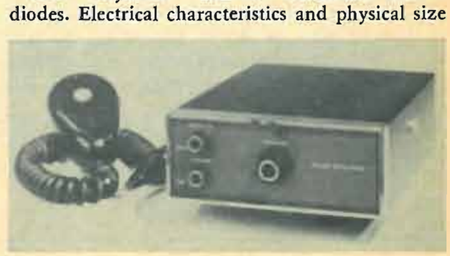
Circle No. 30 on Reader Service Card

CB TRANSCEIVERS

Two new CB transceivers have been introduced recently as the "Skylark", an 11-channel unit and the "Skyhawk Mark II", a 23-channel model.

The "Skylark" employs all-solid-state circuitry, tantalum capacitors, filtered power leads, glass epoxy circuit board, zener diode voltage regulator, and an enclosed plug-in relay. It is equipped for use as a paging system and an external speaker jack is provided. It measures $2\frac{5}{8}$" x $6\frac{1}{2}$" x $9\frac{1}{4}$" and weighs 7 pounds.

The "Skyhawk" uses 25 transistors and 9 diodes. Electrical characteristics and physical size



are the same as for the "Skylark" except that it has 23-channel capability. Both models are available with a choice of colored front panels. Kaar
Circle No. 31 on Reader Service Card

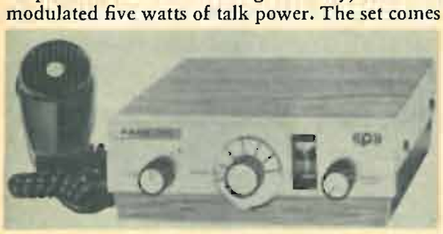
PORTABLE FM TRANSCEIVER

The Model HH-300 is a hand-held portable v.h.f. FM transceiver designed for service in the 132-174 MHz band. Completely solid-state and weighing only 30 ounces, the new transceiver has a carrier power of more than 2 watts and offers five separate crystal-controlled channel capability.

Other features include continuous tone squelch, plug-in circuit modules, rechargeable quick-change nickel-cadmium battery, and various optional accessories. The unit is completely waterproof. Du Mont/Gonset
Circle No. 32 on Reader Service Card

SIX-CHANNEL CB UNIT

A new solid-state, six-channel mobile CB radio with built-in "S" meter is now available as the Model 100. This low-cost transceiver has a double-conversion receiver for maximum sensitivity, coupled with noise limiting circuitry, and full modulated five watts of talk power. The set comes



equipped with the channel-11 crystal installed. Up to five more channels may be added for business or personal use.

Designed specifically for mobile use, the Model 100 is packaged in a walnut-grained metal case with polished chrome front panel. The all-silicon circuit is mounted on a glass fiber circuit board. Pace
Circle No. 33 on Reader Service Card

MANUFACTURERS' LITERATURE

MEASURING FM

A new 17-page application note (No. 87) describing the many ways that wide-band FM discriminators can be used for the measurement of FM and PM has been published.

The illustrated booklet covers basic frequency-modulation theory and discusses a wide range of discriminator applications, including direct FM, down-converted FM, measurement of small deviations and flutter, swept-frequency measurement, and signal bursts and chirped pulses.

Featured in the note is a complete description of the company's Model 5210A/B frequency meter/FM discriminator, along with accessories and other instruments suitable for use with the meter/discriminator. Hewlett-Packard
Circle No. 137 on Reader Service Card

SPEAKER SYSTEMS

A new 6-page illustrated brochure on a line of high-fidelity loudspeakers has been issued. Featured are the Cornwall, Heresy, and Model H designs, along with the La Scala system intended for theater and commercial use.

Included in the booklet is an insert price list, which contains an extensive bibliography of papers and articles on loudspeakers and related topics. Klipsch
Circle No. 34 on Reader Service Card

ELECTROLYTIC CAPACITORS

Complete technical specifications on the new Types MTA and MTV molded aluminum electrolytic capacitors are contained in a new 12-page illustrated bulletin (No. 4-74B). Included are performance characteristics, typical life test data, dimensional drawings, and a size and rating chart. Mallory
Circle No. 138 on Reader Service Card

TEST EQUIPMENT

Described and illustrated in a new 8-page quick-reference catalogue (No. 67D) is a complete line of electronic test equipment. Included are color-bar generators, CRT testers, oscilloscopes, signal and sweep generators, transistor and tube testers, v.o.m.'s, and v.t.v.m.'s. Hickok
Circle No. 35 on Reader Service Card

PRINTED CIRCUITS

A new 12-page illustrated booklet entitled "A Buyer's Guide to Printed Circuits" has been made available. Covered in detail are the specific steps followed by the company in production planning and actual fabrication, along with a discussion of cost and the numerous factors affecting it. Lockheed Electronics
Circle No. 139 on Reader Service Card

COMPONENTS CATALOGUE

A wide line of miniature devices, including electronic switches, remote-control relays, readout indicators, pilot lights, and ceramic terminal strips, is presented in a new 12-page illustrated catalogue.

Entitled "Design Ideas for Engineers," the booklet contains complete specifications for all products listed. Alco
Circle No. 140 on Reader Service Card

SILICON TRANSISTORS

A new 16-page product selector for industrial small-signal devices has been published. Listed in the booklet are r.f. and i.f. amplifiers, oscillators, saturated switches, general-purpose and differential amplifiers, and diodes.

Included in the publication is a complete listing of the more than 800 different 1N and 2N silicon diodes and transistors manufactured by the company. Fairchild Semiconductor
Circle No. 141 on Reader Service Card

CONNECTOR CATALOGUE

Described and illustrated in a new 12-page catalogue (No. 4-674) is a line of miniature high-voltage r.f. coaxial-cable connectors, receptacles, and adapters.

The booklet also contains a cable and cross-reference chart, mounting diagrams, and a detailed description of cabling procedures. Kings Electronics
Circle No. 142 on Reader Service Card

SEMICONDUCTOR CATALOGUE

A new 57-page semiconductor catalogue (No. 640:13) has been made available. Included are silicon economy transistors, tunnel diodes, SCR's, triacs, and thyrectors.

In addition, the catalogue contains a listing of available application notes and reprints from technical journals covering general applications for signal and power semiconductors, SCR and test circuits, tunnel diode and unijunction applications, and transistor circuits. General Electric
Circle No. 143 on Reader Service Card

READOUT DEVICES

A complete line of single-plane rear-projection readout devices is described and illustrated in a new 44-page catalogue (No. 202). Units range in size from the microminiature Series 345 through the Series 80 which is capable of displaying characters 3⅜ inches high.

In addition, the catalogue discusses operating principles and lamp selection. IEE
Circle No. 144 on Reader Service Card

AEROSOLS FOR ELECTRONICS

A new "family" of aerosol products specially formulated for electrical and electronic manufacturing and maintenance is presented in a new 2-page data sheet.

The line includes cleaners, demoisturants, lubricants, and protective and insulating coatings, as well as such special-purpose items as a circuit cooler, an anti-static spray, and a cutting fluid. Sprayon
Circle No. 145 on Reader Service Card

MICROPHONE CATALOGUE

A complete line of dynamic, dynamic cardioid, and ceramic microphones is described and illustrated in a new 12-page catalogue. Featured in the booklet, entitled "A Microphone for Every

Purpose," is the new slim-line DM70 series for taping, p.a. systems, and music combos.

Also included is a listing of accessories and replacement parts. Sonotone

Circle No. 36 on Reader Service Card

POTENTIOMETER SELECTOR

A handy reference guide for selecting potentiometers to meet specific voltage-measuring requirements is now available. Listed on the pocket-sized plastic card are ranges, accuracies, resolutions, and thermal characteristics of the company's laboratory and portable potentiometers. Honeywell

Circle No. 146 on Reader Service Card

ELECTRONIC HARDWARE

A complete line of electronic hardware is described and illustrated in a new 88-page 1967 engineering standards manual. Included are terminal boards, and tube retainers.

Highlighted is an 8-page section devoted exclusively to self-punching components. USECO

Circle No. 147 on Reader Service Card

STANDARD CONNECTORS

Complete specifications on more than 50 types of standard connectors are contained in a new 180-page illustrated handbook. Listed are miniature, subminiature, environmental, and removable crimp/solder contact rectangular connectors; subminiature and miniature round devices; printed-circuit connectors, including wire-wrap; and special-application types, including underwater, tube sockets, and relay sockets. Winchester

Circle No. 148 on Reader Service Card

IMPEDANCE MEASUREMENT

Presented in a new 11-page illustrated application note (No. 77-3) are techniques for determining impedance ($R + jX$), referenced to 50 ohms, in the frequency range from 1 to 1000 MHz with the company's Model 8405A vector voltmeter.

The booklet covers basic theory, presents practical measurement examples, and discusses accuracy considerations. Hewlett-Packard

Circle No. 149 on Reader Service Card

RECHARGEABLE BATTERIES

Complete technical information in a line of sintered-plate rechargeable nickel-cadmium sealed battery cells is presented in a new 4-page illustrated brochure (No. BA-125).

Discharge and charging characteristics are given, along with a cutaway diagram explaining construction and a table listing the physical and electrical characteristics of 20 types of cells. Sonotone

Circle No. 37 on Reader Service Card

VARIABLE INDUCTORS

A new 16-page engineering handbook describing the new Type NV communications-grade variable inductors has been issued. Designed for circuit-board mounting, the devices have a recommended frequency range of 800 Hz to 100 kHz.

The illustrated booklet (No. 5103) gives nominal inductance values, tuning ranges, and d.c. resistances for several hundred standard versions of the Type NV. In addition, the publication contains mounting diagrams, performance curves, and several pages of technical information. Sangamo

Circle No. 150 on Reader Service Card

TV PICTURE TUBES

Technical information on 750 types of black-and-white and color-TV picture tubes is contained in a new 42-page illustrated reference book. Included are comparisons of various picture-tube protection systems, basing diagrams, interchangeability data, and information on the handling of picture tubes. Sylvania

Circle No. 38 on Reader Service Card

TAPE RECORDING

A new 16-page combination catalogue and tape-recording handbook is now available. Entitled "The Tape Recording Omnibook," the illustrated booklet discusses tape-recorder uses, such as sound for slides and home movies, tape correspondence, and learning a language; how to select a tape recorder; tape splicing, editing, and handling; selection of a microphone and microphone characteristics; and how to get the most out of a tape recorder.

The catalogue portion of the handbook lists various Revox, Editall, and Beyer products. Elpa Marketing

Circle No. 39 on Reader Service Card

INDUSTRIAL FASTENERS

Described and illustrated in a new 36-page catalogue is a broad line of plastic and metal industrial fasteners. Applications include shelf supports in refrigerators, locks in electronic equipment and carrying cases, devices for joining removable panels, and pressure-tight fasteners for missile containers.

Complete mounting, installing, and securing instructions are provided for all products listed. Simmons

Circle No. 151 on Reader Service Card

MEASURING VIBRATION

A new 24-page illustrated catalogue (No. 797-J) that describes a line of sound- and vibration-measuring equipment and accessories has been released.

Among the new instruments presented in the booklet are a tape data recorder, a sound-level calibrator for instrument microphones, and a 1%-bandwidth wave analyzer. Other devices listed include sound-level meters, an impact-noise analyzer, a graphic level recorder, and a motion analyzer and tachometer. General Radio

Circle No. 152 on Reader Service Card

PHOTO CREDITS

Page	Credit
16	Allied Radio Corporation
23	NASA
24, 25 (top & center)	U.S. Air Force Photo
25 (bottom)	Pan American World Airways
28 (top), 29 (bottom left)	RCA Laboratories
28 (center)	IBM
28 (bottom)	Westinghouse Electric Corp.
29 (top)	Steel Products News Bureau
29 (center)	3M Company
29 (bottom right)	Sylvania Electric Products Inc.
33	Kahl Scientific Instrument Corp.
34	Hydro Products
35	Barnes Engineering Co.
36	Sippican Corp.
76	Ercona Corp.
95	Hewlett-Packard

Answer to Crossword Puzzle appearing on page 81

I	N	D	U	C	T	I	O	N		N	E	P	E	R
N		I		H		D	C			A	D	O		E
S	I	G	N	A	L		T	A	C	T		T		L
U				S		L	O	G		U	S	E		A
L	E	A	D	S			D	O	O	R		N		Y
A			O	I	L		E			A	N	T	E	
T	R	E	E	S		L		B	E	L		I		R
O		L			S	O	S		A		T	A	P	E
R	H	E	O	S	T	A	T		R	C		L		S
		C	R		A	D	A	M		L			N	O
D	E	T	E	N	T		I		P	I	S	T	O	N
R		R		A	E	O	N			M	A		D	A
A	B	O	H	M		V			M	A	G	N	E	T
I		D	U	E		E		I		T		E		O
N	E	E	D	S		R	E	F	L	E	C	T	O	R

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 70¢ per word (including name and address). Minimum order $7.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.
READER RATE: For individuals with a personal item to buy or sell. 40¢ per word (including name and address). No Minimum! Payment must accompany copy.
GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publication, 6556 W. Higgins Rd., Chicago, Ill. 60656.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 5577, Riverside, Calif. 92507.

INVESTIGATORS, FREE BROCHURE, LATEST SUBMINIATURE ELECTRONIC SURVEILLANCE EQUIPMENT. ACE ELECTRONICS, 11500-J NW 7TH AVE., MIAMI, FLA. 33168.

R.F. CONVERTERS World's largest selection. Also CCTV cameras, etc. Lowest factory prices. Catalog 10¢. Vanguard, 196-23 Jamaica Ave., Hollis, N.Y. 11423.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

FREE ELECTRONICS (new and surplus) parts catalog. We repair multimeters. Bigelow Electronics, Bluffton, Ohio 45817.

DETECTIVES! Free brochures! Electronic Surveillance devices. **SILMAR ELECTRONICS,** 3476 N.W. 7th Street, Miami, Florida 33125.

MUSIC LOVERS, CONTINUOUS, UNINTERRUPTED BACKGROUND MUSIC FROM YOUR FM RADIO, USING NEW INEXPENSIVE ADAPTOR. FREE LITERATURE. ELECTRONICS, 11500-Z NW 7th AVE., MIAMI, FLORIDA 33168.

SURVEILLANCE EQUIPMENT—NEW HIGH PERFORMANCE SUBMINIATURE MODELS. ELECTRONIC COUNTERMEASURE DEVICES TO PROTECT PRIVACY. FREE DATA: SECURITY ELECTRONICS-EW, 15 EAST 43RD STREET, NEW YORK, N.Y. 10017.

CRYSTALS . . . largest selection in United States at lowest prices. 48 Hr. delivery. Thousands of frequencies in stock. Types include HC6/U, HC18/U, FT-241, FT-243, FT-171, etc. Send 10¢ for catalog with oscillator circuits. Refunded on first order. Jan Crystals, 2400E Crystal Dr., Fort Myers, Fla. 33901.

JAPANESE PRODUCTS CATALOG by air mail $5, sea $3. Intercontinental, CPO 1717, Tokyo, Japan.

TREASURE HUNTERS! Prospectors! Relco's new instruments detect buried gold, silver, coins. Kits, assembled models. Transistorized. Weighs 3 pounds. $19.95 up. Free catalog. Relco-A22, Box 10839, Houston, Texas 77018.

ELECTRONIC PARTS! Components, transistors, diodes, kits, relays, and many special items. Guaranteed. Send 25¢ for 100 page catalog. General Sales Co., P.O. Box 2031, Freeport, Texas 77541.

MESHNA'S TRANSISTORIZED CONVERTER KIT. Converts car radio to receive police and fire. 30-50MHz and 100-200MHz. (one MHz Tuning) $5.00 with easy to follow step instruction. Meshna, No. Reading, Mass. 01864.

ELECTRONIC Ignition. Kits, components, systems. Diagrams. Anderson Engineering, Epsom, N.H. 03239.

METAL-TREASURE Detectors, transistorized, lightweight. $39.95 to $89.95. Free Catalog. **JETCO INSTRUMENTS,** Box 2880-E, Huntsville, Texas 77340.

600 PIV @ 1.5 Amps. Tophats, includes bypass capacitors and resistors, 10 for $3.00 postpaid U.S.A. fully guaranteed. East Coast Electronics, 123 St. Boniface Rd., Cheektowaga, New York 14225.

DIAGRAMS, SERVICE MANUALS, $1. Technical Services Associates, Box 1167, Berkeley, California 94701.

ELECTRONICS ENGINEERING AND INSTRUCTION

REI First Class Radio Telephone License in (5) weeks Guaranteed. Tuition $295.00. Job placement free. **(KANSAS CITY) R.E.I.,** 3123 Gillham Road, Kansas City, Missouri, Telephone WE1-5444. **(SARASOTA) R.E.I.,** 1336 Main Street, Sarasota, Florida 33577, Telephone 955-6922.

HIGHLY—effective home study review for FCC commercial phone exams. Free literature! **COOK'S SCHOOL OF ELECTRONICS,** P.O. Box 36185, Houston, Texas 77036.

WANTED! TV—Radiomen to learn aircraft electronics servicing. Numerous job openings everywhere. Write: **ACADEMY AVIONICS,** Reno/Stead Airport, Reno, Nevada 89500.

ASSOCIATE Degree in Electronics Engineering earned through combination correspondence-classroom educational program. Free brochure. Grantham Technical Institute, 1505 N. Western Ave., Hollywood, Calif. 90027.

ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start September, February. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana 46383.

LEARN ELECTRONIC ORGAN SERVICING at home. All Makes including transistors. Experimental kit—troubleshooting. Accredited NHSC. Free Booklet. **NILES BRYANT SCHOOL,** 3631 Stockton, Dept. A, Sacramento, Calif. 95820.

HIGHLY effective home study course in Electronics Engineering Mathematics with circuit applications. Earn your Associate in Science Degree. Free literature. **COOK'S INSTITUTE OF ELECTRONICS ENGINEERING,** P.O. Box 36185, Houston, Texas 77036.

FCC LICENSE training by correspondence. Low cost, pay-as-you-go plan. Free particulars. The Willard Foundation, Department EW, P.O. Box 1049, Washington, N.C. 27889.

FCC First Class License in six weeks—nation's highest success rate—approved for Veterans Training. Write Elkins Institute, 2603C Inwood Road, Dallas, Texas 75235.

TUBES

RECEIVING & INDUSTRIAL TUBES, TRANSISTORS, All Brands—Biggest Discounts. Technicians, Hobbyists, Experimenters—Request FREE Giant Catalog and **SAVE! ZALYTRON** 469 Jericho Turnpike, Mineola, N.Y. 11501.

FREE ARCTURUS CATALOG
A trusted name in electronics since 1925
Electronic parts, tubes. Wholesale.
Thousands of items. Unbeatable prices.
ARCTURUS ELECTRONICS CO.
502-22nd St., Dept. EW, Union City, N.J. 07087

TUBES, SEMICONDUCTORS, ELECTRONIC EQUIPMENT & COMPONENTS. Quality merchandise only! Serving engineers, Purchasing Agents, TV/HiFi Servicemen and Hams for 20 years. Write for Catalog or call 212-WA 5-7000. **BARRY ELECTRONICS,** 512 Broadway, New York, N.Y. 10012.

TUBES—33¢ each. Year guarantee. Tuner Cleaner $1.09. Free catalog. Cornell, 4213-W University, San Diego, Calif. 92105.

DON'T BUY TUBES — Radio, TV-Xmitting, special-purpose types until you get our price list! Lowest prices in U.S.A. 5,000 types—Guaranteed Brand New. Send postcard for TV—Special Purpose Price List. **UNITED RADIO COMPANY, P.O. BOX 1000, NEWARK, N.J. 07101.**

GOVERNMENT SURPLUS

JEEPS Typically From $53.90. . . Trucks From $78.40. . . Boats, Typewriters, Airplanes, Electronics Equipment, Photographic Equipment, used. 100,000 Bargains Direct From Government. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). Surplus Service, Box 820-K, Holland, Michigan 49423.

RECTIFIERS, TRANSISTORS & COMPONENTS

6 tube Amplifier, New 4 lbs. ....2/$1.98
¼ Watt Resistors, asstd. 50/1.00
½ Watt Resistors, asstd. 60/1.00
2N4138 Sil. Chopper To-46 NPN 1.50
Precision Resistors, asstd. 50/1.00
Pots, 2-4 Watt, asstd. 15/1.00
2N1724 Sil. Pow. 50 W. 80 V. Stud. 1.50
2N1047B Sil. Pow. 80V. To-57 .... .60
Tantalum Capacitors, asstd. 10/1.00
2N1722 Sil. Pow. 50W. 80V. To-53 .... 1.45
2N2944 Sil. Chopper To-46 .... 1.00
50W. Zeners 10 to 19 Volts 1.00
Thermistor head, 1200 ohm. 2/1.00
2N1021, Ger. Power, 7amp, 100V., To —3.... .60
2N456A, 7A. 40V. Ger. Power To —3 .... .45
2N1718, Sil. Power, 10W., 60V., Heatsink 3/1.00
70 amp Stud. 50PIV—$2.50; 100PV....$3.50

SILICON CONTROLLED RECTIFIERS

AMPS.	300PRV.	400PRV.	500PRV.
7A.	1.50	2.05	2.75
16A.	2.15	2.65	3.25

Pots, 1W. 100K, or ½W. 500K, ...5/1.00
Surprise Kit, 10 lbs. components 2.50
Epoxy Hi-Vol diode, 200ma, 3000PIV .... .98
Computer Board, TO-3 Power, Heat Sink 1.00
I.C., TO-5, untested 5/100
I.C., Dual-inline, untested 10/1.00
2N389,85W 60 V. TO53 .... .79
2N3707-11 Asstd. Plastic Silicon Xisters 20/1.00
2N3704-3706, Asstd. Plastic Sil. Xisters 10/1.00
2N2151, Sil. Power Xister .... .65
2N1009 Ger. Min. Xister untested 30/1.00
3N35 Tetrode, NPN, untested 5/1.00
Ger. Diodes, Asstd. 15/100
2N458A, 7A. 80V. Ger. Power, TO —3 .... .55
Sil. Diodes, Switching, Signal, Asst. 15/1.00
2N118, Silicon, NPN 10/1.00
2N1149, Silicon, NPN, untested 20/1.00
2N1300, Untest. PNP & NPN, ¼" leads 25/1.00
2N1714, Silicon Power 10W, 60V. 4/1.00
Computer Boards, Parts Free, per transistor .... .05
Germanium Power, 2N457A, 7A; 60V .... .50
Silicon Power 40 W, 2N1047, TO-57 ....2/1.00
Tophats 750 ma., 200PIV-8¢, 400, 12¢ 600 PIV .18
1N34A 100/2.98
Varicaps, 27, 47, or 100 pf.... 1.25
2N1038, Germanium 20 W. 40 V 4/1.00

With any $10.00 Order any $1.00 item Free. On $25.00 order any (3) $1.00 items Free. Catalog.
Minimum order $3.00 plus postage, C.O.D.'s 25%
ELECTRONIC COMPONENTS
Post Office Box 2902 Baton Rouge, Louisiana 70821

CIRCLE NO. 115 ON READER SERVICE CARD

BIG CATALOG
World's "BEST BUYS" in GOV'T. SURPLUS Electronic Equipment

TCS EQUIPMENT

NAVY TCS RECEIVER AM

1.5 MC to 12 MC in two (2) bands. Variable freq. oscillator & crystal control on four (4) preset channels in the entire freq. range. Audio output 1.5 watts into 500 ohm load; uses tubes 12SK7 RF A., 12SA7 converter, 2/12SK7 IF A., 12SQ7 detector BFO, 12A6 oscillator, 12A6 audio Amp. 456 KC IF Freq. Large vernier & spin dial, audio gain, AVC, BFO and all controls on the front panel. Voltages required: 12 VDC & approx. 220 VDC 100 MA. Size: 11¾ x 11¾ x 13¾". Wt.: 37 lbs. USED: **$44.95**
Checked for Operation—$10.00 extra.

NAVY TCS TRANSMITTER AM

1.5 MC to 12 MC in three (3) bands, CW 40 watts, voice modulation 20 watts, master oscillator variable and crystal control on 4 preset channels in the entire freq. range. Uses 3/12A6 in oscillator & buffer-doubler, 4/1625 in modulator & power amplifier stages, 2½" meters for PA Plate 0-200 DC RF meter 0-3, all tuning and operating controls on front panel. Voltages required: 12 VDC & 400-440 VDC 200 MA. W/tubes. Size: 11¾ x 11¾ x 13¾".
Wt.: 41 lbs. ....USED: **$34.50**
Checked for Operation—$10.00 extra.

Antenna Loading Coil #47205 ....Used: $6.95
Remote Control Box—w/Speaker #23270 Re-New: 9.95
Dual Dynamotor Power Supply 12 V. #21881 ....Re-New: 14.95
D-401 Transmitter Dynamotor 12 V. ....New: 6.95
D-402 Receiver Dynamotor 12 V. ....New: 4.95
CABLE—Receiver to Power Supply ....New: 2.75
CABLE—Transmitter to Power Supply ....New: 2.75
Connector Plugs f/Remote Control Box ....New: 1.50
A C POWER SUPPLY—115 V. 60 cycle (Not Gov't. Surplus)
Receiver: $20.00 — Transmitter: $35.00
Shock Mounting for Receiver or Transmitter Used: 2.95
Noise Limiter Conversion Kit—W/6H6 tubes 2.00
PARTS available for Rec. & Trans. Advise us your needs!

For CATALOG—Send 25¢ in stamps or coins, and receive 50¢ CREDIT on your order!

Address Dept. EW • Prices F.O.B. Lima, O. • 25% Deposit on C.O.D.'s

FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

WANTED

QUICKSILVER, Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Mass. 02062.

QUICK CASH . . . for Electronic Tubes, Semiconductors, Equipment (Receivers, Transmitters, Scopes, Vacuum Variables, etc.) Send lists now! Write: **BARRY ELECTRONICS,** 512 Broadway, New York, N.Y. 10012 (212-WA 5-7000).

WANTED TO BUY—TV tuners. Any make, any quantity. Write, J. W. Electronics, Box 51B, Bloomington, Indiana 47401.

RELAYS—Sigma 80030. Any quantities. **ALARM RELAY SUPPLY,** 20725 Burbank Blvd., Woodland Hills, Calif. 91364.

TAPE AND RECORDERS

BEFORE renting Stereo Tapes, try us. Postpaid both ways — no deposit — immediate delivery. Quality—Dependability—Service—Satisfaction—prevail here. If you've been dissatisfied in the past, your initial order will prove this is no idle boast. Free Catalog. Gold Coast Tape Library, Box 2262, Palm Village Station, Hialeah, Fla. 33012.

STEREO TAPES. Save up to 60% (no membership fees, postpaid anywhere USA). Free 60-page catalog. We discount batteries, recorders, tape accessories. Beware of slogans "not undersold," as the discount information you supply our competitor is usually reported to the factory. **SAXITONE,** 1776 Columbia Rd., Washington, D.C. 20009.

RENT Stereo Tapes—Over 2,500 Different—all major labels—free brochure. Stereo-Parti, 1616—E. W. Terrace Way, Santa Rosa, California 95404.

TAPE RECORDER SALE. Brand new, nationally advertised brands, $10.00 above cost. Arkay Sales, 1028-B Commonwealth Avenue, Boston, Mass. 02215.

HI-FI Components, Tape Recorders at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 239 (LT) East 149th Street, New York 10451.

CLASSIFIED ADVERTISING ORDER FORM

Please refer to heading on first page of this section for complete data concerning terms, frequency discounts, closing dates, etc.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

_______ Words { @ .40 Reader Rate / @ .70 Commercial Rate } = $_______

Insert _______ time(s) Total Enclosed $_______

NAME_______

ADDRESS_______

CITY_______ STATE_______ ZIP_______

SIGNATURE_______

WORD COUNT: Include name and address. Name of city (Des Moines) or of state (New York) counts as one word each. Zip Code numbers not counted. (Publisher reserves right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols such as 35mm, COD, PO, AC, etc., count as one word. Hyphenated words count as two words. EW-967

35 fascinating ways to spend your next 250 spare hours

Announcing the Spring 1967 edition of the "what-to-do-with-your-spare-time" problem-solver: the ELECTRONIC EXPERIMENTER'S HANDBOOK!

Roll up your sleeves, heat up the iron and get set to meet 35 of the most challenging, fun-to-build electronics projects you've ever seen . . . or assembled with your own two hands!

Included are: a transistorized auto-light minder • a $2 intrusion alarm • a tape recorder echo chamber (for under $10!) • a powerhouse 2-tube SW receiver • a solid-state scope calibrator • and even a supercharged salt shaker!

You get complete schematics, illustrations, parts lists and easy-to-follow instructions . . .

PLUS expert tips 'n techniques designed to build your electronics skill. You'll keep up with the latest advances in the field, learn many valuable professional methods and short-cuts . . . and develop that extra technical know-how that comes only from practical, firsthand experience.

Don't chance missing your copy of the Spring 1967 ELECTRONIC EXPERIMENTER'S HANDBOOK. Use the coupon below to order yours **today!** **only $1.25**

Get the handsome **LEATHERFLEX-BOUND** edition for just **$3 postpaid!** The Spring 1967 **ELECTRONIC EXPERIMENTER'S HANDBOOK** is also available in a splendid deluxe edition. Rugged Leatherflex cover provides lasting protection yet is softly textured and gold-embossed for the look of elegance. A collector's item—a superb addition to your electronics bookshelf. And it's yours, for just $3 postpaid, when you check the appropriate box on the order form.

ZIFF-DAVIS SERVICE DIVISION • DEPT. EEH-S
595 Broadway • New York, N. Y. 10012

OK! Send me the all-new SPRING 1967 ELECTRONIC EXPERIMENTER'S HANDBOOK.

☐ **$1.25 enclosed,** plus 15c for shipping and handling. Send me the regular edition. ($1.75 for orders outside the U.S.A.)

☐ **$3.00 enclosed.** Send me the Deluxe Leatherflex-bound edition, **postpaid.** ($3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

name _______ please print _______ EW-97

address _______

city _______ state _______ zip _______

— PAYMENT MUST BE ENCLOSED WITH ORDER —

Boy, do I have spare time! Send me the big **Fall 1966** edition, too! I want the ☐ regular edition ☐ Deluxe Leatherflex-bound edition. (Prices same as above.)

DO-IT-YOURSELF

PROFESSIONAL ELECTRONICS PROJECTS — $1.00 up. Catalog 25¢. **PARKS,** Box 25565B, Seattle, Wash. 98125.

PRINTING

FREE Booklet — "Secrets of Cutting Printing Cost", Dept. 1, 305 S. 4th, Springfield, Illinois 62701.

HIGH FIDELITY

FREE! Send for money saving stereo catalog #E9W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values Inc., 200 West 20th Street, N.Y., N.Y. 10011.

HI-FI Components, Tape Recorders at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 239 (L) East 149th Street, New York 10451.

HIFI EQUIPMENT—Get Our "ROCK BOTTOM" prices on **NAME BRAND** amplifiers—tuners—tape-recorders — speakers **FRANCHISED — 59 YEARS IN BUSINESS.** Write for this month's specials—**NOW!** Rabson's 57th St., Inc., Dept. 569, 119 W. 57th St., New York, New York 10019.

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn, Penn. 19001.

HI-FI components, tape recorders, sleep learn equipment, tapes. Unusual Values. Free catalog. Dressner, 1523 R Jericho Turnpike, New Hyde Park, N.Y. 11040.

HYPNOTISM

FREE Hypnotism, Self-Hypnosis, Sleep Learning. Catalog! Drawer H400, Ruidoso, N.M. 88345.

FREE TRIAL!! Sensational self-hypnosis record kit improves memory, concentration, personality. Results guaranteed! Forum, 333-AA9, Michigan, Chicago 60601.

HYPNOTIZE FEMALES!—Unnoticed! Instantly! Nerves! Exciting! Send $2.25. Research Enterprises, 29-SN21 Samoset, Woburn, Mass. 01801.

FEMALE HYPNOTISM! Easily! Instantly! Secret Nerve Centers! $2.20. Brugenheimer Publishers. Box 158-E30, Lexington, Mass.

AUTHORS' SERVICES

AUTHORS! Learn how to have your book published, promoted, distributed. FREE booklet "ZD," Vantage, 120 West 31 St., New York 10001.

POEMS WANTED for new song hits and recordings by America's most popular studio. Tin Pan Alley, 1650-ZD Broadway, New York 10019.

RUBBER STAMPS

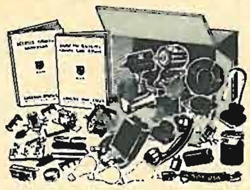
RUBBER ADDRESS STAMP $1.50. SIGNATURE $2.88. FREE CATALOG. JACKSON PRODUCTS, 1433 WINNEMAC, CHICAGO, ILL. 60640.

U.S. GOV'T ELECTRONIC SURPLUS

- **Nationally Known-World Famous SURPLUS CENTER offers finest, most expensive, Government Surplus electronic units and components at a fraction of their original acquisition cost.**

ORDER DIRECT FROM AD or WRITE FOR CATALOGS

LABORATORY EXPERIMENTAL KIT



PERFORM 100'S OF FASCINATING ELECTRICAL EXPERIMENTS

Gov't Aquisition Cost Of Parts Over $50.00

$14.85 F.O.B.

- **(ITEM #A222) - -** Amazing Value! Valuable gift for son or husband. Hundreds of fascinating experiments. Teaches modern electronic theory and practice. Easy, interesting way to learn.
- Experiment with electro-plating, electro-magnetic phenomena, resonance, burglar alarm, relay circuits, rectification, test circuits, eavesdropping, motor experiments, transformer phenomena, etc.
- **Kit Contains:** DC motor, AC motor, electro-magnetic coils, ac and dc relays, set of lab capacitors, compass, test bulbs, plating chemicals, silicon diodes, germanium diode, burglar alarm actuator, carbon microphone eavesdropping element, ac test sockets, permanent magnets, telephone handset, cords, test clips, wire, and other items. Over 35 pieces. Includes fine Experimental Manual with drawings, procedures, etc., written by professional engineers.
- Also furnished with each kit our popular book Home Laboratory Bench and Experimental Procedures. (Reg. $1.00). Shows how to build wonderful home laboratory test bench, and how to get the most out of your experimental work. (12 lbs.) Parts cost gov't over $50.00.

AC PROGRAM TIMING CLOCK

- **(ITEM #158) - -** Zenith 115-VAC program timer. Use for periodic signalling, work breaks, school classes, turn on radio for newscasts, etc. Adjustable clips permit switching On or Off anytime during 24-hour period. Sufficient clips for multiple programing. Also has "skip-a-day" feature. Contacts can handle up to 15-amps. 8½" x 6½" x 4". Wt. 8 lbs. Gov't Cost Over $30.00.

Instructions Furnished. F.O.B. **$9.49**

AUTO-PILOT GYROSCOPE

- **(ITEM #115) - -** DC motor driven, gimbal mounted gyroscope. Ultra-expensive precision unit used to "steer" large, multi-engine planes. Deviation from established plane sends potentiometer controlled signals to bring about change in other motors. Unit can be used as auto-pilot for boats. Wonderful class room unit to demonstrate and study gyro action. Missiles, planes, boats all use gyros. Size 9" x 8" x 10". Wt. 21 lbs. Cost Gov't Over $500.00.

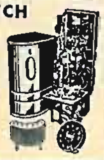
F.O.B. **$12.47**

STANDARD DIAL TELEPHONE

- **(ITEM #715) - -** Standard, commercial telephone same as used throughout U.S.A. Attractive polished black, like new condition. Use as extension phone to private systems or connect several phones together for local intercom system. Full instructions are furnished. Wt. 9 lbs. Original Cost $24.50.

F.O.B. **$5.95**

STEP-BY-STEP AUTOMATIC SWITCH



- **(ITEM #738) - -** Amazing "up-and-around", electro-magnetic telephone switch. Dial any bank pair from 1 to 100. Make your own telephone system. Can also be used to remotely control up to 100 circuits over a single pair of wires.
- One of our FOUR STAR bargains. Comes complete with data, one dial and one line bank. Size, 5" x 7" x 15". Wt. 16 lbs. Cost Gov't Over $75.00.

Complete; Switch, cover, dial, line bank, instructions...... F.O.B. **$9.95**

STEP UP/DOWN TRANSFORMER

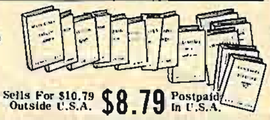
- **(ITEM #1643) - -** Step voltage up or down. Has many uses. Will step 115-volts up to 230-volts or step 230-volts down to 115-volts. Will also transform 115-volts to 55-volts. Rated 1.75 amps. output with 175-watt capacity. Size... 4¾" x 3¾" x 2". Wt. 4 lbs. Gov't Cost $12.75.

F.O.B. **$4.99**

TYPICAL BUYS FROM OUR 1967 CATALOGS

$ 350.00 - Geared 2-hp Battery Golf Car Motor **$24.95**
$ 15.00 - Westinghouse DC Ammeter, 0 to 300............. **$ 7.11**
$ 40.00 - Vacuum/Pressure Pump, 12-VDC **$11.95**
- - - - 80-MW Walkie-Talkies, Per Pair **$19.60**
- - - - Deluxe, Multi-Range, AC/DC Tester .... **$ 8.98**
$4000.00 - Carrier Telephone Amplifier System **$13.91**

SPECIAL SALE Correspondence Course In ELECTRICAL ENGINEERING



Sells For $10.79 Outside U.S.A. **$8.79** Postpaid In U.S.A.

- **(ITEM #A181) - -** Wonderful chance to obtain technical training at Amazing Low Cost! Lincoln Engineering School has suspended its Correspondence Courses because of increased operating costs. We offer a limited number of the school's complete Electrical Engineering Course but without the examination paper grading service. The course consists of 14 lesson unit books. Each book has the regular exams, and in a separate section, "Standard Answers" to each exam question.
- Course is well written, easy to understand, profusely illustrated. Reader's Digest size, easy to carry and study in spare time. Many Lincoln Engineering School students holding excellent jobs as a result of L.E.S. training. Course contains latest information on transistors, silicon diodes, etc. Additional book on how to build and operate a "Home Laboratory and Experimental Bench" furnished with each course.

SEND 25¢ COIN OR STAMPS FOR 3 MAIN CATALOGS
All Items FOB Lincoln — Money Back Guarantee

SURPLUS CENTER
DEPT. EW-097 LINCOLN, NEBR. 68501

CIRCLE NO. 91 ON READER SERVICE CARD

MAIL SERVICES

HERMITAGE—most **SECRET** mail forwarding. Unique plus **FREE GIFTS.** $3/month, 25¢/singles. **HERMITAGE HOUSE (EW),** 2783 Market, San Diego, California 92102.

RECORDS

LOWEST prices. New records. All labels. Harvey, Box 1402, Newport News, Va. 23601.

PHOTOGRAPHY—FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W. Greenvale, Long Island, New York 11548.

SCIENCE Bargains—Request Free Giant Catalog "CJ"—148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War Surplus bargains. Edmund Scientific Co., Barrington, New Jersey 08007.

EDUCATIONAL OPPORTUNITIES

LEARN .While Asleep, hypnotize with your recorder, phonograph. Astonishing details, sensational catalog free! Sleep-Learning Association, Box 24-ZD, Olympia, Washington 98501.

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog free (Courses Bought). Lee Mountain, Pisgah, Alabama 35765.

LEARN WHILE ASLEEP. Miraculously build Mind Power, achieve Self Confidence, improve Health, gain Success. Method 92% effective. Details free. ASR Foundation, Box 7021EG Henry Clay Station, Lexington, Kentucky 40502.

INVENTIONS WANTED

INVENTORS. We will develop, help sell your idea or invention, patented or unpatented. Our national manufacturer clients are urgently seeking new items for outright cash sale or royalties. Financial assistance available. 10 years proven performance. For free information, write Dept. 42, Wall Street Invention Brokerage, 79 Wall Street, New York, N.Y. 10005.

PATENT SEARCHES, $6.00! **FREE** "Invention Record"/Information. Miss Hayward. 1029HE Vermont, District of Columbia 20005.

INVENTIONS – IDEAS developed Cash/Royalty Sales. Member: United States Chamber Commerce. Raymond Lee, 230-GE Park Avenue, New York City 10017.

INVENTIONS wanted! Highest cash or royalties. Financial assistance. Free analysis. International Invention Institute, Dept. 31, 160 Broadway, New York, New York 10038.

INVENTORS! Get your "Little Piggy" to market. Highest cash or royalties. New York Invention Service, Dept. 13, 160 Broadway, New York, N.Y. 10038.

EMPLOYMENT INFORMATION

FOREIGN and USA job opportunities available now. Construction, all trades. Earnings to $2,000.00 monthly. Paid overtime, travel, bonuses. Write: Universal Employment, Woodbridge, Connecticut 06525.

FOREIGN EMPLOYMENT. Construction, other work projects. Good paying overseas jobs with extras, travel expenses. Write only: Foreign Service Bureau, Dept. D, Bradenton Beach, Florida 33510.

PLANS AND KITS

TEACHERS—Students build visual aid. Four tube regen. RCVR.; four individual etched printed circuits, 3"x5" ea., connectors, plans $3.00. Plans 50¢. Teacher, 1751 Greek Dr., San Jose, Calif. 95125.

INTEGRATED CIRCUIT KITS; COMPUTER LOGIC; parts; others. Catalogue free. Kaye Engineering, Box 3932, Long Beach, California 90803.

GREGORY ELECTRONICS

Reconditioned & Used FM 2-WAY RADIO SAVINGS

Partial list—Send for New '67 Catalog

Voice Commander

132 to 172 MC, 1W 9.5" x 5.3" x 1.7" Lowest price ever, including brand New Rechargeable Nickel Cadmium Battery Pack

$148

If crystal & tuning is desired add $45.00
Battery charger for these units $16.00
Write for Quantity Prices

VOICE COMMANDER
Monitor Receiver only—Tuned & Crystalled with dry Batteries **$78**

GE RECEIVER
4ER6 30-40 MC, 40-50 MC, 6 or 12 Volts
3 Coil I. F. **$28**
4 Coil I. F. **$34**

MOTOROLA P33 Series Pack Set 5 Watt 150-170 MC with Nicad Supply and Nicad Batteries **$95.00**

MOTOROLA T41GGV 30-50mc 6/12 V,
30 watt vibrator power supply fully narrow banded complete with accessories less crystals and antenna **$148**
Add $45.00 for tuning to desired frequency and new antenna

MOTOROLA 30-50mc 6/12 V,
T51GGV vibrator power supply.
Fully narrow banded (TX & RX) **$198**
Above price include accessories less crystals and antenna (less accessories, deduct $30.00)
To tune unit to desired frequency including new antenna add $45.00

GE 2-Piece unit—6 volt or 12 volt 4ER6—4ET5, 30w 30-40, mc.—40-50 mc. Wide Band **$48**
Fully narrow band (TX+RX) **$68**
Complete Accessories
4ER6—4ET6, 60w 30-40 mc—40-50 mc.
Wide Band **$68**
Fully Narrow Band **$88**
Complete Accessories
Add $45.00 for tuning and crystals to desired frequency, including new antenna.

RCA—CMCT 30 148-172 mc. transistorized power supply fully narrow banded complete with accessories **$198**
Add $40.00 for crystals and tuning and new antenna.

G.E. PACERS—EG43SA6 150-170 mc Transistorized Power Supply 13-15 watts, 12 v Front Mount (Complete accessories, less crystals and antenna) **$108.00**

We Buy Late Model Equipment for Cash —Write; Wire or Phone!

GREGORY ELECTRONICS CORPORATION
249 RT. 46, Saddle Brook, N.J., 07662
Phone: (201) 489-9000

CIRCLE NO. 112 ON READER SERVICE CARD

BUSINESS OPPORTUNITIES

INVESTIGATE ACCIDENTS: Earn up to $1,000 and more a month in your own business. Work spare time with average earnings of $5 to $8 per hour. No selling. Send for FREE booklet. No obligation. No salesman will call. Write: Universal Schools, CZ-9, 6801 Hillcrest, Dallas, Texas 75205.

FREE CATALOGS. Repair air conditioning, refrigeration. Tools, supplies, full instructions. Doolin, 2016 Canton, Dallas, Texas 75201.

IMPROVE YOUR BUSINESS OPPORTUNITIES BY ADVERTISING IN THESE COLUMNS. Reach the largest audience of Electronics Professionals any medium can make available. A low cost ad here (70¢ per word, minimum $7.00) can virtually guarantee a profitable return in additional mail order sales responses for you. Use the handy order coupon printed in this section. Mail it today to: Hal Cymes, Classified Ad Mgr., **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016.

ALL NEW!

FIRST TIME EVER PUBLISHED!

These are the men who made the headlines in 1966—the top drivers who walked off with the big prizes! And this year, there's a new headline-maker that's required reading for racing enthusiasts! It's the CAR and DRIVER RACING ANNUAL—the first one ever published!

It contains complete box scores of every major event in this country and abroad, including order of finish, equipment and official times . . . over a dozen feature stories of individual races—Indy, Daytona, LeMans, Watkins Glen, the National Drags—all of them . . . plus the champions of the year, FIA, SCCA, NASCAR and USAC winners, and personality wrap-ups on the top drivers in every category of racing.

The RACING ANNUAL is an almanac of competition information covering the entire year of 1966—as a reference book it's the finest, most complete manual of its kind—as a thriller, it brings every suspenseful heat back to life with lavish use of dramatic photos, and words that spell "speed" from start to finish!

Better order yours now . . . without the RACING ANNUAL, you're buried at the starting line. With it, you're **really** with it! Use the coupon below to get your copy with the utmost speed—after all, speed is what you're going to get!

GET THE HANDSOME LEATHERFLEX–BOUND EDITION for just $3 **POSTPAID!** The **CAR and DRIVER RACING ANNUAL** is also available in a splendid deluxe edition. Rugged Leatherflex cover provides lasting protection yet is softly textured and gold-embossed for the look of elegance. A collector's item—a superb addition to your permanent automotive reference library. And it's yours, for just $3 **postpaid**, when you check the appropriate box on the order form.

ZIFF-DAVIS SERVICE DIVISION • DEPT. RA
595 Broadway, New York, N.Y. 10012

YES! Send me the new CAR and DRIVER RACING ANNUAL.

☐ **$1.25 enclosed,** plus 15c for shipping and handling. Send me the regular edition. ($1.75 for orders outside the U.S.A.)

☐ **$3.00 enclosed.** Send me the Deluxe Leatherflex-bound edition, **postpaid.** ($3.75 for orders outside the U.S.A.) Allow three additional weeks for delivery.

name ____________ please print ____________ EW-97

address ____________

city ____________

state ____________ zip code ____________

PAYMENT MUST BE ENCLOSED WITH ORDER

FREE!

$25 WORTH OF ■ TRANSISTORS ■ RECTIFIERS ■ RESISTORS ■ CONDENSERS ■ DIODES ■ ETC

PLUS CHOOSE ANY $1.00 ITEM FREE

Add 25¢ for handling

BOTH FREE WITH ANY $10 ORDER

Special! MOVIN' sale

FACTORY TESTED $1 SEMI-KON-DUCTORS

☐ 2—85 WATT 2N424 PLANAR, silicon. TO-53 npn $1
☐ DUAL TRANSISTORS ☐ PNP (2N2807) ☐ NPN 2N2060 . . . . $1
☐ 3—40W NPN SILICON MESA 2N1648, transistor $1
☐ 4 2N170 TRANSISTORS, by GE, npn for gen'l rf . . $1
☐ 10 3 Amp RECT's, studs, silicon, to 800 V no test $1
☐ 4—2N255 POWER TRANSISTOR EQUALS. $1
☐ 10 PNP SWITCHING TRANS'TRS. 2N404. no test $1
☐ 2N3088 "N" Channel FET'S Very High Input Z . . $1
☐ 5 2N107 TRANS'TRS, by GE, pnp, pop, audio pak $1
☐ 3—2N1613 3W NPN SIL. 120 mc, by "Rheem" . . $1
☐ 3—45 AMP POWER RECTIFIERS, stud, silicon. . . $1

1 AMP SILICON RECTIFIERS

TESTED

PIV	Sale	PIV	Sale	PIV	Sale
50	☐ 5¢	800	☐ 23¢	1800	☐ 99¢
100	☐ 7¢	1000	☐ 40¢	2000	☐ 1.50
200	☐ 9¢	1200	☐ 59¢	3000	☐ 1.90
400	☐ 11¢	1400	☐ 69¢	4000	☐ 2.50
600	☐ 19¢	1600	☐ 89¢		

☐ 5 2N706 500MW, 300MC NPN transtrs, TO18 $1
☐ 10 PNP SWITCHING TRANSISTORS. no test. TO5 . $1
☐ 4 2N43 OUTPUT TRANSISTORS, by GE, pnp, TO5 . $1
☐ 1—IGNITION SWITCHING TRANSISTORS, 10 AMP $1
☐ 25 GERMANIUM & SILICON DIODES. no test $1
☐ 25 TOP HAT RECTIFIERS, silicon, 750 ma, no test $1
☐ 2—1000 MC-TRANSISTOR 2N918 NPN SILICON . . $1
☐ 4 2N333 NPN SILICON transistors, Transitron . . $1
☐ 4 BIDIRECTIONAL TRANSISTORS, 2N1641 . . . . $1
☐ 10 NPN SWITCHING TRANS'TRS, 2N338 no test $1
☐ 15 PNP TRANS'TRS, CK722, 2N35, 107, no test $1
☐ 15 NPN TRANSISTORS, 2N35, 170, 440, no test $1
☐ 30 TRANSISTORS, rf, lf, audio osc-ifs, TO5 no test $1
☐ 10 FAMOUS CK722 TRANSISTORS. pnp no test . . $1
☐ 30 TRANSISTORS, rf, lf, audio, no test, TO5 no test $1
☐ 4 35-W. TRANS'TRS, 2N1434, CBS, TO10, stud. . . $1

SILICON POWER STUD RECTIFIERS

Factory Tested — All Tests

AMPS	50 PIV	100 PIV	200 PIV
3	☐ 7¢	☐ 11¢	☐ 17¢
15	☐ 22¢	☐ 40¢	☐ 65¢
45	☐ 75¢	☐ 90¢	☐ 1.25
160	☐ 2.50	☐ 2.95	☐ 4.05
250	☐ 4.50	☐ 5.50	☐ 6.89

AMPS	400 PIV	600 PIV	800 PIV	1000 PIV
3	☐ 22¢	☐ 31¢	☐ 40¢	☐ 59¢
15	☐ 90¢	☐ 1.35	☐ 1.59	☐ 1.79
45	☐ 1.59	☐ 1.90	☐ 2.50	☐ 2.95
160	☐ 5.75	☐ 7.50	☐ 9.25	☐ 10.95
250	☐ 9.59	☐ 12.50	☐ 15.00	☐ 19.95

Factory Tested SILICON CONTROLLED RECTIFIERS

PRV	7 AMP	16 AMP	25 AMP
50	☐ 48	☐ 70	☐ 80
100	☐ 70	☐ 1.05	☐ 1.20
200	☐ 1.05	☐ 1.30	☐ 1.70
300	☐ 1.60	☐ 1.90	☐ 2.20
400	☐ 2.10	☐ 2.30	☐ 2.70
500	☐ 2.80	☐ 3.00	☐ 3.30
600	☐ 3.00	☐ 3.30	☐ 3.90

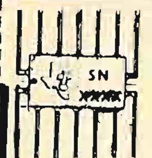
SILICON TUBE SPECIALS

☐ 5U4GB 2.39
☐ 5R4 . . . . 4.39
☐ OZ4 . . . . 2.39
☐ 6AU4GTA 2.39
☐ 866A 11.19

☐ 2 Amp 1000 PIV 39¢ EA

6-MONTHS' GUARANTEE

Poly Paks, the only company of its kind in the world due to its tremendous purchasing power, quality and factory testing procedures, **GUARANTEES** all items **AS ADVERTISED** for 6 months or your money back. **A 'FIRST' ANYWHERE**



Sale - "TEXAS" INTEGRATED BRAND NEW CIRCUITS

A 'FIRST' ANYWHERE with data chart.

$1.49 EACH

☐ SN7360 Quadruple 2-input NAND/NOR Gate
☐ SN7400 Quadruple 2-input Positive NAND Gate
☐ SN15833 Dual 4-input Expander
☐ SN15832 Dual 4-input Expandable Buffer
☐ SN15846 Quadruple 2-input NAND Gate
☐ . . . . . . 13 Planar diode array

Worth $10 — $1.99 EACH

☐ SN7304 Dual J-K Flip-flop, Preset/Clear
☐ SN7453 Quad AND/OR Invert
☐ SN7473 Dual Master/Slave Flip-flop
☐ SN7490N Decade Counter
☐ SN7491 9-bit Shift Register
☐ SN15848 Fast-rise-time J-K/R S Flip-flop

VISIT OUR BARGAIN 'RETAIL' STORE
211 ALBION ST., WAKEFIELD, MASS.
Across Transitron

WORLD'S MOST POPULAR $1 PARTS PAKS

☐ 30 "YELLOW" MYLAR CONDENSERS, asstd val $1
☐ 60 CERAMIC CONDENSERS, discs, npo's, to .05 $1
☐ 60 TUBULAR CONDEN'RS, to .5 mf, to 1 Kv, asst $1
☐ 40 DISC CONDENSERS, 27mmf to .05mf to 1Kv $1
☐ 60 TUBE SOCKETS, receptacles, plugs, audio, etc. $1
☐ 30 POWER RESISTORS, 5 to 50W, to 24K ohms $1
☐ 65 HALF WATTERS, asst incl: A.B., 5% too! . . . $1
☐ 60 HI-Q RESIST'RS. ½, 1, 2W, 1% & 5% values $1
☐ 10 VOLUME CONTROLS, to 1 meg, switch too! . . $1
☐ 10 ELECTROLYTICS, to 500mf, asst FP & tubulars $1
☐ 50 RADIO & TV KNOBS, asst. colors & styles . . . $1
☐ 4 TRANSISTOR TRANSFORMERS, asst. worth $25 $1
☐ 40 PRECISION RESISTORS, ½, 1, 2W; 1% values $1
☐ 40 CORNING "LOW NOISE" resistors, asst. . . . $1
☐ 10 PHONO PLUG & JACK SETS, tuners, amps . . . $1
☐ 50 TERMINAL STRIPS. 1 to 8 solder lug types . . $1

MAIL ORDER ADDRESS

10¢ FOR OUR "XMAS" BARGAIN CATALOG ON: ☐ Semiconductors ☐ Poly Paks ☐ Parts

POLY PAKS

TERMS: send check, money order, include postage—avg. wt. per pak 1 lb. Rated, net 30 days. CODs 25%

P.O. BOX 942W
SO. LYNNFIELD, MASS. 01940
"PAK-KING" of the World

CIRCLE NO. 99 ON READER SERVICE CARD

MISCELLANEOUS

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 7208, Minneapolis, Minn. 55412.

EMPLOYMENT Resumes. Get a better job & earn more! Send only $2.00 for expert, complete Resume Writing Instructions. J. Ross, 80-34 Kent St., Jamaica, N.Y. 11432 Dept. EW.

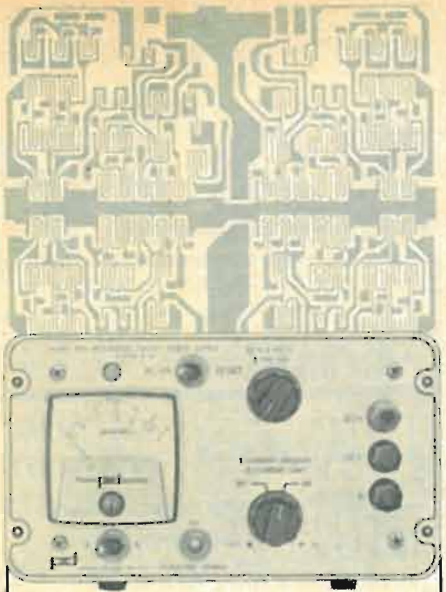
SPARE TIME OPPORTUNITY—MONEY. WE PAY at the rate of **$10** hr. for **NOTHING** but your opinions, written from home about our clients' products and publications, sent you free. Nothing to buy, sell, canvass, or learn. **NO SKILL. NO GIMMICKS.** Just honesty. Details from **RESEARCH,** ZD-3, Box 669, Mineola, N.Y. 11501.

STOP BURGLARS THE EASY WAY!! Affix authentic "Protected by Electronic Sentry Alarm" Decals to auto windows, doors & windows of home, retail stores; vending machines, etc. Whether you have an alarm or not—thieves stay away! Only $1.00 for each set of two. J. Ross, 80-34 Kent St., Jamaica, N.Y. 11432. Dept. EW.

TEN Winemaking Recipes and Winemaking Supplies catalog. 10¢. Country Winemaker, Box 243EGA, Lexington, Massachusetts 02173.

GENUINE DIGGER AUSTRALIAN ARMY SLOUCH HATS! Sizes 6½ to 8⅛". Cost & Post. $10. A. Unger, "The Ranch", Alectown, N.S.W. Australia.

AS YOU SCAN THESE COLUMNS, more than 185,000 monthly buyers of **ELECTRONICS WORLD** are doing the same. These men are all Electronics Professionals—individuals involved actively in electronics from a business or hobby viewpoint—they are doubly interested in those advertisements which will enhance their careers or their leisure hours. They look to the pages of the **ELECTRONICS MARKET PLACE** for prime sources of products and services of interest to them. They will buy from you if your advertising appears regularly in their favorite magazine. Use the handy order form printed in this section or write today to: Hal Cymes, Classified Advertising Manager, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016. **REMEMBER:** November issue, on sale October 19th, closes September 1st.



ELECTRONICS WORLD SEPTEMBER 1967
ADVERTISERS INDEX

READER SERVICE NO.	ADVERTISER	PAGE NO.
125	Allied Radio	53, 54
	American Institute of Engineering & Technology	66
	Arcturus Electronics Co.	103
124	Belden Corporation	78, 79
	Capital Radio Engineering Institute, The	18, 19, 20, 21
122	Cleveland Institute of Electronics	62, 63, 64, 65
121	Cleveland Institute of Electronics	67
120	Cleveland Institute of Electronics	93
119	Delta Products, Inc.	55
118	Edmund Scientific Co.	105
117	Electro-Voice, Inc.	SECOND COVER
116	Electronic Chemical Corp.	67
115	Electronic Components	103
	Fair Radio Sales	104
114	Finney Company, The	56, 57
	G & G Radio Supply Company	105
113	Goodheart Co. Inc., R.E.	105
112	Gregory Electronics Corporation	106
111	Heath Company	82, 83
	Institute of High Fidelity	7
110	International Crystal Mfg. Co., Inc.	13
109	Jensen Manufacturing Division	6
108	Lafayette Radio Electronics	91, 92
107	Lampkin Laboratories, Inc.	66
200	Lesa of America Corp.	97
106	Magnecord Sales Department	76
105	Mallory & Co. Inc., P.R.	2
104	Microflame, Inc.	81
	Morhan National Sales	69
103	Mosley Electronics, Inc.	69
102	Motorola Training Institute	86
101	Multicore Sales Corp.	101
100	Music Associated	94
	National Radio Institute	8, 9, 10, 11
	Norelco	60
99	Poly Paks	107
196	Power Designs, Inc.	108
	RCA Electronic Components and Devices	FOURTH COVER
	RCA Institutes, Inc.	72, 73, 74, 75
98	Radar Devices Manufacturing Corp.	1
97	Sams & Co., Inc., Howard W.	12
123	Sentry Manufacturing Company	94
96	Shure Brothers, Inc.	17
88	Solid State Sales	105
94	Sonar Radio Corporation	81
93	Sony/Superscope, Inc.	68
92	Sprague Products Company	95
91	Surplus Center	106
199	Sylvania	5
90	Sylvania	14, 15
89	Telex	87
198	Texas Crystals	67
95	Triplett Electrical Instrument Company	THIRD COVER
87	University Sound	70
	Valparaiso Technical Institute	60
86	Viking	60
85	Weller Electric Corporation	71
84	Xcelite, Inc.	4
83	Zenith	77
82	Zenith	99

CLASSIFIED ADVERTISING 103, 104, 105, 106, 107

Printed in U.S.A.

ONE MILLION OHMS PER VOLT

TRIPLETT

V-O-M

Model 630-M

VOLT-OHM-MICROAMMETER

$210.00

Suggested U.S.A. user net

Triplett Model 630-M features the input impedance of a VTVM with the convenience of a V-O-M. The 630-M's sensitivity is derived from the singular achievement of its basic 0-1 D.C. microampere movement. The 630-M incorporates no amplifiers, no warm-up, and no power requirements. Model 630-M is a true V-O-M whose engineering excellence is based on 60 years of instrument manufacturing, and contains the top quality associated only with Triplett.

1. 1,000,000 ohms per volt D.C. for greater accuracy on high resistance circuits. 20,000 ohms per volt A.C.
2. 1 ua Suspension Meter Movement. No pivots, bearings, or rolling friction. Extremely rugged. Greater sensitivity and repeatability.
3. 61 ranges, usable with frequencies through 100KC. Temperature compensated. 1½% D.C. accuracy, 3% A.C. in horizontal position.

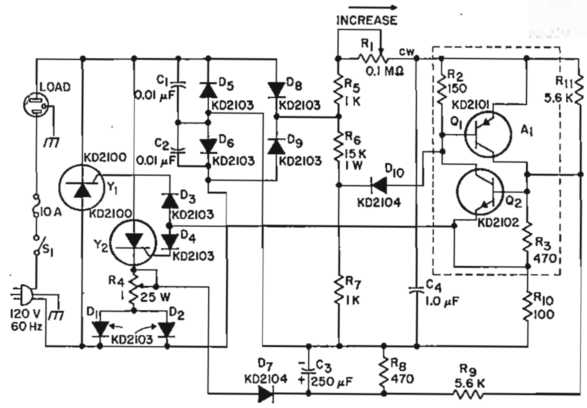
TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

CIRCLE NO. 95 ON READER SERVICE CARD

MANUFACTURERS OF PANEL AND PORTABLE INSTRUMENTS; ELECTRICAL AND ELECTRONIC TEST EQUIPMENT

Build your own motor speed control with RCA experimenter kits

Control Motors With Name Plate Ratings Up to 6 Amperes. Available from Your RCA Distributor



Now, using two RCA Silicon Controlled Rectifier Experimenter Kits (KD2105) together with additional passive components, you can build a motor speed control for ac/dc universal motors (series wound) with name plate ratings up to 6 amperes.

RCA's twin-kit circuits offer you flexibility in that you may control any one of many individual tools or appliances such as half-inch power drills, jigsaws, buffers, floor polishers, and mixers.

The RCA Experimenter Twin-Kits are part of a complete program fully explained and illustrated in the new 136-page Experimenter's Manual KM-71 on sale at your RCA Distributor. In it you'll find detailed information on more than 24 different and useful circuits you can build including 6- and 12-Volt battery chargers, lamp dimmers, audio frequency operated switches, and heat and light-operated switches.

Technical Series KM-71

Check with your RCA Distributor on RCA Experimenter's Kits. Select the kit or kits for the solid-state circuits you have in mind. Do it today.

RCA Electronic Components and Devices, Harrison, N.J. 07029

RCA The Most Trusted Name in Electronics ®