100th ISSUE

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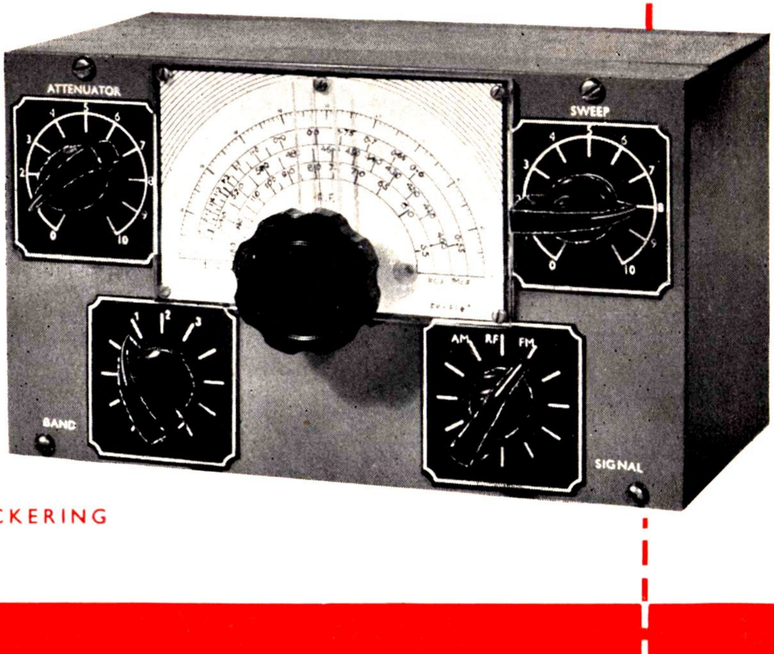
Build Your Own A.M.-F.M. SIGNAL GENERATOR



By W. PICKERING

Also in this issue

PRACTICAL BAND III TELEVISION, Part 5
ADD-ON FM TUNING INDICATOR
RADIO—AND CONTROL, PART I
AERIALS FOR BAND III
HI-FI 10W ULTRA-LINEAR AMPLIFIER, Part 2
and all the usual features.

DATA Publications 1/6

80 METRE AM BAND RECEIV

By M. V. Hastings

Expressly designed for s.s.b. and c.w. amateur signals.

Minimal alignm

This easily built and fairly inexpensive receiver has been specifically designed for beginners who want to get started on amateur band reception. Unfortunately, most broadcast receivers having one or more short wave bands are not suitable for reception on any amateur bands which fall within their frequency coverage. This is because the two modes of transmission most commonly employed on the amateur bands are single sideband (s.s.b.) and morse (c.w.), neither of which can be resolved with an ordinary a.m. receiver. Communications receivers are obviously ideal for amateur bands reception but these are relatively expensive even when home-built. Quite good results can be obtained employing a much simpler receiver using the "homodyne" or "direct conversion" principle. Such a receiver is described here and it will provide reception of British and other European amateur stations, as well as reception of stations from further afield when conditions are suitable. A considerable simplification in design is given by having the receiver operate on a single band only, this being the popular 80 metre band.

In most countries, including the U.K., the 80 metre band extends from 3.5 to 3.8MHz. In the U.S.A. and a few other countries it extends from 3.5 to 4.0MHz. This set covers slightly more than the second of these two ranges whereupon little difficulty will be experienced in aligning it for the required frequency coverage. Alignment, in any case, merely consists of adjusting the cores of two coils, one to give the correct frequency coverage and the other to give maximum sensitivity over this range. No test equipment of any type is needed for the alignment. The receiver is not intended for the reception of ordinary a.m. signals.

Power is obtained from an internal 9 volt battery type PP6, and the output is suitable for high impedance magnetic headphones (2kΩ or 4kΩ) or a crystal earphone. An external aerial is required. However, a short indoor aerial will give reasonably good results, and an outdoor aerial is by no means essential.

DIRECT CONVERSION

An s.s.b. transmitter is basically an a.m. transmitter with the carrier and one sideband removed. If the s.s.b. signal is to be resolved the missing carrier must be re-inserted at the receiver and this and the signal passed through a suitable detector. Normally, a product detector will be used. In a superhet receiver the locally generated carrier can be inserted into the i.f. amplifier. With a receiver of the type described here, the locally generated carrier has the same frequency as would the carrier of the received signal.

The transmitted signal can be upper sideband (u.s.b.) or lower sideband (l.s.b.). If a 1kHz audio modulating tone were fed to a u.s.b. transmitter tuned to 3.6MHz, the corresponding upper sideband of 3.601MHz would be transmitted, whilst with an l.s.b. transmitter it would be the lower sideband of 3.599MHz which would be radiated. In either case the modulating tone of 1kHz can be resolved at the receiver by injecting a locally generated carrier frequency of 3.6MHz. When the 3.6MHz s.s.b. transmitter is modulated by a speech signal, the speech can similarly be resolved by injecting the local carrier of 3.6MHz. It is important, however, that the local oscillator be tuned as precisely as possible to 3.6MHz or

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Simple homodyne design for the beginner.

t requirements.

all the components of the speech signal will be raised or lowered in frequency. Only slight detuning can make the received speech signal difficult to comprehend.

A c.w. signal merely consists of a radio frequency signal which is keyed on and off. A local oscillator at the receiver can then be adjusted to beat with the signal and produce an audible heterodyne note. The locally generated signal used for s.s.b. reception can also be employed here, its frequency simply being adjusted to produce a comfortable tone.

The basic line-up of the receiver is shown in Fig.1. The aerial is connected to an r.f. amplifier with a tuned output filter, the latter being set to the centre of the 80 metre amateur band. This filter stops breakthrough from signals outside the band. The r.f. amplifier output is fed to a product detector, as also is an output from a variable frequency oscillator. The v.f.o. provides the missing carrier with s.s.b. signals or gives a heterodyne with c.w. signals. A second function of the r.f. amplifier and filter stage is to prevent signals from the v.f.o. being passed to the aerial, where they would be radiated and cause interference with other receivers.

The product detector couples into an r.f. filter which passes the detected audio signal to the a.f. amplifier whilst removing the r.f. signals present at the detector output. These r.f. signals, consisting of the received signal and the v.f.o. signal, are at a much higher frequency than the audio signal and can easily be filtered out by a single RC circuit.

The audio output from the product detector is very weak, and a considerable amount of audio amplification is required to bring it up to headphone level. The majority of the gain in the receiver is provided by the high gain a.f. amplifier which follows the r.f. filter.

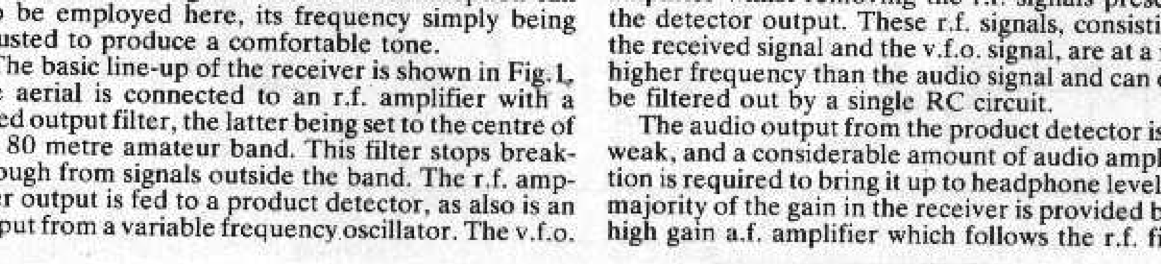


Fig.1. Block diagram representing the stage line-up of the receiver

The receiver is tuned by adjusting the v.f.o. frequency. This selects the s.s.b. signal to be received by inserting the missing carrier. The tuning here is much more critical than is given with ordinary a.m. reception because, as was just explained, a slight inaccuracy in v.f.o. frequency can make the detected signal incomprehensible. With c.w. signals tuning is similar to a.m. reception, however, as it is merely necessary to set the v.f.o. to a frequency which produces an acceptable heterodyne note.

THE CIRCUIT

The full circuit of the receiver is shown in Fig.2. TR1 is the r.f. amplifier and is used in the common emitter mode with an untuned base input circuit. Two aerial sockets, SK1 and SK2 are provided. SK2 couples direct to TR1 base and is used with short indoor aerials. SK1 couples to the base via trimmer TC1 and is employed with longer and more efficient aerials, which could cause the r.f. amplifier to be overloaded by strong signals if the aerial were connected direct to the transistor base. TC1 is adjusted to suit the particular aerial used.

The collector of TR1 connects to a coupling winding of coil L1. The winding between pins 1 and 6 is tuned by C2, and the core of the coil is adjusted so that this tuned circuit is resonant at the centre of the 80 metre amateur band. A second coupling winding on the coil connects to the product detector, consisting of D1, D2 and R2. The v.f.o. signal is introduced, via capacitor C3, at the junction of the two diodes. R2 is adjusted to minimise breakthrough of out-of-band signals.

The variable frequency oscillator is provided by the circuitry around TR4. This is a Jfet device used in the source follower mode. The gain from gate to source is somewhat less than unity, but there is a voltage step-up from the source coupling winding to the tuned winding of L2., which ensures that there is sufficient positive feedback to produce strong and reliable oscillation. Tuning is controlled by VC1 and VC2. VC1 is the bandset capacitor and VC2 the bandspread capacitor. Because of its low value and the fact that C11 is in series with it, VC2 can tune over only a small part of the band, but fine tuning is much easier to carry out with this capacitor. The oscillator signal is taken from TR4 source and passes to the product detector through C3.

R4 and C4 constitute the low pass r.f. filter which follows the product detector, and the remaining audio signal is coupled via C5 to the high gain low noise a.f. amplifier given by TR2 and TR3. These are both employed in the conventional common emitter configuration. C6 and C8 provide negative feedback of the higher audio frequencies, and thus roll off the high frequency response of the receiver. This is beneficial as it gives an improved signal-to-noise ratio and decreases adjacent channel interference. A good audio frequency response is of no benefit at all in a receiver of this nature since s.s.b. amateur transmitters normally incorporate filtering which limits the audio frequencies to a range suitable for good communications quality speech, with frequencies above 3kHz being virtually eliminated. C9 couples the output of the amplifier to SK4, the phones socket.

On-off switching is provided by S1, and C1, R3 and C10 are the only supply decoupling components

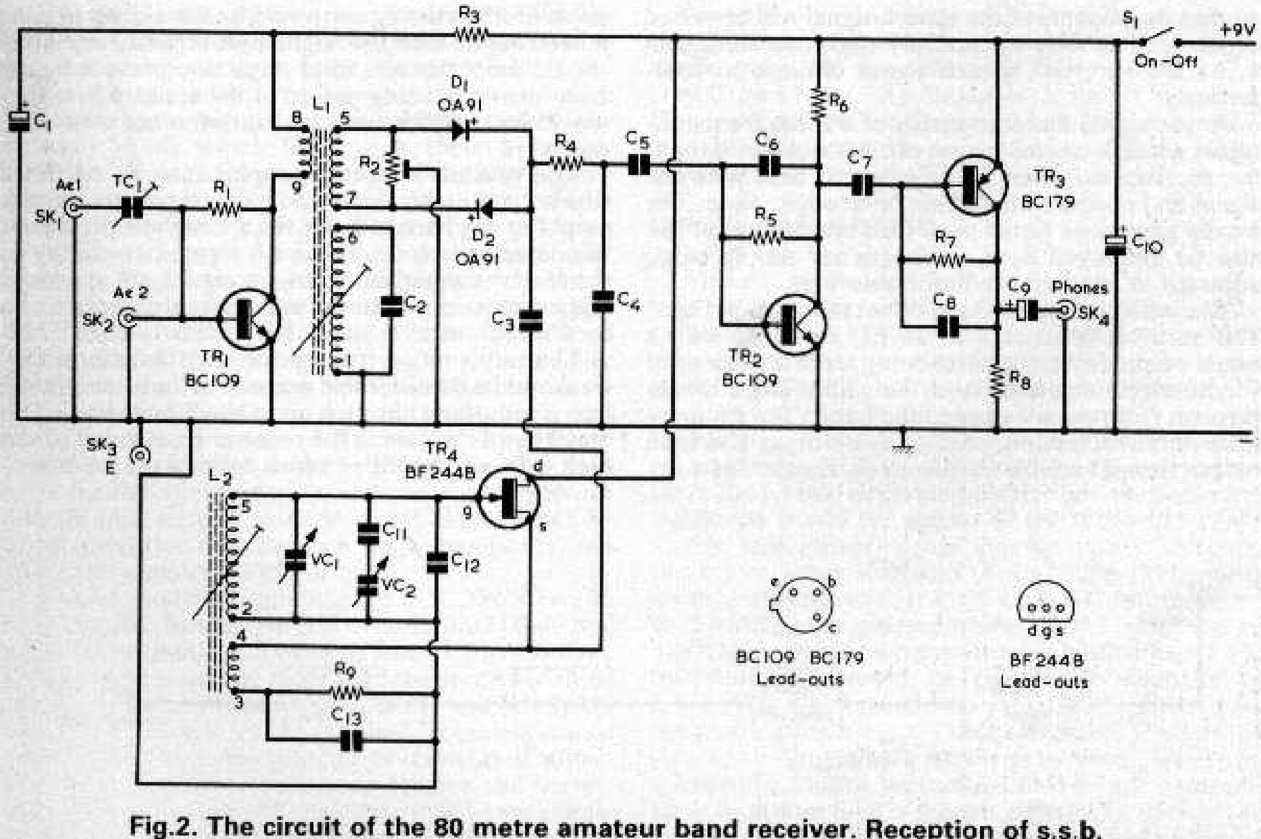
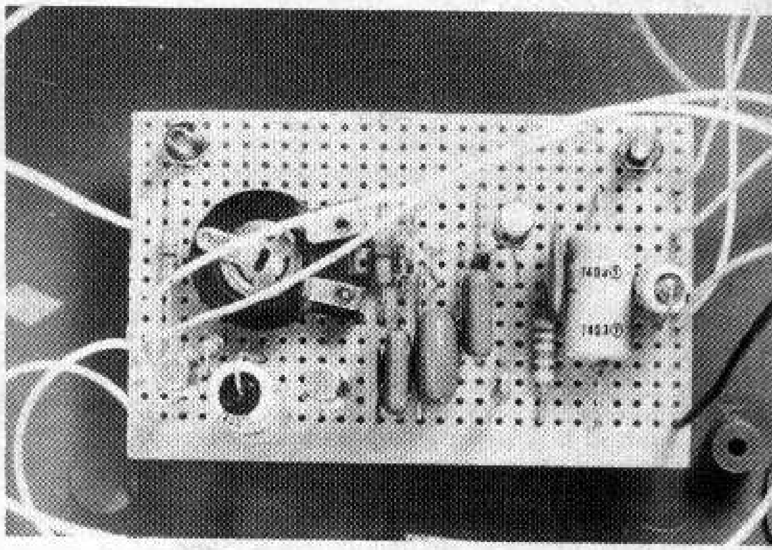


Fig.2. The circuit of the 80 metre amateur band receiver. Reception of s.s.b. signals is achieved by "direct conversion" with the output of oscillator TR4 inserting the missing carrier at the product detector stage

The components on the veroboard panel. This takes transistors TR1, TR2 and TR3 and their immediate components



which are required. Current consumption from the 9 volt battery is approximately 7mA only.

A few notes need to be made concerning components. SK4 should be a 3.5mm. jack socket of open construction, i.e. it should not have an insulated body. This is because a chassis connection to the front panel of the receiver is made by way of its mounting bush and nut. If difficulty is experienced in finding a source for the coil specified for L2, this may be obtained (as may also L1) direct from the manufacturer at Denco (Clacton) Limited, 355-7-9 Old Road, Clacton-on-Sea, Essex, CO15 3RH. The coil has a third winding, incidentally, which connects between pins 8 and 9. This winding has no effect on circuit operation and is not shown in Fig.2.

Trimmer TC1 can be any small trimming capacitor having a maximum value of about 20pF. The BF244B specified for TR4 is available from a number of suppliers, including Greenweld, 443 Millbrook Road, Southampton, S01 OHX.

COMPONENTS

Resistors
(All fixed values ¼ watt 5% unless otherwise stated)

R1 1MΩ
R2 470Ω pre-set potentiometer, 0.25 watt, horizontal
R3 470Ω
R4 3.9kΩ
R5 1.8MΩ 10%
R6 4.7kΩ
R7 1.2MΩ 10%
R8 2.2kΩ
R9 3.3kΩ

Capacitors
C1 100μF electrolytic 10V Wkg.
C2 56pF ceramic plate or polystyrene
C3 27pF ceramic plate
C4 0.01μF polyester type C280
C5 0.1μF polyester type C280
C6 1,000pF ceramic plate
C7 0.1μF polyester type C280
C8 390pF ceramic plate
C9 10μF electrolytic, 10V Wkg.
C10 100μF electrolytic, 10V Wkg.
C11 3.9pF ceramic plate
C12 22pF ceramic plate or polystyrene
C13 4,700pF ceramic plate
VC1 25pF variable type C804 (Jackson)
VC2 10pF variable type C804 (Jackson)
TC1 20pF trimmer (see text)

Coils
L1 Dual purpose, coil, transistor usage, Blue, Range 3T (Denco)
L2 Dual purpose coil, valve usage, Green, Range 3 (Denco)

Semiconductors

TR1 BC109
TR2 BC109
TR3 BC179
TR4 BF244B
D1 OA91
D2 OA91

Switch
S1 s.p.s.t. toggle, rotary

Sockets
SK1 insulated socket, red
SK2 insulated socket, red
SK3 insulated socket, black
SK4 3.5mm. jack socket

Miscellaneous
Verocase type 75-1411-D
3 control knobs
Veroboard, 0.1 in. matrix
9-volt battery type PP6

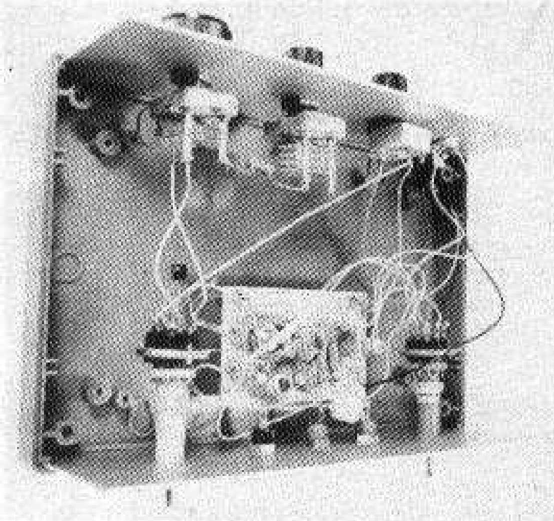
Battery connector
2B9A valveholders
High impedance (2,000Ω or 4,000Ω) headphones or crystal earphone with 3.5mm. jack plug
Wire, solder, etc.

A Verocase type 75-1411-D with dimensions of 205 by 140 by 75mm. makes an excellent housing for the receiver.

This has a metal front panel which screens some of the circuitry and prevents hand capacitance effects on the tuning.

The general layout of the set can be seen from the photographs. On the front panel, from left to right, are SK4, S1 VC2 and VC1. On the rear panel are mounted L1, L2, the two aerial sockets and the earth socket. Looking at the receiver from the front, L1 is to the left, with SK2 next to it, followed by SK1, SK3 and, at the right, L2. Each of these coils requires a ¼in. mounting hole and is held in place by a plastic nut provided with it. It is important that these nuts be tightened by hand only as excessive force here could easily strip the plastic thread on the nut or the former. Soldered connections can be made directly to the pins of the two coils, but these are held in plastic which melts readily when heated. In consequence, a B9A valveholder is passed onto the pins of each coil and connections are made to the valveholder tags.

A Veroboard panel of 0.1in. matrix having 28 holes by 16 copper strips takes most of the components, and this is cut down from a larger panel. The Veroboard layout is shown in Fig.3. The two mount-



Looking into the receiver from the L2 end. Each of the coils has a B9A valveholder fitted over its pins, and connections are made to the valveholder tags

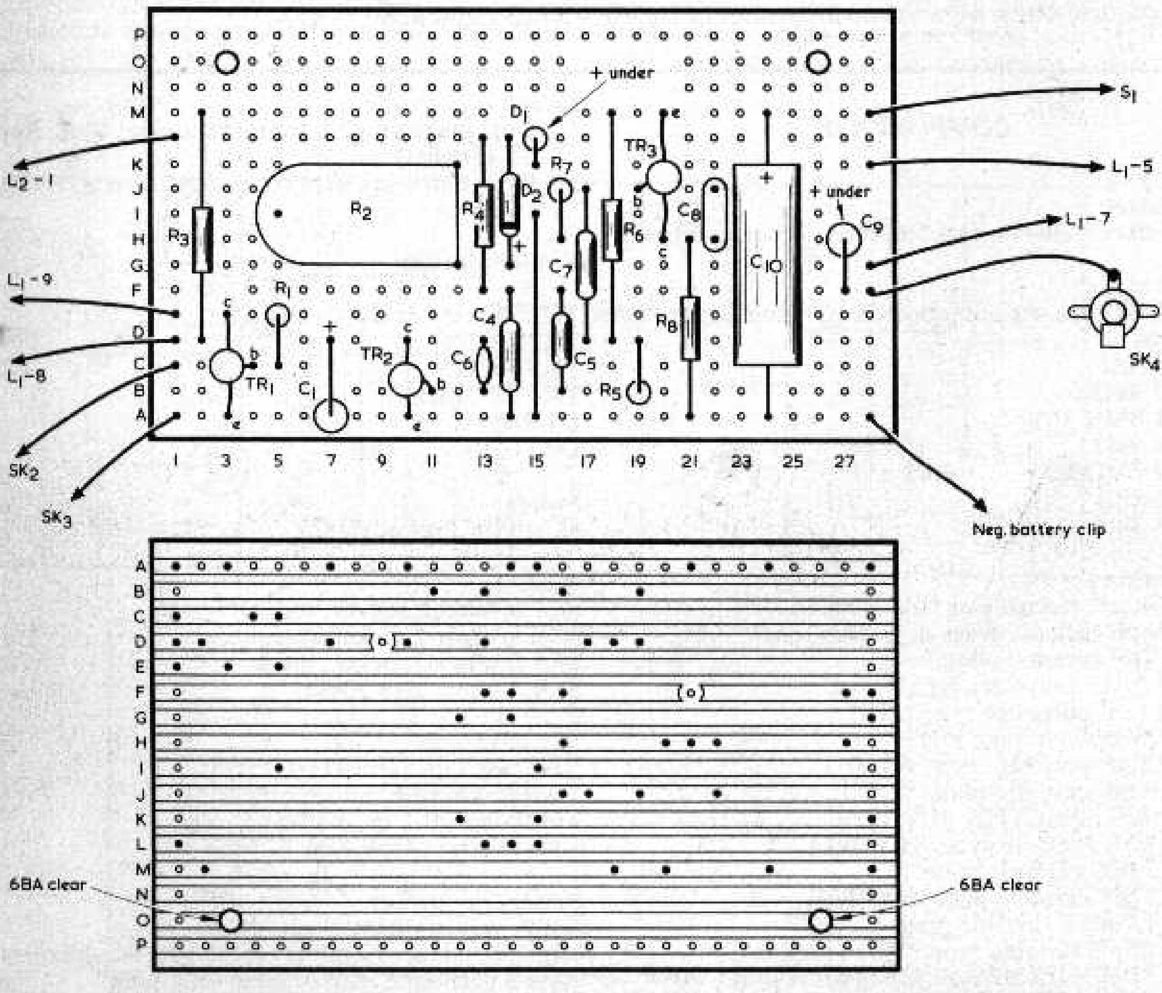


Fig.3. The component and copper sides of the Veroboard assembly. Wiring to components on the rear and front panels is also shown in Fig.4

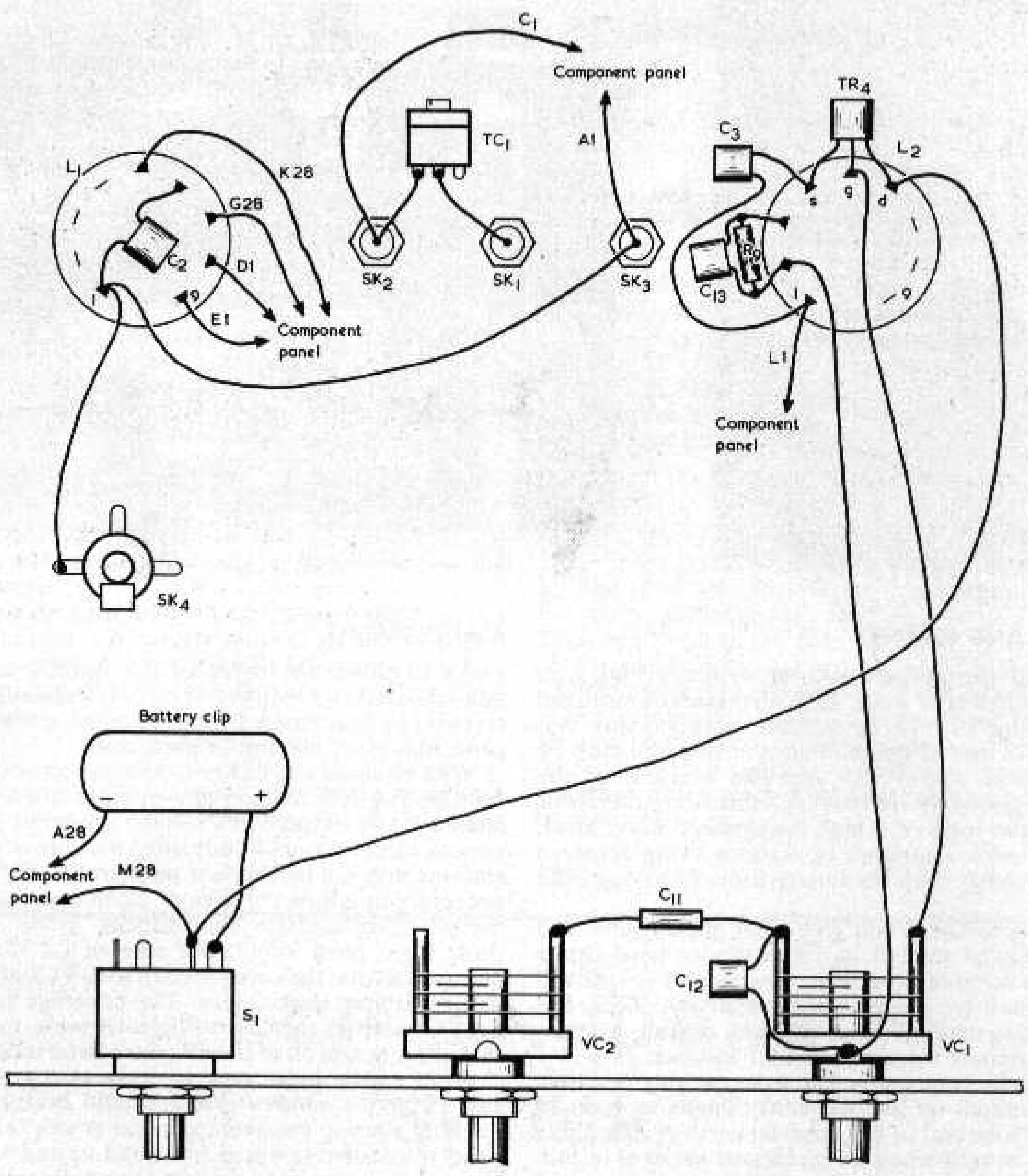
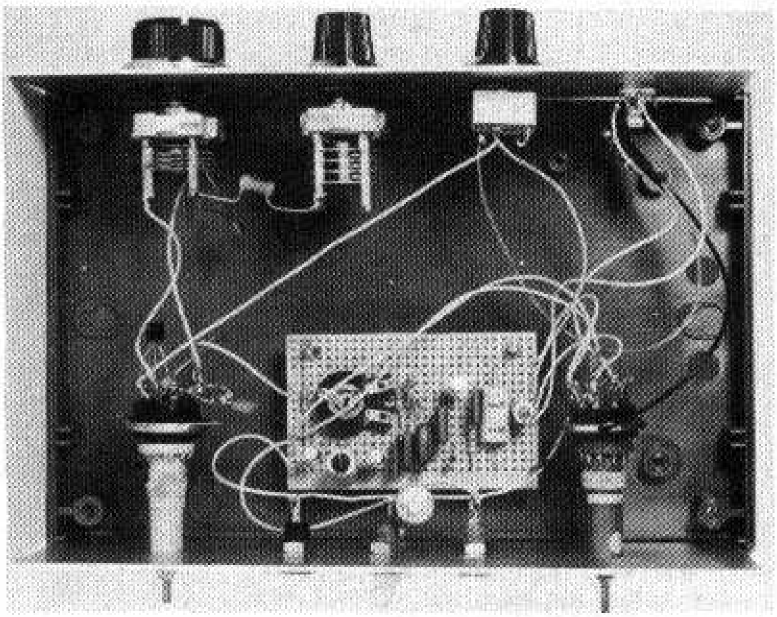


Fig.4. Point-to-point wiring. The letter and number references apply to the corresponding Veroboard holes. This diagram shows the remaining connection to SK4, shown removed from the front panel for clarity

ing holes have to be drilled out, and the two breaks made in the copper strips before soldering components to the board. Note that there is a link wire near the centre of the board. The two diodes should be the last components to be soldered to the board. The soldering of these diodes should be carried out fairly quickly as they are germanium types which can be damaged by excessive heat.

The panel is mounted on the base of the case just in front of the aerial and earth sockets. The two mounting holes are to the front. Two 6BA bolts and nuts are employed here, with spacing washers to keep the panel underside clear of the case bottom.

Before it is finally mounted in place, the Veroboard panel must be wired up to the components on the front and rear panels. The point-to-point wiring is shown in Fig.3. and 4. All the wiring should be kept reasonably short and direct. TC1 is connected directly between SK2 and SK1, being supported here by two stout pieces of tinned copper wire soldered to the socket tags. Some of the oscillator circuitry is connected to the valveholder fitted over the pins of L2. Pins 1 and 6 of this valveholder are used as anchor tags and do not connect to any coil windings. The letter and number references in Fig.4 apply to the corresponding Veroboard holes in Fig.3.



Another view into the receiver interior. Transistor TR4 is mounted on the valveholder tags at L2. The battery is positioned behind S1 and SK4

AERIAL AND EARTH

The set can be used with an ordinary long wire aerial consisting of some 10 to 40 metres of insulated wire strung as high as possible between any two convenient anchor points. This type of aerial must be plugged into socket SK1 to avoid overloading the input stages of the receiver. Overloading manifests itself in the form of a high background noise level, together with a number of stations being received simultaneously with the tuning controls having little effect.

An indoor aerial will give quite good results and can consist of some 3 to 10 metres of wire strung around a room or in an attic. Satisfactory results will be obtained by plugging this aerial into SK2, but overloading may still occur at times, making it necessary to connect the aerial to SK1 instead.

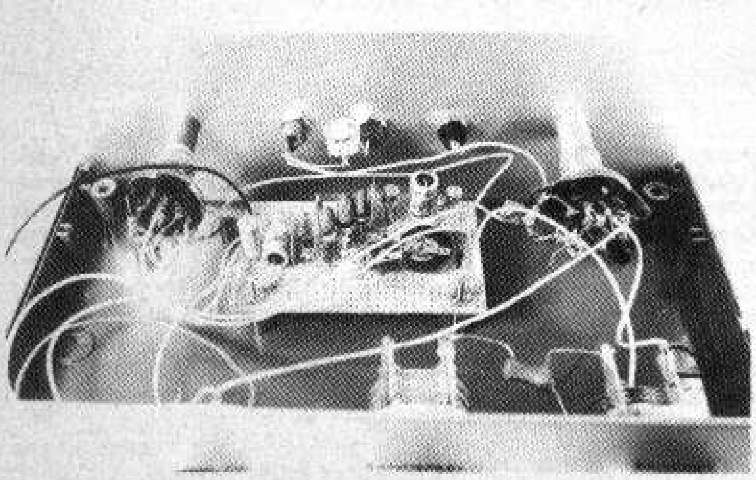
An earth connection can considerably increase signal strength on low frequency bands such as 80 metres. However, in this case, an earth is only likely to be of benefit when an inefficient aerial is in use. The set does not require a very strong input signal and can be overloaded by such a signal. The best type of earth connection is provided by a metal pipe buried or pushed into moist earth, with a lead which is as short as possible connecting it to the receiver.

ADJUSTMENT

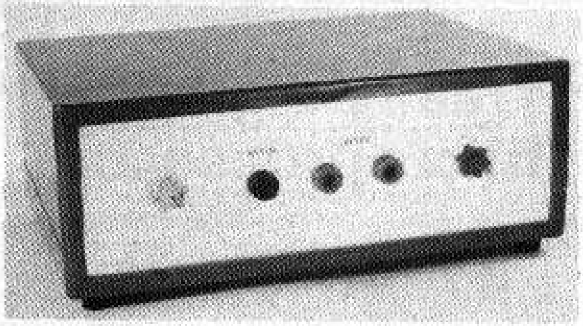
As supplied, the cores of L1 and L2 are fully screwed into the formers. The cores should be unscrewed so that about 10mm. of metal screw thread protrudes from the end of each coil.

With an aerial and headphones connected it should then be possible to tune in a number of stations of some kind by means of VC1 and it should be possible to peak these stations by adjusting the core of L1. The stations may not be amateur ones, and it will then be necessary to adjust the core of L2 in order to locate the 80 metre amateur band signals. When some of these have been found, the core of L2 should be adjusted so that they are tuned in with VC1 at around half maximum capacitance. The coverage provided by VC1 should then be sufficiently wide to ensure that all or nearly all of the 80 metre band is covered.

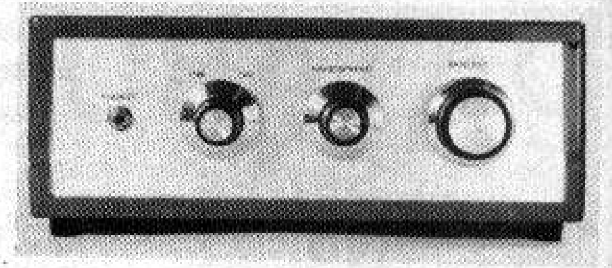
After a little experience with the set the limits of the 80 metre amateur band should become fairly obvious. During the evenings, and at weekends, the band is usually crammed from end to end with stations, and the band limits can then be located quite easily. If necessary, the core of L2 can be given a final slight adjustment to centralise the band in the range covered by VC1. VC1 is then adjusted to the centre of the band and the core of L1 finally adjusted for max-



The rear panel wiring. Trimmer TC1 is wired between sockets SK1 and SK2



The coils and aerial and earth sockets are assembled on the rear panel. The coils are held in position by plastic nuts which are supplied with them, and care must be taken not to over-tighten these nuts



On the front panel socket SK4 is to the left with the on-off switch next to it, followed by VC2. VC1 is to the extreme right. The panel legends are taken from Panel-Signs Set No. 4. It will be found convenient to fit VC1 with a larger knob than is employed with the other two controls

imum sensitivity. The bandwidth of the L1 tuned circuit is wide enough to give good sensitivity over the entire band.

During daylight hours the 80 metre band provides reception over a relatively short range of about 200 miles, but after darkness has fallen the range becomes very much greater and quite distant stations can often be received.

Two remaining adjustments concern R2 and TC1. The set will work perfectly well with R2 at any setting. It may occasionally be found that strong broadcast signals or possibly other transmissions are breaking through whereupon R2 should be adjusted in an attempt to null the interferring signal. Adjustment of R2 may not always remove the signal, whereupon it is necessary to change the aerial input to SK1 if it is at SK2, or to reduce the capacitance of TC1.

When only a modest outside aerial is being used, TC1 will probably give best results when set for maximum capacitance. However, with longer aerials the set may be overloaded unless the capacitance of TC1 is reduced somewhat. This is really a matter of finding a setting which gives good sensitivity without overloading problems. ■

REGENERATIVE

The regenerative v.h.f. receiver is assembled in a ready-made case, with a consequent easing of constructional difficulties

By
R. A. Penfold

This simple receiver uses three transistors (including one f.e.t.) and provides full coverage of the normal 88 to 108MHz f.m. broadcast band. The set is completely self-contained as it incorporates a 9 volt battery supply and a telescopic aerial. The output is intended to feed a crystal earphone, but in practice it seems to work into any normal type of headphones perfectly satisfactorily.

The circuit is rather unusual in that it uses a regenerative detector which demodulates the received f.m. signal using slope detection. While it is possible to resolve quite weak stations with this receiver, it is only really intended for use in areas where f.m. reception is reasonably good. Adjustment of the set is then not too critical, and a high signal-to-noise ratio with good volume should be obtained. With weak stations it is rather difficult to get optimum results and what are normally only slight hand-capacitance effects become considerably more apparent.

The output quality of the set is very acceptable, and is better than that which is normally produced by a simple a.m. receiver, or by more complicated ones for that matter. This is due to the relatively wide bandwidth which can be used at v.h.f., and which enables a good treble response to be obtained. Also, except under exceptional conditions, reception will be of a fairly local nature and so interference from foreign stations is virtually non-existent. On the deficit side, it is obviously impossible to receive foreign stations on a receiver such as this.

CIRCUIT DETAILS

Fig. 1 shows the complete circuit diagram of the receiver. The aerial is coupled to the detector stage by C1, this capacitor being needed to reduce the loading effect of the aerial on the detector. Without this low value series capacitance the detector would be so heavily damped that it would be prevented from functioning at all.

TR1 is in the detector stage and is connected in the common gate Colpitts oscillator mode, with feedback being provided by C12. The operating frequency of the circuit is determined by the tuned circuit given by L1, C11 and VC1. The last component is the tuning capacitor of the receiver. L2 is an r.f. choke which ensures that there is a fairly high impedance at v.h.f. in the source circuit, whilst maintaining a low impedance at audio frequencies. R1 is the source bias resistor as well as the source load, and C4 bypasses this at v.h.f. The audio output is developed across R1. C2 and C3 are decoupling capacitors.

Although, as was just stated, the detector transistor is connected in the Colpitts oscillator mode, the circuit is adjusted in practice such that there is just not quite enough feedback to cause oscillation. This is normal practice with a regenerative a.m. detector, and the feedback level causes the circuit to offer maximum gain and selectivity. In consequence the tuning response curve of the receiver features a sharp peak with steeply falling skirts on either side. When a frequency modulated signal is

V.H.F. RECEIVER

Employing slope detection, this 3-transistor f.m. radio requires no alignment.

applied to one of these tuning response skirts the result is a detected signal whose amplitide varies with the frequency modulation. The closer the detector is brought to the oscillation point the greater is the detected a.f. output for a given frequency modulated signal. Since the background noise level does not vary greatly with different levels of regeneration, there is an increase also in signal-to-noise ratio. The linearity of the detector is found, in addition, to be at its best when it is adjusted just below the threshold of oscillation.

VR1 provides the regeneration control by varying the supply voltage applied to the drain of TR1, and hence the gain offered by this transistor. It can therefore be adjusted to a point where the gain of TR1 is just insufficient to cause oscillation. This is a more convenient method of regeneration control than would be given by varying the value of the feedback capacitor, C12, and the control is in practice smooth and relatively easy to set up.

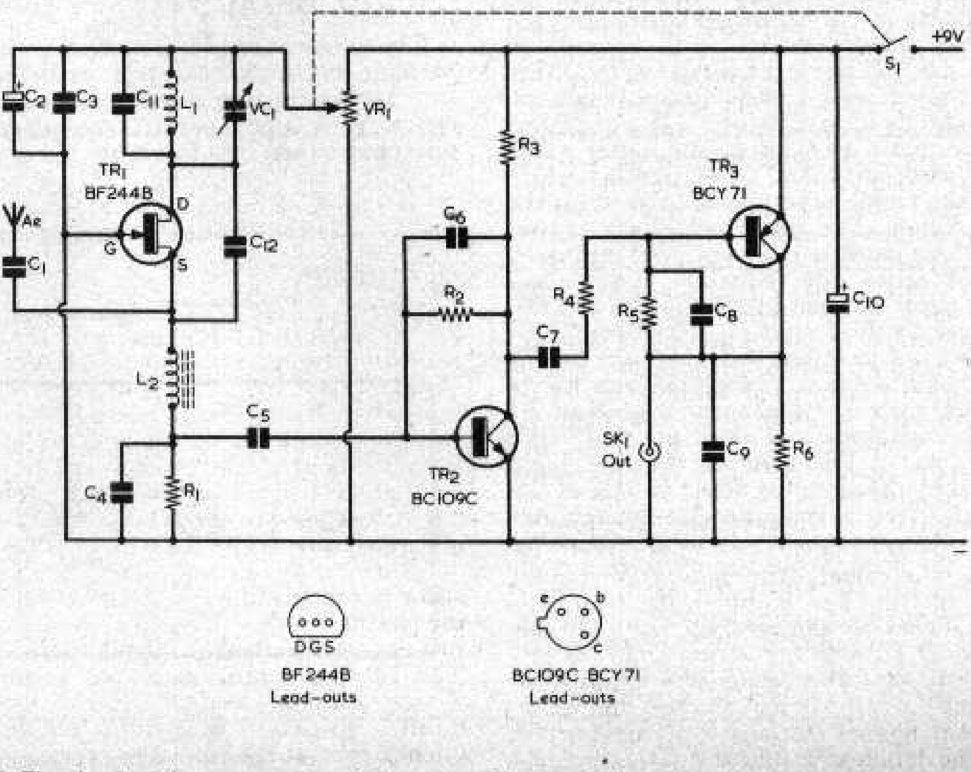


Fig. 1. The circuit of the regenerative v.h.f. receiver. The use of slope detection makes this a very simple receiver which requires no alignment

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)
R1 1kΩ
R2 1.8MΩ
R3 5.6kΩ
R4 1kΩ
R5 1.2MΩ
R6 4.7kΩ
VR1 5kΩ potentiometer, log, with switch S1

Capacitors
C1 3.9pF ceramic
C2 10μF electrolytic, 10V. Wkg.
C3 0.022μF disc ceramic
C4 0.01μF disc ceramic
C5 0.22μF type C280 (Mullard)
C6 330pF ceramic plate
C7 0.22μF type C280 (Mullard)
C8 270pF ceramic plate
C9 0.047μF disc ceramic
C10 100μF electrolytic, 10V. Wkg.
C11 6.8pF polystyrene or silvered mica
C12 6.8pF ceramic
VC1 25pF variable, type C804 (Jackson)

Inductors
L1, L2 see text

Semiconductors
TR1 BF244B
TR2 BC109C
TR3 BCY71

Switch
S1 s.p.s.t., part of VR1

Socket
SK1 3.5mm. jack socket

Miscellaneous
Verobox type 65-2520J
Telescopic aerial (see text)
2 control knobs
Plain perforated s.r.b.p. board, 0.1in. matrix
Iron dust core, 17 x 8mm. (see text)
Enammelled copper wire, 0.9mm. dia. (20 s.w.g.)
9 volt battery type PP3 (Ever Ready)
Battery connector
Wire, solder, etc.

A.F. STAGES

TR2 and TR3 are both high gain low noise common emitter a.f. amplifiers, and they provide by far the majority of the receiver's overall gain. Both stages are quite conventional. C5 couples the a.f. signal across R1 to the base of the n.p.n. TR2, and C7 couples the output of TR2 to the base of the p.n.p. TR3.

It is important that both the a.f. stages have a reduced response at the higher audio frequencies, since the two transistors are both capable of operating at v.h.f. If any v.h.f. signal were to find its way into the a.f. section and be amplified there, the result would be instability and a loss of performance. The reduced response at the higher audio frequencies also provides de-emphasis, which counteracts the treble premphasis present on the transmitted signal. The combined effect of pre-emphasis and de-emphasis is to give an improved signal-to-noise ratio. The reduction in high frequency response is effected by C6, R4, C8 and C9.

The receiver audio output is taken from TR3 collector by way of jack socket SK1. A direct connection without a series d.c. blocking capacitor is employed here, since a crystal earphone has an extremely high resistance and does not upset the voltage conditions at TR3 collector. The earphone is not affected by the standing direct voltage at the output socket. Even when magnetic headphones are used it is still unnecessary to have a blocking capacitor, as the headphones simply form a load, in parallel with R6, for TR3 collector.

C10 is the supply decoupling capacitor. The on-off switch, S1, is ganged with VR1. Power is obtained from a PP3 9 volt battery, and the current consumption of the receiver is approximately 3.5mA only. The battery will thus have quite a long life, even if the set is used frequently.

The BF244B specified for TR1 is available from several suppliers, including Electrovalue Limited.

BUILDING THE SET

The receiver is housed in a plastic Verobox type 65-2520J, which has dimensions of 150 by 80 by 50mm. The two controls and the 3.5mm. jack socket, SK1, are mounted on the lid of the case, which now becomes the front panel for this particular application. Details of the drilling required are given in Fig. 2. The diameter of the hole required for SK1 should be checked from the component itself.

The telescopic aerial is mounted vertically at the extreme left of the case, looking at the front of the set. As can be seen in the photograph of the interior, it is right against the plastic mounting pillars moulded into the case. The type employed

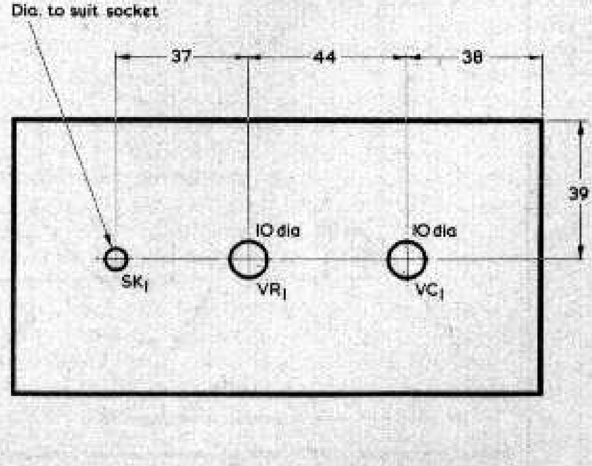


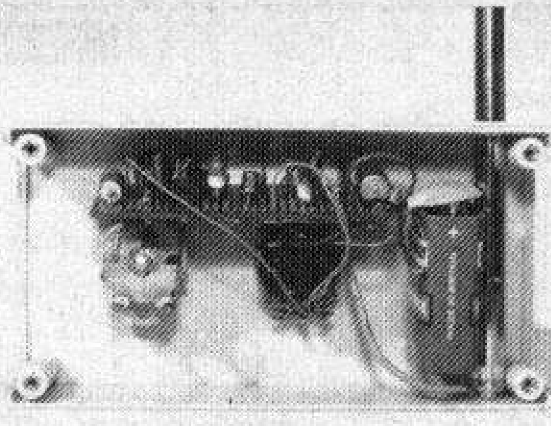
Fig. 2. Three holes are required in the front panel of the plastic case. These are positioned as shown here

in the prototype has an extended length of 975mm. and a hinged base section, and is available from Doram Electronics. A 9mm. diameter hole is drilled in what is now the top of the case, and a 4BA clear countersunk hole exactly below it in the case bottom. The body of the aerial passes through the 9mm. hole and it is secured at the bottom with a 4BA countersunk screw. A 4BA solder tag is fitted over this screw between the bottom of the aerial and the case inside surface, and connection to the aerial is made by way of this tag.

COMPONENT PANEL

With the exception of C11, all the small components are assembled on a plain perforated s.r.b.p. panel of 0.1in. matrix and having 31 by 13 holes. The component layout and the underside wiring on this panel are illustrated in Fig. 3.

First, the panel has to be carefully cut out from a



The battery is positioned between the end of the component panel and the telescopic aerial. A piece of foam plastic glued to the inside of the case rear is sufficient to keep it in place

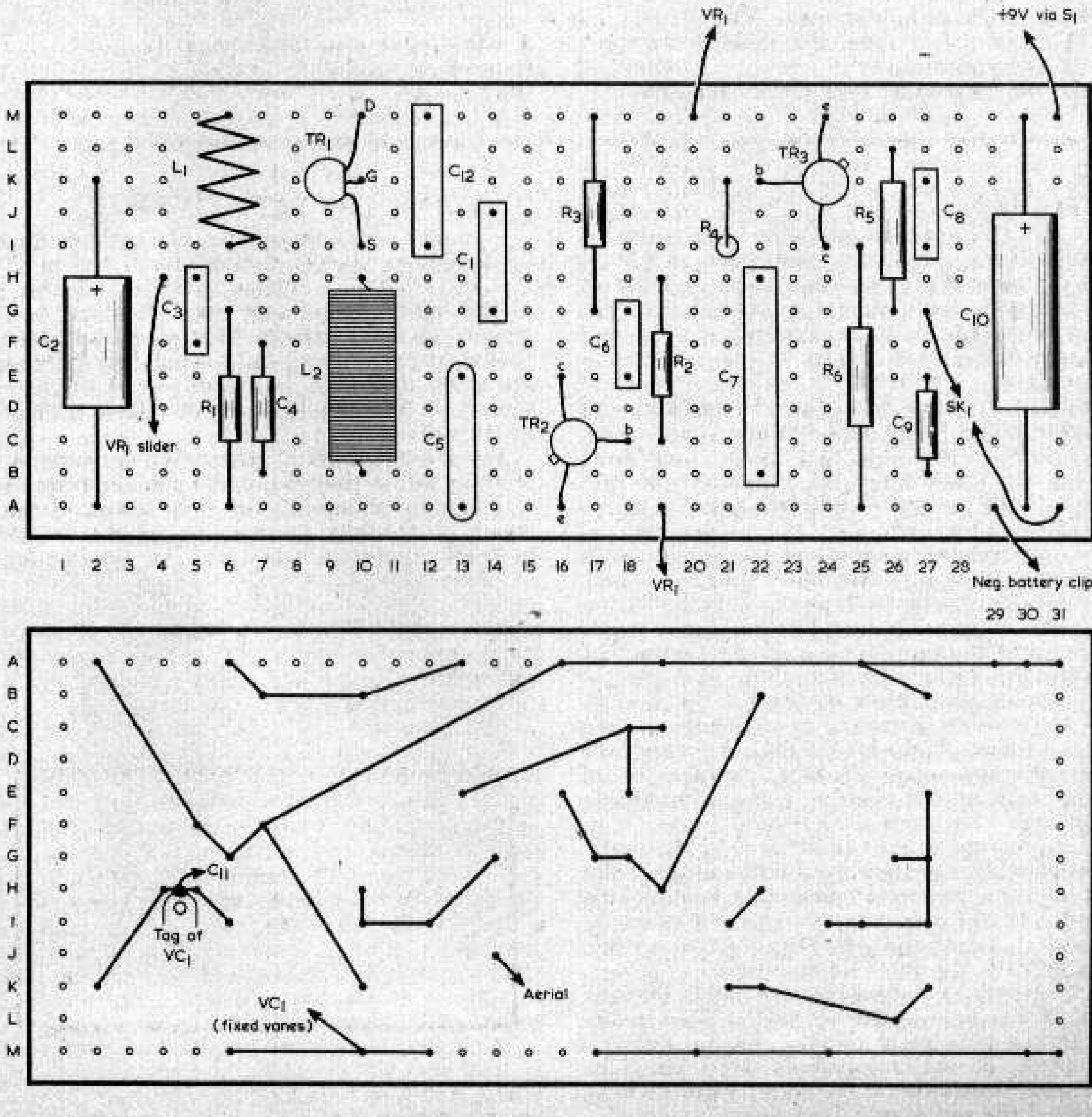
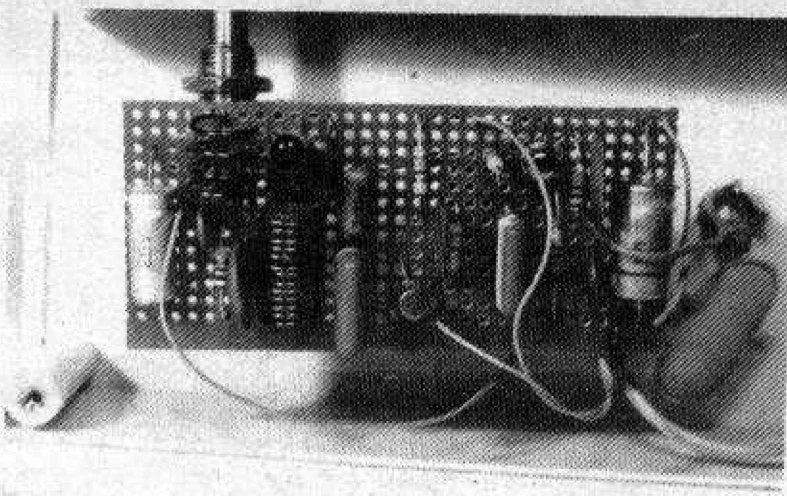


Fig. 3. Wiring of the components on the perforated s.r.b.p. panel



The perforated s.r.b.p. panel with components mounted and external leads attached

larger piece. The components are then fitted, their leads being bent flat under the panel so that they may be soldered together in the wiring pattern of Fig. 3. In some cases the component lead-outs may be too short for the required connections, whereupon tinned copper wire of around 22 s.w.g. can be used to extend any wires where necessary.

Both coils are home-made and are wound using enamelled copper wire of 0.9mm. diameter (about 20 s.w.g.). L1 is self-supporting and is wound on a temporary former of $\frac{5}{16}$in. diameter such as the shank of a twist drill of this size. It has precisely 4 turns equally spaced and its length is 0.4in. The lead-out wires project downwards and are trimmed to a length of about 5 to 10mm. The enamel insulation is then scraped off and the lead-outs are tinned with solder. These operations should be carried out before the coil is removed from its temporary former. When the coil has been completely prepared, its lead-outs pass through the appropriate holes in the component panel and are connected into circuit.

L2 is wound on a dust iron core having a diameter of 8mm. and a length of 17mm., this component being available as "Dust Core type 8" from Maplin Electronic Supplies. The winding consists of 13 turns of the same 0.9mm. enamelled copper wire wound in a single layer around the dust core; these turns will cover most if not all of the core. As with L1, the wire ends are bent down, scraped clean and tinned, before being passed through the holes in the component panel. L2 is not a tuned winding, and its inductance is not particularly critical.

The moving vanes tag of VC1 is soldered to the panel underside wiring at the position indicated in Fig. 3, using a generous amount of solder. This joint provides the actual mounting for the component panel and causes it to be held in position when VC1 is fitted in the case. C11 is soldered between the moving vane tag and one of the fixed vane tags of VC1. The few remaining connections external to the panel may next be completed, employing flexible insulated wires. These connections should be fairly short and direct, as long leads trailing around in the case could cause hand-capacitance effects and may also affect performance in other ways. The lead from hole A19 connects to the track tag of VR1 corresponding to full anti-clockwise rotation of its control knob. If the lead from the panel to the negative terminal of the battery connector is kept fairly short, this will assist in maintaining the battery in position between the end of the board and the telescopic aerial.

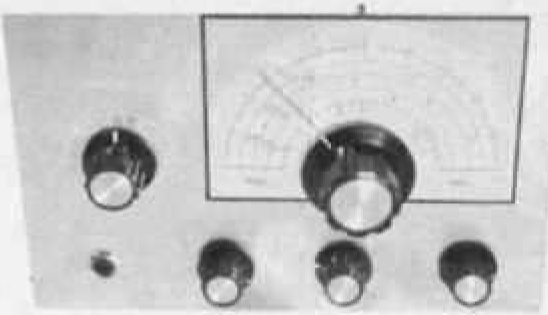
USING THE SET

The set has purposely been designed to cover somewhat more than the normal f.m. Band II so that stray capacitances and small errors in the construction of L1 will not result in part of the band being lost from the coverage of the set. Therefore, no alignment of any kind is necessary.

In order to obtain good results it is essential that VR1 be adjusted properly. By gradually advancing this control while adjusting the tuning control it should eventually be possible to receive a few stations. Further advancing VR1 should result in an increase in quality and volume, but care must be taken not to adjust the detector beyond the threshold of oscillation. This will result in signals being unintelligible, with the set radiating interference which could upset reception on other f.m. receivers nearby.

For those who are unfamiliar with slope detection of an f.m. signal, it should perhaps be explained that the receiver is not tuned to the centre of the signal's bandwidth, as it would be for normal a.m. or f.m. reception. Instead, the tuning is adjusted just off-centre, and it does not matter on which side of the centre the tuning is off-set. In practice, the effect is not excessively noticeable as there is quite a wide range of tuning settings which will produce a satisfactory output with any given signal, and there is only an extremely narrow range of settings at the centre where a completely distorted audio signal is given.

In order to obtain best results it will probably be necessary to tilt the aerial at 45 degrees. Also, the strength of f.m. broadcast signals often varies considerably from one part of a room to another, and it might be necessary to change the position of the set itself in order to obtain optimum reception. ■



REFLEX

By R. A. Penfold

Intended for a crystal earphone or crystal headphones, this simple receiver can be initially constructed in the form of a single transistor circuit. If desired, a l-transistor a.f. amplifier may then be added on the same chassis.

THIS LITTLE RECEIVER HAS A FREQUENCY COVERAGE extending from around 1.5 to 36MHz in three bands, and it thus covers virtually the complete short wave frequency spectrum. The approximate coverage for Range 3 is 1.5 to 5.5MHz (200 to 54.5 metres), for Range 4 5.0 to 17MHz (60 to 17.5 metres), and for Range 5 10 to 36MHz (30 to 8.5 metres). These Range numbers correspond to the Denco Blue plug-in coils type 3T, 4T and 5T respectively, and the band required is selected by merely plugging the appropriate Denco coil into its holder. The complications which would arise if bandswitching were used are thus avoided.

The basic receiver employs only a single transistor in a reflex circuit having controlled regeneration. An optional single transistor a.f. amplifier can be added to give the set a degree of extra gain. The output, either with or without the a.f. amplifier, is intended for a crystal earphone or crystal headphones. As with any small short wave receiver, an efficient outdoor aerial is required to obtain good results.

THE CIRCUIT

The circuit diagram for the basic single transistor version of the receiver is shown in Fig. 1. Signals received by the aerial are coupled via L1 to the tuned winding, L2. This is tuned by VC1 and VC2 and selects signals at the desired frequency, these being coupled to the base of the transistor by way of coupling winding L3. C2 bypasses the earthy end of L3 to chassis for r.f. signals. Of the two tuning capacitors, VC1 is the main tuning control, whilst the lower value VC2 is the bandspread control.

TR1 operates as an r.f. amplifier, and the amplified r.f. signals appear at its collector. The r.f. choke, L4, presents a high impedance to r.f. signals whilst C4 offers a low impedance at these frequencies. In consequence, the r.f. signals pass via C4 and D1 back to the base coupling winding, L3. Although it has no d.c. return, diode D1 functions in practice as a non-linear device and the signal now passed to L3 consists of the detected r.f. signal.

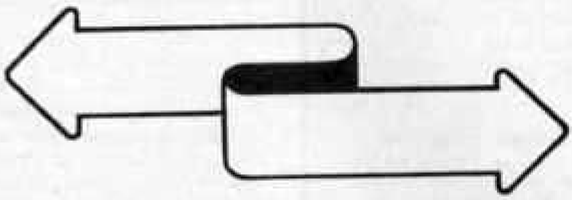
TR1 functions this time as an a.f. amplifier. L4 offers a low impedance at audio frequencies and the amplified a.f. signal passes through this choke and the d.c. blocking capacitor to the volume control, VR3. The signal from this control is then fed to the jack socket SK4 and thence to the earphone or headphones. C5 filters out any residual r.f. component in the output signal which is still present after the r.f. choke. R2 is the collector load for the transistor, both at r.f. and at a.f., and R1 is the base bias resistor.

Two aerial sockets are provided, one coupling direct to L1, and the other coupling to that winding via C1. The aerial is normally plugged into SK2, but it can be plugged into SK1 under conditions of high signal strength which could cause overloading of the receiver.

In order to increase gain and selectivity, regeneration, or r.f. positive feedback, is incorporated in the circuit. The signals at the collector of the transistor and the non-earthy end of L2 are in phase, whereupon C3 and VR1 are employed to provide a controllable level of r.f. feedback. VR1 functions as a coarse control of regeneration, fine control being given by VR2 which varies the supply voltage applied to the transistor. This arrangement enables an extremely smooth control of regeneration to be provided.

It will be noted that the ends of winding L3 are designated '5 or 7' and '7 or 5'. This is because it was found that the coils for Ranges 3 and 4 had this winding

SHORT WAVE RECEIVER



connected one way round to its pins in relation to L2, whilst the Range 5 coil had the winding connected the other way round. The two methods of connection are accommodated by providing two coil holders, one for the Ranges 3 and 4 coils, and the other for the Range 5 coil.

Of the components, the only ones that require special comment are VC1 and VC2. VC1 can be any small air-spaced capacitor having a maximum capacitance of around 365pF and a Jackson type '0' or '00' would be suitable. VC2 requires a maximum capacitance of 50pF and can be a Jackson type C804. VC1 is provided with a scale taken from 'Panel Signs' Set No. 5, and this causes its spindle to be 2¼ in. from the top of the front panel. Before cutting out the front panel ascertain that there will be sufficient space above the chassis to accommodate the body of the particular component used for VC1. If not, the height of the panel should be increased or a capacitor of smaller size employed. 'Panel Signs' are available from the publishers of this journal.

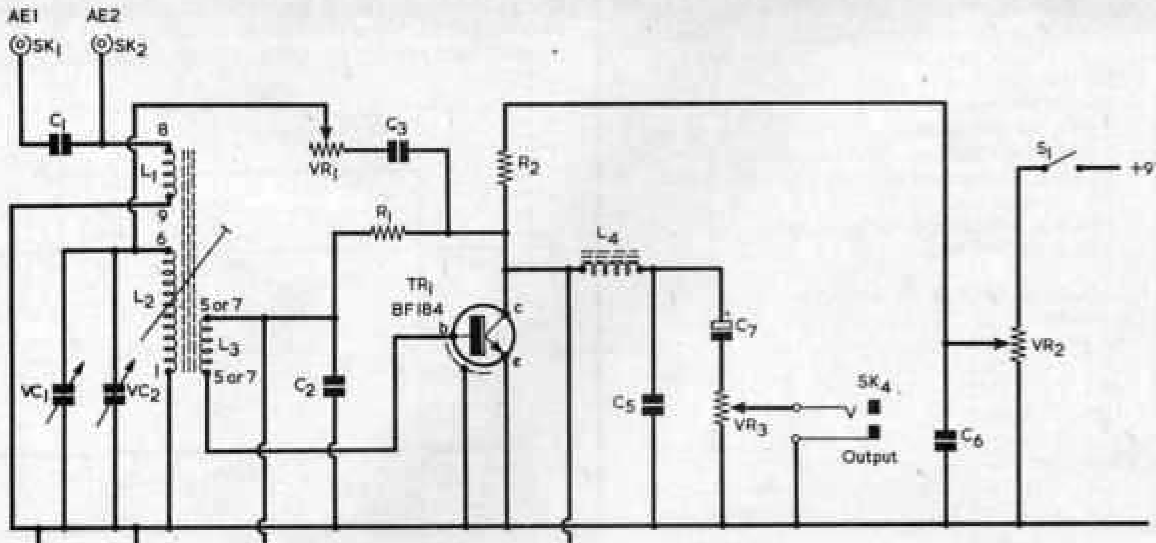


Fig. 1. The circuit of the single transistor reflex short wave receiver

COMPONENTS

Resistors

R1	470kΩ, ¼ watt 10%
R2	4.7kΩ, ¼ watt 10%
VR1	100kΩ potentiometer, linear
VR2	25kΩ potentiometer, linear
VR3	25kΩ potentiometer, log, with switch S1

Capacitors

C1	10pF ceramic or silvered mica
C2	0.01μF plastic foil
C3	8.2pF ceramic or silvered mica
C4	0.022μF plastic foil
C5	0.01μF plastic foil
C6	0.01μF ceramic or plastic foil
C7	2 or 2.2μF electrolytic, 16 V. Wkg.
VC1	365pF variable (see text)
VC2	50pF variable (see text)

Inductors

L1, 2, 3	Miniature Dual Purpose coils, Blue, transistor usage, Ranges 3T, 4T and 5T (Denco)
L4	2.5mH r.f. choke, type CH1 (Repanco)

Semiconductors

TR1	BF184
D1	0A90

Switch

S1	s.p.s.t., part of VR3

Sockets

SK1	Wander plug socket, red
SK2	Wander plug socket, red
SK3	Wander plug socket, black
SK4	3.5mm jack socket

Miscellaneous

Crystal earphone or headphones with 3.5mm jack plug
PP3 battery (Ever Ready)
Battery connector
2 B9A valveholders
5 control knobs and scales (see text)
16 s.w.g. aluminium chassis, 7 by 4 by 1½ in. (see text)
18 s.w.g. aluminium for front panel
¼ in. grommet

Components for Add-On Amplifier

Resistors
(All ¼ watt 10%)

R3	2.2kΩ
R4	3.3MΩ
R5	6.8kΩ

Capacitors

C8	0.1μF plastic foil, side wires
C9	150pF polystyrene or silvered mica

Transistor

TR2	BC169C

Miscellaneous

0.1 in. matrix Veroboard.

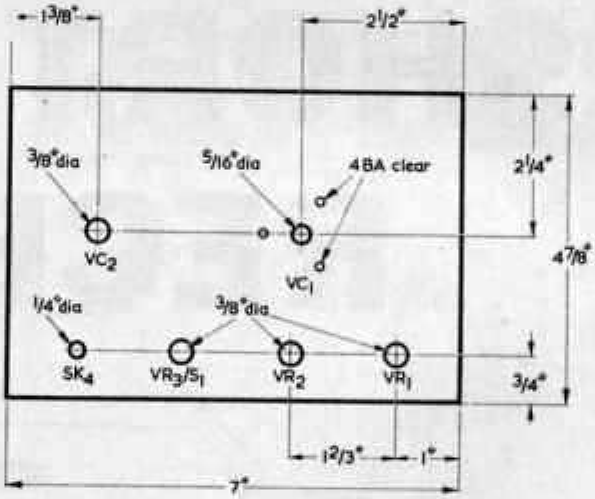


Fig. 2. Dimensions and drilling details for the front panel

CHASSIS AND PANEL

The front panel is home-made from 18 s.w.g. aluminium sheet and it has the dimensions shown in Fig. 2. This diagram also gives drilling details.

If the capacitor employed for VC1 is a Jackson type '0' or '00' component, it is mounted to the front panel by three 4BA countersunk bolts which pass into tapped holes in the front plate of the capacitor. Spacing washers, which could consist of 2BA nuts, are fitted between the panel and the capacitor front plate to provide clearance for the raised centre section. The bolts must be short and their ends must not pass beyond the inside surface of the capacitor front plate or they may damage the fixed or moving vanes. The capacitor is mounted so that its fixed vanes are towards VC2, as illustrated in the photograph showing the rear of the receiver. A piece of paper placed against the front plate of the capacitor can

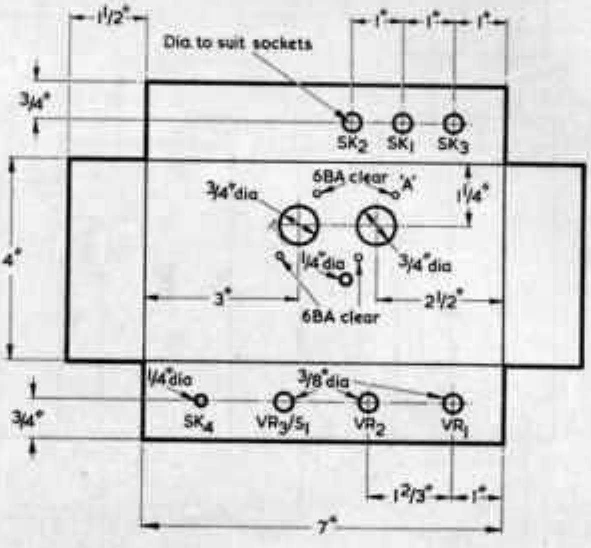


Fig. 3. Top view of the chassis. The flanges are shown opened out for clarity

be marked with the positions of the three holes. The paper can then be used as a template to mark out the corresponding holes on the front panel.

The aluminium chassis measures 7 by 4 by 1½ in., and can be obtained ready-made from H. L. Smith & Co. Ltd., 287-289 Edgware Road, London, W2 1BE. Fig. 3 gives a top view of the chassis, with flanges opened out for clarity, and shows the drilling details.

The two ¾ in. holes on the deck of the chassis are for the two B9A valveholders which take the coils. These are most easily cut out with the aid of a chassis punch or cutter. Alternatively, a series of small closely spaced holes may be drilled inside the periphery of the cut-out, and the centre piece then snipped or punched out. The rough edges of the holes can be finally smoothed out to the correct diameter with the aid of a small half-round file. The positions of the two 6BA clear holes for each valveholder are marked out with the aid of the valveholder itself. When they are mounted, the valveholders should have the orientation shown in the wiring diagram of Fig. 4.

The front flange of the chassis and the front panel are held together by the bush mounting nuts of SK4, VR3, VR2 and VR1. It is therefore important that the mounting holes for these components are drilled accurately in the correct positions in both the chassis and the front panel. The ½ in. hole in the deck of the chassis in front of the valveholder holes will later allow several leads to pass through, and should be fitted with a rubber or p.v.c. grommet. Its precise positioning is not important.

Once all the drilling has been completed the chassis and panel can be assembled, and the controls, sockets and valveholders mounted in the appropriate positions. A solder tag is secured, below the chassis, under the valveholder mounting nut at the hole marked 'A' in Fig. 2. Make sure that the lower fixed vane tag of VC1 does not touch the upper surface of the chassis deck.

WIRING

The wiring below the chassis is shown in Fig. 4. Valveholder tags which do not connect to coil pins are used as anchoring tags. This assists in easing the process of wiring.

Make sure that the lead-outs of TR1 do not touch each other (except for the emitter and shield lead-outs which are both connected to chassis) and if necessary insulate the lead-outs with short lengths of sleeving. A lead from pin 6 of the right-hand valveholder in the diagram passes through the ½ in. hole in the chassis to the fixed vane tag of VC1. This lead should be kept short. Above the chassis, the fixed vane tag of VC1 is connected to the fixed vane tag of VC2. Also passing through the ½ in. hole are the two leads to the battery connector. There is no other wiring above the chassis, and the moving vanes of VC1 and VC2 take their chassis connection by way of the front panel.

As stated earlier, one valveholder is used for the Range 3 and 4 coils, whilst the other is used for the Range 5 coil. When the set is viewed from above the chassis and from the front, the Range 3 or 4 coil

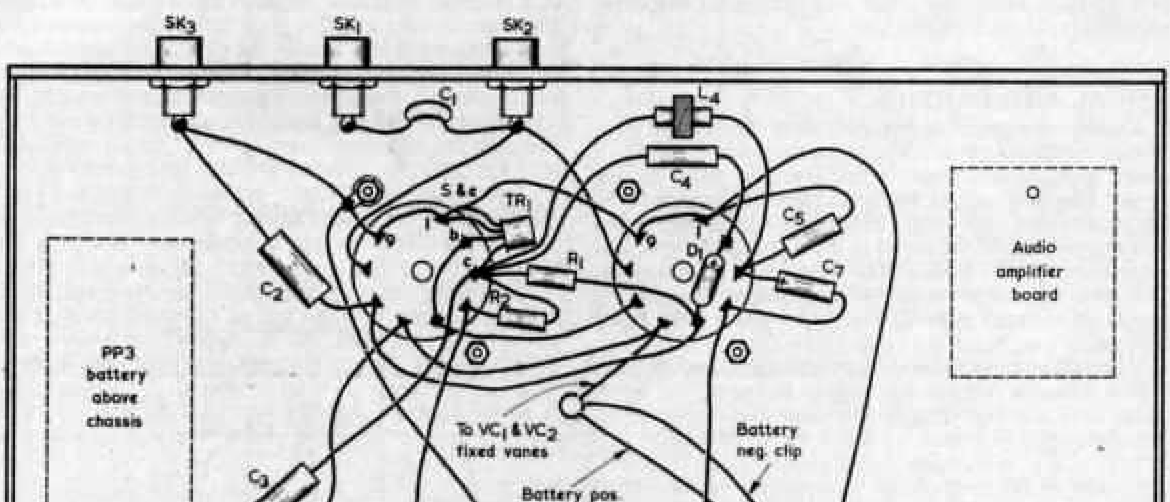
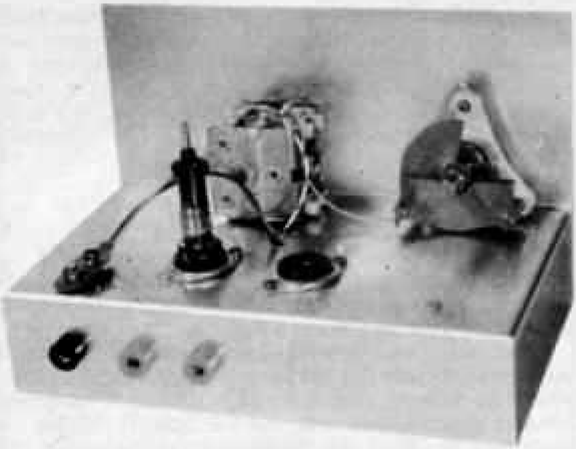


Fig. 4. Wiring and component layout under the chassis. The few connections needed above the chassis are discussed in the text



Rear view of the receiver with a coil inserted

occupies the holder on the right and the Range 5 coil occupies the holder on the left-hand side. It should be mentioned that the regeneration circuit used in this receiver is not one for which the coils are specifically designed, and it is possible that the connections to pins 5 and 7 may differ in some coils. Whilst this would not upset operation when the coil is used in its normal circuit application it could prevent regeneration taking place in the present receiver. The coils should be initially fitted to the valveholders in the manner just described. Should it be found that a coil does not allow regeneration to take place, the effect of fitting it to the other valveholder should be checked.

AERIAL AND EARTH

A long wire aerial is required, and this should be a proper outdoor type as very few stations will be received under average conditions when using a short indoor aerial. For best results the aerial should consist of 50 feet or more of wire strung between any two convenient points which place the aerial at a reasonable height, and preferably clear of buildings or other large obstructions. The wire should be reliably insulated at its securing points in order to prevent received signals from being earthed.

Normally, the aerial will be plugged into socket SK2. When using a very long aerial, however, or when conditions are very good, the receiver may be overloaded. Overloading will result in stations in parts of the band being inseparable, together with a loud hissing sound in the background. This is due to cross-modulation.

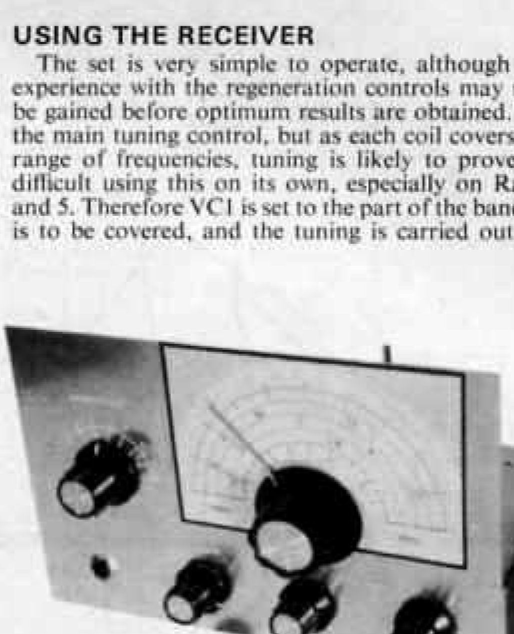
Under these conditions it is necessary to reduce the signal input from the aerial, and this is achieved by plugging the aerial into SK1.

An earth connection can be plugged into SK3, but this will probably have little effect on the performance of the set except, perhaps, on the 80 metre and, more particularly, on the 160 metre amateur bands.

An earth can consist of a length of metal pipe with a lead connected to it. The pipe is buried in moist earth, and the lead taken to the receiver. The earth lead-in should be as short as possible. The effectiveness of the earth is largely dependent upon the area of metal which is in contact with the ground, and therefore the larger the pipe the better.

USING THE RECEIVER

The set is very simple to operate, although a little experience with the regeneration controls may need to be gained before optimum results are obtained. VC1 is the main tuning control, but as each coil covers a wide range of frequencies, tuning is likely to prove rather difficult using this on its own, especially on Ranges 4 and 5. Therefore VC1 is set to the part of the band which is to be covered, and the tuning is carried out by the



Another view of the receiver as seen from the front bandspread control, VC2. This has a much lower value than VC1, and so covers only a small portion of the band.

VR3 is the combined a.f. volume control and on-off switch, and in the single transistor version of the receiver will need to be kept at maximum all the time.

The settings of VR1 and VR2 are very critical if maximum sensitivity is to be obtained. Start with VR1 adjusted fully anti-clockwise, and VR2 advanced about two-thirds to three-quarters of full travel in the clockwise direction. If VR1 is now advanced there should be a small increase in sensitivity. Continuing to advance VR1 will cause the sensitivity to steadily increase until a point is reached where the set breaks into oscillation. This will be heard as a reduction in background hiss and as whistles when the set is tuned across transmissions.

VR1 should be backed off to a point just below that at which oscillation occurs. VR2 is then advanced in a clockwise direction as far as is possible without the set oscillating. It is at the setting just below the oscillation point that the sensitivity and selectivity of the receiver are at their greatest. In order to obtain good results it is important to ensure that the regeneration controls are adjusted accurately to this setting.

Do not try to obtain fine adjustment of regeneration by means of VR1 as this is only the coarse control. A much more precise setting can be obtained by using VR2. Always ensure that VR2 is well advanced in a clockwise direction, as if this control is advanced less than about half-way a serious loss of gain may result. The required settings for VR1 and VR2 will vary with the settings of the tuning controls and the coil which is in use.

The specific coverage of each coil depends upon the position of its adjustable core, and this should be set so that about ⅜ in. of its metal thread protrudes from the top of the coil former. The Range 4 coil is likely to prove of most use since this range contains most of the popular broadcast bands. It also contains the 40 metre amateur band. The Range 5 coil gives coverage of the h.f. broadcast bands and amateur bands. Coverage with the Range 3 coil includes the 80 and 160 metre bands, as well as numerous maritime transmissions.

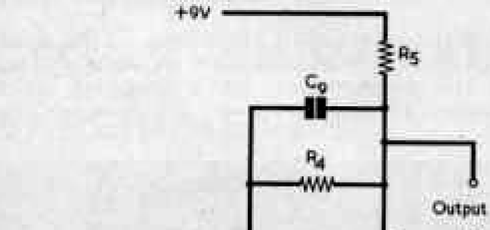


Fig. 5. Circuit of the add-on amplifier stage

The front panel has one of the medium size tuning scales in 'Panel Signs' Set No. 5 affixed to it, and this appears behind VC1 control knob. It may be marked up in terms of the main frequency bands after these have been located and identified. A home-made cursor is fitted to the control knob by means of adhesive. A small scale, also taken from 'Panel Signs' Set No. 5, is positioned behind the knob for VC2. With the prototype, white wording, taken from 'Panel Signs' Set No. 3, was positioned alongside the controls to indicate their functions.

ADD-ON STAGE

The maximum volume and gain of the basic receiver are not very high, and results are considerably enhanced by the addition of an a.f. amplifier stage. The circuit of a suitable amplifier is shown in Fig. 5. This is a straightforward high gain common emitter stage.

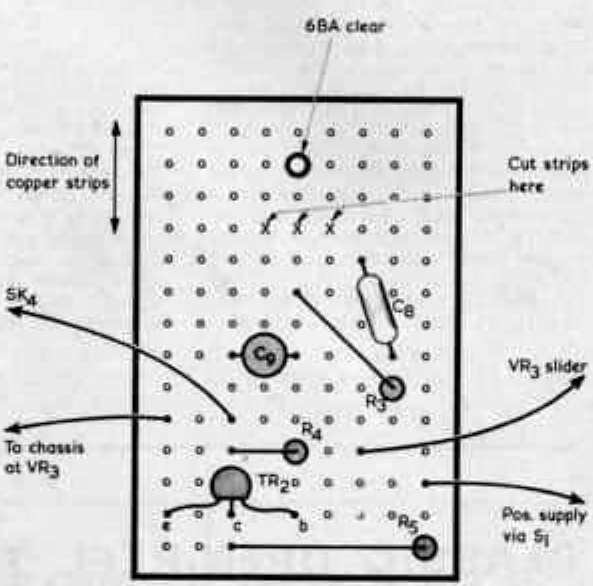


Fig. 6. Component side of the Veroboard panel on which the amplifier stage is assembled

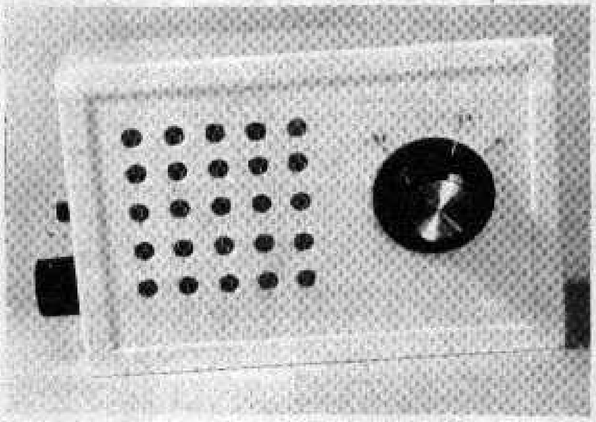
It is assembled on a 0.1 in. matrix Veroboard panel having 9 by 14 holes. Fig. 6 shows the layout on this panel as viewed from the component side. The copper strips have to be cut at three points, as indicated in the diagram. The only major wiring modifications required to the single transistor version consist of disconnecting the lead from VR3 slider to SK4 and of making the alternative connections between these circuit points and the amplifier which are shown in Fig. 6. A 6BA clear hole has also to be drilled in the chassis to take a bolt for mounting the amplifier board. Its position, under the chassis, is indicated in Fig. 4. The board is mounted by means of a single 6BA bolt ½ in. long, an insulated spacing washer about ¼ in. thick being placed over this between the chassis and the board.

As a final point, the current consumption of the receiver is very low. It is approximately 2mA for the single transistor version, and 2.6mA for the two transistor version. ■

THREE TRANSISTOR REGENERATIVE RECEIVER

By

A. P. Roberts



A self-contained transistor portable giving loudspeaker or earphone reception on the medium wave band.

THIS IS A SIMPLE PORTABLE 3-TRANSISTOR RECEIVER covering the medium wave band, and providing loudspeaker reception. Due to the simplicity of the circuit the available volume is not great, but the set makes a good bedside receiver. An output socket is provided for a magnetic earphone.

CLASS A OUTPUT

A Class A output stage is used, and the total current consumption of the receiver is approximately 12mA. This is economically provided by four 1.5 volt cells connected in series to give 6 volts. The set is completely self-contained, having an internal ferrite aerial, and it can be made up in reasonably compact form. The author's receiver was housed in a case measuring approximately 6 by 4 by 2 in.

With the prototype a number of stations can be received at a reasonable volume level, including B.B.C. Radios 1, 3 and 4 during daylight. Additionally, Radio Luxembourg and several other Continental stations can be received after dark.

The circuit diagram of the receiver is shown in Fig. 1. The circuit consists of a single transistor regenerative detector, TR1, feeding a 2-stage audio amplifier incorporating TR2 and TR3.

VC1 is the tuning capacitor and L1 is the tuned winding on the ferrite aerial. L2 is a coupling winding, and it couples the received signals into the low input impedance of TR1 base via the d.c. blocking capacitor, C1. TR1 is biased by R1, and has L3 and VR1 as its collector load for r.f., whilst R2 acts as its a.f. collector load. C2 is an r.f. bypass capacitor.

The way in which this type of circuit detects the signal is quite simple. The transistor is biased so that it is conducting only a low current between its emitter and collector. Negative r.f. half-cycles at the base cause a larger collector current to flow. The gain of the transistor increases with increasing collector current, and so these half-cycles receive a higher degree of amplification.

Positive r.f. half-cycles have the opposite effect, and cause a smaller collector current to flow with, in consequence, a lower degree of amplification. The overall non-linear amplification thus given by the transistor results in detection of the received signal.

The use of controllable regeneration, or positive feedback, increases the level of the input r.f. signal, and also the difference in the amplification which is given to half-cycles of opposite polarity. Detection is therefore more efficient as also is the amplification provided by the transistor.

In Fig. 1, L3 is the regenerative feedback winding, and it couples the amplified r.f. signal at TR1 collector back to its base by way of L2. Potentiometer VR1 controls the level of feedback. If VR1 is set to insert minimum resistance into circuit, L3 on its own forms the r.f. collector load for TR1. There will be a relatively high r.f. current in this winding and a similarly high r.f. signal fed back via L2 to the base. The feedback, under these conditions, will be such as to cause the stage to oscillate. If VR1 is next adjusted to insert an increasing resistance into circuit, there will be a lower r.f. current flowing in L3 and the level of feedback will reduce. At a certain setting of VR1 the feedback will be insufficient to maintain oscillation in TR1, although the feedback

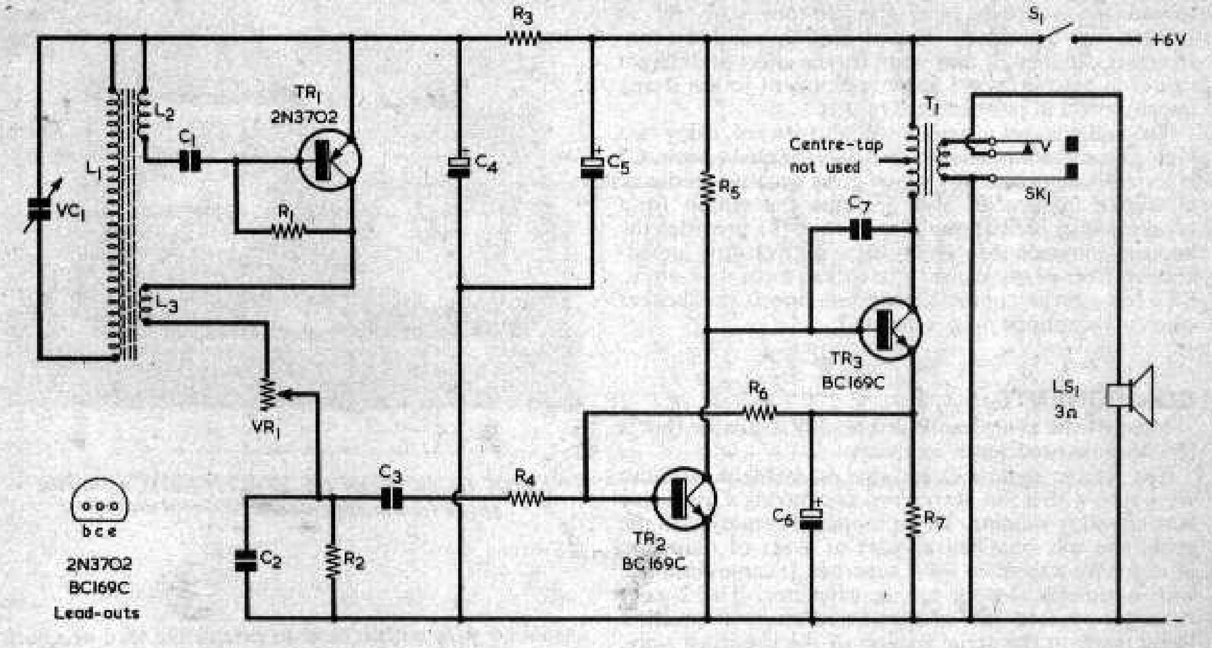


Fig. 1. The circuit of the 3-transistor regenerative receiver

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	1.5MΩ (see text)
R2	5.6kΩ
R3	1kΩ
R4	2.7kΩ
R5	4.7kΩ
R6	150kΩ
R7	82Ω
VR1	5kΩ potentiometer, linear

Capacitors

C1	0.022μF plastic foil
C2	0.015μF plastic foil
C3	0.22μF plastic foil, side wires
C4	100μF electrolytic, 10 V. Wkg.
C5	100μF electrolytic, 10 V. Wkg.
C6	400μF electrolytic, 4 V. Wkg.
C7	1,000pF disc ceramic
VC1	Value to suit ferrite aerial (see text)

Inductors

L1, 2, 3	Medium wave ferrite aerial (see text)
T1	Output transformer type LT700 (Eagle)

Transistors

TR1	2N3702
TR2	BC169C
TR3	BC169C

Switch

S1	Slide switch

Socket

SK1	3.5mm jack socket with break contact

Speaker

LS1	3Ω speaker, 3 in. square

Miscellaneous

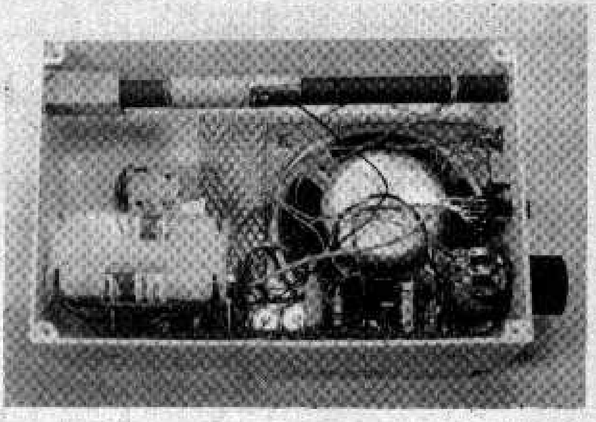
8Ω magnetic earphone with 3.5mm jack plug (if required)
Plain Veroboard, 0.15 in. matrix
4 cells, 1.5 volt type HP7 or equivalent (Ever Ready)
Battery holder (see text)
PP3 connector clip for battery holder
Case (see text)
Speaker mesh material
2 knobs

will still boost the signal applied to TR1 base. The feedback reduces further as VR1 inserts yet more resistance into circuit. Normally, VR1 is adjusted such that the feedback is just below the point at which oscillation takes place.

C2 has a low impedance at r.f. and a high impedance at audio frequencies. In consequence it bypasses the r.f. signal at the junction of VR1 and R2 but allows the appearance of the detected a.f. signal across R2.

The value of bias resistor R1 is a little critical as it has to enable TR1 to have a collector current which is sufficiently low to allow non-linear amplification, and hence detection, to take place, but which is not so low as to give too small an overall amplification. Some transistors of the type specified may function better with a slightly different value in the R1 position. The receiver should be assembled and checked out with R1 at 1.5MΩ, as specified. Experimentally-minded constructors can then, if they wish, try the effect of different values in place of the 1.5MΩ component to see if any improvement in performance results.

The audio stages are quite straightforward, using two high gain silicon transistors in a d.c. coupled circuit. C7 is a stablilizing capacitor which gives negative feedback at higher frequencies and prevents the circuit from breaking into oscillation. Transformer T1 provides the necessary impedance step down to allow a low impedance speaker or earphone to be driven from the output. SK1 has a break contact which disconnects the speaker when the earphone plug is inserted.



The layout inside the case. There is adequate space for the components without crowding

COMPONENTS

Most of the components are readily available, but a few of these need some comment.

The ferrite aerial can be any ready-made medium wave type with a 5 in. ferrite rod and having a transistor base coupling winding. The component employed in the prototype was obtained as part of a set of inductors intended for a medium wave superhet. It came complete with a suitable 2-gang tuning capacitor. The 2-gang capacitor is used in the present receiver, connection being made to the aerial section of the capacitor only. The author tried other ready-made medium wave ferrite aerials with complete success, these including the Denco ferrite aerial type MW/5FR. If the Denco ferrite aerial is employed, VC1 should have a value of 208pF. A single gang 208pF capacitor (Jackson type 01), or the 208pF section of a 208 – 176pF 2-gang capacitor can be used. In some cases, and particularly if a 2-gang component is employed, the tuning capacitor may be fitted with an integral trimmer. This trimmer is initially left at about half maximum capacitance.

It is important to ensure that the lead-outs of the aerial are connected properly, and Fig. 2 shows the correct connections. It also gives details of the additional winding, L3, which is made from a length of thin p.v.c. insulated single core wire. L3 is positioned away from L1 and L2, as illustrated.

Most ready-made aerials have a base coupling winding consisting of about four or five turns of wire. Ideally, this receiver should have a coupling winding with about ten turns. It is an easy matter to use one of the lead-outs of the coil (the one furthest from the tuned winding) to add another five or six turns to the winding, the extra turns being taped to the coil former. A piece of thin insulated wire is then used to extend the lead-out back to its original length.

It is by no means essential to alter the ferrite aerial in this way, but the modification will give a worth-while increase in sensitivity.

The speaker in the prototype was a 3 in. square type with an impedance of 3Ω. Smaller speakers of the same impedance could be used, but these will probably have a lower efficiency.

The four 1.5 volt cells are fitted in a battery holder of the type illustrated in the photograph of the interior. This is an Eagle type BH4N or, alternatively, the Bulgin type 2/CB/4U7 can be used.

The author's receiver was housed in a plastic case measuring 6 by 4 by 2 in. Any non-metallic case of similar dimensions may be used, or could be constructed from plywood, but first make sure that it will be large enough to take the particular speaker and variable capacitor employed, in company with the Veroboard assembly and the other components. The space needed by the Veroboard assembly will be apparent from Fig. 3 and the photograph of the case interior.

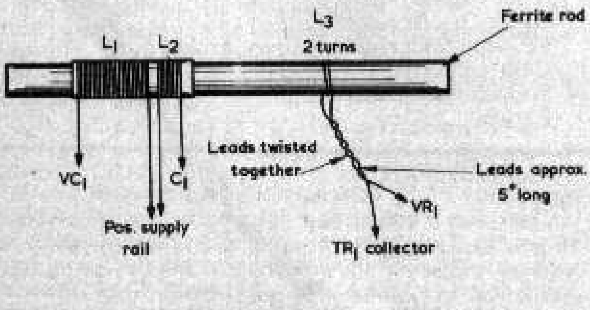


Fig. 2. Illustrating how the ferrite rod aerial windings are connected into circuit

CONSTRUCTION

Construction starts with the preparation of the main component panel. This is a piece of plain Veroboard (i.e. without copper strips) having a matrix of 0.15 in. and 33 by 10 holes. This takes all the small components, and a component layout and wiring diagram is given in Fig. 3.

First drill out the two 6BA clear mounting holes in the positions shown. Next drill out two $\frac{3}{16}$ in. holes to take the mounting lugs of T1. In Fig. 3 these holes appear in the first and fifth row of holes from the top. If the transformer does not fit comfortably into holes with this spacing, drill out the lower hole in the sixth row of holes from the top.

The components are then mounted in the positions indicated in the diagram, which shows the board from the component side. The underside wiring is illustrated in broken line. In many instances, the component lead-

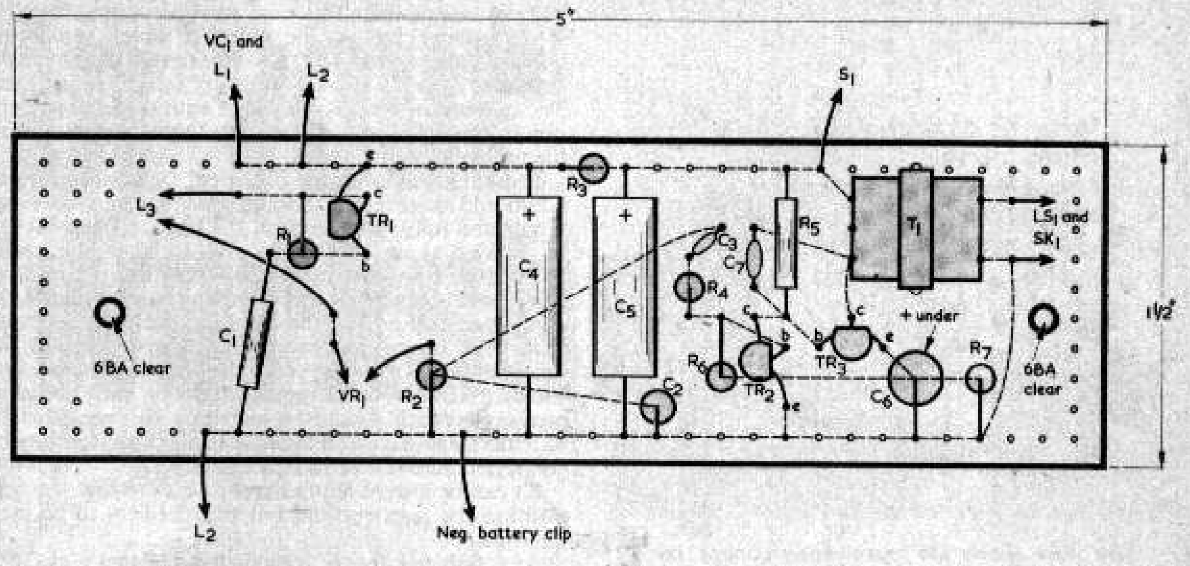


Fig. 3. The smaller components are assembled on a plain Veroboard panel, shown here as viewed from the component side

outs will be long enough to reach their connection points. Additional lengths of wire carry the positive and negative supply connections, and it will be found helpful to carry out this part of the wiring first. Where adjacent leads pass very close to one another, one of these is insulated with sleeving. When connecting L3 to the board it should be borne in mind that its connections may have to be transposed during the setting up procedure.

The finished panel is later mounted on the inside bottom of the case by means of two 1 in. 6BA countersunk screws, with suitable spacing washers between the underside of the board and the inside surface of the case. T1 is near the left hand end of the case, as seen from the front. The board may be used as a template to mark out the positions of the two countersunk holes required in the case. The panel will be mounted when the connections between it and the other components have been made.

The general layout inside the case can be seen from the photographs. With the author's receiver, a matrix of 25 ½ in. diameter holes, with ½ in. spacing, was drilled on the left front side of the case, after which a square of speaker mesh material was glued behind this. The speaker was, in turn, glued to the mesh. Alternatively, the speaker could be mounted to the front panel by four bolts and nuts, with the mesh sandwiched in between. The ferrite aerial is mounted at the top of the case, as far away from metal objects such as the speaker, VC1 and the battery, as possible. A piece of ⅜ in. square wood was glued to one end of the rod to give a total length equal to the inside width of the case, and both were then glued in position in the case.

VC1 is mounted on the front panel next to the speaker, whilst VR1, S1 and SK1 are mounted on the left hand side of the case, as seen from the front. VR1 is at the bottom, S1 in the centre and SK1 at the top. Ensure that clearance exists between VR1 and the Veroboard panel. VC1 will probably have a construction which allows it to be mounted by three 4BA bolts passing through tapped holes in its front plate. A piece of paper can be used as a template for marking out these holes on the front panel by initially pressing it against the capacitor front plate. The 4BA bolts used to secure the capacitor must be short. If their ends pass beyond the inside surface of the capacitor front plate they can damage the fixed or moving vanes.

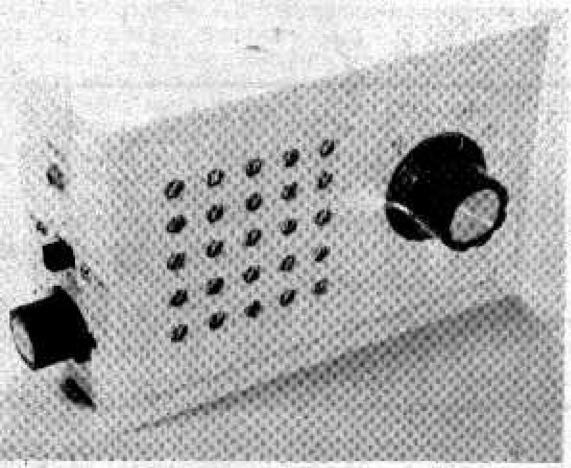
When all these parts have been mounted, the remaining wiring can be completed. Most of the wiring is illustrated in Figs. 2 and 3, and the few connections which are not are shown in the circuit diagram. VR1 is wired so that the resistance it inserts into circuit decreases as it is turned clockwise. (When the photographs were taken it was wired to insert increasing resistance.) All the interconnecting leads must be insulated.

The battery holder fits behind VC1 and can be held in position by a piece of foam rubber or plastic glued to the inside of the cabinet back.

SETTING UP AND USE

Before switching on the completed receiver, set L1 and L2 towards one end of the ferrite rod, and L3 at about the centre. VR1 should be adjusted to insert maximum resistance into circuit.

Upon switching on the set, a rushing sound should be heard from the speaker. Adjusting VC1 will probably not cause any stations to be received until VR1 is advanced clockwise. If VR1 should be advanced too far the set will break into oscillation, and proper reception



This view shows the regeneration control, the on-off switch and the earphone socket, all of which are mounted on the left side of the case

will not be possible. The most sensitive setting for VR1 is immediately below the point at which oscillation occurs, and not when it is fully advanced. For all but the strongest signals VR1 will need very careful adjustment. The best setting for VR1 will vary with the setting of the tuning control, and it will need readjustment each time the tuning is altered.

If oscillation cannot be obtained, the connections to L3 should be reversed. Should the frequency coverage not extend fully to the ends of the band, L1 and L2 can be moved along the ferrite rod to alter the range covered and so correct this. If VC1 has an integral trimmer this can be adjusted to control coverage at the high frequency end of the band. In the unlikely event that there is any tendency towards instability at the extreme high frequency end of the range when the trimmer is set for minimum capacitance, then the trimmer capacitance should be increased to avoid this. If VC1 does not have a trimmer, a 10pF capacitor may be connected across it in this eventuality.

L3 can be moved along the rod so as to find the best position for regeneration, but this is likely to be very uncritical.

As a finishing touch, legends from 'Panel Signs' Set No. 4 can be added at VR1, S1 and SK1, together with suitable indications of station positions behind the control knob of VC1. ■

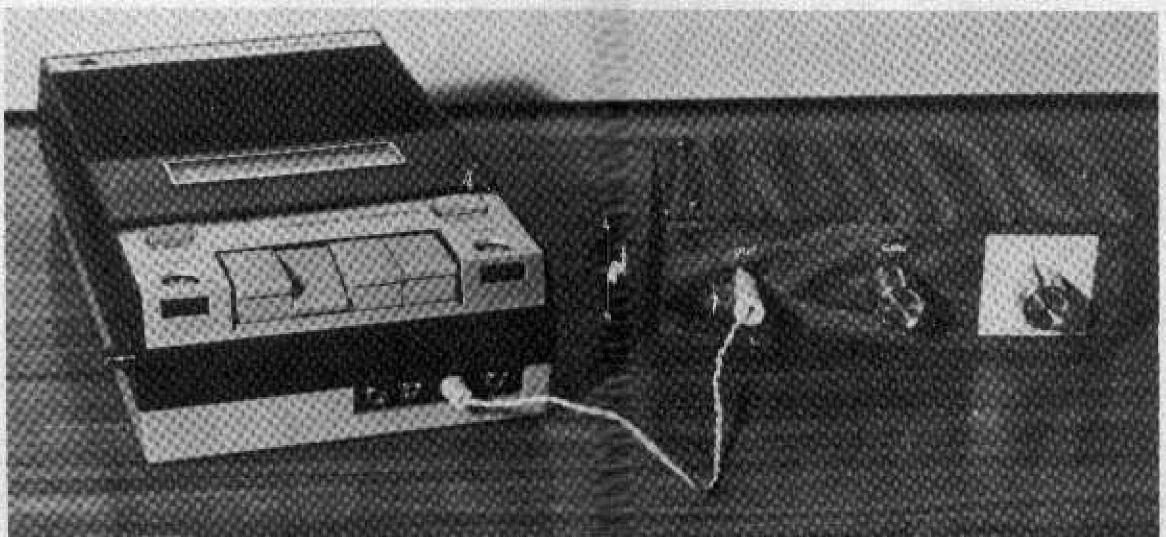
THREE TRANSISTOR REGENERATIVE RECEIVER

In Fig. 3 of this article, which appeared in the November issue, the lower lead-out of C1 is shown connected to the lower lead-out of R2. There should be no connection between these two points.

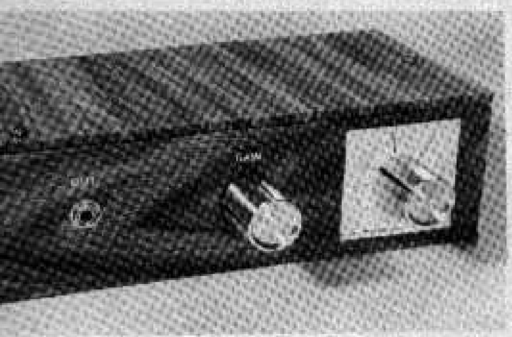
MEDIUM WAVE TUNER-RECEIVER

by R. A. Penfold

Employing three inexpensive transistors, this receiver can be coupled to an external amplifier or tape recorder, or it can be used as a complete receiver in conjunction with a crystal or high impedance magnetic earphone



The tuner-receiver coupled to the input of a cassette tape recorder



The tuner-receiver is housed in a case which gives it an attractive appearance

THIS PROJECT IS A SIMPLE 3-TRANSISTOR MEDIUM WAVE tuner-receiver which is self-contained with its own internal ferrite aerial and battery supply. The a.f. output is at low impedance and has a fairly high amplitude, this being as much as 2 volts peak-to-peak with strong signals. The unit is therefore capable of driving virtually any amplifier. Alternatively, it can be used to feed a crystal or high impedance magnetic earphone of 1,000Ω or more, whereupon it makes a very useful personal portable receiver.

For simplicity a t.r.f. circuit has been employed, with the result that the unit is both inexpensive and easy to construct. It is reasonably compact and its case measures 6¼ by 3 by 2 in.

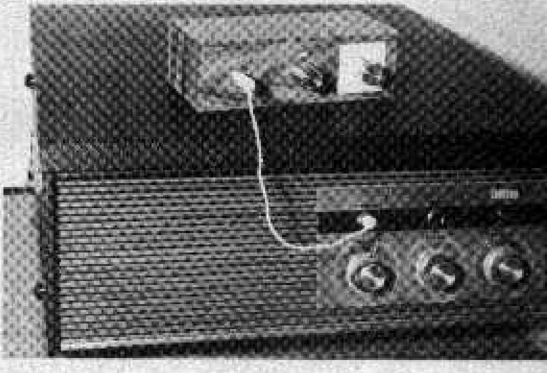
THE CIRCUIT

The circuit of the tuner-receiver is shown in Fig. 1. TR1 is in a reflex stage with pre-set regeneration, TR2 is a high gain common emitter amplifier and TR3 is an emitter follower with the volume control in its emitter circuit. All three stages are directly coupled to each other.

Describing the circuit in greater detail, L1 is the tuned aerial coil and is wound on a ferrite rod. Signals selected by L1 and the tuning capacitor VC1 are induced into the low impedance coupling winding, L2. One end of this winding is bypassed to the lower supply rail via C2 whilst the other end connects to the base of TR1. This transistor now functions as an r.f. amplifier and the signal appears, greatly amplified, at its collector.

Resistor R2 presents a relatively high impedance to the r.f. signal and a much lower impedance is offered by C3. In consequence, most of the amplified r.f. signal passes through C3 to D1 and thence to the base of TR1. Despite the lack of a resistive return for D1 cathode the whole circuit offers, in practice, detection of the amplified r.f. signal and C2 bypasses the r.f. content of the detected signal. TR1 then carries out its secondary function of a.f. amplifier and the detected signal undergoes further amplification, to appear at TR1 collector.

A small amount of the amplified r.f. signal at TR1 collector is fed back to the aerial tuned circuit via C1, and this gives the stage a certain amount of regeneration. It would seem better, theoretically, to use an r.f. choke rather than resistor R2. However, a choke here causes the circuit to become over-sensitive and rather difficult to control.



Here the tuner-receiver is feeding into an external amplifier

TR2 operates as a straightforward common emitter audio amplifier. R4 is the collector load resistor and R3 the emitter bias resistor. R5 stabilizes the bias conditions for both TR2 and TR1. Since the base of TR1 is 180° out of phase with the emitter of TR2 the circuit provides negative feedback but, due to the presence of C4, the feedback is of a d.c. nature only. Capacitor C6, connected between the collector and base of TR2, reduces its high frequency response. It also fully attenuates any r.f. signals which may find their way to TR2 base via R2.

TR3 is an emitter follower and gives no voltage amplification, merely ensuring a low output impedance. This may seem a little unnecessary, but it is just as easy to use this circuit as it would be to couple TR2 collector to VR1 by way of a capacitor. There is very little difference in cost, either. VR1 is the volume control and it also forms the emitter load for TR3. The output is taken from VR1 slider via the d.c. blocking capacitor, C5.

Current consumption from the battery is very small and there is no need for any supply decoupling components. S1 is the on-off switch, and it is ganged with VR1.

COMPONENTS

In the prototype, VC1 was one section of a 2-gang 250+250pF air-spaced variable capacitor. However, any reasonably small component of 250 to 300pF maximum capacitance may be employed, the main proviso being that it fits into the 1¾ in. depth of the case and does not project backwards from the front panel by more than 1¼ in. There are many variable capacitors which meet these requirements and a suitable type could be, say, a 192+78pF capacitor with both sections in parallel or a single gang 300pF Jackson Brothers 'Dilemin' capacitor.

Miniature disc ceramic capacitors are ideal for C2, C3 and C6, but there are other types available which could also be used provided they are miniature types. Construction will be much easier if these alternatives have side wire lead-outs, as for printed circuit board mounting. C1 is not a physical capacitor and is given by two lengths of insulated wire twisted together.

The ferrite aerial is a ready-made component incorporating a 4½ in. rod complete with windings L1 and L2, and is available from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey, CR2 0DE. The

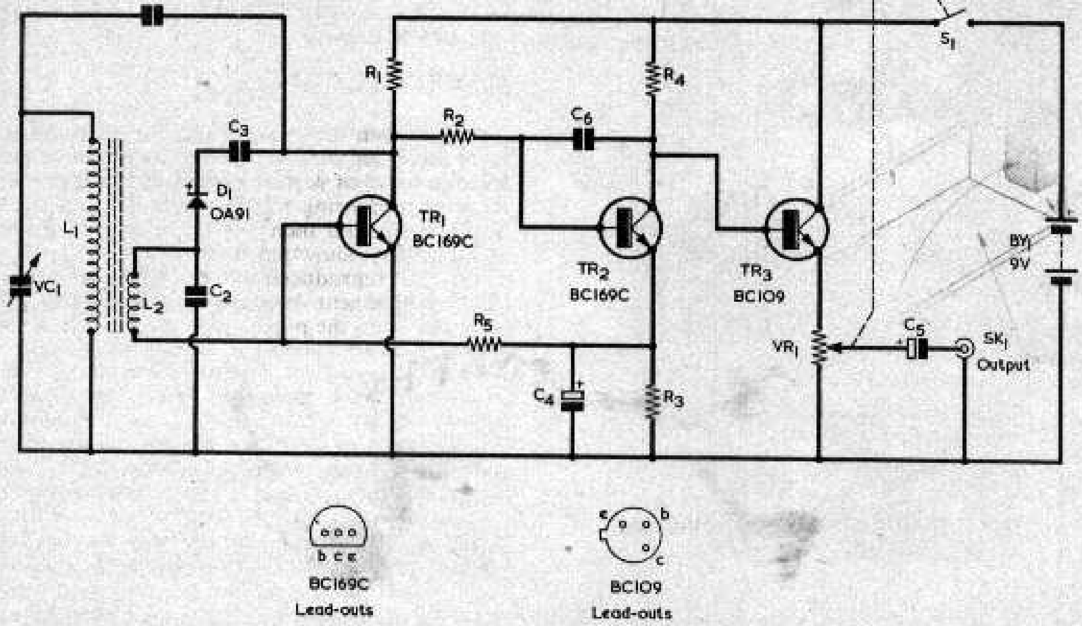


Fig. 1. Circuit diagram of the tuner-receiver. Current consumption from the 9 volt battery is of the order of 2.5 mA only

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	4.7kΩ
R2	2.7kΩ
R3	1.5kΩ
R4	5.6kΩ
R5	270kΩ
VR1	5kΩ log, with switch S1.

Capacitors

C1	Twisted pair (see text)
C2	4,700 or 5,000pF disc ceramic
C3	1,000pF disc ceramic
C4	30μF miniature electrolytic, 10 V.Wkg.
C5	10μF miniature electrolytic, 10 V.Wkg.
C6	470 or 500pF disc ceramic
VC1	250 or 300pF variable (see text)

Inductors

L1, L2	Medium wave ferrite aerial (see text)

Semiconductors

TR1	BC169C
TR2	BC169C
TR3	BC109
D1	OA91

Socket

SK1	3.5mm. jack socket

Battery

BY1	9 volt battery type PP3 (Ever Ready)

Switch

S1	Part of VR1

Miscellaneous
2 control knobs
Battery connector
Connecting lead with plugs (tuner to amplifier), if required
Crystal or high impedance magnetic earphone, if required
Materials for case
Paxolin for component panel

larger coil is L1 and the smaller coil L2. The lead-out from L1 which is closer to L2 is that which connects to the negative supply rail, and the lead-out of L1 which is further from L2 is that which connects to the junction of C1 and VC1. The connections to L2 are found by trial and error; initially, L2 lead-outs are connected into circuit temporarily as it may be necessary to transpose them to obtain the correct phase relationship for regeneration.

The potentiometer used for VR1/S1 should be a small component whose switch tags do not project more than 1⅛ in. behind the panel on which it is mounted.

The socket SK1 is a 3.5 mm. jack socket. This type of socket usually has an additional contact which breaks when the jack plug is inserted. The additional contact is ignored here.

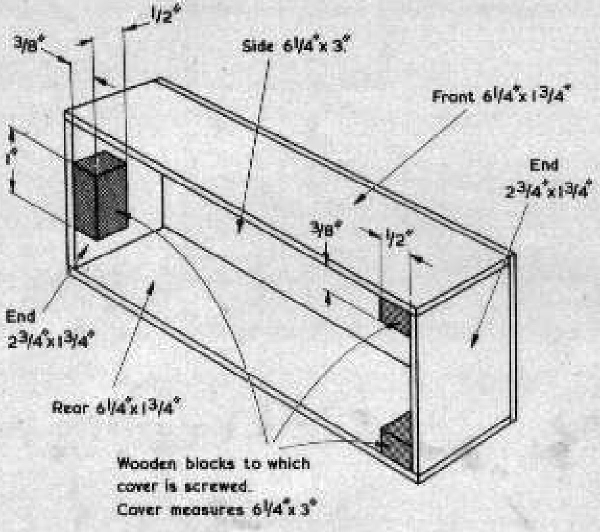


Fig. 2. Illustrating the assembly of the case

The case of the prototype unit was finished by being covered with a plastic veneer having a wood grain effect, but any other desired finish can be given according to individual taste.

CONSTRUCTION

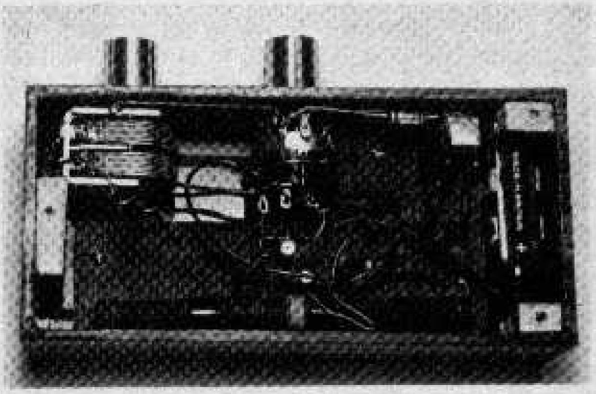
Apart from the battery and the parts fitted to the front panel, all the components are mounted on a plain Paxolin panel of 1/16 in. thickness, as illustrated in Fig. 4. A panel measuring 5 by 2 3/8 in. is first cut out from a larger piece, and then two pieces are cut from this to give the shape shown in the diagram.

Fig. 4 is reproduced actual size, and the positioning of the component mounting holes can easily be traced from this onto the panel. All holes for component lead-outs and the four holes for the ferrite rod aerial mounting are 1/16 in. or 2/64 in. diameter. The ferrite rod is held in place by two loops of thin single core insulated wire passed over the rod and through the appropriate holes. The two ends of each loop are twisted together on the reverse side of the board so that the rod is held down firmly. It is essential that the wire used here be insulated and that the core ends of each loop do not touch each other, as this will then constitute a 'shorted turn' and will prevent the ferrite aerial from working correctly.

THE CASE

The case is home-made and, as mentioned earlier, measures 6 1/4 by 3 by 2 in. It is made from material 1/8 in. thick, and this may be hardboard, plywood or Paxolin. Fig. 2 shows the method of assembly. In this diagram the panel on which are mounted VR1, VC1 and the output jack socket is referred to as the front panel. The panel not shown is the cover. The front, rear, end and side panels of Fig. 2 are secured together with a strong adhesive such as Araldite. Fig. 3 shows the holes required in the front panel. Mounting requirements for variable capacitors vary considerably, and the hole or holes required for fitting VC1 must be made to suit the particular component employed.

The cover is removable and is held in position by three wood screws passing into the wooden blocks shown in Fig. 2. The two smaller blocks in the corners are approximately 1/2 in. by 3/8 in., and the larger block is approximately 1 in by 3/8 in. All three blocks are 1/2 in. deep only, and they are glued in position with adhesive.



A view of the components inside the case

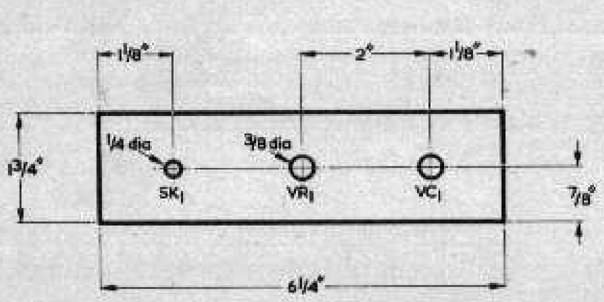


Fig. 3. Component positioning on the front panel.

Components on the panel are mounted by passing their lead-out wires through the holes indicated in Fig. 4, the wires then being bent over at right angles on the reverse side. These are then soldered together as represented by the broken lines in the diagram. There are three external connections from the panel to the positive battery terminal, to the high volume end of VR1 track and to the negative supply rail. A flexible insulated lead about 3 to 4 in. long can be used for each of these connections. A further single core lead of about the same length is connected to the collector of TR1 on the reverse side of the board. This is one of the leads which form C1 and it is not shown in Fig. 4. The non-earthy lead-out of L1 (the lead-out further away from L2) will also connect, later, to the fixed vanes of VC1.

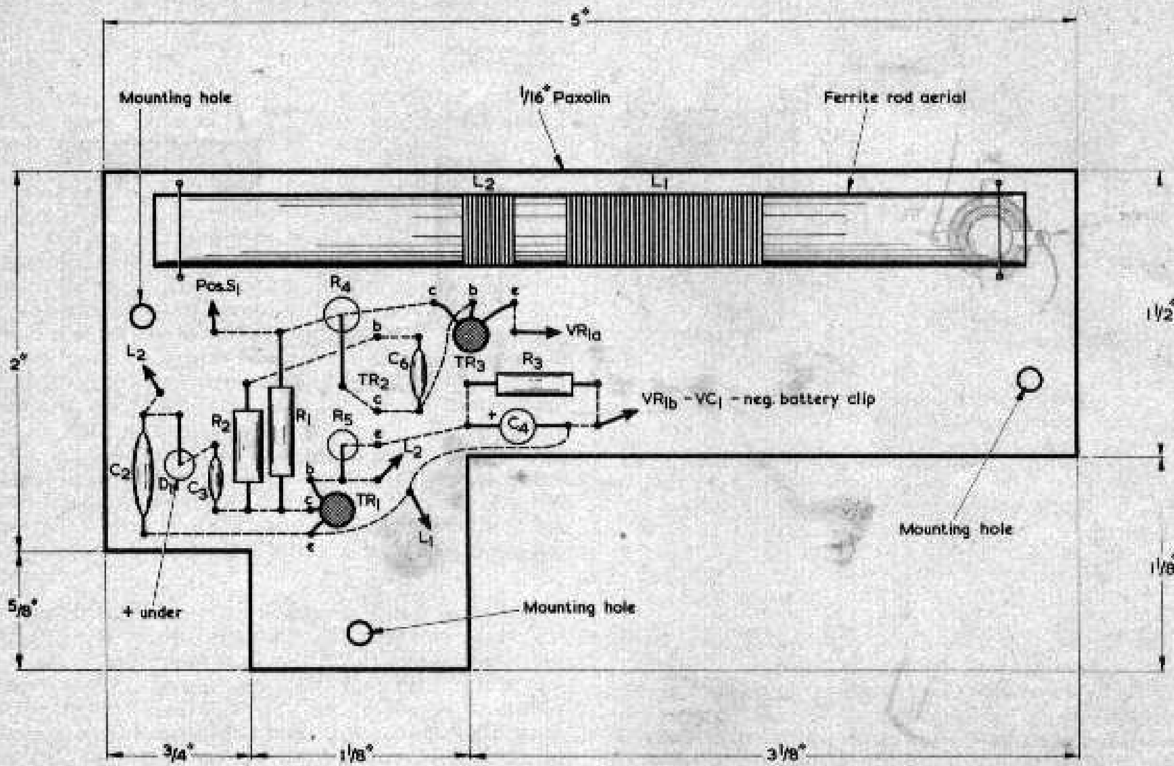


Fig. 4. The wiring layout on the component panel. For clarity the body of TR2 is omitted. The panel is reproduced full size fof tracing

Three blocks of wood, each 1 in. by 1 in. and ⅜ in. thick are next secured to the inside surface of the case side, as shown in Fig. 5. They are positioned such that they take wood screws passed through the three large holes in the component panel, thereby allowing the panel to be mounted in the case. Positioning need not be precise but the dimension marked 'X' should be such as to allow the PP3 battery to be gripped, on its side, between the block of wood and the adjacent case end. The blocks are secured in position with adhesive. The panel should fit quite neatly into place, the large 3⅛ by 1⅛ in. cut-out allowing space for VC1 and VR1, when these are fitted, and the small cut-out allowing space for the output jack socket. The component panel is not finally fitted yet.

The components on the front panel are next mounted, and these are then wired up as illustrated in Fig. 6. The leads to the battery connector should be sufficiently long to reach the battery when the latter is fitted later. The positions of the tags for S1 may differ, with some components, from those shown in the diagram. It will save possible trouble later if the requisite tags are traced through with an ohmmeter or continuity tester before wiring up. The jack socket should be wired such that the sleeve of the plug, when inserted, is connected to the negative supply rail. An ohmmeter or continuity tester

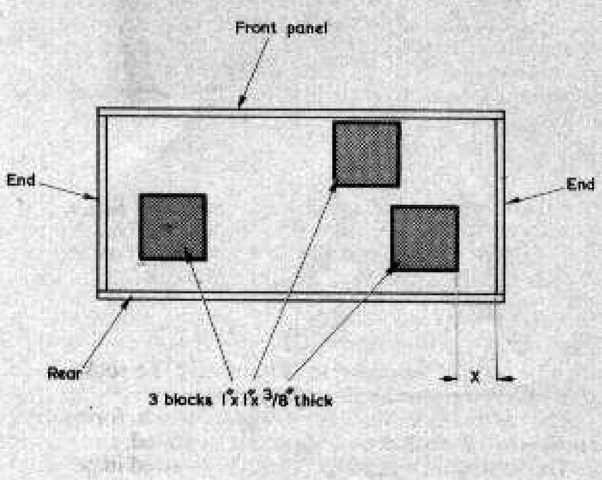


Fig. 5. The three wood blocks to which the component panel is secured take up the positions shown here. Again for clarity the wooden blocks of Fig. 2 are omitted here

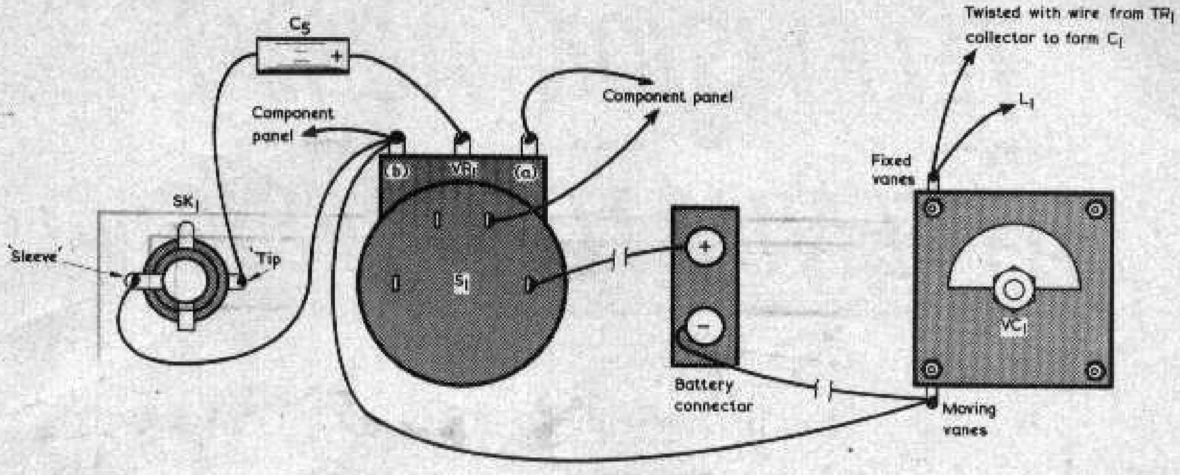
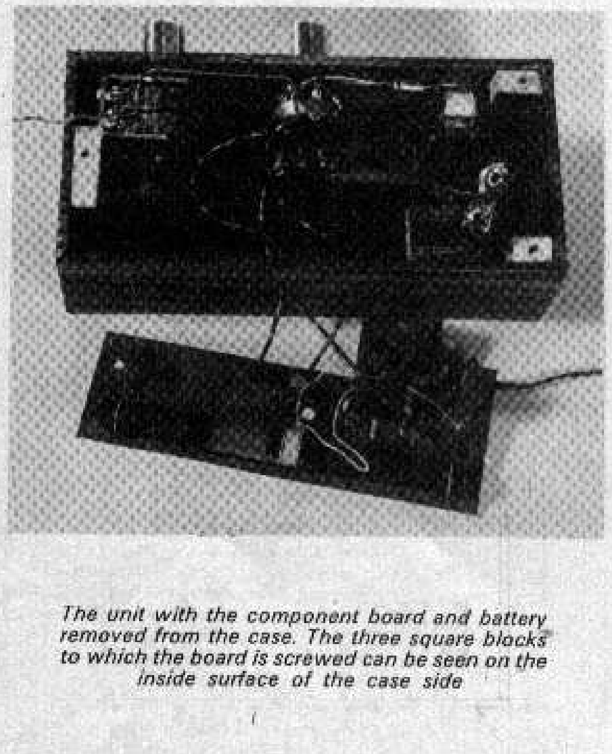


Fig. 6. Wiring of the components at the front panel. The terms 'sleeve' and 'tip' at SK1 refer to the corresponding sleeve and tip of the jack plug which fits into it



The unit with the component board and battery removed from the case. The three square blocks to which the board is screwed can be seen on the inside surface of the case side

may be helpful here also in determining the socket tags to which connections should be made.

The wire from VC1 fixed vanes which forms one section of C1 should be single core insulated.

The component panel may next be screwed in position and the interconnections between this panel and the components of Fig. 6 completed. The two insulated wires which form C1 are twisted together very loosely at this stage.

TESTING

The unit is now complete and ready for testing. A testmeter switched to a high current range is inserted in the positive supply lead and the unit is switched on. If it appears that no excessively high current is flowing the testmeter should be set to progressively lower ranges until it is capable of giving useful readings of currents up to 5mA. With a new battery fitted, the current consumption of the unit should be roughly of the order of 2.5mA. If the current reading is considerably different from this figure the unit should be switched off immediately and checked for wiring faults. If a correct current reading is given, a crystal earphone, a high impedance magnetic earphone or an amplifier can be connected to the output. Adjusting VC1 should permit a few stations to be received.

The effect of twisting the two wires which form C1 more closely together can then be checked. If the constructor is lucky this will cause the received stations to increase in volume and number. Should the opposite occur the connections from L2 must be reversed. The two wires which form C1 should be twisted together as tightly as possible without the set breaking into oscillation at any setting of VC1. Oscillation is evident as a loud 'pop' followed by a hissing noise. With the unit adjusted in this way it should be possible in the daytime to receive B.B.C. Radios 1, 3 and 4 in most parts of the U.K. plus two or three Continental stations. After dark many more stations will appear.

If the unit is to be used as a tuner for an amplifier or tape recorder it will be necessary to provide a lead to connect the two items of equipment together. If this lead is short it will probably not need to be screened, but if it is more than a foot or so in length it will be essential to use screened wire. The outer braiding of this lead connects, of course, to the jack plug sleeve at the tuner and, thence, to its negative supply rail. It may be found that using the unit close to a mains powered amplifier will cause an excessive mains hum to be heard. This is due to magnetic pick-up of the field around the amplifier mains transformer by the ferrite rod aerial. If trouble of this nature is experienced the tuner should be sited a few feet away from the amplifier.

★★★ T.R. 3 REFLEX RADIO

By A. Sapciyan

A low cost medium wave local stations receiver incorporating three inexpensive transistors.

THIS SIMPLE MEDIUM WAVE REFLEX RECEIVER GIVES good results with three transistors. The output is sufficiently high for personal listening in a room where background noise is at average level. The receiver is intended for reception of local stations only, although in practice it should be possible to pick up a number of foreign transmissions after dark. With a circuit employing as few components as does this set, performance cannot of course be compared with that given by a superhet.

REFLEX OPERATION

The input stage uses an AF127, TR1, connected in the reflex mode. In common with other reflex amplifiers, TR1 provides amplification both at radio frequencies and then at audio frequencies. Initially, r.f. signals picked up on the ferrite aerial coil, L1, are applied to the base of TR1 and they next appear, in amplified form, at the collector of this transistor. The r.f. choke L2, offers a high impedance at r.f., and the r.f. signals are passed via C4 to the voltage doubling detector given by D1 and D2. The demodulated signal, which is now at a.f., is applied to the base of TR1 and this again provides amplification. Choke L2 offers only a low impedance to a.f. signals and these are in consequence built up across R3. C5 ensures that any r.f. signal still present after the choke is bypassed to chassis and does not enter the following a.f. stages.

R1, in series with R2, controls the base current of TR1 and, hence, the amplification it gives. When R1 is set to insert a low resistance into circuit the resultant high gain in TR1 produces oscillation. R1 can therefore be employed as a reaction control, it being adjusted to the point which is just below that at which oscillation occurs. Under this condition the receiver exhibits optimum selectivity and sensitivity.

The tendency towards oscillation is increased by C1. This is a home-made trimmer and the manner in which it is assembled and set up is described later. The value for R2 given in the Components List should be satisfactory with most transistors and diodes in the TR1, D1 and D2 positions. In some occasional instances, however, it may be necessary to alter the value of R2 and this point is also discussed later. No connection is made to the shield of TR1, and this factor improves regeneration.

The a.f. signal at the junction of L2 and R3 is passed via C7 to the base of transistor TR2. This functions as an audio amplifier, its collector connecting directly to the base of the output transistor, TR3. The collector of TR3 feeds the primary of output transformer T1, whilst R7 and C8 provide emitter bias.

TR2 and TR3 appear in a d.c. negative feedback loop. If, for any reason, the emitter of TR3 were made to go more negative this would cause TR2 to be biased harder on. The collector voltage of TR2 would then go positive as also would the base of TR3, thereby counteracting the original change in voltage at TR3 emitter. There is no corresponding feedback at audio frequencies due to the presence of C8.

Output transformer T1 should present a primary impedance of around 600Ω and, to drive a 3Ω speaker, it requires a step-down ratio of 14:1. The Eagle LT700 output transformer, which has a centre-tapped primary and a ratio of slightly higher than 15:1, may be used here. No connection is made to the primary centre tap. It is desirable to use a fairly large and sensitive speaker.

The total current drawn by the receiver from the 6 volt battery is approximately 10mA.

The AF127 and AC128 specified for TR1 and TR3 are readily available. The transistor type AC151 needed for TR2 can be obtained from a number of suppliers, including Electrovalue, Ltd.

HOME-MADE COMPONENTS

The ferrite aerial coil, L1, consists of 70 turns of 30 s.w.g. enamelled wire wound side-by-side on a ferrite slab measuring 6 by ½ by 5/32in., as illustrated in Fig. 2. The chassis tap is made 10 turns from one end. Due

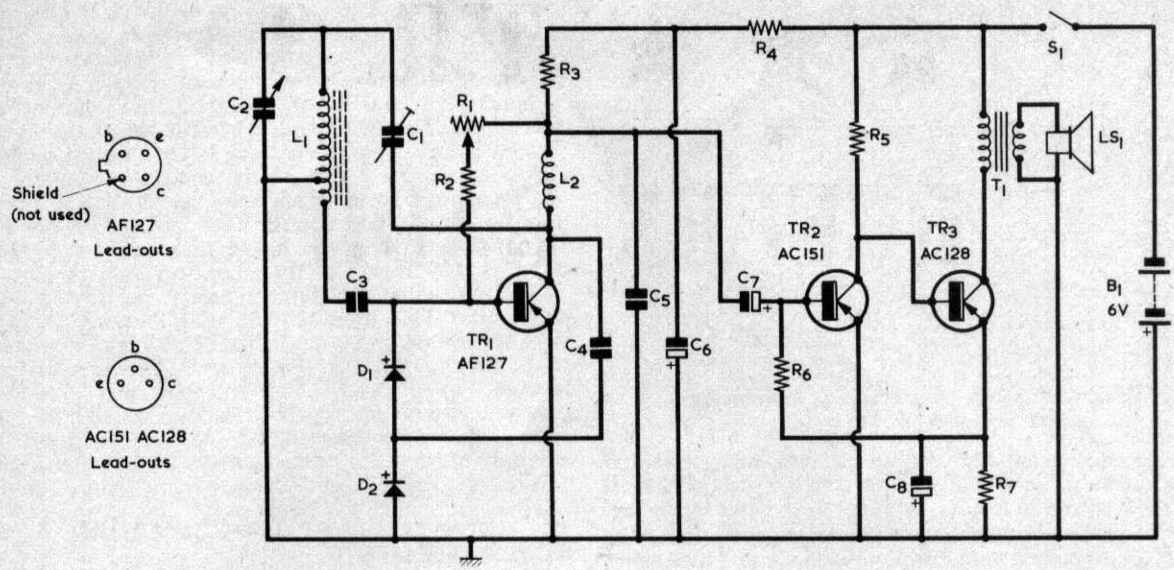


Fig. 1. The circuit of the reflex receiver.

COMPONENTS

Semiconductors
- TR1 AF127
- TR2 AC151
- TR3 AC128
- D1 0A91
- D2 0A91

Switch
- S1 s.p.s.t., toggle

Speaker
- LS1 3Ω speaker

Battery
- B1 6 volt battery

Miscellaneous
- Ferrite slab, 6 by ½ by 5/32in. (Henry's Radio)
- 2 knobs
- Battery connectors

Resistors
(All fixed values ¼ watt 10%)
- R1 100kΩ potentiometer, linear
- R2 330kΩ (see text)
- R3 1kΩ
- R4 1kΩ
- R5 5.6kΩ
- R6 15kΩ
- R7 47Ω

Capacitors
- C1 Trimmer (see text)
- C2 300pF variable, solid dielectric
- C3 0.001µF, plastic foil or ceramic
- C4 100pF, ceramic or silvered mica
- C5 0.01µF, plastic foil
- C6 100µF electrolytic, 6 V.Wkg.
- C7 4µF electrolytic, 6 V.Wkg.
- C8 100µF electrolytic, 6 V.Wkg.

Inductors
- L1 Ferrite aerial (see text)
- L2 R. F. choke (see text)
- T1 Output transformer (see text)

to differences in slab permeability, it is desirable to initially wind on a few too many turns at the end which connects to C1 and the fixed vanes of C2. These turns can then later be removed, as required, to give more precise coverage of the medium wave band after the set has been completed. Some control of inductance is also given by sliding the winding along the ferrite slab.

The r.f. choke, L2, is also home-made and consists of 200 turns of 36 s.w.g. enamelled wire pile-wound on a ¼in. former.

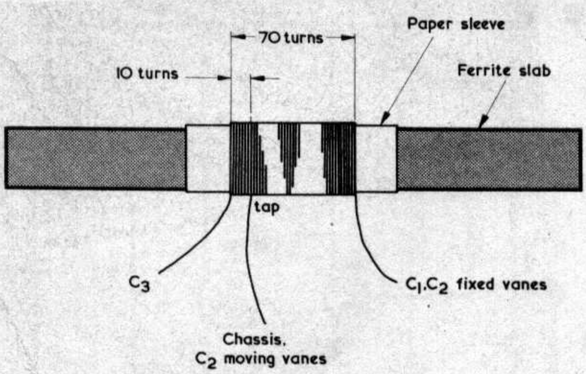


Fig. 2. The ferrite aerial winding. Further details are given in the text.

An unconventional but quite satisfactory method of assembly is employed for trimmer capacitor C1. This is shown in Fig. 3, and it consists of one enamelled wire twisted around a second. A straight piece of 16 s.w.g. enamelled wire 1in. long has one end cleaned of enamel. This end is tinned and connects to the fixed vanes of C2. It can be soldered direct to the tuning capacitor tag. One end of a length of 36 s.w.g. enamelled wire is also cleaned and tinned, and this is connected to the junction of L2 and the collector of TR1. The 36 s.w.g. wire is then close-wound over the 16 s.w.g. wire, the two ends of the wires being left open-circuit. Only the enamelled surfaces of the two wires are in contact with each other and so they do not short-circuit together. The trimmer capacitance is adjusted later by untwisting the 36 s.w.g. wire as necessary.

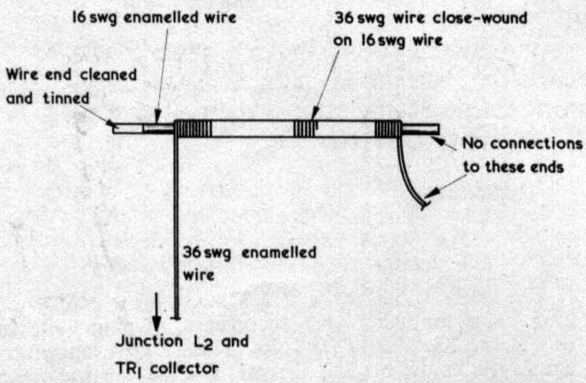


Fig. 3. This unconventional but quite practicable assembly forms the trimmer C1.

Construction and layout are not particularly critical provided that lead lengths are kept reasonably short. A good plan consists of mounting the components, apart from C2, R1, S1 and the ferrite aerial, on a perforated piece of plain Veroboard (i.e. without copper strips) measuring about 4½ by 2½in., the component leads passing through the holes and being soldered into the circuit underneath. The components should be positioned along the board in roughly the same order as they appear in the circuit diagram of Fig. 1. This ensures that the output stage is positioned well away from TR1 input circuit. C2, R1 and S1 may then be mounted on a small front panel at right angles to the board. However, any other method of assembly favoured by the constructor may be used provided that the general approach to layout which has just been described is observed. L2 and T1 should not be mounted close to L1. Also, R1 should be wired such that the resistance it inserts into circuit reduces as its spindle is turned clockwise.

ADJUSTMENTS

When the receiver has been completed, a new 6 volt battery should be connected and the set switched on by means of S1. There should be a noticeable hiss from the speaker, this increasing in intensity as R1 spindle is turned clockwise. It should be possible to take the set into oscillation by means of R1 over all the tuning range offered by C2. The setting of R1 at which oscillation occurs varies with the capacitance given by C2.

If oscillation is too fierce and cannot be reliably controlled by R1 the capacitance inserted by C1 should be reduced by removing some of the turns of 36 s.w.g. wire. It is in order for oscillation to occur when R1 is only partly advanced, because this allows the receiver to continue operating after battery voltage falls with use, in which case R1 can be advanced further to provide regeneration. Initial setting up should be carried out, nevertheless, with a new battery.

In some instances it may be found that C1 does not provide sufficient control. If regeneration is weak and can only be obtained when R1 is at, or very near, its maximum position, the value of R2 should be reduced. Values of 220kΩ and 150kΩ, etc., should be tried until the desired operation is obtained. If, on the other hand, regeneration is too fierce, the value of R2 may be increased, and performance checked with values here of 470kΩ and 560kΩ, etc.

As was stated at the start of this article, the receiver is intended mainly for reception of local stations only. R1 should be adjusted for optimum sensitivity with each station tuned in. ■

★ ★ ★ T.R. 3

REFLEX RADIO

By A. Sapciyan

A low cost medium wave local stations receiver incorporating three inexpensive transistors.

This simple medium wave reflex receiver gives good results with three transistors. The output is sufficiently high for personal listening in a room where background noise is at average level. The receiver is intended for reception of local stations only, although in practice it should be possible to pick up a number of foreign transmissions after dark. With a circuit employing as few components as does this set, performance cannot of course be compared with that given by a superhet.

REFLEX OPERATION

The input stage uses an AF127, TR1, connected in the reflex mode. In common with other reflex amplifiers, TR1 provides amplification both at radio frequencies and then at audio frequencies. Initially, r.f. signals picked up on the ferrite aerial coil, L1, are applied to the base of TR1 and they next appear, in amplified form, at the collector of this transistor. The r.f. choke L2, offers a high impedance at r.f., and the r.f. signals are passed via C4 to the voltage doubling detector given by D1 and D2. The demodulated signal, which is now at a.f., is applied to the base of TR1 and this again provides amplification. Choke L2 offers only a low impedance to a.f. signals and these are in consequence built up across R3. C5 ensures that any r.f. signal still present after the choke is bypassed to chassis and does not enter the following a.f. stages.

R1, in series with R2, controls the base current of TR1 and, hence, the amplification it gives. When R1 is set to insert a low resistance into circuit the resultant high gain in TR1 produces oscillation. R1 can therefore be employed as a reaction control, it being adjusted to the point which is just below that at which oscillation occurs. Under this condition the receiver exhibits optimum selectivity and sensitivity.

The tendency towards oscillation is increased by C1. This is a home-made trimmer and the manner in which it is assembled and set up is described later. The value for R2 given in the Components List should be satisfactory with most transistors and diodes in the TR1, D1 and D2 positions. In some occasional instances, however, it may be necessary to alter the value of R2 and this point is also discussed later. No connection is made to the shield of TR1, and this factor improves regeneration.

The a.f. signal at the junction of L2 and R3 is passed via C7 to the base of transistor TR2. This functions as an audio amplifier, its collector connecting directly to the base of the output transistor, TR3. The collector of TR3 feeds the primary of output transformer T1, whilst R7 and C8 provide emitter bias.

TR2 and TR3 appear in a d.c. negative feedback loop. If, for any reason, the emitter of TR3 were made to go more negative this would cause TR2 to be biased harder on. The collector voltage of TR2 would then go positive as also would the base of TR3, thereby counteracting the original change in voltage at TR3 emitter. There is no corresponding feedback at audio frequencies due to the presence of C8.

Output transformer T1 should present a primary impedance of around 600Ω and, to drive a 3Ω speaker, it requires a step-down ratio of 14:1. The Eagle LT700 output transformer, which has a centre-tapped primary and a ratio of slightly higher than 15:1, may be used here. No connection is made to the primary centre tap. It is desirable to use a fairly large and sensitive speaker.

The total current drawn by the receiver from the 6 volt battery is approximately 10mA.

The AF127 and AC128 specified for TR1 and TR3 are readily available. The transistor type AC151 needed for TR2 can be obtained from a number of suppliers, including Electrovalue, Ltd.

HOME-MADE COMPONENTS

The ferrite aerial coil, L1, consists of 70 turns of 30 s.w.g. enamelled wire wound side-by-side on a ferrite slab measuring 6 by ½ by 5/32in., as illustrated in Fig. 2. The chassis tap is made 10 turns from one end. Due

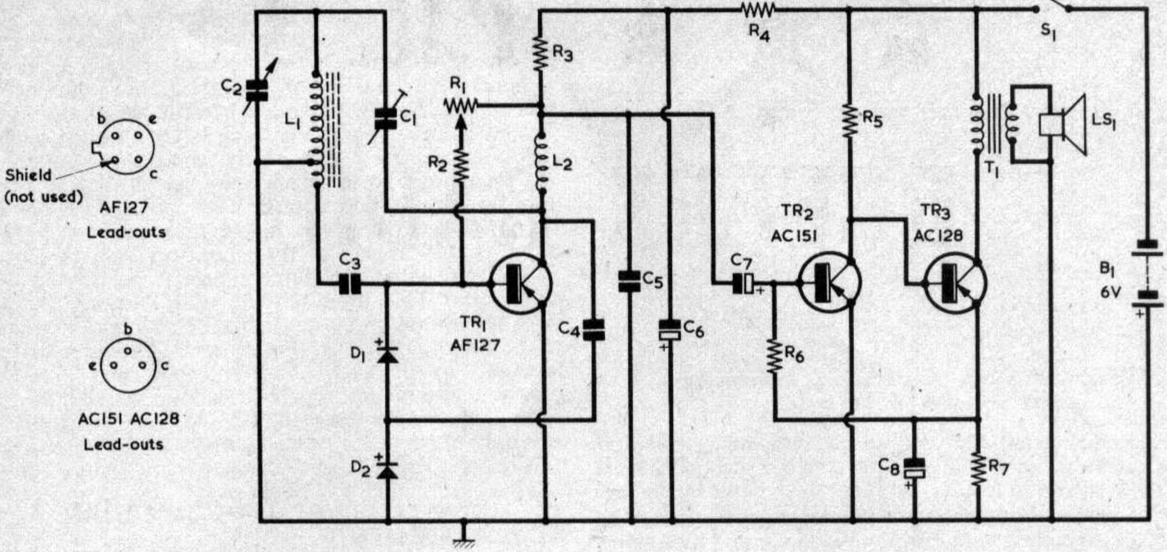


Fig. 1. The circuit of the reflex receiver.

COMPONENTS

Semiconductors
- TR1 AF127
- TR2 AC151
- TR3 AC128
- D1 0A91
- D2 0A91

Switch
- S1 s.p.s.t., toggle

Speaker
- LS1 3Ω speaker

Battery
- B1 6 volt battery

Miscellaneous
- Ferrite slab, 6 by $\frac{1}{2}$ by 5/32in. (Henry's Radio)
- 2 knobs
- Battery connectors

Resistors
(All fixed values $\frac{1}{4}$ watt 10%)
- R1 100kΩ potentiometer, linear
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- R3 1kΩ
- R4 1kΩ
- R5 5.6kΩ
- R6 15kΩ
- R7 47Ω

Capacitors
- C1 Trimmer (see text)
- C2 300pF variable, solid dielectric
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Inductors
- L1 Ferrite aerial (see text)
- L2 R. F. choke (see text)
- T1 Output transformer (see text)

to differences in slab permeability, it is desirable to initially wind on a few too many turns at the end which connects to C1 and the fixed vanes of C2. These turns can then later be removed, as required, to give more precise coverage of the medium wave band after the set has been completed. Some control of inductance is also given by sliding the winding along the ferrite slab.

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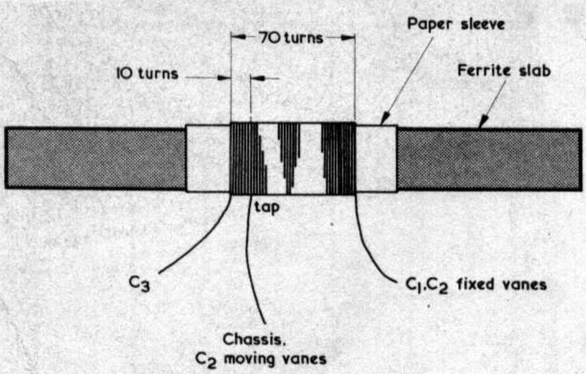

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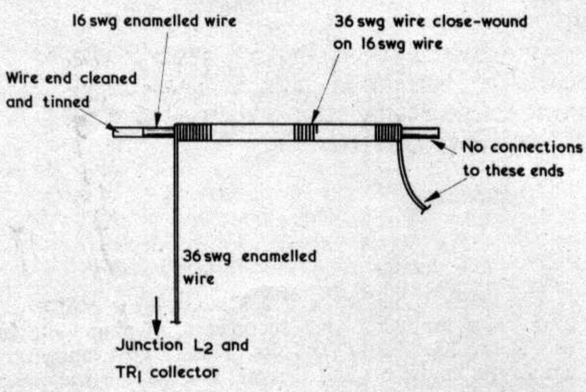

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ADJUSTMENTS

When the receiver has been completed, a new 6 volt battery should be connected and the set switched on by means of S1. There should be a noticeable hiss from the speaker, this increasing in intensity as R1 spindle is turned clockwise. It should be possible to take the set into oscillation by means of R1 over all the tuning range offered by C2. The setting of R1 at which oscillation occurs varies with the capacitance given by C2.

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In some instances it may be found that C1 does not provide sufficient control. If regeneration is weak and can only be obtained when R1 is at, or very near, its maximum position, the value of R2 should be reduced. Values of 220kΩ and 150kΩ, etc., should be tried until the desired operation is obtained. If, on the other hand, regeneration is too fierce, the value of R2 may be increased, and performance checked with values here of 470kΩ and 560kΩ, etc.

As was stated at the start of this article, the receiver is intended mainly for reception of local stations only. R1 should be adjusted for optimum sensitivity with each station tuned in. ■

SELECTIVE REFLEX RECEIVER

by J. B. Jobe

The medium wave receiver described here combines two of our earlier designs to obtain an enhanced overall performance.

THE AUTHOR TEACHES AT A SCHOOL FOR BOYS WHERE he runs a radio and electronics club. Most of the boys start off by building the ubiquitous crystal set and some of them eventually graduate to the construction of G. W. Short's "Silicon Transistor Reflex T.R.F."[1]

This is, in the writer's opinion, the best set of its type yet published, being virtually fool-proof, almost guaranteed to work first time and extremely tolerant as regards transistor types, component values and layout. There is, however, one comment which is frequently heard from boys who have completed the set, and this concerns its rather low selectivity. In the writer's region the local Radio 4 programme is on 285 metres and, with the reflex receiver, this signal interferes with the weaker Radio 1 programme on 247 metres.

MODIFICATION

It was therefore decided to see what could be done to improve the selectivity of this otherwise excellent set. Any modification which was to be made had to conform to the following rules: it must not detract from the basic simplicity of the receiver, the set must be reliable and sure to work after completion, and the modification should add as little as possible to building costs.

The original design has a single tuned circuit with the coil being wound on a ferrite rod. A second coil on the same rod couples the tuned winding to the first transistor. It was considered that the low input impedance of the first transistor was damping the tuned circuit.

The idea of adding a second tuned circuit to increase selectivity was discarded as this would not adhere to the requirement that the modification must not detract from the simplicity of the receiver. The possible use of an f.e.t. input stage was also ruled out as it was felt that f.e.t.'s were expensive and too delicate to be handled by young newcomers to radio.

[1] G. W. Short, "Silicon Transistor Reflex T.R.F.", *The Radio Constructor*, January 1968.

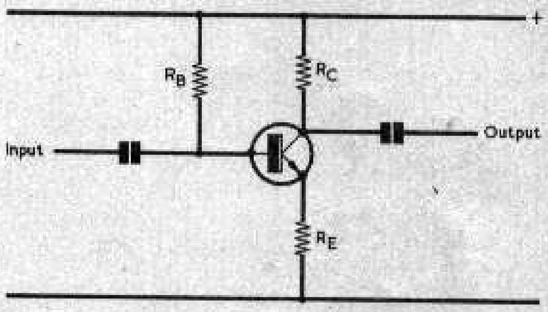


Fig. 1. A high to low impedance 'converter' circuit

What was needed was a simple high impedance unity gain buffer stage incorporating a bipolar transistor, this stage being easy to construct and requiring as few components as possible. The basic circuit eventually chosen is shown in Fig. 1. This has been described before, also by G. W. Short, but for a.f. applications only. It was subsequently found to function very well at r.f. as well.[2]

The voltage gain of this circuit is approximately RC devided by RE and the input impedance is given roughly by the parallel combination of RE multiplied by the small signal current gain, and RB. Since RC has to provide a reasonable match to the following stage a value of 10kΩ is chosen for it, this offering a useful compromise. A high gain transistor is employed, enabling a high value to be used for RB and, consequently, giving the circuit a high input impedance.

[2] G. W. Short, "Simple 'Impedance Converter'," *The Radio Constructor*, April 1969.

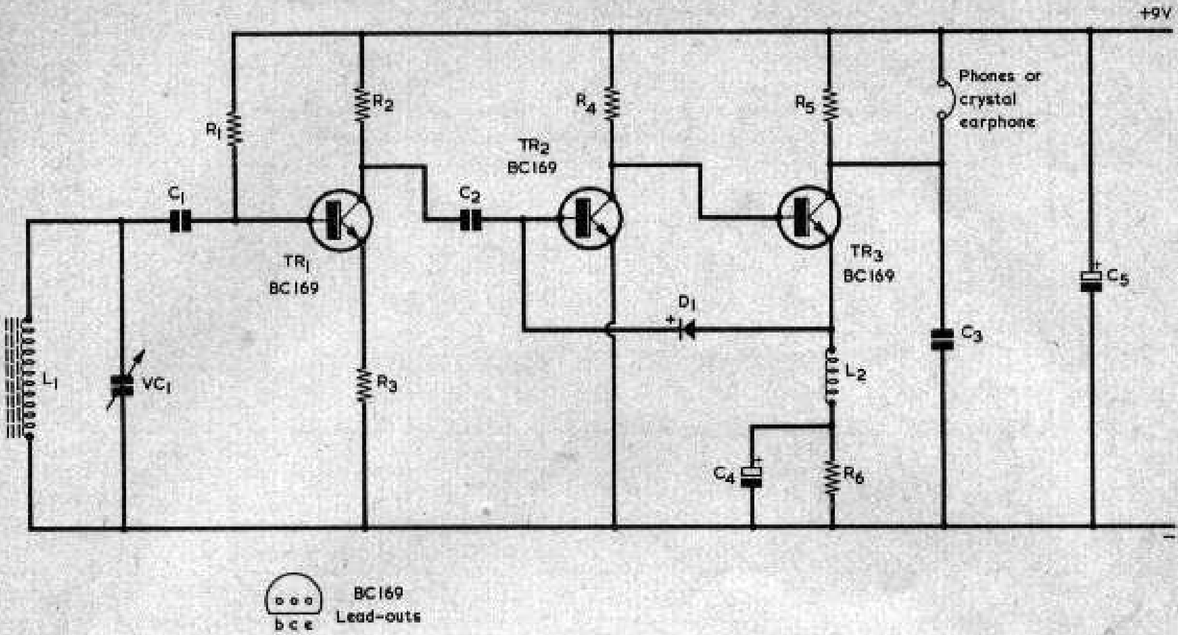


Fig. 2. Circuit of the receiver. TR1 presents a high impedance to the aerial tuned circuit, which is connected directly to its base

COMPLETE CIRCUIT

The complete circuit of the new receiver may be seen in Fig. 2. The circuit to the left of C2 is the same as that of the "Impedance Converter" previously published, and that to the right of C2 is virtually the same as the reflex t.r.f. receiver. The resistor values are unaltered.

The signal from the tuned circuit given by L1 and VC1 is applied via C1 to the high impedance buffer stage incorporating TR1 and thence, by C2, to TR2 where it is amplified and fed to the directly coupled transistor TR3. TR3 operates as an emitter follower at r.f., and the r.f. signal is detected by diode D1 and fed back to the base of TR1. The detected signal is again amplified, this time at a.f., by TR2 and TR3, and is finally fed to the headphones or earphone connected across R5.

R5 is only strictly necessary if a crystal earphone is to be used and it may be omitted if magnetic earphones are employed. However, it is worth including R5, as it increases the versatility of the set and enables it to be coupled up, also, to an a.f. amplifier.

EDITOR'S NOTE

The January 1968 and April 1969 issues of 'The Radio Constructor' referred to in this article are now out of print and cannot be obtained from us. They are not, of course, necessary for the building of the receiver described here, as the present article gives all the assembly and constructional information that is required

COMPONENTS

Resistors
(All values ¼ or ½ watt 10%)

R1	10MΩ
R2	10kΩ
R3	10kΩ
R4	15kΩ
R5	3.9kΩ
R6	680Ω

Capacitors

C1	1,000pF ceramic
C2	1,000pF ceramic
C3	0.01μF paper or plastic foil
C4	32μF electrolytic, 4 V.Wkg.
C5	50μF electrolytic, 10 V.Wkg.
VC1	300pF variable, solid dielectric, "Dilemin" (Jackson Bros.)

Inductors

L1	Ferrite slab aerial – see text
L2	R.F. choke – see text

Semiconductors

TR1, 2, 3	BC169
D1	OA81

Miscellaneous

Headphones, 2000Ω, or crystal earphone
9 volt battery
Battery connectors
Knob
Plywood baseboard

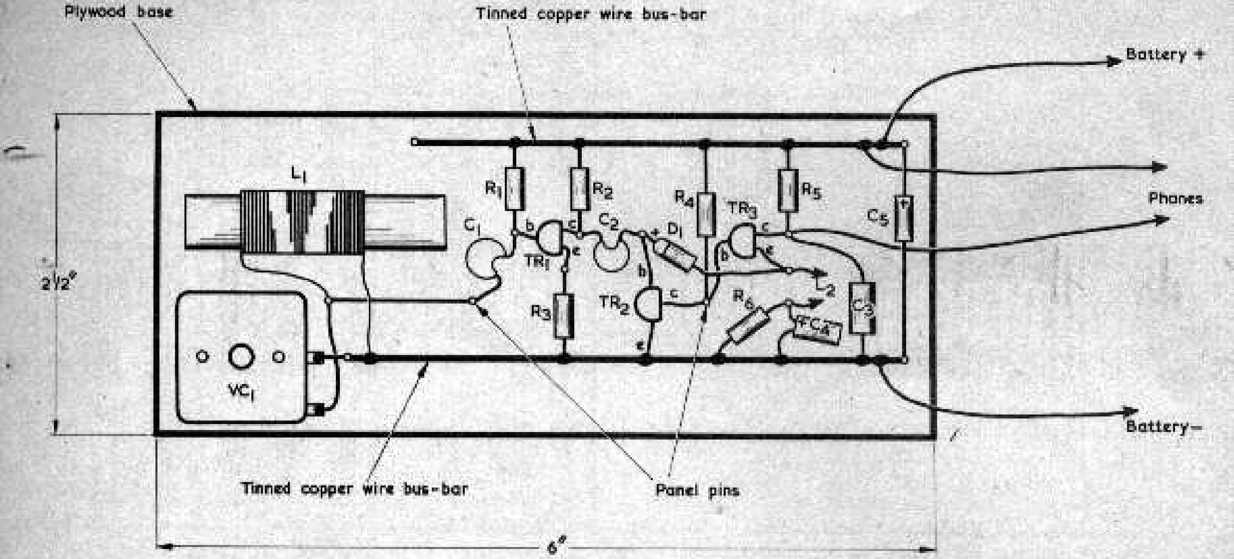


Fig. 3. How the receiver is assembled. The baseboard is a piece of plywood

CONSTRUCTION

The method of construction favoured by the author's pupils is shown in Fig. 3. This extremely economical approach involves the use of a plywood baseboard measuring 6 by 2½in., into which cheap panel pins are driven at the appropriate connection points. Component lead-outs are then soldered to these pins. The general layout of the components is shown in the diagram, and it is by no means critical. The tuning capacitor, VC1, may be secured by a suitable bracket made from scrap aluminium sheet, or similar.

A little experimenting is required with the ferrite slab aerial to obtain precise coverage of the medium wave band. The author's version consists of approximately 65 turns close-wound of 30 s.w.g. enamelled wire on a 2½in. ferrite slab, as shown in Fig. 4. However, ferrite slabs of this size are not generally available, and a suitable alternative would be the 2¼in. slab that is obtainable from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey, CR2 0DE. Longer ferrite rods could also be used and these would require fewer turns. The best approach is to purposely wind on too many turns, say 75, at first and then remove these as required after the receiver has been brought into working order.

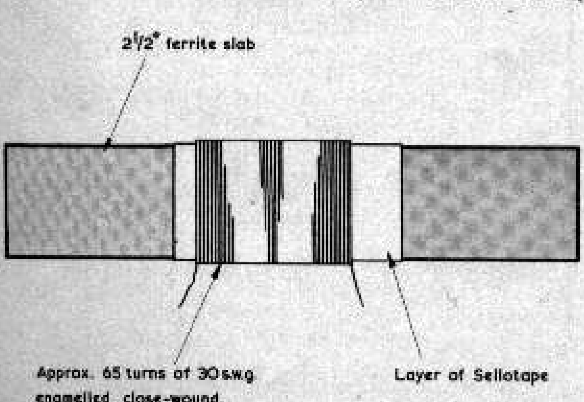


Fig. 4. Details of the ferrite aerial employed with the prototype

Choke L2 simply consists of 150 turns of thin wire around 36 s.w.g. pile-wound on a match-stick or an insulated 'former' of similar small dimensions. Lead-out wires of 28 s.w.g. tinned copper may be secured to this 'former' for connection into the circuit. These lead-outs should be some 3 to 4in. long so that the choke can be moved around the board until the best position is found for it. The choke inductance is of the order of 1mH.

TESTING

A wide variety of transducers was tried with the prototype, best results being obtained with high impedance headphones, as specified in the Components List. Good results were also given with a crystal earphone and balanced armature headphones; even a 3Ω speaker gave audible – albeit faint – results!

To test the completed receiver, connect up the headphones or earphone and a 9 volt battery. Tune in a station and rotate the set horizontally for maximum volume. (The ferrite aerial is highly directional.) L2 may now be moved around. It will be found that some positions of this component will cause the set to oscillate whilst in others signal strength will decrease or the signal will disappear completely. The choke may be experimentally turned, to alter its coupling with L1, whilst finding its optimum position. The best position for L2 will probably be found to be perpendicular to L1 and as far away from it as possible. Some regeneration *can* be obtained, if desired, by allowing L1 and L2 to interact, but this can be a finicky business and should not normally be necessary as selectivity and sensitivity are quite adequate without it. To give an idea of performance, good signals are received from Radio Luxembourg on the prototype, which is sited in the Midlands.

COMPONENTS

The components are not very critical. Any small resistors or capacitors of the stated values may be used. C4 and C5 can have high working voltages than those specified. It is desirable for the transistors to be high gain silicon types, and BC169's were used in the author's version. The "Dilemin" capacitor specified for VC1 is available from Home Radio under Cat. No. VC40B.

CONCLUSION

Up to the time of writing, about a dozen samples of this receiver have been built by club members and all have worked first time with very little trouble being experienced in the constructional work. The sensitivity of these sets has been very good and there have been no complaints about lack of selectivity.

V.H.F. RECEIVER

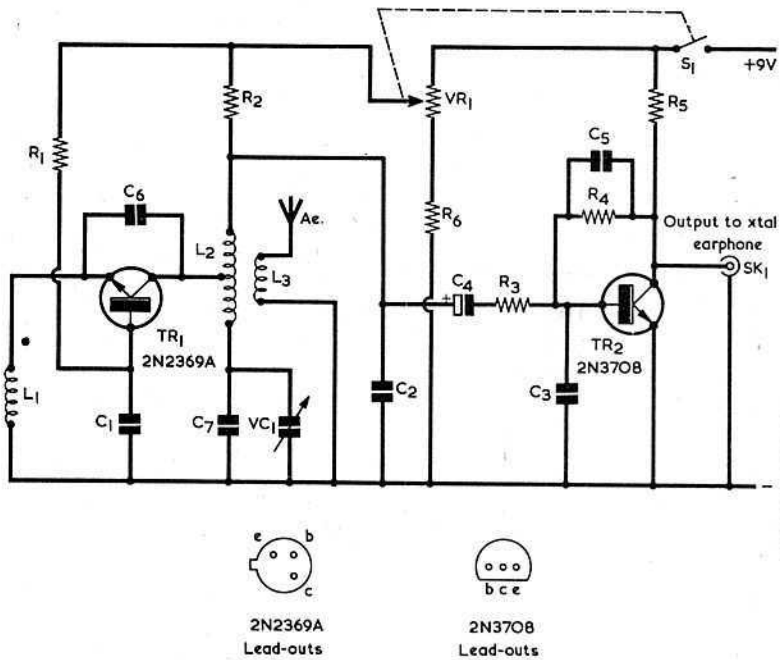
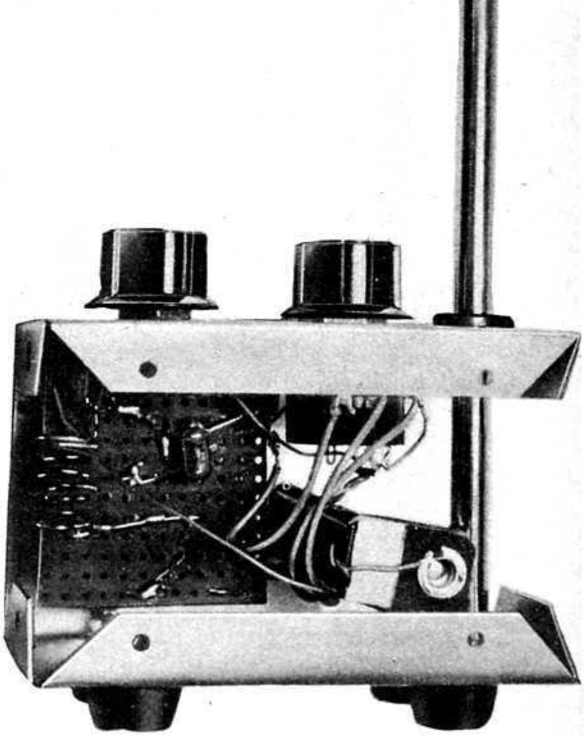


Fig. 1. The circuit of the v.h.f. receiver. TR1 is a regenerative detector and TR2 an a.f. amplifier



COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	330kΩ
R2	3.9kΩ
R3	2.2kΩ
R4	560kΩ
R5	4.7kΩ
R6	1.8kΩ
VR1	10kΩ potentiometer, log, with switch S1

Capacitors

C1	1,000pF disc ceramic
C2	0.022μF polyester
C3	0.01μF disc ceramic
C4	4μF electrolytic, 10 V.Wkg.
C5	220pF ceramic plate
C6	1.8pF tubular ceramic
C7	6.8pF tubular ceramic
VC1	5 or 6pF variable, miniature (see text)

Inductors
L1, L2, L3 See text

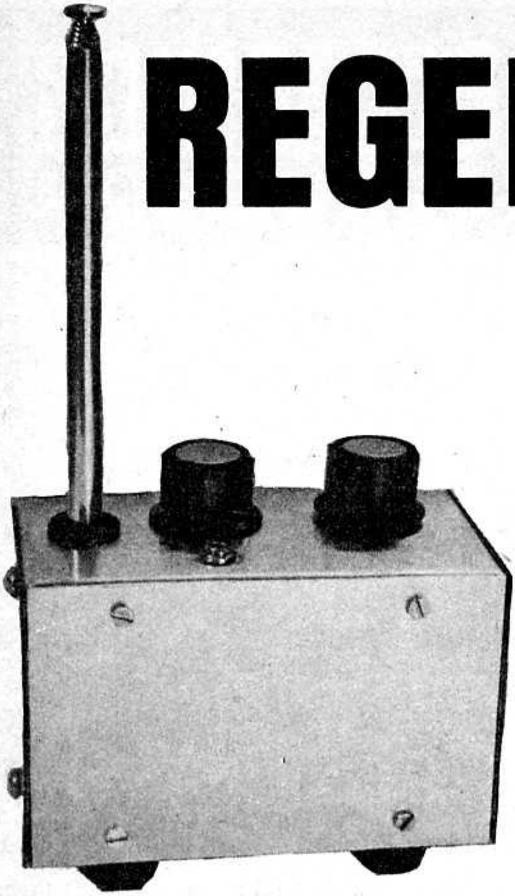
Semiconductors

TR1	2N2369A
TR2	2N3708

Socket
SK1 3.5mm jack socket

Miscellaneous
Telescopic aerial type TA 10 (Eagle – see text)
9 volt battery type PP3 (Ever Ready)
Battery connectors
Crystal earphone with 3.5mm. jack plug
2 control knobs
Plain Veroboard, 0.15 in. matrix
Aluminium sheet
Formica
Grommet (see text)
4 rubber feet

REGENERATIVE



by R. A. Penfold

This unusual receiver, intended primarily for areas where f.m. reception is reasonably good, employs only two transistors. It draws an extremely low current from its internal 9 volt battery

THIS IS A SIMPLE 2-TRANSISTOR REGENERATIVE RECEIVER suitable for the reception of B.B.C. f.m. transmissions in the 88 to 108MHz band. Apart from the ordinary Radios 2, 3 and 4, this band also provides local radio stations in appropriate areas. The set is completely self-contained, having an internal 9 volt PP3 battery and a telescopic aerial. The output is suitable for driving a crystal earphone. The case measures approximately 4 by $2\frac{1}{8}$ by $2\frac{1}{2}$ in., excluding the knobs and telescopic aerial.

Although the set has some advantages over simple medium wave receivers, such as superior treble response and freedom of interference from foreign stations, it does have a few disadvantages. Firstly, as the receiver uses an extremely simple circuit it is only suitable for use in fairly strong reception areas. It should be borne in mind that there are still certain parts of the country which are not effectively covered by v.h.f. f.m. transmissions and there are local black-spots in otherwise good areas of reception. The set should not be built unless the reader resides in an area where v.h.f. reception is reasonably good. The prototype set is operated 25 miles from the Wrotham transmitter and gives satisfactory results. As is explained at the end of this article an improvement in sensitivity can be given by a different type of telescopic aerial, but this improvement cannot be guaranteed to overcome the limitations of the circuit in a poor reception area.

A second disadvantage is that the receiver is slightly more difficult to build and adjust than a simple medium wave set. Thirdly it cannot, of course, receive foreign stations. Nevertheless, it does make an interesting alternative to medium wave receivers and, when properly built and adjusted, is capable of a very high quality output.

CIRCUIT OPERATION

The circuit of the receiver is shown in Fig. 1. TR1 is an inexpensive v.h.f. transistor type 2N2369A, and is used here as the regenerative detector. Basically this circuit consists of a grounded base oscillator with capacitive feedback, the regeneration being set to a point just below the level at which oscillation occurs.

R1 biases the transistor, whilst C1 bypasses the base for radio frequencies. L2 is the v.h.f. tuned winding and VC1 the tuning capacitor. L1 is a choke which provides a d.c. return to the negative supply rail for the emitter and offers a high impedance at the signal frequencies. In the grounded base configuration the emitter and collector are in phase, whereupon C6 introduces positive feedback. The supply for TR1 is obtained via the potentiometer VR1 which, in consequence, controls the gain of the stage. VR1 acts as the regeneration control.

The aerial currents are loosely coupled to the tuned

V.H.F. RECEIVER

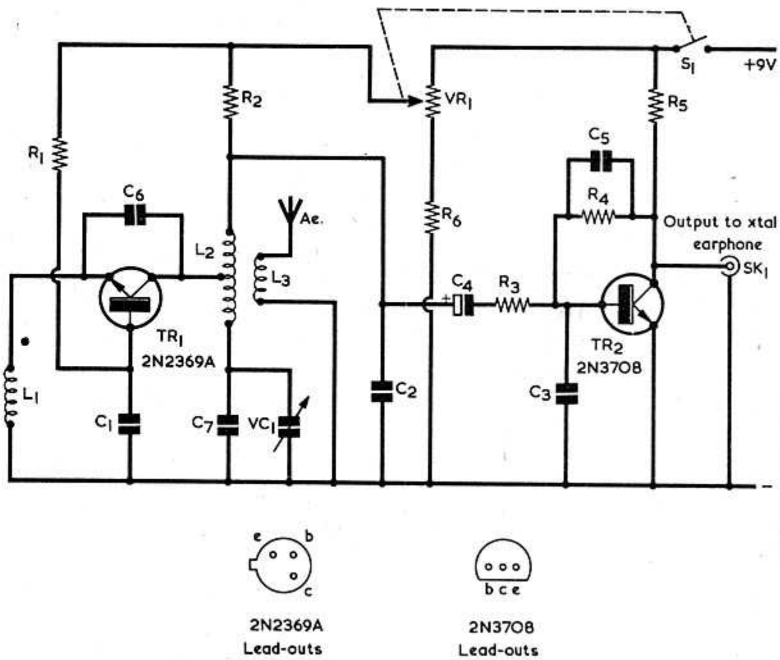
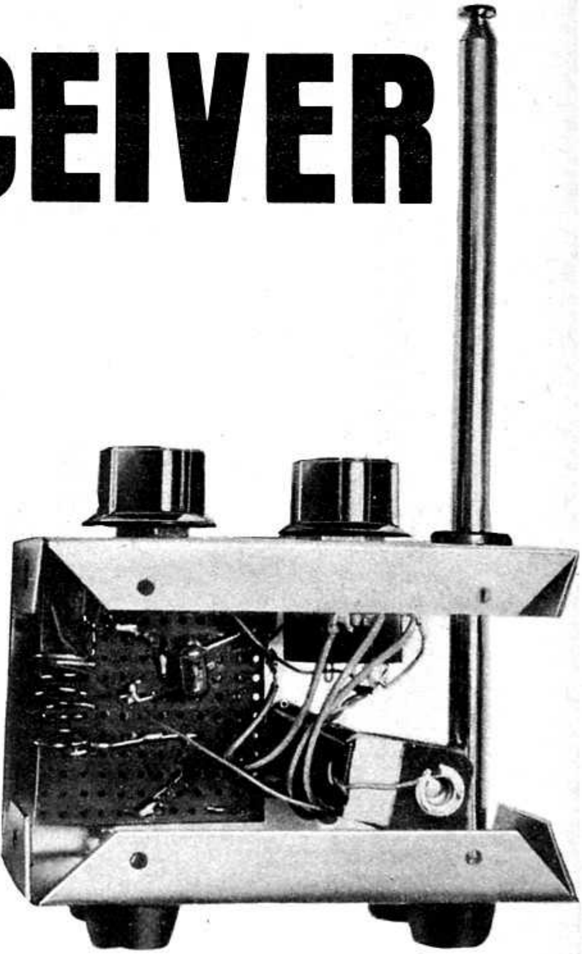


Fig. 1. The circuit of the v.h.f. receiver. TR1 is a regenerative detector and TR2 an a.f. amplifier



COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	330kΩ
R2	3.9kΩ
R3	2.2kΩ
R4	560kΩ
R5	4.7kΩ
R6	1.8kΩ
VR1	10kΩ potentiometer, log, with switch S1

Capacitors

C1	1,000pF disc ceramic
C2	0.022μF polyester
C3	0.01μF disc ceramic
C4	4μF electrolytic, 10 V.Wkg.
C5	220pF ceramic plate
C6	1.8pF tubular ceramic
C7	6.8pF tubular ceramic
VC1	5 or 6pF variable, miniature (see text)

Inductors
L1, L2, L3 See text

Semiconductors
TR1 2N2369A
TR2 2N3708

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SK1 3.5mm jack socket

Miscellaneous
Telescopic aerial type TA 10 (Eagle – see text)
9 volt battery type PP3 (Ever Ready)
Battery connectors
Crystal earphone with 3.5mm. jack plug
2 control knobs
Plain Veroboard, 0.15 in. matrix
Aluminium sheet
Formica
Grommet (see text)
4 rubber feet

circuit via L3. The detected audio signal is developed across R2, whilst C2, R3 and C3 form an r.f. filter. C4 provides a.f. coupling and d.c. blocking. TR2 operates as a straightforward common emitter a.f. amplifier, with R5 as the collector load and R4 as the base biasing resistor.

A certain amount of treble cut is applied in order to compensate for the treble boost given to the signal at the transmitter. The r.f. filter components give a small amount of treble cut and the rest is provided by C6. No output coupling capacitor is required as the receiver is designed for use with a crystal earpiece, which does not allow the passage of direct current. A series coupling capacitor of suitable value would be required if the receiver were coupled to an a.f. amplifier, and this should be positioned at the amplifier end of the screened lead coupling the two units together. There is a very slight possibility that a small amount of v.h.f. signal may still be present in the receiver output. Should this cause any problems in the amplifier a series 2.2kΩ resistor in the non-earthy output lead followed by a 1,000pF ceramic capacitor to earth should be added, these components again being fitted at the amplifier end of the screened cable. But it must be emphasised that the receiver is essentially intended for use with a crystal earphone only, and that it should be initially put into working order with an earphone of this type.

The receiver demodulates by reason of the fact that the received f.m. signal is converted to a.m. on the sloping skirts of the sharp selectivity curve given when regeneration is just below the oscillation point. Because of this method of detection there is a central tuning point for each station received where the signal is applied to the peak of the selectivity curve and is effectively nulled. The signal distorts when the set is tuned next to the central point. The central range over which these effects occur is extremely narrow, and it is not at all difficult to receive the signal properly on either side of it.

The current consumption of the receiver is a mere 2mA, with the result that even a small battery such as the PP3 will have an extremely long life.

The component employed in the VC1 position in the author's receiver is a surplus type which is not generally available. A Jackson Brothers variable capacitor type C804 will fit quite well into the layout, and this capacitor is available with a value of 5pF. Potentiometer VR1 should be a reasonably small component, with a body diameter of 1⅛ in. or less. The 'ceramic plate' capacitor specified for C5 is a miniature low voltage component having a square outline and side wires. A suitable component would be Cat. No. C87N from Home Radio.

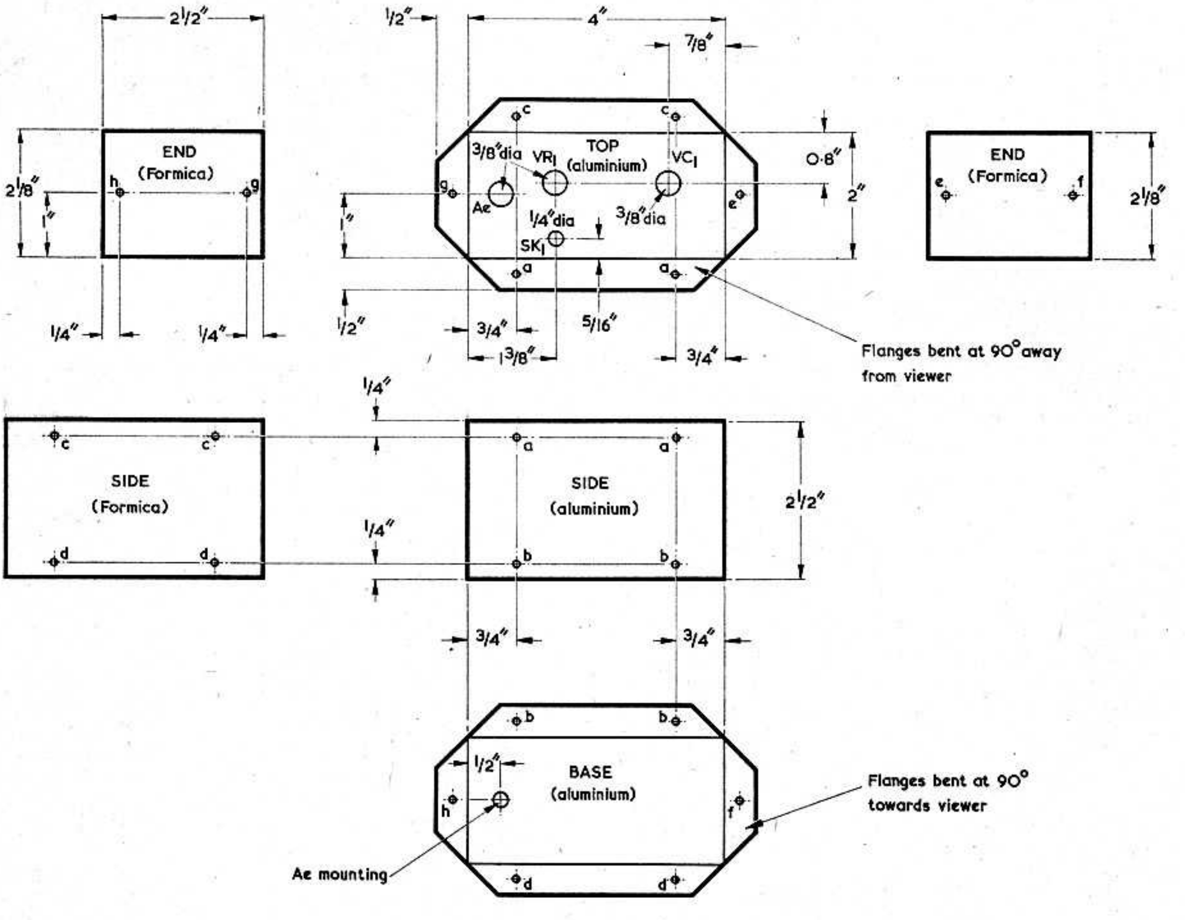


Fig. 2. Details of the parts which make up the case. The panels are aluminium sheet or Formica, as indicated

MAKING THE CASE

The case used to house the receiver is made from aluminium sheet of around 18 s.w.g., and Formica. Fig. 2 shows the individual parts and indicates the manner in which they are assembled together. The case is bolted or screwed together by fastenings which pass through the holes which have the same lettered markings. For example, the two holes marked 'a' on the flange of the top panel correspond with the two holes marked 'a' on the aluminium side.

The top and base panels are each bolted to the aluminium side plate by two ¼ in. 6BA bolts and nuts. Thus, all the holes 'a' and 'b' should be drilled out 6BA clearance. The Formica side is secured to the top and base flanges with self-tapping screws. In consequence, holes 'c' and 'd' on the aluminium flanges should be drilled out tapping size for the self-tapping screws and holes 'c' and 'd' in the Formica side should be drilled out clearance size. The two Formica ends are also secured with self-tapping screws, whereupon holes 'e', 'f', 'g' and 'h' are drilled out tapping size in the aluminium flanges and clearance size in the Formica ends. The finished case is quite attractive and is inexpensive to make. With the Formica side and ends removable, there is easy access to the inside. The Formica employed should not, incidentally, be the heat-resistant type. This type of Formica may have a metal shim laminated inside it, and this might conceivably alter receiver performance.

Two points need to be noted concerning the holes in the top panel. It is assumed that the hole for the telescopic aerial requires a diameter of ⅜ in. It is possible that some aerials may require a hole of different diameter, and this should be checked before drilling the hole. As can be seen from the photographs, the hole accepts a p.v.c. grommet through which the aerial passes. In the prototype the grommet had an inside hole diameter of $\frac{5}{16}$ in. The second point concerning the top panel is that one of the dimensions relating to the holes for VR1 and VC1 bushes is the decimal 0.8 in.; all the remaining dimensions which are not in whole numbers of inches are fractional.

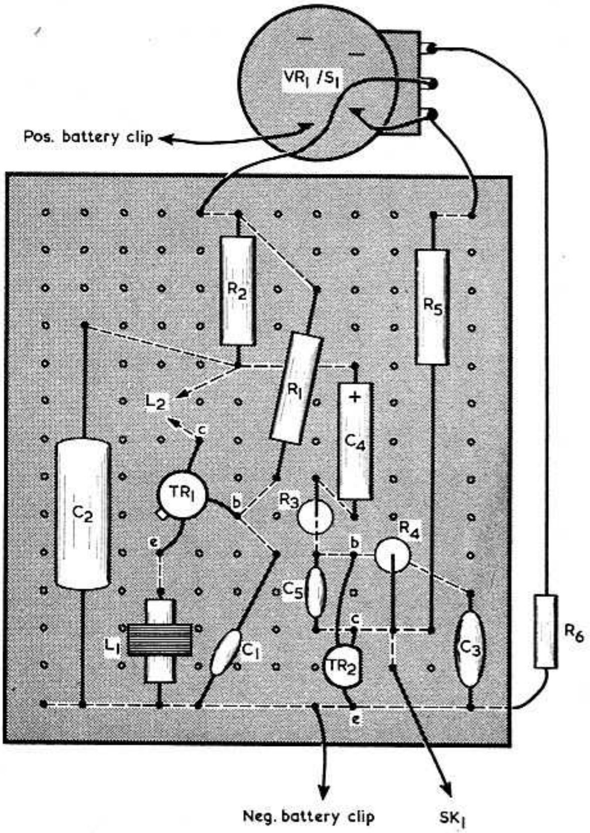
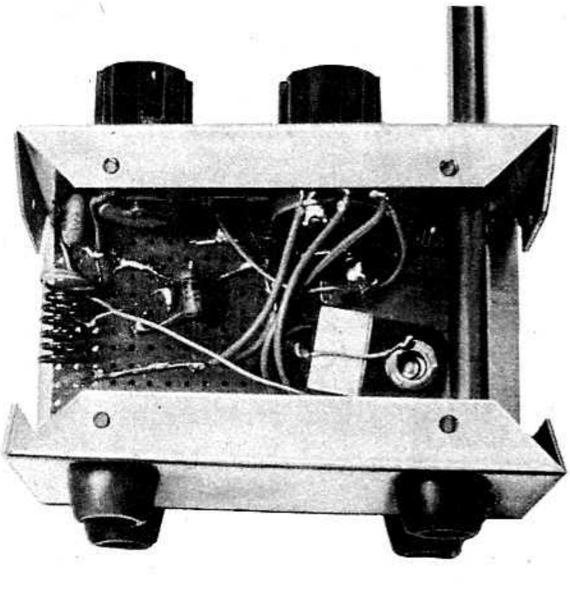


Fig. 3. One side of the component panel, with parts fitted and wired in place

Returning to the telescopic aerial, this has a threaded portion at its bottom which fits into a hole drilled in the aluminium base. The hole is drilled slightly too large and insulating washers are placed over the threaded section of the aerial on each side of the panel. Also, a solder tag is fitted over the threaded section above the upper insulating washer to enable connection to be made to the aerial later. The aerial is positioned so that the threaded section is central in the hole and its mounting nut is then tightened. An ohmmeter or continuity tester is then used to ensure that the aerial is insulated from the aluminium chassis.

Socket SK1 and potentiometer VR1 can be mounted at this stage. VC1 forms part of the main component assembly and is fitted later. Four small rubber feet are mounted on the aluminium base. The holes for the screws which secure these feet in position are not shown in Fig. 2.



A closer view. Note that the side of the component board on which L2 and L3 are fitted is towards the viewer

COMPONENT ASSEMBLY

All the small components including the coils are mounted on a plain 0.15 in. matrix Veroboard panel. This has 12 by 14 holes. Fig. 3 shows the component side of the panel, together with the connections to VR1, S1, SK1 and the battery. The chassis connection to SK1 is given automatically via its mounting bush and nut. The potentiometer switch will very probably be a 2 pole type, and only one pole is needed here. If necessary the appropriate tags can be identified with the aid of a continuity tester or ohmmeter.

The component board is very easy to assemble, the components being mounted in the positions shown with their leads bent over at right angles on the reverse side of the board and then cut to length. The leads are soldered together as indicated by the broken lines in the diagram.

Fig. 4 shows the underside of the board and the additional wiring needed to complete the assembly. A piece of thick tinned copper wire, of around 16 s.w.g., passes along the bottom of the board, and ensures that all the components which run to earth make a good connection. The moving vane tag of VC1 is soldered to this wire, and it is through VC1 that the board is earthed to the aluminium section of the case. This soldered connection also provides the physical mounting for the board.

L2 consists of 6 turns of 16 s.w.g. enamelled copper wire wound on a $\frac{5}{16}$ in. diameter former. It is important that the coil is exactly 6 turns, as if it is even a quarter of a turn out the set will have an incorrect frequency coverage. Initially, the coil is given a length of 0.6 in. It has a centre tap for the collector of TR1. Any round object of the required diameter can be used for the former, and this is removed after the coil has been wound and the centre tap point has been scraped clean of enamel and tinned, ready for connection. The ends of the coil are also, of course, scraped clean and tinned before connection. These ends are positioned and soldered in the manner shown in Fig. 4. The lead from the junction of L2 and C7 to the fixed vanes tag of VC1 should be kept reasonably short.

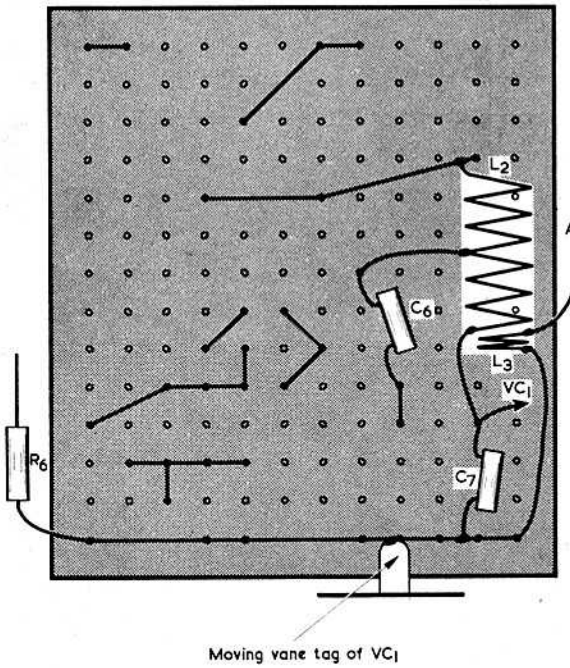
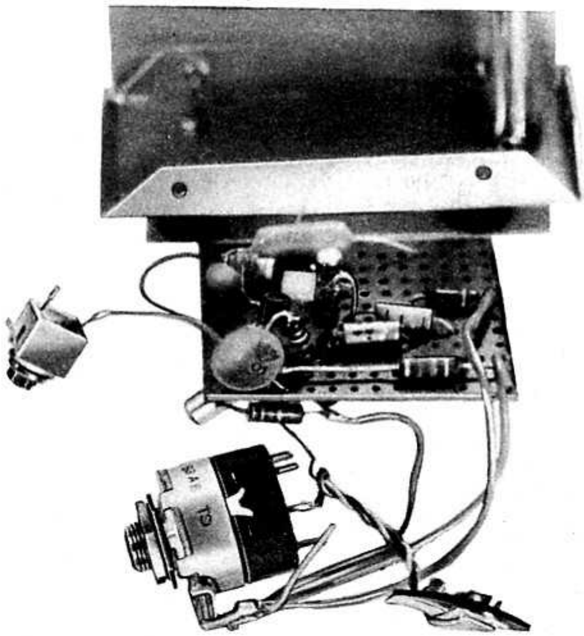


Fig. 4. The other side of the panel, on which are fitted C6, C7, L2 and L3



The component board removed from the case. The tuning capacitor is below the board and was a little out of position when this photograph was taken

L3 is merely two turns of wire, again with an inside diameter of $\frac{5}{16}$ in., which are wound in the lead which travels from aerial to earth. When the component board is mounted, this lead runs across the surface of the board. The wire is ordinary p.v.c. covered connecting wire with a single core for stiffness. The turns are closely wound and the coil is pushed close up to the end of L2, as illustrated.

L1 is wound on a 100kΩ $\frac{1}{4}$ watt 10% or 20% resistor, and consists of 40 turns of enamelled or rayon covered wire of around 34 s.w.g. The coil is scramble-wound and its ends are anchored by being soldered to the lead-outs of the resistor. The resistor lead-outs also provide a convenient means of connection to the coil. (Do not use a 5% resistor here. Close tolerance carbon composition resistors are occasionally subjected to a 'copper spray' at the factory, and this constitutes a short-circuited turn. – Editor.)

VC1 may now be fitted, whereupon the component board takes up the position shown in the photographs of the interior of the receiver. The battery fits in the space between the component board and the aerial. It is secured in position when the Formica side panel is screwed on. If necessary, a piece of plastic foam may be fitted between the panel and the battery to hold it securely.

RECEIVER OPERATION

With the prototype it was found necessary to have the telescopic aerial fully extended for best results. It is therefore not recommended that an aerial be used which is shorter than that specified. This has an extended length of 120 cm.

With the set turned on and VR1 advanced slightly, background noise should be heard in the earphone. If VR1 is advanced further a point will be reached where the noise suddenly becomes greatly diminished. Any further advancement of VR1 will probably cause an extremely loud hissing noise to be heard. The set is at its most sensitive when VR1 is adjusted to the point where background noise is just beginning to be diminished. *When the set is in use, VR1 should not be advanced beyond this point as this will cause the set to oscillate and radiate interference.* When the receiver is actually tuned to a station it is easy to accidentally turn VR1 too far, and this may not be noticed because the first stage of the set will then be operating as a super-regenerative detector. *Great care should therefore be exercised when tuning the receiver.*

It may be found that the receiver does not quite cover the desired range, making it impossible to tune in all three main B.B.C. stations. In such a case a little experimental alteration of the inductance of L2 by either stretching or compressing the winding should put matters right. However, if L2 is made accurately in the first place subsequent adjustment of its inductance should not normally be necessary.

With the prototype, Radios 2, 3 and 4 can all be received with good volume and quality, and with a reasonably low noise level. In the author's area there is no local radio station, but signals from the Radio Medway transmitter were just perceptible above the noise level of the receiver.

ALTERNATIVE AERIAL

Since the B.B.C. uses horizontally polarised signals and the receiver has a vertical aerial, the author tried the effect of a swivel base telescopic aerial, since this could be oriented to a 45° position or to the horizontal position. This gave quite a large increase in sensitivity, and tuning and regeneration adjustments became less critical. Since the author lives in a fairly good reception area the modification has relatively little advantage to him, as the volume level and signal-to-noise ratio were not much different. However, the point is mentioned because, in a poorer reception area, the use of a swivel base telescopic aerial would probably give an improvement that is more worth-while. The aerial is fitted to an insulated mounting at the top of the case and should have an extended length of around 40 in. or more. A 40½ in. swivel jointed aerial appears in the Henry's Radio catalogue under Type No. TA12A.

■

HIGH-GAIN SILICON REFLEX RECEIVER

by

G. W. Short

A sensitive 2-transistor receiver which requires few components and which can be adapted for a wide range of speaker impedances and battery voltages.

A FEW YEARS AGO THE 'RADIO CONSTRUCTOR' PUBLISHED the writer's design for a simple but effective reflex t.r.f. receiver using silicon planar transistors. This proved to be a reliable circuit with a good performance. Several modifications have appeared, including a low-consumption version for use with a crystal earpiece and a version with an f.e.t. input stage.*

The receiver described here is a new and improved version of the original circuit. Like the original, it has been kept very simple and straightforward. Nevertheless, it has proved possible to obtain a very useful increase in r.f. gain, and to provide enough audio output for low-volume loudspeaker listening indoors. The new circuit works from a 3 volt battery and is easily adapted to other voltages.

CIRCUIT DETAILS

Referring now to the circuit diagram, which is shown in Fig. 1, the heart of the receiver is a 2-stage amplifier with direct coupling between stages and d.c. negative voltage feedback to stabilize the operating conditions of the two transistors. Each transistor operates as a common-emitter amplifier to both a.f. and r.f. signals, giving very high overall gain.

R.F. signals picked up by the ferrite rod aerial L1 are stepped down and applied to the base of TR1 via L2, whose lower end, in the circuit diagram, is earthed to r.f. by C2. At the output of the 2-stage amplifier the r.f. signals are picked out and stepped up in voltage by an r.f. transformer (L3, L4) and applied to the detector D1, this being a point-contact germanium diode. The audio signals which appear across the detector load R4 (which is also the volume control) are fed back to TR1 and are then amplified by both transistors before application to the directly driven 75Ω loudspeaker.

A d.c. bias is applied to the diode by R5, which bleeds a little of the emitter current of TR2. Negative feedback at d.c. is taken via R4 from the emitter of TR2 to the base of TR1.

CONSTRUCTION

There is nothing special about the ferrite rod aerial and tuning capacitor C1. The prototype employed a 300pF Jackson Bros. 'Dilemin' tuning capacitor. This covers the medium wave band when L1 consists of about 70 turns of 5/46 litz wire close-wound on a paper former at the centre of a 4in. by ⅜in. ferrite rod. The secondary winding has 4 turns of insulated wire wound over the earthy end of L1. The precise gauge of wire is not important. (A suitable rod is available from Amatronix Ltd., 396 Selsdon Road, S. Croydon, Surrey, CR2 0DE. The same company also stocks wound rods to suit a 300pF tuning capacitance, but the secondary has too many turns for this receiver and six turns should be removed.)

The r.f. transformer L3, L4 is made by winding 50 turns of 32 s.w.g. enamelled, silk or cotton insulated wire on top of the existing winding of a 2.5mH r.f. choke,

* G. W. Short, "Silicon Transistor Reflex T.R.F.", *The Radio Constructor*, January 1968; G. W. Short, "'Milliwatt' Silicon Reflex T.R.F. Receiver", *The Radio Constructor*, September 1969; A. W. Whittington, "F.E.T. Reflex Receiver", *The Radio Constructor*, August 1971.

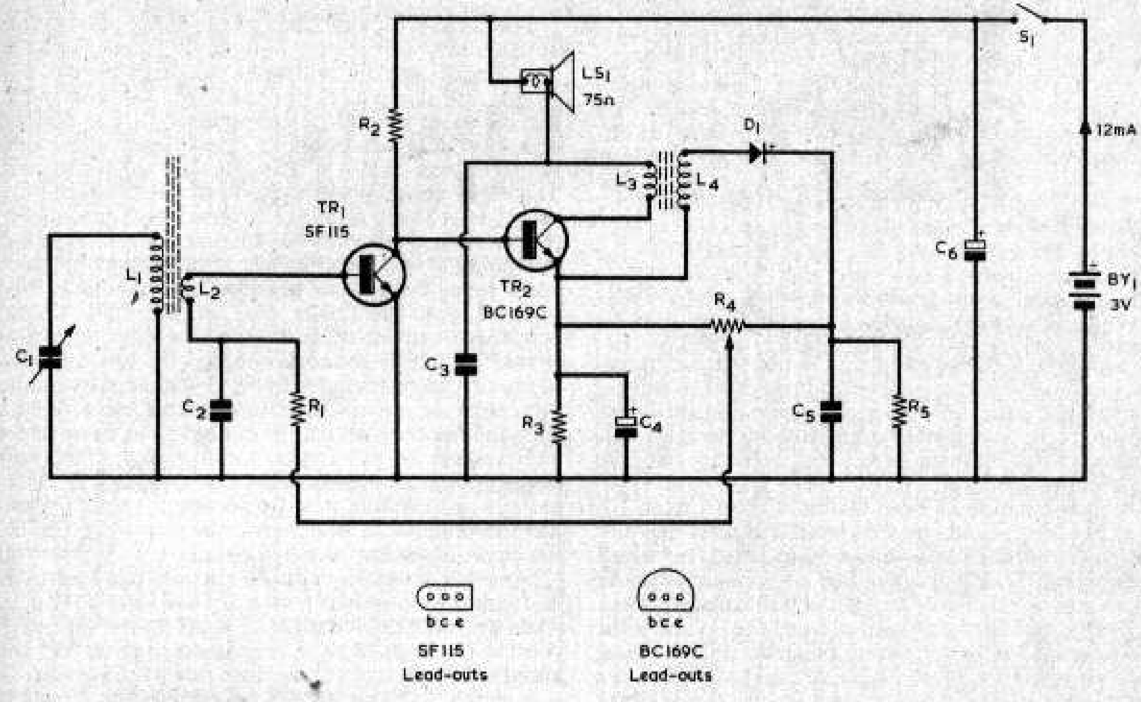


Fig. 1. The circuit of the high-gain silicon reflex receiver

COMPONENTS

Resistors
(All fixed values $\frac{1}{10}$ watt 10%)

R1	3.3kΩ
R2	1.2kΩ
R3	68Ω
R4	10kΩ potentiometer, log track
R5	22kΩ

Inductors

L1, L2	Windings on 4in. × $\frac{3}{8}$in. ferrite rod (see text)
L3	Overwind on L4 (see text)
L4	R.F. choke type CH1 (Repanco)

Semiconductors

TR1	SF115
TR2	BC169C
D1	OA90

Capacitors

C1	Tuning capacitor, to suit L1 (see text)
C2	0.1µF
C3	0.1µF (see text)
C4	320µF electrolytic, 2.5 V.Wkg.
C5	0.01µF
C6	125µF electrolytic, 4 V.Wkg. (see text)

Switch

S1	s.p.s.t. switch (may be ganged with R4)

Loudspeaker

LS1	75Ω approx. (see text)

Battery

BY1	3 volt battery

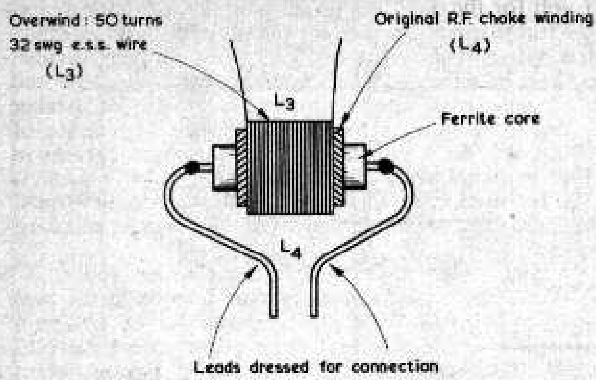


Fig. 2. Making up the r.f. transformer L3, L4

Repanco type CH1. See Fig. 2. Do not use a different kind of choke – it may not be suitable for the present purpose. The gauge of wire used for the added 50-turn winding is not important and any moderately fine insulated wire may be used. The winding may be 'scramble-wound'.

A wiring diagram is given in Fig. 3. Apart from L1, L2, all the components may be fitted to a small piece of insulating material fitted with a front panel, on which are mounted C1, R4 and S1. The components may be anchored to metal pins or tags at the positions indicated. For clarity, the transistors are omitted. The layout of the circuit should follow the circuit diagram and it is most important, in view of the high r.f. gain, to keep the output clear of the input or else screen the relevant portions.

A convenient means of providing the 3 volt supply consists of employing an Eagle battery holder type BH2, in which are fitted two U7 cells.

OVERCOMING INSTABILITY

The receiver is wide open to two quite distinct forms of instability, fortunately both easily cured. First, there is a chance that a.f. will break through the r.f. transformer and set up a continuous howl. This is cured, if it occurs, by reversing the connections to L3. Secondly, it is inevitable, unless the r.f. transformer is put into a screening box, that it will couple with the ferrite aerial. This may cause positive feedback and instability or negative feedback and loss of sensitivity, depending on the winding directions. To minimise such undesirable interactions, the transformer should be kept as far away from the rod as possible, and it should be so oriented that the ferrite core of the CH1 choke is pointing broadside off to L1 (like the down stroke of a capital T). Before connecting up L3, L4, dress the leads of the r.f. choke as shown in Fig. 2, so that the two ends of the leads can be soldered into circuit close together. This enables the choke to be twisted so as to re-orient it with respect to the ferrite aerial rod. In this way a position can be found where the coupling is zero or perhaps just slightly positive so that a useful improvement is obtained in selectivity. Varying the position of the ferrite aerial can also be helpful.

No other setting up adjustments are required. It will be found however that a sort of false instability occurs when the receiver is tuned in to a strong station with the volume too high. This is merely an overloading effect and the remedy is obvious – turn down the volume.

A simple test that the d.c. conditions are correct can be made by measuring the voltage drop across R3. This should be in the range 0.65 to 0.75V.

If desired, the on-off switch, S1, may be ganged to the volume control.

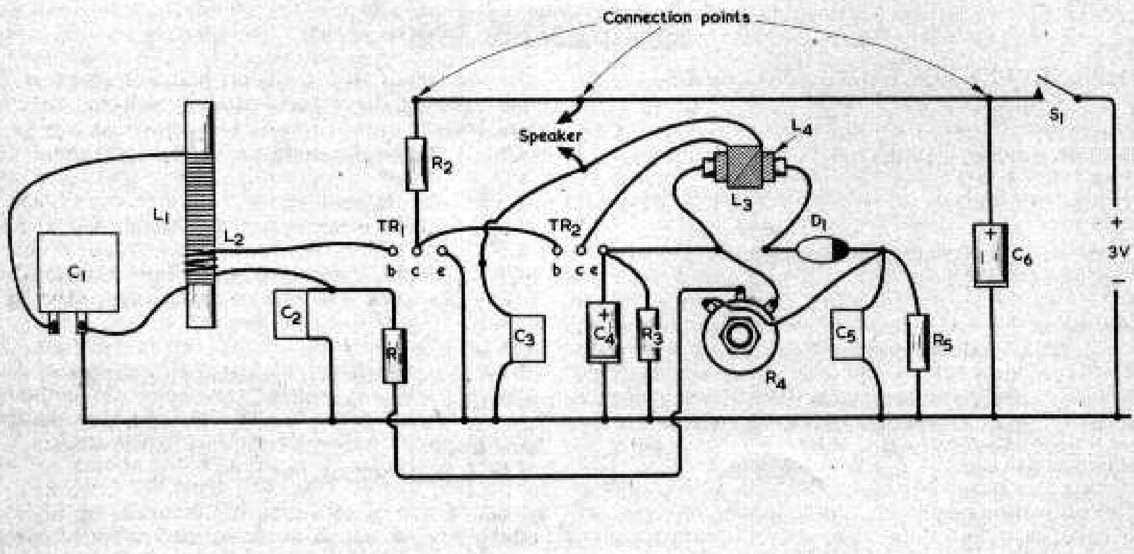


Fig. 3. A suitable component layout

LONG WAVE RECEPTION

The circuit will work on long waves given a suitable ferrite rod with long wave windings. (There is not room on a 4in. rod for both medium wave and long wave windings.) Alternatively, a single long wave station could be received by switching a suitable fixed capacitor across L1 and using C1 for fine tuning, as shown in Fig. 4. For reception of the Radio 2 transmission on 200kHz the added capacitor should be 2,200pF. A polystyrene film or silvered mica capacitor should be used.

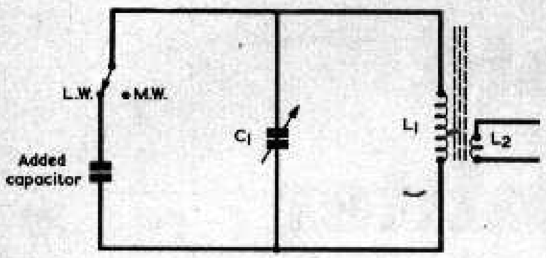


Fig. 4. Reception of a single long wave transmission is possible by switching an added capacitor across C1

OTHER SUPPLY VOLTAGES AND LOADS

In this direct-drive circuit it is essential to use a high impedance loudspeaker. The preferred impedance is 70 to 80Ω but speakers of somewhat different impedance may work: it depends upon how sensitive they are. A transformer may be used to match speakers of low impedance.

The voltage across R3 is stabilized at about 0.7 volt irrespective of the battery voltage. This makes it easy to set TR2 to take some particular collector current. At present, with R3 at 68Ω, TR2 takes a little over 10mA. If it were required to set the current at 1mA to suit an earphone of around 500Ω impedance in place of the speaker, R3 would be 680Ω.

With a 75Ω speaker, some increase in volume is obtainable by using the present resistor values but increasing the supply voltage to 4.5 volts. The circuit will go on working quite happily at higher voltages, up to 9 volts, but 75Ω is not then the optimum speaker impedance. (This rises to about 800Ω at 9 volts.)

Some constructors will want to use 3Ω speakers, which must be matched with a transformer. It is then useful to tailor the current in TR2 and the supply voltage to suit the load and transformer ratio. Allowing 1 volt for the drop across R3 plus the d.c. drop across the transformer primary, we are left with 1 volt less than the battery voltage across TR2. This voltage, divided by the transformed speaker impedance, should equal the collector current. Suppose we have a 3Ω speaker and a 10:1 transformer, giving a load impedance of 300Ω. With a 3 volt supply, the optimum current in TR2 is then 2 volts divided by 300Ω, which is 6.7mA. The required value of R3 is 0.7 volt divided by 6.7mA, or 106Ω, and we could use 100Ω, the nearest standard value.

Again, if we have a 20:1 transformer and a 5Ω speaker, the transformed speaker impedance is then $400 \times 5 = 2{,}000\Omega$. With a 3 volt supply the optimum current is 1mA, but since the power input to TR2 would then only be 2mW the audio power output cannot exceed 1mW, which may well be inadequate. The remedy is to use a higher battery voltage. With a 9 volt supply, the optimum current becomes 8 volts divided by 2,000Ω, or 4mA, and the d.c. input power to TR2 32mW, giving a possible 16mW of audio output (and a likely 8mW, assuming 50% transformer efficiency). The value of R2 for 4mA is 0.7 volt divided by 4mA, or 175Ω, so the appropriate standard resistor in this case is 180Ω.

When a high load impedance is used it may be necessary to reduce the value of the r.f. bypass capacitor C3, to avoid cutting the treble. Values down to 0.01μF may be used.

When working with supply voltages much above 3 volts it may be helpful, in the interests of battery economy, to reduce the current in TR1. This is done by increasing the value of R2. The voltage drop in R2 is held, by the d.c. feedback, at 1.4 volts less than the battery voltage, and a current in it of 1 to 2mA is adequate.

The working voltage of C6 must be increased for supply voltages greater than 3 volts. Constructors who intend experimenting with different supply voltages will find it useful to initially fit a capacitor here of 10 V.Wkg.

SEMICONDUCTORS

It is essential to use silicon planar transistors. The types specified have been carefully selected to give a good performance. (The SF115 transistor can be obtained from Amatronix Ltd., as can the other semiconductors and components.) Other transistor types will probably work, but less well. The input transistor must be an r.f. type with a low feedback capacitance and the SF115 specified has the added advantage of low a.f. noise as well. It should be possible to substitute BF115, which is the same transistor in a metal case. The BF167 will also work in this position.

The requirement for TR2 is rather different. This transistor may have to handle peak currents of 20mA or more, which rules out some r.f. types. It should have a low input capacitance and a fairly low feedback capacitance as well, to avoid putting too great a stray capacitance across R2 and so reducing the r.f. gain. Fortunately the BC169C has these features, and also the added one of very high hfe: some other high-gain audio types are much worse in the matter of capacitances.

In principle any point-contact diode will be satisfactory for D1, but here again some are better than others, and the OA90 is very suitable. ■

Bedside Reflex Receiver

by
A. Sapciyan

Circuit design for a low-cost 3-transistor medium-wave receiver

SIMPLE RECEIVERS ARE AMONG THE MOST INTERESTING projects for the home constructor. Receivers of this type frequently use the reflex principle, which provides a high gain with the minimum of components. The reflex receiver to be described in this article is capable of giving adequate loudspeaker volume for bedside listening without the need for an external aerial or earth. The sensitivity and selectivity are sufficient to enable several foreign stations to be tuned in after dark.

CIRCUIT DETAILS

The circuit is shown in Fig. 1. This has a variable resistor, VR1, which enables the set to be brought just below the oscillation level, thereby offering best sensitivity and selectivity for the reception of local and foreign transmissions. L1 is a ferrite aerial coil and is tuned by VC1. The signals picked up are passed to TR1 for r.f. amplification, the amplified signals being largely prevented by r.f. choke L2 from passing to the later stages. These r.f. signals then pass through C2 and are detected by D1, the resultant a.f. being reapplied to the base of TR1 via the electrolytic capacitor C9 and the lower end of L1. TR1 now functions as an a.f. amplifier and the amplified a.f. signals at its collector pass readily through the r.f. choke for application to TR2. C4 functions as a bypass capacitor for any r.f. signals that may still be present after the r.f. choke.

The a.f. signals next pass via C5 to TR2 and then via C7 to TR3. In the prototype, TR3 feeds a high impedance speaker directly but, as will be explained shortly, it may also couple into a 3Ω speaker via a step-down transformer.

The transistor in the first stage is an AF117 or AF127. The shield connection for either type is left open-circuit as this assists in providing regeneration. The current consumption of the first stage should be about 1.5mA.

The second stage uses an AC126 whilst the output stage employs an AC128. In the prototype, the output transistor coupled directly into a 150Ω speaker. However, speakers of this impedance are not widely available, and an alternative arrangement consists of coupling the collector of TR3 to the primary of a 9.2:1 step-down transformer (R.S. Components type T/T4), the secondary of which connects to a 3Ω speaker. The circuit incorporating the transformer is given in Fig. 2.

The total consumption of all three stages should not exceed 15mA, which is quite reasonable.

Sensitivity depends on the first stage providing a high gain. This stage can be checked for gain, if necessary, by connecting a pair of high impedance headphones in parallel with the load resistor, R2. R1, in series with VR1, controls the setting of the latter which allows oscillation to occur, and it may require adjustment in some cases for best results. R4 and C3 are decoupling components, and prevent motor-boating as the battery ages.

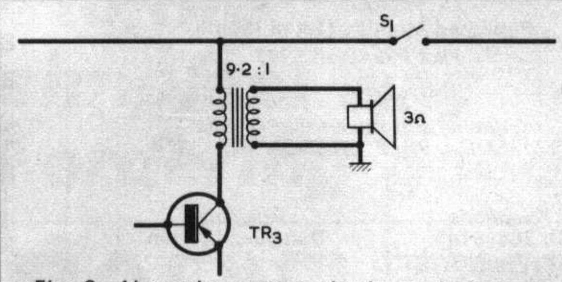


Fig. 2. Alternative output circuit employing a step-down transformer

AERIAL COIL

The aerial coil is wound on a ferrite rod 4 in. long by ⅜ in. in diameter, and consists of 75 turns close-wound on a paper sleeve that is free to slide along the rod. See Fig. 3. A tap is made at the 9th turn for the connection to the base of TR1, and the wire is 30 s.w.g. enamelled. Different grades of ferrite may give slightly varying values of inductance to the coil, and the constructor is advised to commence with 85 turns overall, still keeping the tap at the 9th turn. After the set has been completed and brought into working order, turns can then be

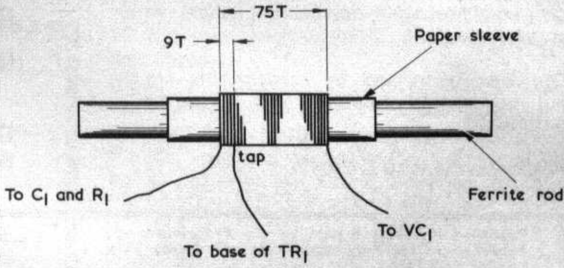


Fig. 3. Details of the ferrite rod aerial

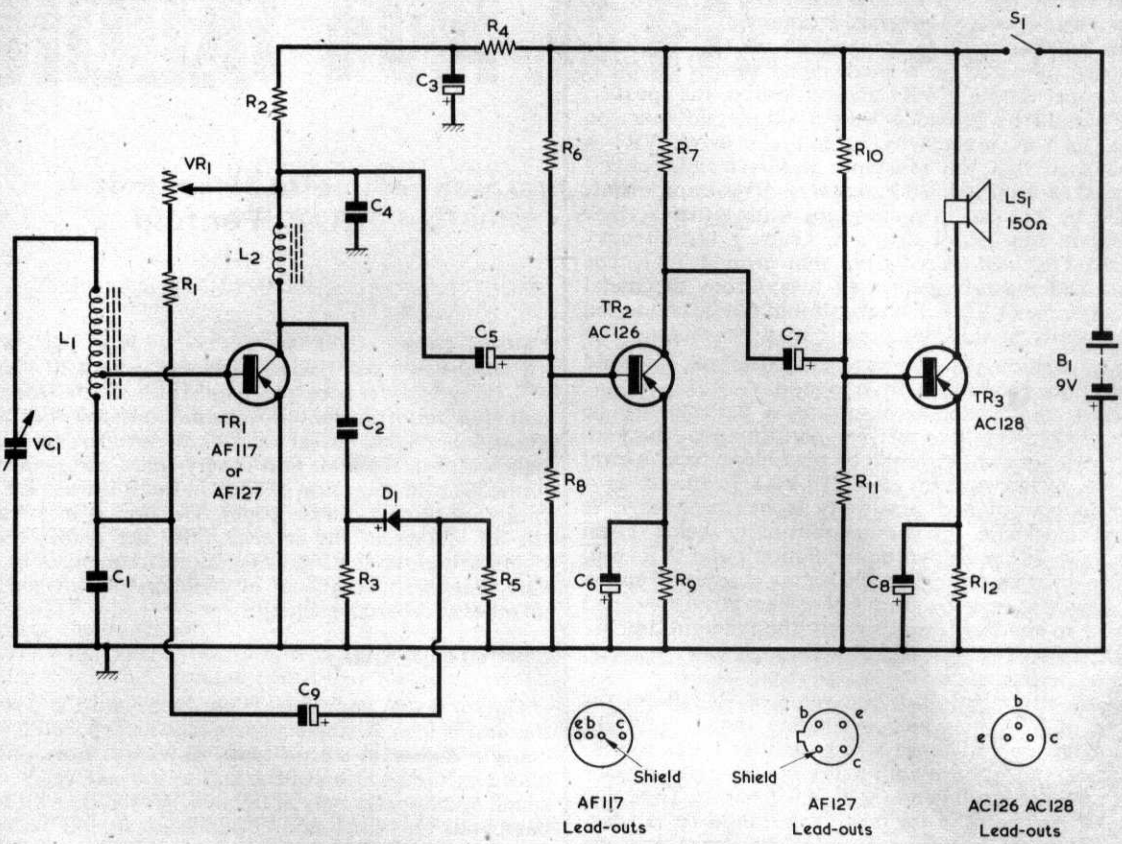


Fig. 1. The circuit of the reflex receiver

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1 68kΩ (see text)
R2 1kΩ
R3 4.7kΩ
R4 1kΩ
R5 10kΩ
R6 68kΩ
R7 5.6kΩ
R8 10kΩ
R9 680Ω
R10 33kΩ
R11 5.6kΩ
R12 150Ω
VR1 100kΩ potentiometer, linear

Capacitors

C1 0.01μF paper or plastic foil
C2 330pF ceramic or silvered mica
C3 50μF electrolytic, 10 V.Wkg.
C4 0.01μF paper or plastic foil
C5 5μF electrolytic, 10 V.Wkg.
C6 50μF electrolytic, 6 V.Wkg.
C7 5μF electrolytic, 10 V.Wkg.
C8 100μF electrolytic, 6 V.Wkg.
C9 10μF electrolytic, 2.5 V.Wkg.
VC1 300pF variable, solid dielectric

Inductors

L1 Ferrite aerial coil (see text)
L2 2.5mH r.f. choke type CH1 (Repanco)

Semiconductors

TR1 AF117 or AF127
TR2 AC126
TR3 AC128
D1 OA85

Switch

S1 s.p.s.t., toggle or rotary

Speaker

LS1 Miniature speaker, 150Ω, or 3Ω with R.S. Components transformer type T/T4

Battery

B1 9-volt battery

Miscellaneous

Slow-motion drive and knob
Chassis, as required
Tagstrips or tagboard.

taken off at the end remote from the tap until the desired medium-wave coverage is obtained.

The receiver may be constructed on tagstrips or a tagboard mounted on a small metal chassis having a front panel for VC1, VR1 and, if desired, the speaker. VC1 should be provided with a simple slow-motion drive, such as is given by an epicyclic drive. VR1 is wired such that the resistance it inserts into circuit reduces as it is turned clockwise. The components should be laid out in roughly the same order as they appear in the circuit diagram, keeping the circuitry around TR3 well-spaced from that around TR1. The ferrite rod must be kept well away from the metal chassis or panel. The r.f. choke should not be connected permanently at this stage, as it may be necessary to alter its position with respect to the ferrite rod. It should be positioned about 2 in. from the rod.

When construction is complete, a battery may be connected and the receiver performance checked. After switching on, it should be possible to receive local stations by adjustment of VC1. VR1 functions as a reaction control and sensitivity is increased as it is turned clockwise, maximum sensitivity being given when it is set just below the oscillation point. VR1 will require different settings as the tuning is adjusted across the range. It may be found that the position of L2 relative to the ferrite rod affects the reaction and L2 should be rotated, if necessary through 180°, for best reaction performance.

As already mentioned, the value of R1 affects the setting of VR1 at which oscillation occurs, and R1 should have a resistance which enables VR1 to offer adequate control both with a new battery and with one whose voltage has fallen to some 7 volts or so. The value of 68kΩ employed in the prototype should be satisfactory in general, but it may need to be varied in some instances.

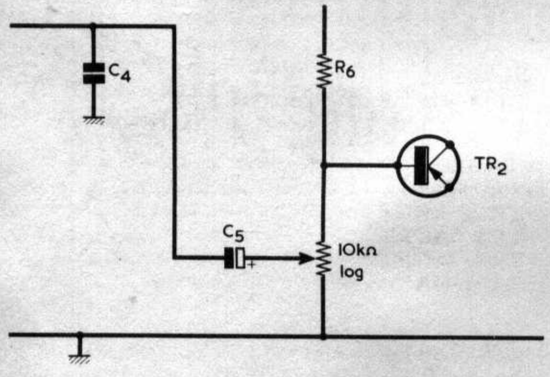


Fig. 4. In areas of very high signal strength R8 may be changed to an a.f. volume control, as illustrated here

No overloading problems were evident with the author's receiver, but they are feasible if the set should be employed close to a powerful station. Should overloading occur, resistor R8 may be replaced by a 10kΩ log potentiometer, connected as shown in Fig. 4. This will function as an a.f. gain control. It should be remembered that VR1 is a reaction control and is not a gain control, as such. VR1 should always be kept at a setting which provides adequate selectivity and sensitivity. ■

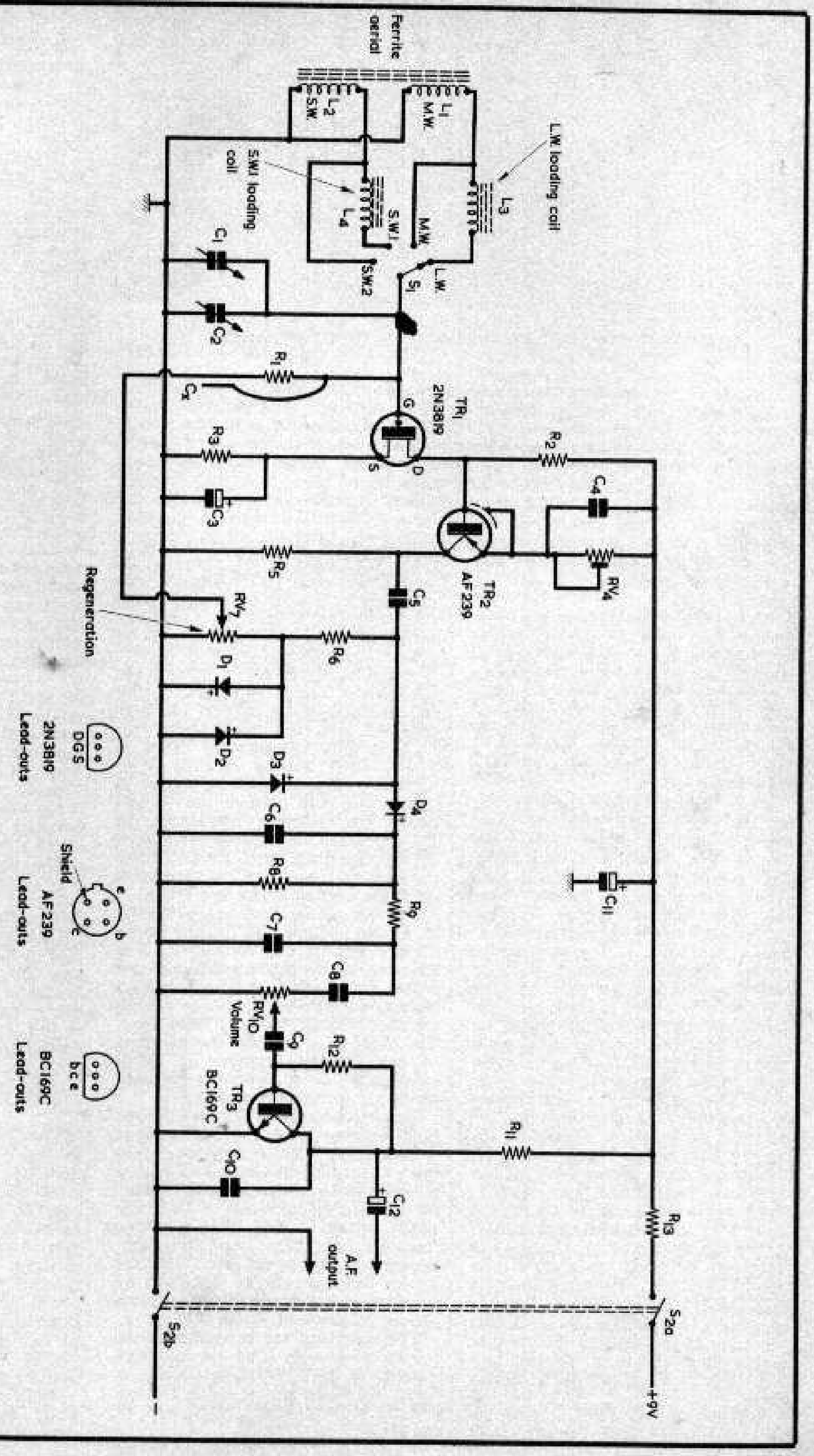


Fig. 4. The complete circuit of the modern homodyne receiver. This can receive a.m., c.w. and s.s.b. transmissions

A MODERN HOMODYNE RECEIVER

Part 1

By

G. W. Short

Recent interest in 'direct conversion' receivers has prompted our contributor to offer his own design. In this month's article he discusses the background to homodyne reception, leading up to the basic mode of operation employed in his receiver. In the concluding article, to be published next month, the receiver will be described in full.

'DIRECT CONVERSION RECEIVER' is a fairly recent term though, strictly speaking, it might be applied to any type of receiver which converts the incoming signal directly to audio. On this basis even a crystal set would qualify, but in fact the term is usually restricted to receivers in which the audio is recovered with the help of an oscillator.

REACTION CIRCUIT

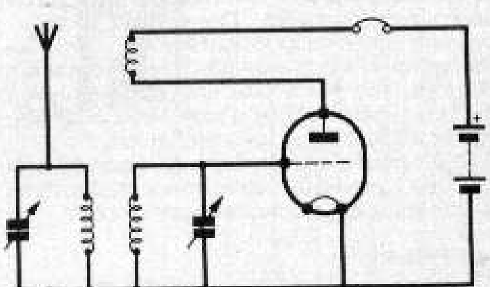
The simplest and earliest of this type of direct conversion receiver was the 'homodyne'. In its original form, described in 1924 by F. M. Colebrook, who became Director of the National Physical Laboratory, it was just a triode dedector with 'reaction' (Fig. 1). The reaction was set to make the circuit oscillate strongly. As many readers will have discovered for themselves, when a signal is tuned in with such an oscillating detector there is first of all an ear-splitting howl caused by the incoming carrier beating with the local oscillation. Then, as the circuit is adjusted closer and closer towards 'zero beat', a point is reached where the beat note suddenly disappears, and the incoming programme is heard, rather faintly and with background hiss but otherwise with good quality.

What has happened is that the local oscillation has become locked to the incoming carrier. The combined signal is then an ordinary a.m. signal with an abnormally strong carrier – the result of the local oscillation which, being now synchronised, adds to the signal carrier. The net result is an a.m. signal with a low depth of modulation, which makes for low distortion of the detected audio. The background hiss arises from the same cause as the background hiss of a c.w. receiver when the b.f.o. is switched on or any sensitive receiver tuned to an unmodulated carrier. That is, the carrier or local oscillation beats with any r.f. noise close to it in frequency, giving a.f. noise at the output of the detector.

Colebrook's homodyne was a very simple affair, but it did embody the important principle of a local oscillation lockeu in frequency to an incoming carrier. All modern direct conversion a.m. receivers use this principle, though the means by which synchronism is obtained may be very different from Colebrook's direct-injection method.

The knowledge that an LC oscillator can be synchronised in this way predates Colebrook's homodyne by a small period. A little over a year earlier, Appleton (the ionosphere researcher) had written a learned paper

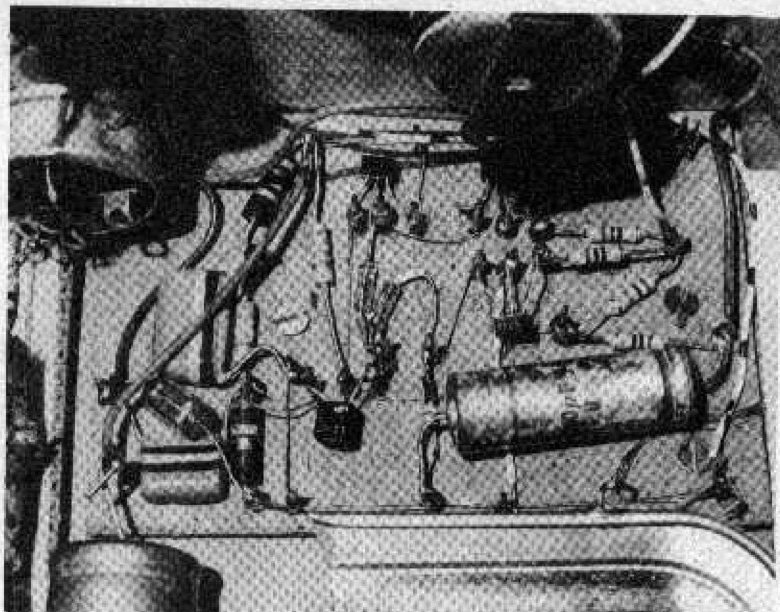
Fig. 1. An early approach to direct conversion' reception consisted of using a triode detector with reaction, as illustrated in basic form here



amplifier could be used instead. For completeness, nevertheless, the present amplifier will next be described.

The amplifier circuit is given in Fig. 7 and it has the advantage of offering a low battery consumption, the quiescent current being approximately 0.8mA only. The input signal is applied to the base of the BC169C, whose collector couples to the base of the first 2N4289. This drives the BC168B and 2N4289 in the complementary Class B output stage. Two silicon 'bias diodes' (available, as is the BC168B, from Amatronix Ltd.) keep the output transistors conductive for the zero signal condition, and these couple to the speaker, which may be 75Ω or 80Ω. The speaker employed in the prototype was a 75Ω 2½in. unit (which is also available from Amatronix Ltd.). Feedback to the BC169C is taken from the junction of the 1kΩ and 10Ω resistors across the speaker, and it will be noted that this particular part of the circuit exhibits a considerable economy in components. It is desirable that the 250μF 16V capacitor be a Mullard miniature electrolytic component, as its internal series resistance was taken into account when the feedback component values were calculated. As already stated, the 1,000μF capacitor across the supply lines is only required to reduce the risk of feedback to the homodyne receiver. If the amplifier were used on its own for a different application the 1,000μF capacitor could, in most instances, be omitted.

In the present design the amplifier is assembled on a piece of hardboard measuring 2¼ by 3¼in. and uses domestic pins for anchorage points in the same manner as with the homodyne receiver board. Components are laid out along the board in roughly the same order as they appear in the circuit. The 1,000μF capacitor is not mounted on the amplifier board, but is external to both this board and the homodyne board. It appears between the homodyne board and the battery, and is clearly visible in the photographs showing the interior of the overall receiver.



Close-up of the a.f. amplifier board. The BC169C is at bottom left, whilst the two output transistors are to the right

OPERATION

Operating a homodyne takes a little getting used to. The background hiss and the howls during tuning-in may be rather off-putting at first, but do not be discouraged! You will be surprised at the stations it can pull in once you have learned to use it. Here are a few general tips and guide lines:

1. If the circuit is detuned a little, but not far enough to lose synchronisation, the audio output falls and becomes distorted. The best tuning point is usually nearer one edge of the locking band than the other.

2. Loss of sync. may occur momentarily during deep modulation troughs, giving a rasping quality. This is a sign that the circuit is slightly off tune or that a.f. signals are getting back into the r.f. amplifier.

3. Loss of sync. may occur if the signal fades. The best strategy is usually to let well alone until the signal fades up again.

4. It is an advantage to use the lowest practicable level of oscillation. If you have to increase the level to override a strong signal in the next channel turn up the reaction, until the intelligible breakthrough turns into unintelligible 'monkey chatter'. This is as far as you need go. However, when receiving s.s.b. signals the question of synchronization doesn't arise, so in this case the best level of oscillation is set by other factors. First, the level must be at least high enough always to exceed the incoming signal, otherwise intelligibility will suffer. Secondly, it turns out with this receiver that it is possible so to set the regeneration that a useful increase in signal amplification can be had even with the receiver oscillating. On weak signals this is what dictates the maximum level which can usefully be set up. (If strong s.s.b. signals are being received you may as well turn the regeneration right up and so get the maximum selectivity from the outset).

As a final point, Fig. 8 shows received frequencies corresponding to the 0 – 100 scale of the slow-motion tuning drive employed with the prototype. It must be emphasised that this diagram, which applies to a 500pF tuning capacitor, is intended for guidance only, and it should not be assumed that receivers built up to the circuit will exhibit exactly the same frequency/scale relationship. Nevertheless, the diagram will still be of assistance since it gives the constructor an approximate idea of received frequencies on the four bands covered. ■

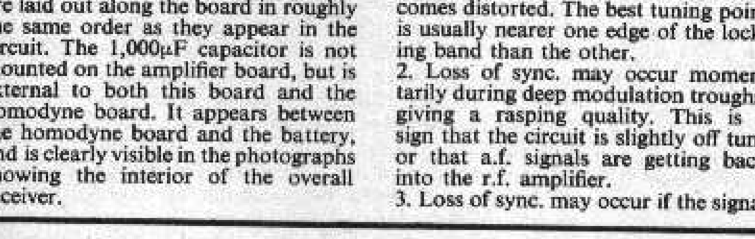


Fig. 8. The frequencies received with the prototype, plotted against the 0 → 100 calibration of its slow-motion tuning drive

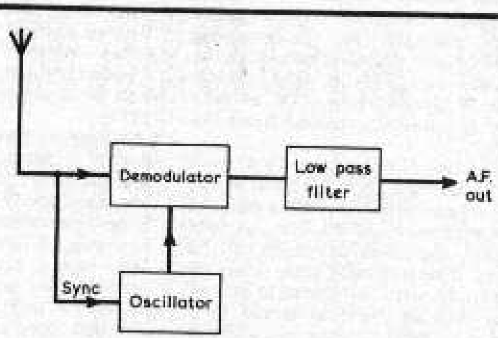


Fig. 2. Demonstrating typical synchrodyne operation

on the subject. Some of his co-workers had actually used Colebrook's method of reception.

Despite this promising beginning, the homodyne never became popular. This may seem strange in the light of present-day interest, but it should be remembered that the superheterodyne method of reception had already been invented and seemed to be the answer to all the problems of the day, since it gave high gain, good selectivity, and a simple method of automatic gain control.

In any case the domestic t.r.f. receivers of the twenties and thirties were often operated as homodynes . . . and very unpopular they were when this was done. In those days of long outdoor wire aerials, an oscillating detector first stage acted as a local c.w. transmitter producing, when off tune, annoying whistles in neighbouring sets. The outdoor aerial also brought with it a particular disadvantage. When it swayed in the wind, the resulting variations in capacitance to earth tended to throw the receiver out of synchronism.

THE SYNCHRODYNE

As Colebrook had realised, the homodyne method of reception can give greatly enhanced selectivity. The way in which it does so is not very obvious from the original circuit, but it becomes clear when one examines the much improved form of the technique known as the 'synchrodyne' (Fig. 2).

In the synchrodyne the path of the incoming signal is split into two separate branches. One branch goes straight to the demodulator, that is, the circuit which carries out the direct conversion to audio. The demodulator is driven by an oscillator, and the other branch of the signal path goes to this oscillator: this is the synchronising path and its job is to injection-lock the oscillator to the incoming carrier of the wanted station.

Now, the demodulator, although usually regarded as a detector (and in certain forms called a 'product detector'), is in reality a kind of frequency changer. The unorthodox thing about *this* frequency-changer, however, is that, unlike the one in a superhet where the oscillator is on a completely different frequency from the signal, here the oscillator is on exactly the same frequency. The 'i.f.' output is at the difference frequency between signal and local oscillation, but the difference frequency is zero! This does not mean that there is no output but that the output is at zero frequency, or d.c.

Not very useful, you may think. But this is where the nature of an a.m. signal comes into the picture. An a.m. signal has a carrier *and sidebands*. The oscillator in a synchrodyne is locked to the carrier frequency, so it is the carrier frequency only which gives a d.c. output. The sidebands, being on slightly different frequencies, give beat-frequency outputs. It just happens that the beat frequencies are the original modulation frequencies, so that the output of the demodulator consists of the original audio modulation frequencies which constitute the programme.

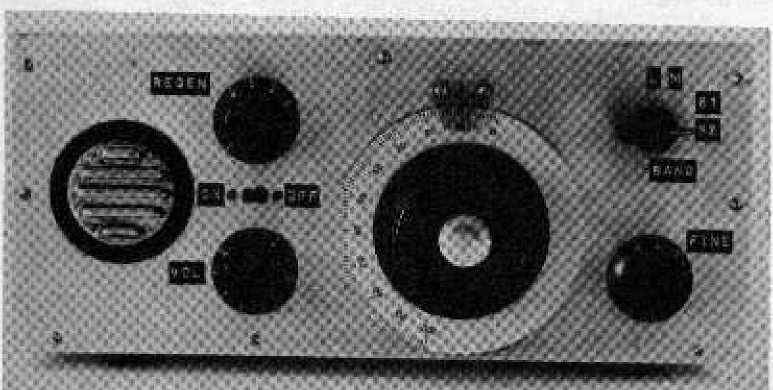
To take an actual example, suppose the carrier frequency is 200kHz, modulated by a.f. at 1kHz. There are in consequence the usual two sideband frequencies, one at 199kHz and the other at 201kHz. Both these beat with the local oscillation on 200kHz to give 1kHz, i.e. the original modulation. The same thing happens with any other modulating frequency, and for any mixture of frequencies which form a voice or music signal.

What happens to unwanted frequencies on other channels? The carrier of an adjacent channel, say 209kHz, gives an output from the demodulator of 9kHz. This is a whistle at a relatively high audio frequency, and is rejected by the low-pass filter which follows the demodulator, whose cut-off frequency can be set at, say, 5kHz. It will be clear that signals on channels above 209kHz, such as 218kHz, come out at still higher frequencies and are also rejected. What about unwanted channels on lower frequencies? If the next lower channel is at 191kHz it gives a beat at 9kHz, which is also dealt with by the low-pass filter. Any still lower channel comes out, once again, at a *higher* difference frequency and is likewise eliminated by the filter.

We therefore have the delightfully simple situation that, so long as the local oscillator stays locked to the wanted carrier, unwanted signals on any other frequency are eliminated. There is no possibility of 'second channel' (image frequency) breakthrough as in a superhet. Note, too, that the selectivity comes from the demodulation process; even r.f. tuning can, in theory, be dispensed with!

OSCILLATOR STABILITY

The problem, of course, is to keep the oscillator synchronised, and we must now look at this requirement



The panel layout of the author's homodyne receiver. Details of this will be given in the article to be published next month more closely. Common sense suggests that the stronger the synchronising signal the easier it should be to lock the local oscillator. This is true, and it provides a starting point for an estimate of the stability needed from the oscillator.

Careful tests will show that even when the tuning is shifted a little to one side or other of the correct point the oscillator remains locked. The stronger the signal, the more detuning can be tolerated. This would be great if all one needed to do were to tune in to strong stations, but in the real world it is necessary to pluck a weak signal from a surrounding array of strong ones, each eager to jump in and take over. In theory, it is indeed possible to stay locked to the wanted weak carrier when there are strong unwanted ones nearby. To do it, you must increase the amplitude of the local oscillation. This makes it *harder* to lock, but it turns out that a weak signal tuned in 'right on the nose' can then dominate a strong one slightly off tune. The price demanded for this performance is great stability of frequency.

If the local oscillator were absolutely stable it would not be necessary to lock it at all. One would just set it to the right frequency and sit back. Unless the transmitter frequency drifted the receiver would stay tuned indefinitely. Unfortunately, absolutely stable oscillators just do not exist, so locking is necessary. If drift is very low, the locking signal need only be small, which is what we want.

How stable must the oscillator be? Suppose, to begin with, that we are in the rather favourable situation of having to lock to one signal when another, of exactly equal strength, is 10kHz away. Now let the oscillator drift, but without loss of sync. If it drifts towards the unwanted carrier, a point will be reached at the half-way mark between the two stations where there is an even chance that the unwanted carrier will take command. In other words, the natural, unlocked frequency must not drift by more than half the channel spacing, in this case by 5kHz.

So far we haven't specified what the carrier frequency is. When we do, we find we have come to the crunch. If the wanted carrier is 500kHz, then the allowable drift in this case of 5kHz amounts to one per cent – 1 part per 100. Not a very difficult stability to achieve. But what if the carrier were 5MHz? A drift of 5kHz is now 1 part in 1,000. And at 50MHz, a stability of 1 in 10,000 is required, or 0.01%. Clearly, life gets harder as one goes up the frequency scale.

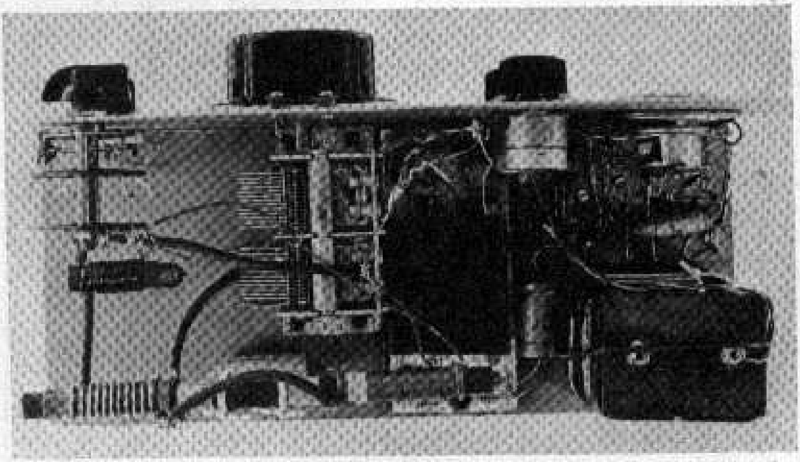
Next, look at the unfavourable situation where the unwanted carrier is not equal in strength to the wanted one but 100 times stronger. The oscillator must be 100 times more stable than before, and this calls for a drift of less than 1 part in 10,000 at 500kHz, 1 in 100,000 at 5MHz, and 1 in a million at 50MHz. Clearly, the synchrodyne is a receiver for lowish frequencies, or quick hands on the tuning control, or oscillators of exceptional stability.

The original synchrodyne designs, published in 1947, were for medium wave receivers. Their originator, D. G. Tucker (now Professor of Electrical Engineering at Birmingham University) had a background in line communications engineering and a special interest in the rectifier types of modulators and demodulators, such as the ring modulator, used in carrier telephony. These have the degree of linearity between input signal and output which is required in the synchrodyne, and were used in the most successful version, though Tucker did also produce a simple version using a triode-hexode frequency changer instead. The synchrodyne created a stir when it first appeared, but subsequent research by Tucker showed that between 1924 and 1947 there had been a number of patented circuits which embodied the essential principle of separating the synchronising path from the main signal path.

INTEREST REVIVES

The most obvious attraction of the synchrodyne (and homodyne, which can be regarded as a synchrodyne whose funcions are all mixed up in one circuit) is its ability to provide high selectivity without the use of a lot of tuned circuits. There is, however, another less obvious attraction. It can be called in as an ally against what many communications engineers have come to regard as the last great enemy – intermodulation. In a shortwave receiver, the aerial tuned circuit cannot be made selective enough to get rid of strong interfering stations somewhere in the band to which it is tuned. The result is that the first stage of the receiver, usually an r.f. amplifier, is presented with a mixture of weak and strong signals. Since no amplifier is perfectly linear the consequence is that the weak ones have the modulation of the strong ones impressed upon them, and no amount of subsequent filtering (in i.f. stages, for example) can then get rid of the interference.

In a direct-conversion receiver, all the selectivity is obtained in one stage, the demodulator. And in the demodulator the strongest signal, the signal which overrides all others, is of course the local oscillation. By dispensing with r.f. amplification and feeding the input signals straight to a demodulator supplied with a good strong local oscillation there is a sporting chance that cross-modulation will be greatly reduced. This is of particular interest on the amateur bands, where there may be very strong interfering signals from broadcast transmitters or the amateur in the next street. Another encouraging fact is that for single-sideband suppressed carrier reception, now popular with amateur transmitters, a small frequency error at the local oscillator is permissible. Given a stability which confines drift to a few tens of cycles during a 'contact' there is no need to attempt precise synchronisation, which is just as well, since in a suppressed-carrier system there is no carrier to provide a locking signal. (It is possible, at the expense of great complexity, to derive one from the audio output, but that's another story).



A view inside the homodyne receiver. Signal pick-up on medium and long waves, and on two short wave bands, is provided by a ferrite rod aerial

IMPROVING THE HOMODYNE

In general, however, we are interested in receiving ordinary double sideband a.m. signals with carrier and and all. In this case it is absolutely necessary to synchronise the oscillator. For most purposes we need some r.f. amplification as well.

The original homodyne did give some protection against cross-modula-

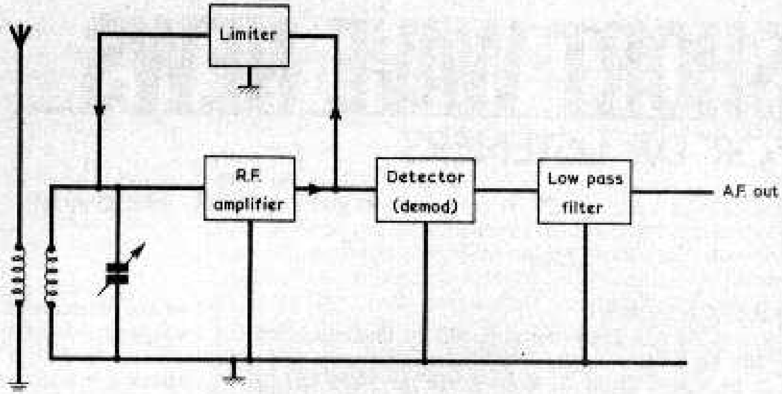


Fig. 3. The homodyne method of reception employed in the author's design

tion, by making the local oscillation the strongest 'signal' around. But it provided no r.f. amplification. What is needed, then, is a circuit which preserves the simplicity of the homodyne but gives r.f. amplification as well. A way of achieving this is shown in Fig. 3.

In Fig. 3, signals are tuned by an aerial circuit, amplified by an otherwise untuned r.f. amplifier, and passed to a detector. So far all we have is a simple t.r.f. receiver. This is turned into a homodyne by introducing regenerative feedback (reaction) from amplifier output to the aerial circuit. This feedback takes place via a limiter. The job of the limiter is twofold: to suppress the modulation of the fed-back carrier and to prevent the amplitude of oscillation from getting too large. What is fed back, when the circuit is oscillating strongly, is a more or less unmodulated carrier of fixed amplitude.

Provided that the fed-back carrier is not so strong that it overloads the amplifier any other signals present will still be amplified in the normal way, except that cross-modulation may be discouraged by making the oscillation stronger than any other signal.

No means of controlling regeneration (other than the limiter) are shown in Fig. 3, but it is very easy to add an attenuator between the limiter and the tuned circuit. Once this is done it becomes possible to set the circuit so that it acts either as a simple non-regenerative receiver with no 'reaction', or as a normal reacting t.r.f., or as a fully oscillating homodyne. For most purposes the ordinary regenerative t.r.f. condition is adequate, since it provides enhanced gain and selectivity without the need for the critical tuning of a homodyne. But when conditions are bad, with a strong interfering station or stations in the band, the superior selectivity of the homodyne is worth the trouble of the careful adjustment which this mode of reception calls for. Single-sideband transmissions can also be received, if the tuning is fine enough, once the knack of hitting the right tuning point is acquired. Readers who have not tried s.s.b. reception before are warned that it takes some practice!

(To be concluded)

A MODERN HOMODYNE RECEIVER

Part 2

By

G. W. SHORT

In this concluding article our contributor deals with the construction of his homodyne receiver. Also described is a suitable a.f. amplifier, together with details showing how this amplifier and the homodyne receiver may be assembled to form a complete receiver with loudspeaker output.

COMPLETE CIRCUIT

THE COMPLETE CIRCUIT OF A MODERN homodyne receiver on the lines discussed last month is shown in Fig. 4. This is basically a two-stage r.f. amplifier, tuned at the input only, and driving a double-diode detector, D3, D4, which acts as a demodulator when the receiver is made to behave as a homodyne. A single a.f. stage completes the circuit as shown here, but of course a separate power amplifier must be used for loudspeaker reception.

In Fig. 4 the aerial tuned circuit is given by C1, C2 and whatever inductance is selected by wave-change switch S1. L1 and L2 are medium and short wave coils on a ferrite aerial rod offering, with a 500pF tuning capacitor, ranges of 500 to 2,000kHz and 3.5 to 10MHz respectively. When S1 is set to the 'L.W.' position, loading coil L3 is inserted in series with L1, whereupon the range covered is 150 to 500kHz. Similarly, setting S1 to 'S.W.1.' causes loading coil L4 to be inserted in series with the ferrite rod short wave coil, L2, whereupon the range covered is 1.6 to 5MHz. C1 is a 'fine tuner' with a capacitance of 5pF, and is helpful for final tuning of short wave signals. The aerial tuned circuit arrangements are discussed in more detail later.

The r.f. amplifier (TR1, TR2) calls for a little explanation. A junction f.e.t. is used in the input stage. This produces little r.f. gain in itself, but simplifies the band-switching by making it possible to dispense with the usual tapping on the input coil and to connect the whole aerial tuned circuit directly to the amplifier. Most of the actual gain comes from TR2,

COMPONENTS

Resistors
(All fixed values ¼ watt 10% or closer tolerance)

R1	220kΩ
R2	1kΩ
R3	1kΩ
RV4	500Ω potentiometer, pre-set, miniature skeleton
R5	1kΩ
R6	10kΩ
RV7	10kΩ potentiometer, log, with metal case (see text)
R8	10kΩ
R9	10kΩ
RV10	25kΩ potentiometer, log
R11	10kΩ
R12	2.7MΩ
R13	180Ω

Capacitors

C1	5pF variable
C2	365 or 500pF, variable
C3	2.5μF electrolytic, 6V. Wkg.
C4	0.01μF metallised polyester
C5	0.01μF metallised polyester
C6	0.01μF metallised polyester
C7	0.01μF metallised polyester
C8	0.1μF metallised polyester
C9	0.1μF metallised polyester
C10	0.01μF metallised polyester
C11	125μF electrolytic, 10V. Wkg.
C12	10μF electrolytic, 10V Wkg.*
Cx	See text

* Omitted when a.f. amplifier of Fig. 7 is used.

Inductors

L1, L2	Medium and short wave ferrite aerial assembly (Amatronix)
L3	2.5mH r.f. choke type CH1 (Repanco)
L4	Short wave loading coil (see text)

Semiconductors

TR1	2N3819
TR2	AF239
TR3	BC169C
D1–D4	OA90

Switches

S1	1-pole 4-way, rotary
S2	d.p.s.t., slide switch

Loudspeaker

LS1 75Ω or 80Ω loudspeaker†

†Required only when a.f. amplifier of Fig. 7 is used.

Battery

9-volt battery type PP9 (Ever Ready)

A. F. Amplifier

A.F. amplifier of Fig. 7 or suitable alternative

Miscellaneous

Slow-motion tuning drive
4 knobs
Transistor holder
Battery connectors
Material for panel, chassis and cabinet

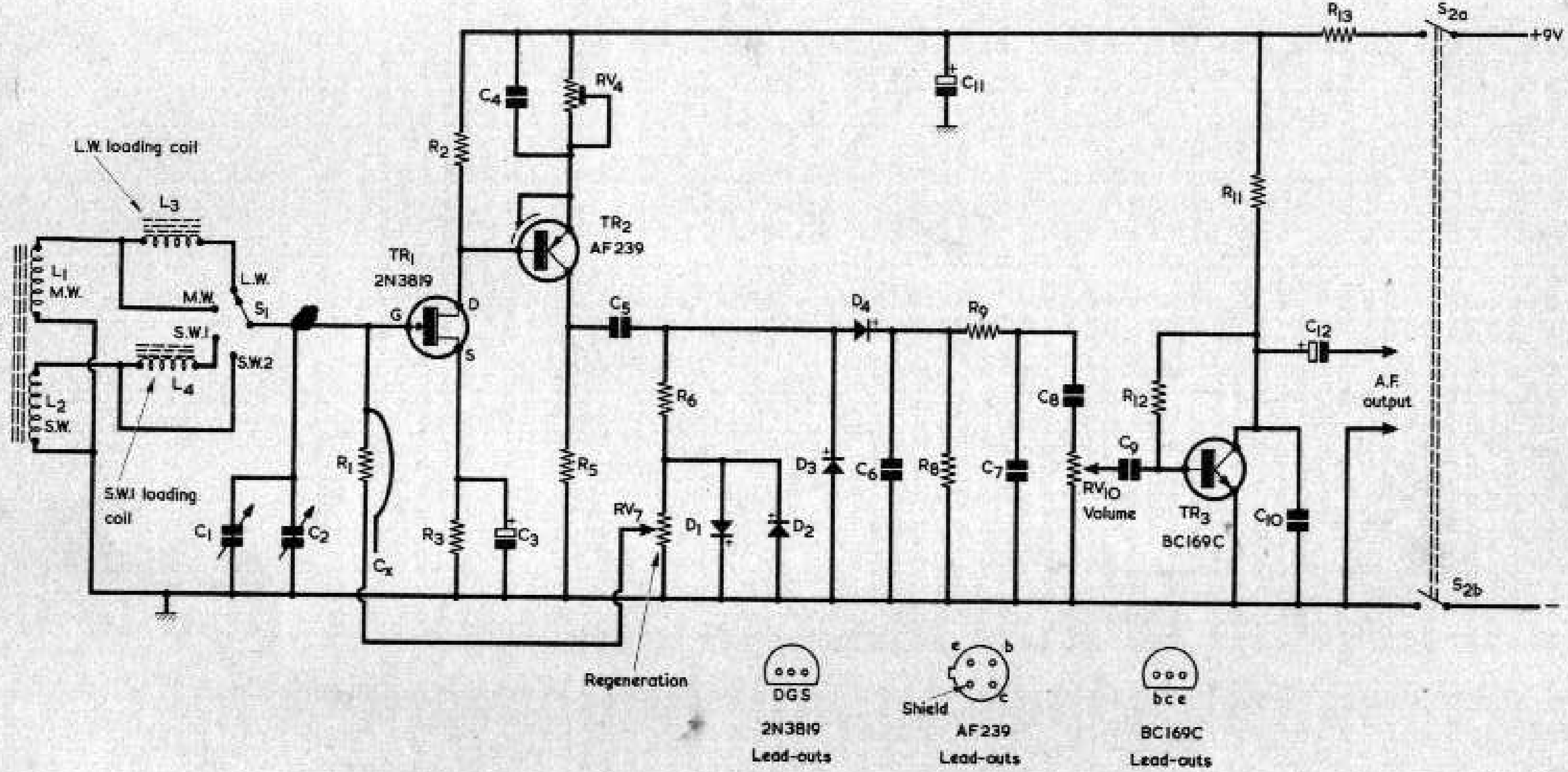
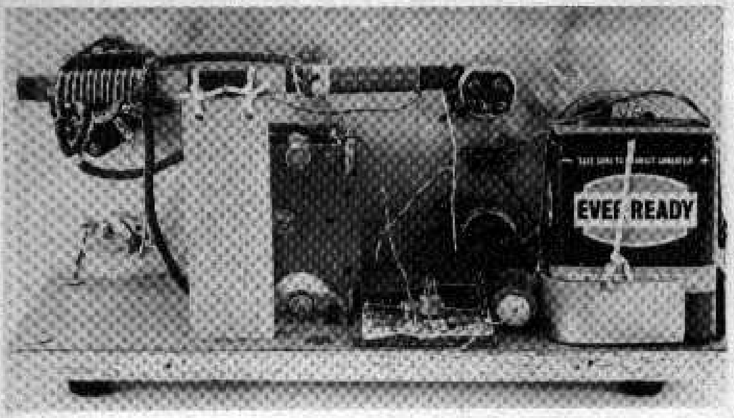


Fig. 4. The complete circuit of the modern homodyne receiver. This can receive a.m., c.w. and s.s.b. transmissions



The inside rear of the complete receiver. The homodyne board is to the right of the tuning capacitor, and its screen and the transistor holder for TR1 can both be seen. The 1,000µF capacitor is to the immediate right of the homodyne board. The a.f. amplifier board appears between the battery and the front panel, being obscured here by the battery

a u.h.f. p.n.p. germanium type which works well in this direct-coupled 'complementary-cascade' type of circuit.

The limiter (D1, D2) is a simple back-to-back pair of diodes, driven by a high enough resistance (R6) to ensure good clipping and at the same time prevent the limiter from loading the input to the detector. The regeneration control is RV7, an ordinary carbon track potentiometer with a metal case which is earthed to 'keep the r.f. inside'.

At lowish frequencies the amplifier has 360° phase shift, because there are two inverting stages, and so the output is in phase with the input. This means that the feedback path should not introduce further phase shift, since this would begin to bring the fed-back signal towards an out-of-phase condition, and give negative instead of positive feedback. For this reason the regenerative path on long and medium waves is completed via a resistor, R1, which introduces no phase shift. This resistor is given a high value to avoid damping the input tuned circuit excessively. On short waves there is an appreciable amount of phase shift in the amplifier, and the output is no longer in phase with the input. Above about 2MHz, therefore, feedback is taken increasingly by way of a small capacitance, given by Cx, which bypasses R1. It is convenient to use for Cx a twisted-wire capacitor, i.e. the capacitance is provided by two pieces of insulated connecting wire twisted together. The capacitance is then easily preset by twisting or untwisting to achieve the required condition of just enough feedback to enable the circuit to be brought into oscillation at all points in the tuning range.

The function of RV4 is to set up the current in TR2 for optimum results. In the prototype, this is given (with RV7 adjusted to give zero regeneration) when TR2 passes 3mA, as indicated by a drop of 3 volts across R5. However, it may be found desirable to experiment a little and try results with different values of current in TR2. RV4 should be initially set up for the 3mA current then, after experience with the receiver has been obtained, the effect of different currents in TR2 between the limits of 1 and 4mA can be checked. It is necessary to provide some means of adjustment here because the current taken by different specimens of 2N3819 in the TR1 position will vary. The voltage drop across R2 and hence the base voltage of TR2 is dependent upon the current drawn by TR1.

The audio frequency low-pass filter is a very simple RC affair whose components are C6, R9 and C7. The d.c. load for the detector/demodulator is R8. This resistor has been deliberately given a rather low value (10kΩ) for the type of detector used here. The effect is to increase the damping of the amplifier output as signal strength builds up, which is the right condition for smooth reaction.

Volume control RV10 is followed here by one stage of a.f. voltage amplification, TR3. It is intended that the a.f. output will be used to drive a conventional loudspeaker amplifier. It is, however, possible to use the audio output of TR3 for headphone reception, provided that sensitive high-impedance phones are used. (Rather greater volume will be obtained by connecting high-impedance magnetic phones in place of R11).

The total current consumption of the receiver, with RV4 set for 3mA current in TR2, is of the order of 4mA. However, this is liable to vary a little with different specimens of the 2N3819.

FREQUENCY COVERAGE

It will be clear to experienced constructors that the circuit lends itself to the reception of any tuning range within reason by the simple process of switching in appropriate ferrite aerial coils.

Ordinary grades of ferrite are not much good above about 2MHz, but special h.f. rods are made which operate well up to about 20MHz. The prototype uses a special h.f. rod, 6½in. by ⅜in. in diameter, which is suitable for medium and long waves as well as the short wave ranges covered. The ferrite rod coils (L1 and L2 in Fig. 4) are designed to be tuned by 365pF, but by using a 500pF tuning capacitor the coverage can be extended down to nearly 450kHz on medium waves, which makes it possible to use the receiver as part of the i.f. chain of a conventional superhet. When L3 is in circuit, as is given by setting S1 to 'L.W.', the receiver can also tune through the conventional superhet intermediate frequencies.

Short-wave coverage, as is given by L1 on its own, is some 3 to 11MHz with 365pF tuning and 3.1 to 10MHz with 500pF, but in both cases the high frequency limit depends entirely on the minimum capacitance of the tuning capacitor and the circuit strays, and will usually extend well beyond the conservative 10 or 11MHz limit just quoted. At the high frequency end of the 'S.W.2' band it is possible, in the London area at least, to receive a number of broadcasting stations. Towards the low frequency end (employ a 500pF tuning capacitor) it is also possible to receive s.s.b. amateur transmissions on the 80 metre band.

The ferrite rod assembly, ready-wound with L1 and L2 fitted, is available from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey, CR2 0DE. The ferrite rod for the 'S.W.1' loading coil, L4, is also available from this source. It consists of 20 turns close-wound of 22 s.w.g. enamelled wire on a 1¼ by ⅜in. piece of rod. Loading coil L3 is simply a Repanco r.f. choke type CH1.

CONSTRUCTION

The complete receiver, as illustrated in the photographs, consists of the homodyne receiver proper plus an additional a.f. amplifier feeding a small speaker. It is not necessary to use this particular a.f. amplifier, since the homodyne section will work into any suitable amplifier. The homodyne receiver is built on its own circuit board, this coupling by wires to the external components, which consist of S1 and the aerial tuned circuits, R1, Cx, RV7 and RV10. The complete receiver could, if desired, be built on a smaller baseboard and with a smaller panel with the a.f. amplifier and speaker omitted. Other variations are possible, provided that the homodyne circuit board layout is retained and connections to the external components are kept short.

In the photograph, published last month, which gave a top view into the receiver, the a.f. amplifier board is between the loudspeaker and the battery. The homodyne receiver board is between the amplifier board and the tuning capacitor, and it extends from the back of the front panel to the rear of the baseboard. The centre of the homodyne board is obscured by a screen, which lays over it horizontally. This particular version of the receiver uses the rear section of a 2-gang 500 + 500pF tuning capacitor, but a single-gang 500pF, or 365pF, capacitor could have been employed just as well. A slow-motion tuning drive is essential and that used here is the Jackson Bros. type 4489, which has a ratio of 6:1 and is calibrated 0 – 100. Any similar slow-motion drive could, of course, be used. The wave-change switch is on the other side of the tuning capacitor, and L3 and L4 are soldered to its tags, L3 being partly hidden, in the photograph, by L4. The ferrite aerial rod, with L1 and L2, is at the rear, and is mounted on a wooden support column, to which it is lashed with plastic sleeving passed through holes in the column. Thick wire is employed for all aerial tuned circuit connections, including in particular those which appear in the short wave circuits.

Also visible in the photograph is R1, which connects between the slider of RV7 and the fixed vanes tag of the tuning capacitor. Cx may be seen across this resistor. The insulated wire forming this capacitance is soldered to the resistor lead-out connecting to the tuning capacitor fixed vanes tag, its other end then being twisted several times round the resistor lead-out which connects to RV7.

The potentiometers visible in the photograph interior both have integral switches. This is an incidental point and is merely due to the fact that these components happened to be on hand. No connections are made to the switches.

The receiver has an aluminium front panel whose dimensions, together with control functions, are shown in Fig. 5. The baseboard is ½in. particle board measuring 12in. by 4¾in., and is covered on the top with aluminium foil which is wrapped over the front edge so as to make good contact with the panel. The tuning capacitor is 'earthed' to the foil via its four fixing feet.

After fixing the capacitor the exposed foil is covered with thin card to insulate it from the circuitry on the receiver and amplifier boards, the latter being made up on pieces of hardboard. 'Earth' connections are made by taking lengths of stranded tinned copper wire, with the strands spread out, between the foil and the card. These 'earths' are positioned so that when the circuit boards are screwed down to the baseboard the strands are sandwiched firmly in place.

Constructors who prefer to use conventional metal chassis for their projects can, of course, adapt the methods shown here for this type of construction. A metal panel, common to the chassis, will still be necessary, to counteract 'hand capacitance' effects.

The top, sides and back of the cabinet are made in one unit, using particle board for the sides, plywood for the top, and hardboard for the back, the assembly being strengthened by corner braces glued in place.

RECEIVER CIRCUIT BOARD

The r.f. amplifier has a gain of several hundred at the lower frequencies and it is necessary to construct it carefully to avoid unwanted feedback which, even if it does not cause instability, will spoil what should be a very smooth reaction control. Unwanted feedback can take place from the amplifier to the tuned circuit. This is avoided by a combination of screening and distance, the latter being satisfied by keeping the base of TR1 reasonably well spaced from the collector of TR2 and all associated components. In the receiver in the photographs the 'danger area' of the circuit board is in effect sandwiched between an 'earth plane', given by the aluminium foil covering the baseboard, and a top screening plate which is just a piece of tinplate closely covering TR2 and associated components, including the diodes. The screen appears, in the component layout given in Fig. 6, between the dashed lines AB and CD. The screening plate is 'earthed' to the negative supply line by soldering it to two of the pins which support the negative line wiring. Note that the positioning of the circuit board relative to tuning components and regeneration potentiometer RV7 has been chosen so as to minimise stray couplings. The component layout also enables resistor R1, with its attendant capacitor Cx, to be suspended in the air, making as direct a connection as possible between RV7 and the tuning capacitor.

The receiver board measures 4½ by 2in. and has the layout given in Fig. 6. It should be noted that the a.f. output coupling capacitor, C12, is omitted in the layout, since the loudspeaker amplifier used here already has an equivalent component. If in other designs incorporating the homodyne receiver it is desired to retain C12 on the board, this can be done by increasing the length of the board by ¼in. to accommodate it.

Anchorage points to which components lead-outs may be soldered are made by driving in bright new domestic pins (plated type, available from stationers) into the board (which consists of hardboard) at each connection point. The heads are cut off, leaving about ⅜in. of stem projecting, and the pins are then tinned before wiring-up begins.

Constructors are advised not to depart from the layout shown, which has been designed for stability. The easiest method of construction is to trace the layout, lay the tracing over the circuit board, and drive pins through the junction points on the diagram. The diagram then forms an on-the-spot wiring guide.

Constructors who prefer to use perforated board should select a piece with 0.1in. hole pitch.

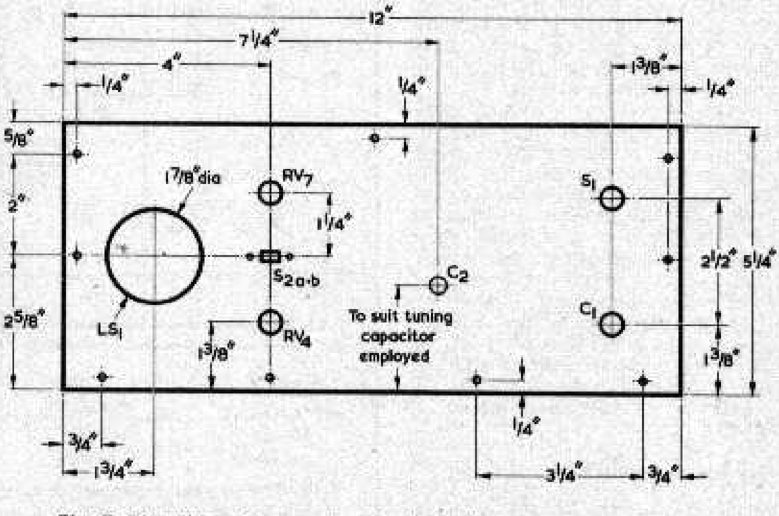


Fig. 5. The dimensions and control spindle centres of the prototype front panel. The height of the hole for C2 may vary for different tuning capacitors and should be marked off with the aid of the capacitor itself

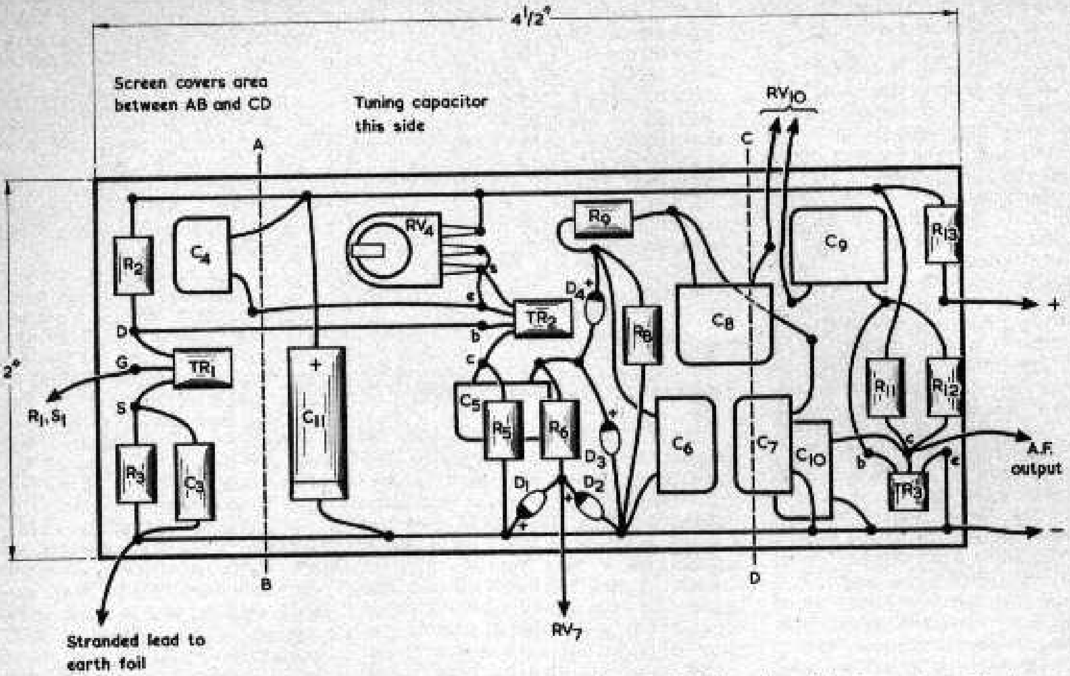


Fig. 6. Layout of the components on the homodyne receiver board. C12 is omitted in this version. The board layout is reproduced full size here, and the diagram may be traced

A transistor holder (Eagle type TS10) was used for the f.e.t. in the receiver in the photographs, the f.e.t. being plugged into this after soldering had been completed. This protects the f.e.t. from the possibility of high voltages on the soldering iron bit breaking down its internal gate insulation. However, the f.e.t. could be wired in directly if precautions are taken during soldering. A suitable precaution consists of making the soldering iron metalwork common with the negative line of the receiver (say, by earthing both to the same point) and keeping the receiver switched off whilst soldering.

If a mains power unit is used, make sure that the output is really smooth. If further a.f. stages are driven from the same supply watch out for audio feedback, which can cause the receiver to 'moan' as the reaction is turned to the critical point. A 1,000μF electrolytic capacitor across the 9 volt supply prevents this from occurring. In the present design such a capacitor is added externally to the boards, being connected between the negative line of the homodyne board and the positive line of the amplifier board. It appears in the amplifier circuit of Fig. 7.

A.F. AMPLIFIER

The a.f. amplifier employed in the overall receiver is, as already mentioned, not a part of the homodyne circuit proper, and any other a.f.

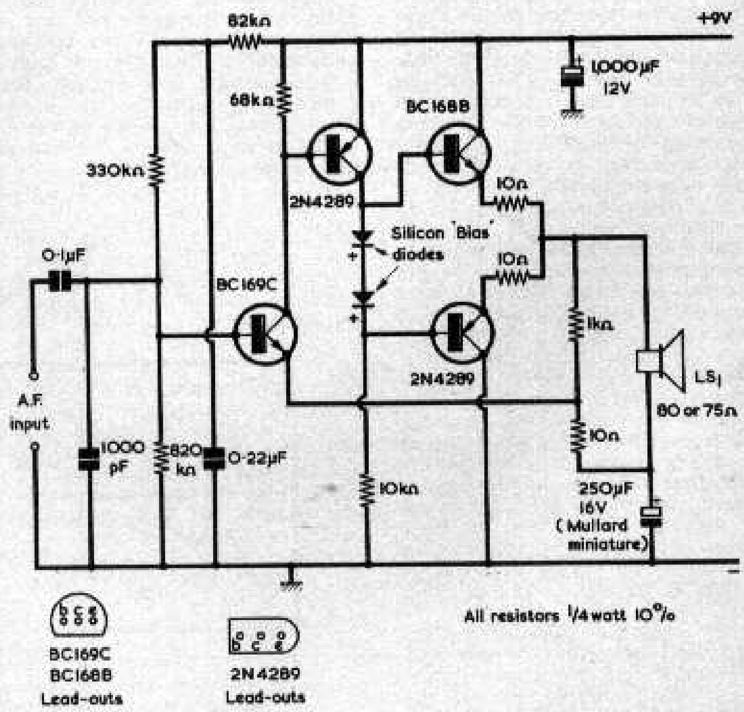
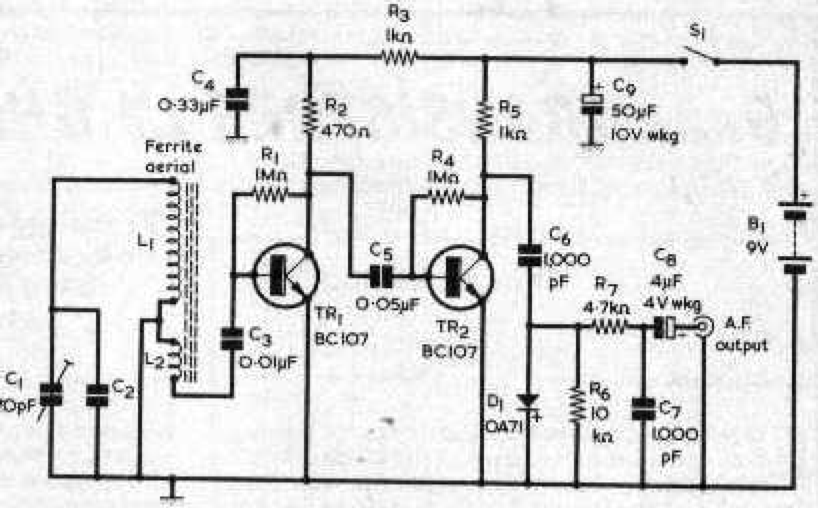


Fig. 7. The circuit of the a.f. amplifier. This picks up its 9 volt supply from S2 (a) and (b) of Fig. 4, whereupon that switch controls both the homodyne receiver and the amplifier. The 1,000μF capacitor may not be needed if the amplifier is employed for other applications



BC 107
Lead-outs

All resistors 1/8 watt 10%
C_1 mica trimmer
C_3, C_4, C_5 polyester
C_6, C_7 ceramic

Fig. 1. The circuit of Smith's Radio 2 tuner. The value of C2 is found experimentally and is of the order of 220pF

TR - 2 REFLEX RECEIVER

By
A. SAPCIYAN

A simple 2-transistor receiver intended for personal earphone medium wave reception

BUILDING RADIO RECEIVERS MIGHT SEEM, TO SOME people, to be a very complicated hobby. However, the beginner often starts by tackling simple receivers and then graduates to more complicated ones. This enables him to recognise radio components and to learn the best way of handling them. Many commence with simple diode plus a.f. amplifier circuits. But, after a time, these seem to be unsatisfactory since they often require a long aerial and a good earth, and sensitivity and selectivity may still not be really adequate.

To satisfy beginners at this stage, a reflex circuit becomes attractive, provided that a miraculous performance is not expected. A reflex circuit will usually be able to hold its own in most areas without an external aerial and earth and, in addition to this, should bring in foreign stations after dark. The receiver to be described can be built easily from readily available components and it will play almost anywhere. Its sensitivity control also enables regeneration to take place, with a consequent increase in selectivity.

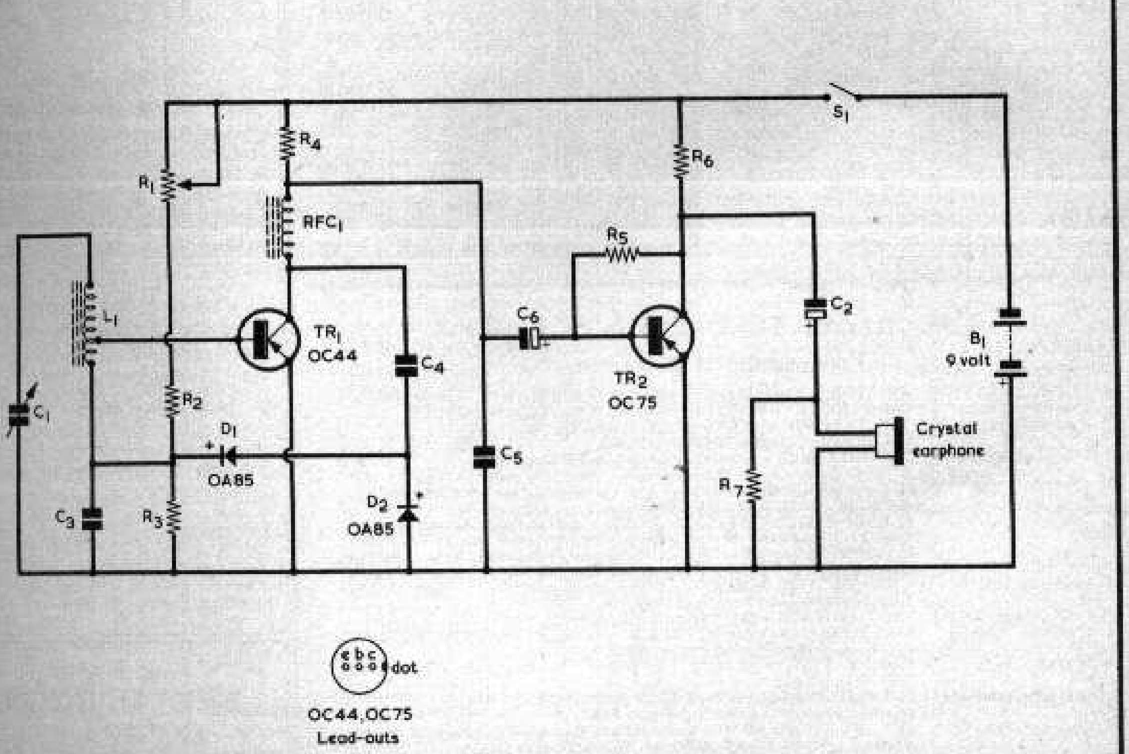


Fig. 1. The circuit of the reflex receiver

THE CIRCUIT

The circuit is given in Fig. 1. As with all reflex receivers of this nature the first stage amplifies at two different frequencies, with the result that the receiver offers greater gain than would be given by two transistors in a conventional circuit. The ferrite rod aerial coil, L1, is tuned by C1, and the selected signals are then passed to the base of TR1. This transistor functions first as an r.f. amplifier, the amplified signals at its collector being passed to the diodes D1 and D2 for detection. These signals cannot pass to the subsequent section of the receiver since their passage is blocked by the r.f. choke RFC1. The detected signals are now returned to the base of TR1 as an audio frequency, and this transistor once more provides amplification, this time at a.f. The amplified a.f. signals pass through the r.f. choke and appear across R4. The base bias for TR1 is controlled by R1, R2 and R3. R1 is the sensitivity control and is adjusted for best reception conditions.

The second stage is a straightforward a.f. amplifier using feedback resistor R5 for stabilisation. The a.f. output at the collector of TR2 is coupled to the crystal earphone via electrolytic capacitor C2. R7 is included to ensure that C2 has a polarising voltage and to prevent the appearance of a direct voltage across the earphone.

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	100kΩ potentiometer, linear, with switch S1
R2	100kΩ
R3	10kΩ
R4	3.9kΩ
R5	390kΩ
R6	5.6kΩ
R7	100kΩ

Capacitors

C1	300pF variable, solid dielectric
C2	4μF electrolytic, 10 V. wkg.
C3	0.01μF paper or plastic foil
C4	200pF silvered mica.
C5	0.01μF paper or plastic foil
C6	4μF electrolytic, 10 V. wkg.

Inductors

L1	See text
RFC1	See text

Semiconductors

TR1	OC44
TR2	OC75
D1	OA85
D2	OA85

Switch

S1	s.p.s.t., part of R1

Battery

B1	9-volt battery type PP3 (Ever Ready)

Miscellaneous
Crystal earphone with jack plug
Jack socket (to suit earphone plug)
2 knobs
Battery connectors
Material for chassis and panel

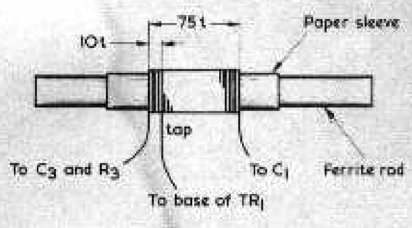


Fig. 2. Winding details of the ferrite rod aerial coil. It is advised that a few extra turns are put on initially, as described in the text, so that the coil inductance may be adjusted for the desired tuning range after the receiver is completed

The total current consumption of the receiver is about 2.5mA.

COMPONENTS

The two transistors are inexpensive and easily obtainable types. It may be necessary to make slight changes to component values if either of the transistors is at an extreme of its gain spread. With TR1 it may be necessary to slightly increase or decrease the value of R2. Whether this is necessary will be indicated by the performance offered as VR1 is adjusted. If TR2 is a low gain specimen the value of R5 may need to be slightly reduced.

The ferrite aerial coil consists of a total of 75 turns of 30 s.w.g. enamelled wire close-wound on a ferrite rod 4in. long with a diameter of ⅜in. The tap is made at the 10th turn, as shown in Fig. 2, and the coil is wound on a paper sleeve which is free to slide along the rod. It is possible that different grades of ferrite rod may give slightly varying values of inductance to the coil and the constructor is advised to commence with 85 turns overall (the tap still being made at the 10th turn). After the set has been completed turns are then, if necessary, taken off at the end remote from C3 until the desired medium wave range is covered.

The r.f. choke is a home-made component and is wound on a polystyrene coil former of ¼in. diameter fitted with a dust core. Cat. Nos. CR4 and CR5 respectively, from Home Radio, would be suitable. The winding consists of 200 turns pile-wound of 38 s.w.g. enamelled wire. The inductance of the choke is not critical and a few turns more or less will not make any difference.

ADJUSTMENT AND OPERATION

The receiver may be built up on a small piece of perforated insulated board fitted with a front panel for C1 and R1. If metal, this panel should be connected to the positive supply line. Alternatively, the components may be mounted on tagstrips or on a tagboard fitted to a small metal chassis and panel, which should similarly be connected to the positive supply line. L1 should be kept well away from either the metal panel or the metal chassis, if these are used, as it will otherwise lose efficiency. Layout is not critical provided wiring is kept reasonably short and the collector circuit of TR2 is spaced away from the base circuit of TR1. An earphone jack socket may be positioned on the front panel at the end remote from C1. R1 should be wired up such that the resistance it inserts into circuit reduces as its spindle is rotated clockwise. The leads to the battery should not be longer than about 6in. RFC1 should not be fitted permanently in position during wiring, as it may be necessary to rotate it when setting up. It should be spaced away from the ferrite rod by about 1 to 2in.

Set L1 winding near the centre of the ferrite rod, switch on and turn R1 fully anticlockwise. If all is well the receiver should then pick up signals, it being at its most sensitive if R1 spindle is turned clockwise to the setting just below that at which oscillation commences. A different setting of R1 is required for each station, although a single setting will suffice for two stations which are close together in frequency. If oscillation is excessive and cannot be controlled by R1 slide L1 coil towards the end of the ferrite rod. The position of RFC1 relative to the rod may have an effect on oscillation and this component should be oriented, if necessary, to see if this reduces or otherwise alters the degree of feedback. In extreme cases, particularly where the transistor used in TR1 position has a high gain, R2 may need to be increased in value, as was mentioned earlier. Suitable alternative values are 120kΩ and 150kΩ. It should be noted that the regeneration effect reduces as the battery ages so that, if R2 is increased to an unnecessarily high value with a new battery, the battery may have to be discarded at an earlier time as its voltage reduces.

The frequency range can be checked by identifying received signals, whereupon the final number of turns required on L1 can be ascertained. The process of finding the frequency range can be made easier if a standard medium wave transistor radio is available since, if VR1 is advanced beyond oscillation point, the reflex receiver acts as a small transmitter whose signal can be picked up by the standard receiver. However, do not allow the reflex receiver to remain in the oscillating condition for more than short periods as it could interfere with other radios. Also, avoid tuning the standard receiver incorrectly to harmonics; the best plan is to set both receivers to an easily identifiable transmission, such as Radio 1 on 247 metres, advance VR1 beyond oscillation point, and then adjust the tuning capacitors of both receivers across the medium wave band, keeping them in step with each other. The range covered by the reflex receiver will then be shown on the tuning scale of the standard receiver. ■


REFLEX-2


VARTA
SUPERLIFE


TRANSISTOR
RADIO
WAVEBAND
OUTPUT
ON
TUNE

MEDIUM AND SHORT WAVE REFLEX RECEIVER

by

A. SAPCIYAN

This simple regenerative reflex receiver provides reception on the medium wave band and on short waves from 5.7MHz to 18MHz

SOONER OR LATER THE NEWCOMER TO RADIO construction becomes attracted by short waves and starts looking for a circuit capable of tuning the various bands satisfactorily.

A superhet is a must for a serious listener, but this type of receiver tends to be expensive and, in addition, its construction is rather complicated. In consequence, most home-constructors use simple regenerative receivers, which are nevertheless capable of giving good results. A reflex circuit with regeneration is quite satisfactory and offers a good performance without any difficulty. It may seem rather unlikely that short wave stations can be tuned in with a simple receiver of this nature, but such sets can perform better on the short wave bands than on medium waves.

SHORT WAVE RECEPTION

The receiver to be described in this article gives continuous coverage of the short wave bands from 5.7MHz to 18MHz in two ranges. A telescopic aerial is employed having a length of 3ft. No earth connection is necessary. In addition to this, medium wave reception is possible by means of a separate ferrite aerial. Range changing is carried out by a rotary switch and the use of plug-in coils is avoided.

The circuit, which is reproduced in Fig. 1, uses the reflex principle. Signals picked up by the telescopic or ferrite aerial are tuned by C1 and are amplified at r.f. by TR1. The diodes D1 and D2, which are in a 'voltage doubler' rectifier configuration, provide detection, and are coupled, for r.f. signals, to the collector of TR2 via C6. The detected signals then pass once more to TR2, this time for a.f. amplification. The collector current of the first stage should, for best results at r.f. and a.f., be around 1mA. VR1 enables this current to be provided and it controls the degree of regeneration and sensitivity. There is a certain level of automatic gain control since the diodes are d.c. coupled to TR1 base via the coupling coils of L1 or L2. Stronger signals cause the base of TR1 to go more positive.

The trimmer capacitors C3 and C4 are the feedback components. The former controls regeneration on the short wave bands and the latter controls regeneration on medium waves. It is necessary to use two different trimmers as the degree of feedback required will not be the same for short and medium waves. Both capacitors need only be adjusted once, after which they are left alone. Variable capacitor C2 is the bandspread component (i.e. it gives 'fine tuning') and is very useful while tuning short wave stations, particularly at the higher frequencies. For TR1 an AF125 is employed, this being the best amongst a wide range of types checked. It was preferred because of its better regeneration performance. The shield of TR1 is left open-circuit, this assisting regeneration. The value of R1 is very critical and that specified proved to be satisfactory with most diodes and transistors checked. It may possibly be necessary to adjust the value of R1 to obtain best results from VR1.

The signals, after being amplified at both r.f. and a.f. by TR1, pass to TR2 via a.f. coupling capacitor C8 and then to TR3 via C9. These two coupling capacitors should not be electrolytic types as these would affect the performance considerably. TR2 could be an OC44 instead of the OC75 quoted in the Components List, and it might be found that it gives better frequency response. TR3 is an OC75. The total consumption for all three stages is around 2.5mA.

The output is suitable for a low impedance magnetic earphone having a resistance around 150Ω; crystal earpieces are not recommended.

AERIAL COILS AND R.F.C.

The coil for the short wave band is wound on a normal Bakelite former of the 'Aladdin' type, with a diameter of approximately ¼in. and a length of 1in. The total number of turns for the tuned winding of L1 is 20 close-wound, being tapped at the 8th turn from the earthy end. The wire gauge is 32 s.w.g., silk covered. The coupling winding of L1 con-

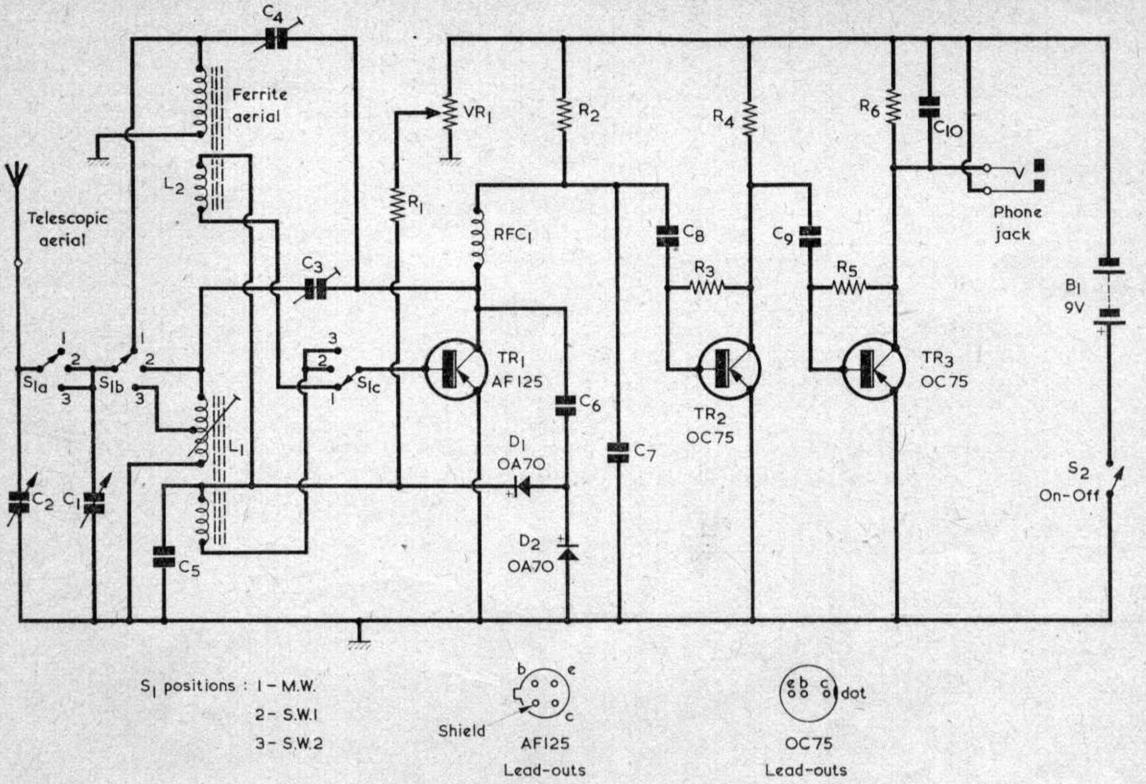


Fig. 1. The circuit of the reflex receiver. This provides coverage on medium waves and two short wave ranges

COMPONENTS

Resistors

(All fixed values ¼ watt 10%)

R1 68kΩ (see text)
R2 3.3kΩ
R3 820kΩ
R4 5.6kΩ
R5 820kΩ
R6 5.6kΩ
VR1 100kΩ potentiometer, linear, with switch S2

Capacitors

C1 150pF variable, air-spaced
C2 25pF variable, air-spaced
C3 60pF trimmer, Philips concentric
C4 30pF trimmer, Philips concentric
C5 0.01μF, paper or plastic foil
C6 250pF, silvered mica
C7 0.005μF, paper or plastic foil
C8 0.25μF, paper or plastic foil
C9 0.25μF, paper or plastic foil
C10 0.01μF, paper or plastic foil

Inductors

L1 Short wave coil (see text)
L2 Medium wave coil (see text)
RFC1 R.F. choke (see text)

Semiconductors

TR1 AF125
TR2 OC75 (see text)
TR3 OC75
D1 OA70
D2 OA70

Switches

S1(a)(b)(c) 4-pole 3-way rotary, miniature
S2 s.p.s.t., part of VR1

Battery

B1 9-volt battery

Miscellaneous

Telescopic aerial, extended length 3ft. approx.
Low impedance earphone, 150Ω, with jack plug
Miniature jack
2 slow-motion drives type 4511/F (Jackson Bros.)
3 knobs
Material for chassis and panel

sists of $1\frac{3}{4}$ turns of the same wire. The coupling winding is wound first and the tuned winding immediately after, the two windings being side by side without any spacing between them. For efficient dust core adjustment the winding should end close to the top of the former. The coil is not screened.

The writer used a ferrite slab with a length of 4in. and a width of $\frac{3}{4}$in. for the medium wave coil, L2. The tuned winding consisted of 73 turns of 30 s.w.g. enamelled wire and the coupling winding employed ten turns of the same wire. Both coils were close-wound and, as with the short wave coil, positioned side by side. The ferrite slab employed is not standard and constructors could alternatively use a $4\frac{5}{8}$ by $\frac{1}{2}$ by 5/32in. ferrite slab, as available from Henry's Radio, Ltd. Some slight adjustment of the number of turns in the tuned winding may be necessary to obtain precise coverage of the medium wave band. The coil is positioned approximately at the centre of the slab.

In both L1 and L2 the earthy end of the coupling winding should be adjacent to the earthy end of the tuned winding, as indicated in the circuit diagram.

A rear view of the wave-change switch and its wiring is given in Fig. 2.

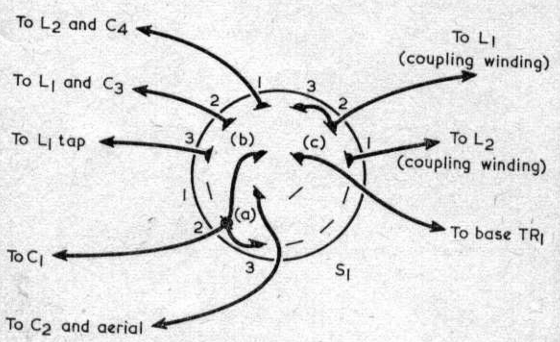


Fig. 2. Connections to S1, the wave-change switch. One of the switch poles is unused

The r.f. choke is a home-made component wound on a 1MΩ 2 watt resistor having a diameter of approximately $\frac{1}{4}$in. and a length of approximately $1\frac{1}{4}$in. The wire gauge is 36 s.w.g. silk covered. The total number of turns required is 900, this being given by random winding three pieces of 300 turns each. The number of turns need not be exact, and a few turns more or less will not make any difference. The coil ends are soldered to the lead-outs of the 2 watt resistor.

CONSTRUCTION

Construction is not critical, and the components can be laid out on a small chassis in much the same order as they appear in the circuit diagram. A metal front panel is required for C1, C2, VR1, S1 and the phone jack. C1 and C2 may each be fitted with a small epicyclic ball drive having a flange to take a piece of wire which functions as a tuning scale cursor. Suitable tuning scales are available in the Data Publications 'Panel Signs' series.

ADJUSTMENT AND OPERATION

In order to facilitate adjustment, the bands should be set up separately. There are two switch positions for the short wave band and one for medium waves. After all connections have been made and battery polarity checked, the receiver is switched on and set to one of the short wave ranges. The sensitivity control VR1 should be turned until oscillation starts. The most sensitive point is just below oscillation level, and VR1 should be capable of adjusting the regeneration level comfortably as it is turned towards maximum, which is given when the slider is at the upper end of its track in Fig. 1. If no oscillation occurs with VR1 at its maximum setting increase the amount of feedback by adjusting C3. If this does not produce satisfactory oscillation, try reversing the connections to the coupling winding of L1. The final setting for C3 is that which gives the best range of control in VR1 for both short wave ranges.

It should then be possible to tune in stations very easily. The degree of regeneration should be readily controllable by VR1, but if control is 'fierce' R1 can be increased to 82kΩ or higher. However, such a change should rarely be necessary.

The process is then repeated on the medium wave band, but in this case it is C4 which is adjusted. If the value of R1 has to be altered it will be necessary to choose a final value for this resistor which suits both medium and short waves.

Frequency coverage can be checked very easily on the short wave ranges by a signal generator, the output of which is very loosely coupled to the receiver aerial. If no signal generator is available a short wave radio could be used for coverage checks. The reflex receiver is put near the short wave radio and sensitivity control VR1 is advanced until the set oscillates. The oscillation can then be picked up on the radio. If will be found that the setting of C3 has an effect on coverage at the high frequency end of the short wave band.

The medium wave band does not require any coverage checking as the number of turns is approximately correct for the band. As already mentioned, it may be necessary to add or take off a few turns depending upon the slab employed.

The telescopic aerial is not employed for medium wave reception and this, together with bandspread capacitor C2, is left open-circuit by the wave-change switch when the medium wave band is selected. It is possible to use an external aerial but, since this may affect the degree of feedback and cause damping, it should be coupled to the receiver via a 100pF variable capacitor, the latter being adjusted for best performance. ■

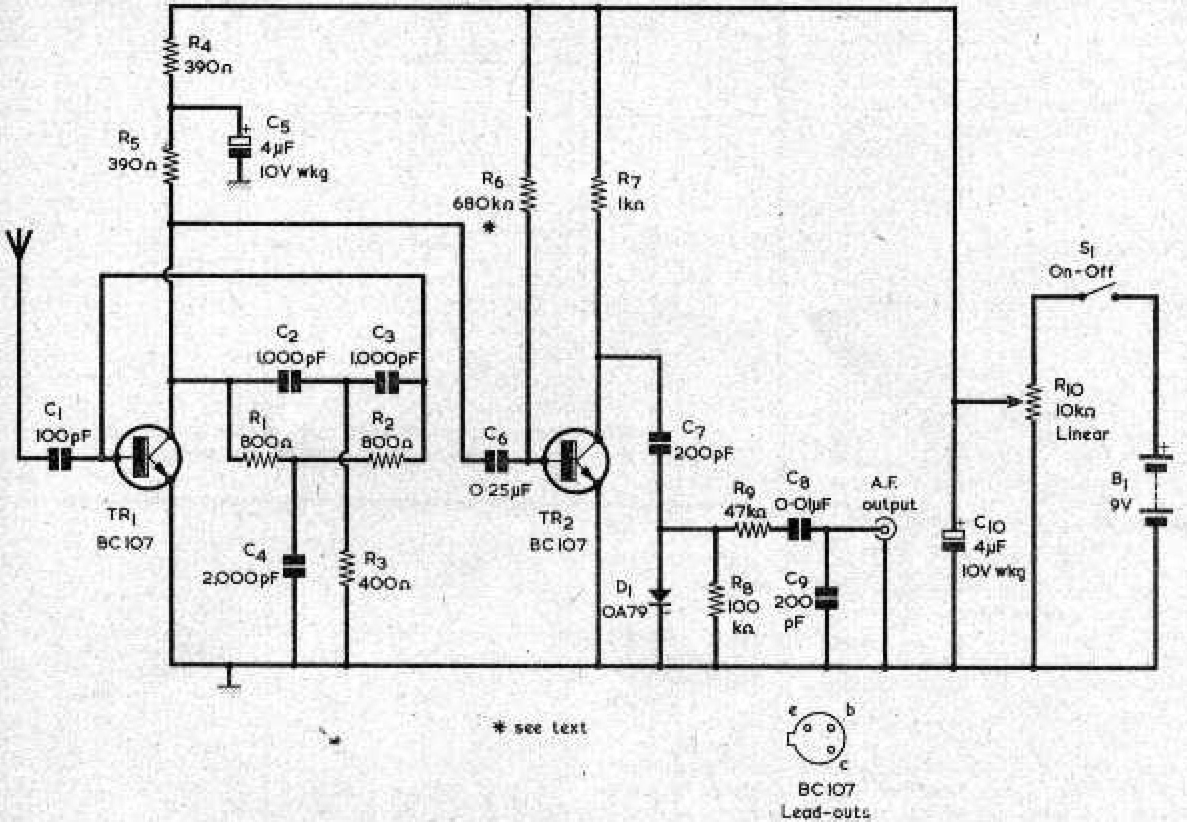
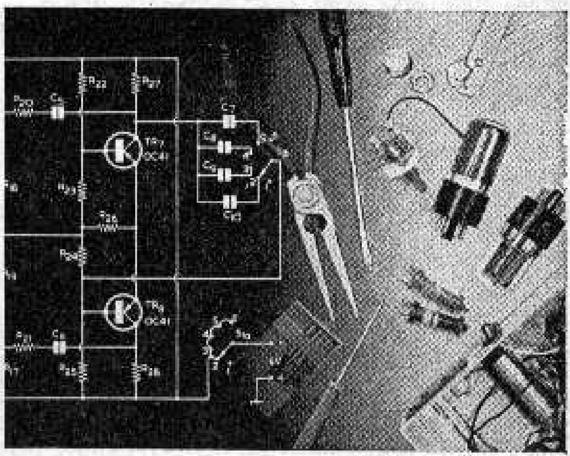


Fig. 2. Circuit of the Radio 2 tuner. Station selection is achieved by means of an RC circuit

PARALLEL-T-RADIO 2 TUNER



by G. A. FRENCH

ELECTRONIC CIRCUITS CAN BE made to provide quite unusual performances, these being far removed from the functions for which they were initially conceived. The tuner unit which is described in this month's 'Suggested Circuit' provides a good example of an unusual application since it incorporates a filter circuit, normally associated with audio frequency work, which allows station selection to be achieved without any tuned circuit whatsoever!

The tuner is intended for single-station reception of the Radio 2 programme on 200kHz (1,500 metres) and is presented primarily as an interesting exercise for constructors who like to experiment with unfamiliar circuits. The tuner is, nevertheless, capable of offering quite a useful performance in practice, and in areas where the long wave Radio 2 transmission is received at reasonable strength and where other signals are not excessively strong it can offer good service as a high quality a.m. tuner. The prototype gave a satisfactory performance in this respect when checked at a location on the West coast, where the local medium wave signal is significantly stronger than the long wave Radio 2 transmission. The a.f. output level from the tuner is of the same order as that given by a crystal pick-up and the subsequent a.f. amplifier should have an input resistance of 250kΩ or more.

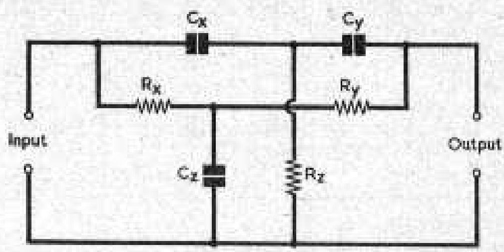
PARALLEL-T FILTER

The filter employed in the receiver is a parallel-T type, and its circuit is given in Fig. 1. When the conditions shown by the equations in this diagram are satisfied, and provided that the output of the filter is not loaded, the circuit offers *infinite* attenuation at the appropriate frequency. This ability to provide infinite attenuation makes the filter extremely useful in a.f. distortion measuring equipment, in which it can cause a fundamental frequency to be suppressed so that its harmonics become available for measurement.

The circuit of the tuner is given in Fig. 2, in which diagram the parallel-T filter appears as the network R1 to R3 and C2 to C4. The values specified for these components cause the theoretical attenuation frequency to be 200kHz.

In Fig. 2, signals picked up by the aerial are applied via C1 to the base of TR1, a silicon planar n.p.n. transistor type BC107. Capacitors C1 and C2 in the filter circuit apply heavy negative feedback from the collector back to the base of TR1 at all frequencies except those at and very close to the attenuation frequency of 200kHz. At this frequency there is virtually no feedback at all since the attenuation provided by the filter approaches infiinity, and the transistor provides the maximum amplification of which it is capable. (The filter does not offer its full infinite attenuation because its output is loaded by the input impedance at TR1 base.) Thus, the circuit around TR1 is frequency-selective, and favours the required 200kHz signal only. The discrimination against unwanted signals is roughly equal to the gain of the transistor, since unwanted signals receive negligible amplification whilst the desired signal receives almost the full amplification which TR1 can offer. This discrimination is not as high as that offered by a tuned circuit with regeneration, but it is still high enough to enable interference-free reception of the Radio 2 transmission to be obtained in localities where other transmissions are not excessively strong.

The r.f. signal at the collector of TR1 is fed via C6 to TR2, another



$R_x = R_y = 2R_z$

$C_x = C_y = \frac{1}{2} C_z$

$f = \frac{1}{2 \pi R_x C_x}$

Fig. 1. The parallel-T filter, together with the appropriate equations

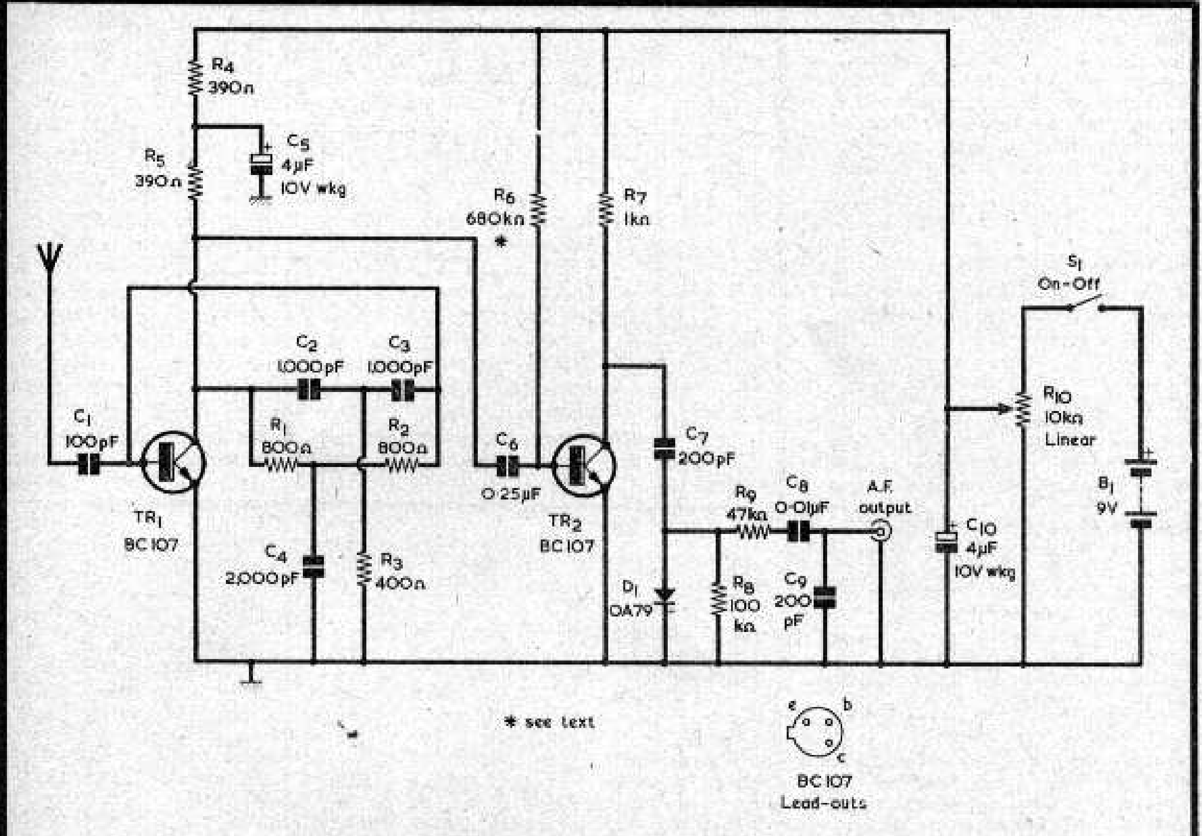


Fig. 2. Circuit of the Radio 2 tuner. Station selection is achieved by means of an RC circuit

BC107. This functions as an r.f. amplifier and the amplified signal at its collector is passed to the shunt detector diode, D1, by way of C7. D1 detects in normal manner and the resulting a.f. signal is fed via C8 to the output coaxial socket. R9 and C9 act as a low-pass filter to remove r.f. from the detected signal.

Because the parallel-T filter coupled to TR1 is operating at a much higher frequency than that for which it is normally intended, stray capacitances in the circuit cause altered phase relationships which would not be present at audio frequencies. In consequence TR1 goes into oscillation when its collector supply current rises above a certain level. This collector current is controlled by the potentiometer R10, which functions as a sensitivity control. As the slider of R10 approaches the upper end of its track the gain offered to the Radio 2 signal increases progressively, reaching a maximum just before the circuit goes into oscillation. Operation of R10 is reminiscent of the operation of a conventional reaction control in a receiver incorporating a tuned circuit: indeed, one would imagine that one was actually operating such a reaction control if one did not already know that there were no tuned circuits in the tuner. Since there is positive feedback just below the oscillation point, it is feasible also that some signal magnification also takes place in the present design. There is a small amount of backlash in the adjustment of R10, but this does not introduce any difficulty in its setting up. It is intentional that R10 also controls the supply voltage for TR2.

The tuner requires a very short aerial, about 3ft. of wire being sufficient. Alternatively, a small telescopic aerial could be employed. Large aerials are not recommended as they merely increase the strength of unwanted signals, and thereby increase the risk of their breaking through.

The current drawn from the 9 volt battery by the prototype was 4mA under non-oscillating conditions. This current rose to 10mA when the circuit went into oscillation with R10 slider at the top of its track.

COMPONENTS

The two transistors in the circuit are standard types, and no difficulty should be experienced in obtaining them.

All the fixed resistors are quarter watt and, with the exception of R1, R2 and R3, 10% in tolerance. R1, R2 and R3 are discussed in detail later when constructional information is given. The value of R6 may need to be adjusted to suit particular transistors in the TR2 position. The potentiometer, R10, should be a standard component and not a miniature type.

C2, C3 and C4 are silvered mica capacitors with a tolerance of 2% or better. C1, C7 and C9 are also silvered mica but they do not, of course, need to have a close tolerance on value. C5 and C10 could be high-value non-electrolytic types, but the electrolytic capacitors specified for these two components are smaller in size and function just as well at the frequencies involved. C6 and C8 are standard paper or plastic foil components.

On-off switch S1 should not be ganged with R10 but should be a separate component. This is because, when local reception conditions enable the tuner to be used as a permanent item of equipment, it will be found convenient to leave R10 set to the position of optimum sensitivity, and to adjust it occasionally only as battery voltage falls. Output level may be controlled by the volume control in the following amplifier.

CONSTRUCTION

The layout of the tuner is not very critical provided that the components around TR1 are kept reasonably well spaced from those around TR2. In particular, R7 and the subsequent detector components should be kept well clear of the circuitry around TR1. The best plan is to lay out the components in three separate groups. The first group consists of all the components to the left of C6, including C5. The second group, positioned about 2in. away, consists of TR2, R6, R7, and C10. Capacitor C6 bridges the gap between these two groups. The third group, again several inches further along the chassis, consists of D1 and the other detector components, with C7 positioned in between. The general idea is shown in Fig. 3. There is no necessity to screen the TR2 circuit from the TR1 circuit. R10 can be positioned at any convenient point, since the connection to its slider is bypassed for r.f. by C10.

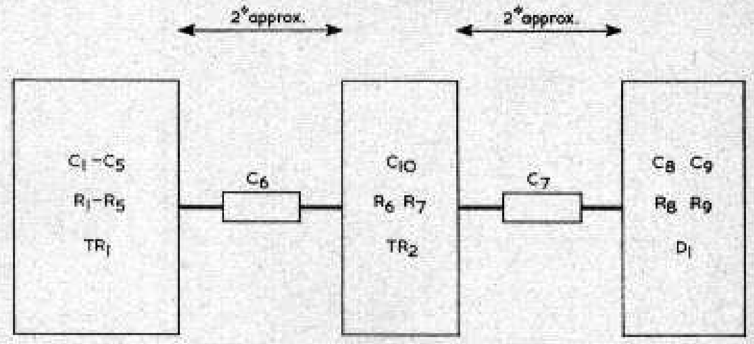


Fig. 3. The tuner components should be laid out along the chassis in three separate groups in the manner shown here

As several unusual processes are involved in setting up the receiver it is best to proceed in stages, checking each stage after its wiring has been completed. An a.f. amplifier is required to enable the tuner output to be tested.

First, wire up TR2, C6 to C10, R6 to R10, S1 and the battery. Switch on and set R10 slider to the top of its track. Measure the voltage between the negative supply rail and the collector of TR2. If this is approximately half the supply voltage within a volt or so, all is well. If the collector voltage differs considerably from half supply voltage adjust the value of R6 to correct it. Increasing R6 causes collector voltage to rise and decreasing R6 causes collector voltage to fall. It is very probable that there will be no necessity to alter R6 but, at the same time, it is still desirable to check that the output transistor is working under the conditions required by the circuit.

Switch off the tuner and next wire in TR1, C1, C5, R4 and R5. Temporarily wire a 680kΩ resistor between the base of TR1 and the positive plate of C5. Switch on and ensure that TR1 collector has a voltage, with respect to the negative supply line, that is roughly half of that on the positive plate of C5. If it is not, alter the value of the temporary resistor accordingly.

Next, connect the a.f. amplifier to the output of the tuner, and connect a 3ft. length of wire, to act as an aerial, to C1. If both transistors are operating correctly, the amplifier will reproduce the modulation of at least one local station. Probably, several transmissions will be reproduced at the same time, the strongest signal predominating.

The tuner is now ready, after removal of the temporary resistor between the base of TR1 and C5, for the addition of the parallel-T filter components. Capacitors C2, C3 and C4 are, as already specified, close-tolerance components. It might be thought advisable to use close-tolerance resistors for R1, R2 and R3, but the expense of such components is not really justified because some slight adjustments to their value may still be necessary to make the filter attenuation frequency exactly 200kHz. As has already been mentioned, the filter output is not unloaded, as is required by the filter equations; this point could make the actual resistance values required in practice slightly different from those calculated theoretically. For the prototype the author simply selected resistors taken from stock by measuring their values with an ohmmeter, and was fortunate enough to find that the filter responded at the first attempt to a frequency very slightly lower than 200kHz. A slight readjustment to one of the resistors then caused the Radio 2 signal to be correctly received.

An alternative approach, not checked by the writer, could consist of using three 1kΩ skeleton preset potentiometers in place of R1, R2 and R3, these being initially set to give resistances of 800Ω, 800Ω and 400Ω respectively. They can then be finally adjusted for optimum reception of the Radio 2 signal, maintaining the correct ratios between their values. A decrease in resistance corresponds to an increase in frequency. Final setting is best carried out using a very short aerial consisting of about 6in. of wire, as this enables reception conditions to be more readily assessed.

If available, a modulated signal generator will be found very helpful. This should be very loosely coupled to C1 and its output frequency adjusted around 200kHz. It will then indicate the frequency at which the circuit offers greatest amplification.

As stated earlier, the author's circuit was at its most sensitive just before the onset of oscillation. The process of oscillation is dependent upon a number of random factors, including the gain and r.f. performance of the transistor in the TR1 position. It is possible that some tuners made up to the circuit will not oscillate even with R10 slider at the top of its track, but this fact need not impair the usefulness of the tuner if Radio 2 reception is otherwise satisfactory. Again, it is possible that oscillation may commence at a low position of R10 slider. This should not detract from the performance of the tuner, but it might be advisable to slightly increase the value of R4, so that oscillation commences with R10 slider at a higher position. TR2 will then have an adequate supply voltage at the point just below oscillation. In the prototype, oscillation commenced when R10 spindle was about 20° removed from the maximum voltage end of the potentiometer travel. ■

F.E.T. REFLEX RECEIVER

by

A. W. WHITTINGTON

Adding an f.e.t. input stage to a well-tried reflex circuit improves selectivity and offers a wide latitude in ferrite aerial design

THE CIRCUIT TO BE DESCRIBED IS A MODIFICATION to a very successful *Radio Constructor* design, and it takes advantage of an f.e.t. to increase selectivity.

Anyone who has built the silicon reflex circuit described by G. W. Short in the January 1968 and September 1969 issues* will have been amazed at the sensitivity of this receiver. The writer has carried out a number of experiments with the circuit, including the use of coils for coverage up to 6MHz.

Since f.e.t.'s are now available to amateur constructors at reasonable prices, it was decided to employ one of these devices to provide an aerial input stage preceding the basic reflex circuit due to G. W. Short. The chief advantages conferred by an f.e.t. are low noise, high input impedance and low cross-modulation. The high input impedance is of particular importance here since there is then less damping of the aerial tuned circuit, which becomes capable of offering greater selectivity. Also, the use of an f.e.t. allows a panel-controlled reaction circuit to be incorporated.

*G. W. Short, 'Silicon Transistor Reflex T.R.F.', *The Radio Constructor*, January 1968; ''Milliwatt' Silicon Reflex T.R.F. Receiver', *The Radio Constructor*, September 1969.

MODIFIED CIRCUIT

The circuit of the complete receiver appears in Fig. 1, the circuitry to the right of C4 which incorporates TR2 and TR3 being based on the receiver design previously published. In the original, D1 was returned to the earthy end of a coupling winding on the aerial ferrite rod, this winding being by-passed to the lower supply rail via a 0.01μF capacitor. The non-earthy end of the coupling winding connected to the base of what is now TR2. In the present circuit the diode couples direct to the base of TR2.

The f.e.t., TR1, is a 2N3819 operated in the common source mode. Gate-source bias is provided by R2 and C3. The ferrite rod aerial tuned circuit

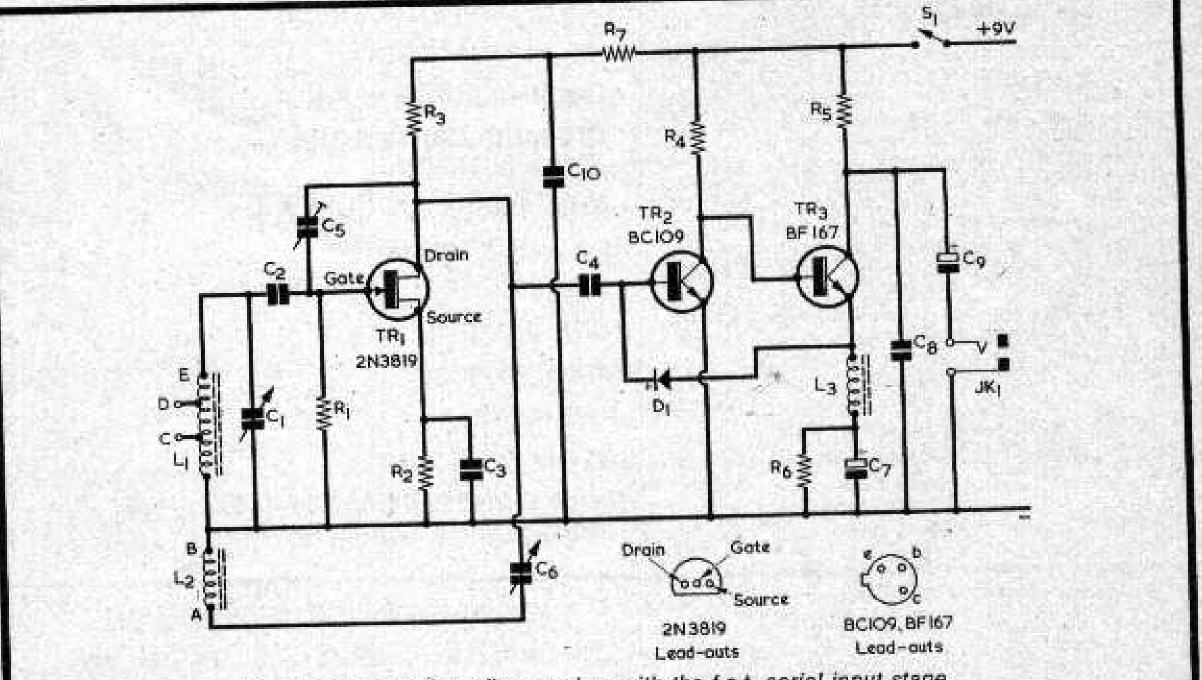


Fig. 1. Circuit of the reflex receiver with the f.e.t. aerial input stage

is applied directly to the gate via C2. The relatively low value drain load resistor, R3, provides adequate matching to TR2. Regeneration is obtained from the drain and is controlled by capacitor C6. Trimmer C5 is incorporated to provide neutralisation.

The aerial coil is wound on a 4in. length of $\frac{3}{8}$in. diameter ferrite rod as shown in Fig. 2. The winding wire was Radiospares 'Miniature' p.v.c. covered flexible wire with a 7/0.0048 (or 7/40 s.w.g.) stranded core and an insulation wall thickness of 0.01in. Similar thin p.v.c. covered connecting wire should work equally well. Start $\frac{1}{2}$in. from one end and close-wind directly onto the rod. The section of the coil between points A and B is the regeneration winding, and that between points B and E the tuned winding. This gives a range of 2.5MHz to 620kHz with the tuning capacitor specified. Taps C and D can be used for the conection of a short aerial, if desired. This should only be a few feet in length and is applied via a 100pF variable capacitor, the latter being adjusted for best results.

CONSTRUCTION

The author's prototype was assembled on a perforated matrix board of 0.15in. hole pitch measuring 7in. long by $2\frac{1}{2}$in. wide. Layout follows the circuit diagram, with the tuning capacitor at the left and the on-off switch to the right. The ferrite rod lies longitudinally at the back and the negative supply rail wire along the front of the board. There is 1in. spacing between the centre lines of the core of L3 and the ferrite aerial rod, the two cores being parallel with each other. Components are connected by means of terminal pins passed through the holes in the board as required. The two variable capacitors, the headphone output jack and the on-off switch are mounted on a small Paxolin front panel. Tuning capacitor C1 is fitted with a slow-motion drive.

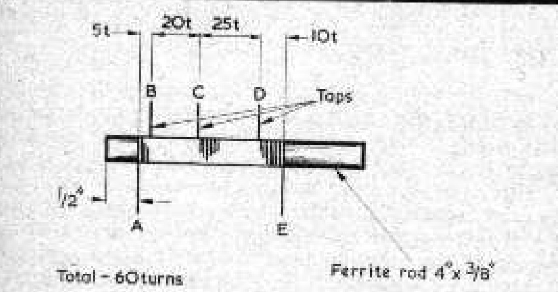


Fig. 2. Winding details of the ferrite rod aerial coil

To avoid damage to the f.e.t. resulting from static voltages on soldering irons, etc., this device must be fitted in a transistor holder. All connections in the receiver, including those to the holder, are soldered before the f.e.t. is inserted. It is necessary to drill out the matrix board in order that it may take the transistor holder. If desired, TR2 and TR3 can also be fitted in transistor holders, whereupon it becomes possible to check a number of transistors for operation in the receiver.

When the assembly and wiring have been completed and carefully checked, the current consumption from the 9 volt battery should be measured. This should be of the order of 2 to 3mA. A strong local signal at the high frequency end of the band is then tuned in and C5 adjusted to eliminate any instability that may be present. Some r.f. feedback is provided by the inductive coupling between L3 and the ferrite rod. If necessary, this feedback may be adjusted by rotating L3.

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 10%)

R1	2.2MΩ
R2	3.3kΩ
R3	1.8kΩ
R4	12kΩ
R5	3.9kΩ
R6	680Ω
R7	220Ω

Capacitors

C1	365pF variable, Type 01 (Jackson Bros.)
C2	100pF silver-mica
C3	0.022μF paper or plastic foil
C4	220pF silver-mica
C5	30pF trimmer
C6	300pF variable, solid dielectric
C7	100μF electrolytic, 3V wkg.
C8	0.022μF paper or plastic foil
C9	8μF electrolytic, 10V wkg.
C10	0.1μF paper or plastic foil

Inductors

L1, L2	Home-wound aerial coil on ferrite rod, 4in. by $\frac{3}{8}$in. dia. (see text)
L3	2.5mH r.f. choke Type CH1 (Repanco)

Semiconductors

TR1	2N3819
TR2	BC109
TR3	BF167
D1	OA81

Switch

S1	s.p.s.t. toggle

Socket

JK1	Headphone jack

Miscellaneous

Headphones, 2,000Ω to 4,000Ω, with jack plug
Slow-motion drive
2 knobs
Material for chassis, front panel, etc.

TRAWLER BAND

Because the tuned circuit only has two connections it is possible to experiment with a wide variety of different aerial inductances.

The 'trawler band' can offer hours of interesting listening for those who live in coastal locations. This band was tuned in with an aerial coil wound on a 6in. length of $\frac{3}{8}$in. diameter ferrite rod, and employing 40 turns of 0.032in. (21 s.w.g.) solid core p.v.c. covered connecting wire. The winding commences about $\frac{1}{2}$in. from one end and the turns should be spread over the greater length of the rod. An extra four turns for regeneration will be adequate. An aerial, of 2ft. *only*, may be connected to the non-earthy end of the tuned coil. ■

THE 'MINISETTE' TWO-TRANSISTOR RADIO

Cover Feature

by

H. WILLIAMS

A simple little medium wave receiver employing two readily obtainable transistors. The earphone jack is modified to switch off the receiver when its plug is removed

ALTHOUGH MOST CONSTRUCTIONAL ARTICLES ON radio receivers describe superhets or sophisticated t.r.f. sets, it is possible to build a small radio operating an earpiece using only a dozen components, and from which perfectly satisfactory reception is available over the complete medium wave band.

The 'Minisette' receiver described here is built into a small plastic box and is small enough to be carried in a pocket or handbag. Although small, the various components are far from crowded and with a little care the size could easily be reduced.

Before starting the prototype it was decided to use a PP3 battery. Batteries for small receivers are always a problem and although mercury cells or other hearing aid batteries can be used, these are expensive and difficult to mount.

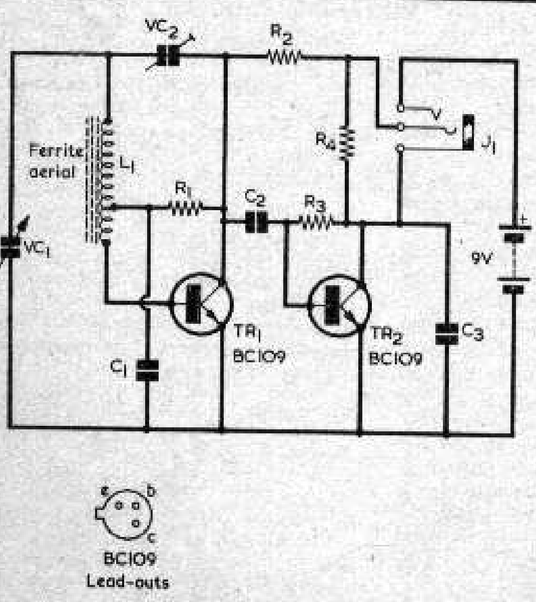


Fig. 1. Circuit diagram of the 'Minisette' two-transistor radio

Reflexing the first stage was rejected; it is fairly easy to use the first transistor for both r.f. and a.f. but this can introduce instability. Also, the cost of the two diodes and associated components needed equals the cost of a second transistor which can, unlike a reflexed transistor, be operated for maximum performance.

COMPONENTS

Resistors
(All ¼ watt 10%)
R1 680kΩ
R2 2.2kΩ
R3 270kΩ
R4 2.7kΩ

Capacitors
C1 0.01µF, miniature plastic foil
C2 0.01µF, miniature plastic foil
C3 0.01µF, miniature plastic foil
VC1 250pF variable, miniature solid dielectric (see text)
VC2 See text

Inductor
L1 Ferrite aerial (see text)

Semiconductors
TR1 BC109
TR2 BC109

Jack
J1 3.5mm closed-circuit jack

Battery
9-volt battery type PP3 (Ever Ready)

Miscellaneous
Plastic case (see text)
Plain Veroboard, 0.15in. matrix
Battery clips

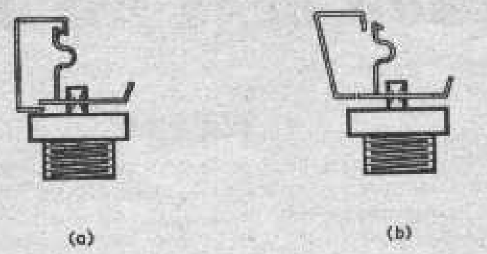
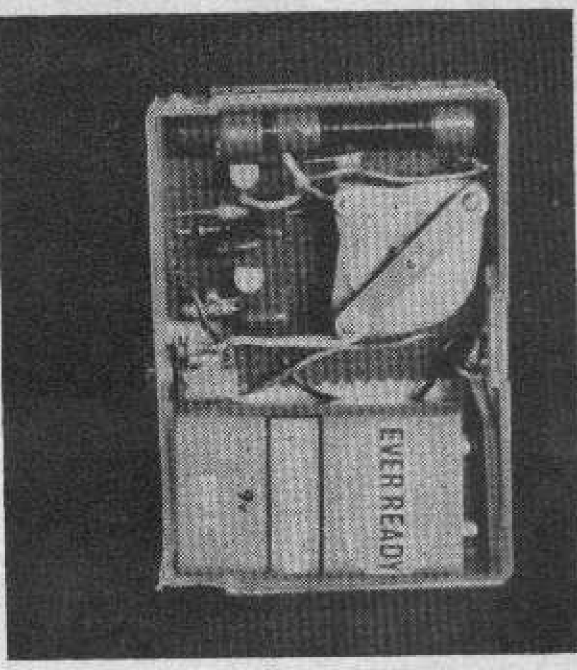


Fig. 2(a). The closed-circuit jack in its normal condition
(b). The modification which causes it to close a circuit when the phone jack plug is inserted



The layout inside the plastic case of the 'Minisette' receiver. Alternative transistors were wired in when this photograph was taken

THE CIRCUIT

TR1, a BC109, is a high gain, low noise transistor. Although designed for audio usage it has a high frequency cut-off point and is ideal in the present type of circuit. The tuned circuit, L1 and VC1, couples to the base. The tapping on L1 earths that point of the coil via C1, so that only the section above it operates as the tuned inductance.

The lower section of L1 transforms the r.f. signal to a suitable impedance to feed TR1. Base bias for TR1 is provided by R1, and a small measure of positive feedback is coupled from TR1 collector back to the tuned circuit by VC2. R2 acts as the collector load.

C2, a 0.01μF capacitor, couples the r.f. signal to the base of TR2 which is biased as a detector so that only the positive-going peaks are amplified. (It is possible also that some detection takes place in TR1, whereupon TR2 provides a.f. amplification.) C3 is necessary to bypass r.f. from the signal which is finally developed across the collector load, R4.

In small radios, switches are a nuisance to fit and so the output jack is altered to perform this function; Fig. 2 shows how this is done. This "trick" was widely used at one time and has applications in other types of equipment.

A crystal earpiece is used by the author but high impedance magnetic types, about 2,000Ω, can be substituted, in which case R4 is unnecessary.

CONSTRUCTION

First the ferrite rod aerial should be wound, the rod itself being 2in. long by $\frac{1}{4}$in. diameter. Initially wind a few turns of Sellotape about $\frac{1}{2}$in. wide around one end of the rod. Using 32 s.w.g. enamelled copper wire, trap one end in the tape and wind 72 turns then wind on more narrow strips of tape, leave a loop and continue with seven more turns. Finally trap the end in further layers of Sellotape. The wire loop should be twisted so that it can be soldered into circuit as one wire. Both the 72 and seven turn sections are close-wound. (If a 2in. by $\frac{1}{4}$in. ferrite rod cannot be obtained, it could be broken from a longer rod of the same diameter. Alternatively, a 2in. by $\frac{7}{16}$in. rod—Home Radio Cat. No. FR1A—could be used instead. This slightly larger rod may necessitate removing several turns from the 72 turn winding to obtain the desired range.—Editor.)

The components are mounted on a piece of plain 0.15in. Veroboard approximately 2in. square, with a small piece cut away to avoid fouling the earphone jack. See Fig. 3. The component leads are bent to allow connections to be made on the underside, these being soldered afterwards.

The tuning capacitor employed for VC1 was a miniature 250pF solid dielectric component. In case of difficulty in obtaining this value a 300pF component may be employed instead.

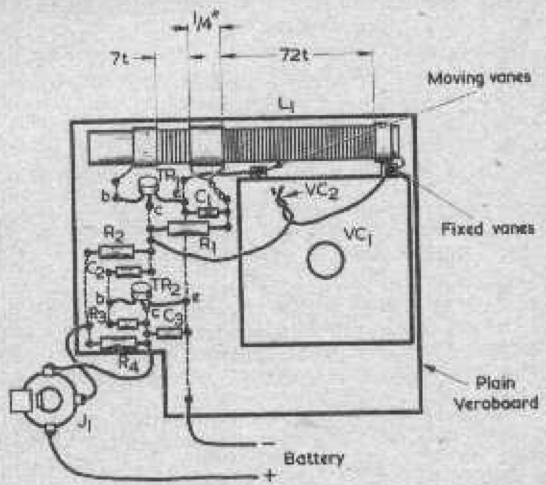


Fig. 3. Layout and wiring. Wiring below the Veroboard is shown in broken line

The dimensions of the case depend mainly upon the size of the capacitor employed for VC1. The plastic case used by the writer measures 3 by $2\frac{1}{4}$ by $\frac{3}{4}$in. and is fitted with a hinged clip-on lid. It is made by the Plastic Box Company. The writer has found it a very simple matter to obtain boxes of this nature from chemist's shops, as they have plenty of samples supplied in them. A PP3 battery with clips fits nicely across the internal width, and the boxes are very useful for a variety of purposes.

Holes should be drilled in the plastic case to take the spindle of VC1 and the earphone jack.

VC2 needs to be very low in value and usually a length of insulated wire connected to the collector of TR1 and laid near L1 will suffice. If not, a second insulated wire can be connected to the non-earthy side of VC1 and twisted with the first wire to provide the capacitance required.

The regeneration should be set so that oscillation just fails to occur at any point on the dial. When this has been done correctly, good reception should be possible from all local stations and a number of Continental stations after dark. ■

LOW-COST REGENERATIVE RECEIVER

by

A. SAPCIYAN

This simple little medium wave receiver can be built as a 2-transistor set driving an earphone, or as a 3-transistor set driving a speaker at moderate volume level. Few components are required, and there is opportunity for experiment with some of these to obtain best results with the particular transistors employed

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	47kΩ
R2	1MΩ potentiometer, linear, with switch S1
R3	3.9kΩ
R4	560kΩ
R5	5.6kΩ

Capacitors

C1	365pF variable, air-spaced
C2	0.01μF, paper or plastic foil
C3	0.01μF, paper or plastic foil
C4	5μF electrolytic, 10V wkg. (see text)

Inductors

L1, L2	See text

Transistors

TR1	AF126
TR2	OC75

Battery

B1	9-volt battery

Switch

S1	s.p.s.t., part of R2

Miscellaneous
1,000Ω magnetic earphone with jack plug and socket (not needed with 3-transistor version)
2 knobs

REGENERATIVE RECEIVERS ARE ideal for those who wish to build simple and reasonably sensitive sets. It has to be remembered, however, that they are rather tricky to operate when compared with commercially made sets, and that their performance can never match a superhet in terms of sensitivity and selectivity. Nevertheless, satisfactory results can be obtained in areas of good signal strength and local stations can be tuned in without interference, which is what most people want. Provided, therefore, that their limitations are appreciated, receivers of this class can be instructive to build and can offer a very useful performance.

The receiver described in this article uses a simple circuit and may be built in either a 2-transistor or a 3-transistor version. If desired, the 2-transistor version can be constructed first and the third stage added at a later date. The 2-transistor receiver drives an earpiece, whilst the 3-transistor receiver drives a loudspeaker at moderate level.

2-TRANSISTOR RECEIVER

The circuit of the 2-transistor receiver appears in Fig. 1. The ferrite rod aerial coil, L1, is tuned by C1, its tap being coupled to the base of TR1. Detection takes place due to non-linearity in TR1 and TR2, with the result that the primary function of TR1 is to amplify at radio frequency. The transistor in the first stage is an AF126, which has a relatively high gain at medium wave frequencies. R.F. transistors such as the OC44 have also been tried, but they did not offer the same degree of sensitivity, particularly at the high frequency end of the band. When set up for best amplification, the collector current for TR1 is around 1mA.

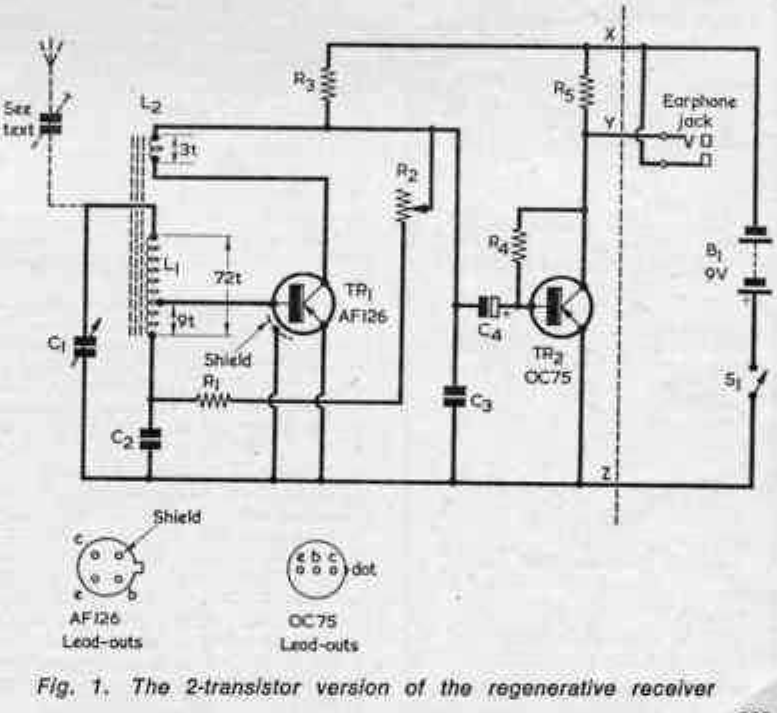


Fig. 1. The 2-transistor version of the regenerative receiver

Coil L2 provides regenerative feedback. The variable resistor R2 controls the base current to TR1 and hence operates both as a volume control and as a reaction control. It is adjusted normally so that TR1 is just below the oscillation point. R2 has a high value in order to accommodate transistors having both low and high gain figures.

The second stage incorporates an OC75 and drives a high impedance (1,000Ω) magnetic earphone. The miniature earphones used with commercially made sets are not satisfactory here since they have low impedances, of the order of 10Ω. Their use will cause disappointment. A measure of stabilisation, which has proved adequate in practice, is given by taking the base bias current for TR2 from its collector via R4. The total current consumption of the first two stages is approximately 2.5mA.

If the constructor wishes to add a third stage of amplification, the circuit shown in Fig. 2 is employed. The components to the right of the dashed line in Fig. 1 (including the

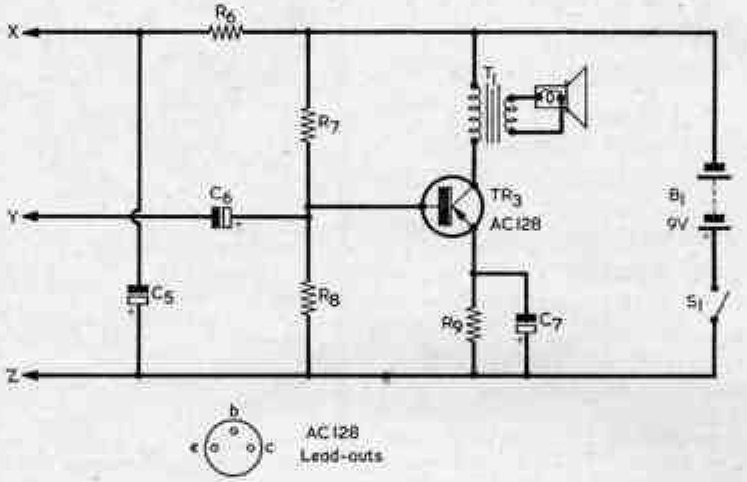


Fig. 2. This extra stage is added to provide the 3-transistor version

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R6	1kΩ
R7	27kΩ
R8	3.9kΩ
R9	150Ω

Capacitors

C5	50μF electrolytic, 10V wkg.
C6	5μF electrolytic, 10V wkg. (see text)
C7	100μF electrolytic, 6V wkg.

Inductor
T1 See text

Transistor
TR3 AC128

Speaker
See text

Battery
B1 Included with Fig. 1 Components List

Switch
S1 Included with Fig. 1 Components List

earphone and jack socket) are not then required, and the circuit of Fig. 2 couples to that of Fig. 1 at points X, Y and Z. TR3 is an AC128 and its base couples to the collector of TR2 via C6. R6 and C5 are decoupling components, and prevent unwanted couplings to the preceding stages via the negative supply line. Without these components there would be instability, evident as "motorboating", when the battery ages and its internal resistance rises. Total current consumption of the 3-transistor version is approximately 10mA.

It is desirable to use a fairly large speaker, say 4in. in diameter or more, to take greatest advantage of the fairly low audio output available. The output transformer, T1, should have a ratio which presents an impedance of some 150Ω to 250Ω to TR3. A suitable type, for use with a 3Ω speaker, would be the Radiospares transformer Type T/T4. (Radiospares components may only be obtained via retailers.—Editor.) If a speaker with an impedance of 130Ω or so can be obtained, this may be connected direct in the collector circuit of TR3, whereupon no output transformer is required.

Switch S1, in both the 2-transistor and 3-transistor versions, is the on-off switch and is ganged with R2. R2 should be wired up such that it inserts maximum resistance into circuit when S1 is switched off.

When the receiver has been completed and the adjustment procedure (to be described later) carried out, it is worth experimentally changing C4 for a 0.25μF capacitor. With some AF126 transistors it may be found that this gives a very useful increase in sensitivity. If it does not, the electrolytic capacitor should, of course, be retained in circuit. It may even be found, in the 3-transistor version, that there is an improvement in performance when a 0.25μF capacitor is similarly connected into circuit in place of C6.

FERRITE AERIAL WINDINGS

The aerial coil, L1 may be wound on a ferrite rod 4in. long and with a diameter of ⅜in. using 28 s.w.g. enamelled copper wire. The total number of turns is 72 close-wound, with the tap at nine turns from the end which connects to C2. Be prepared to add or take off a few turns at the end remote from C2 in order to get the range exactly right. In this respect, it will prove helpful to wind the coil on a paper sleeve which can be moved along the rod to provide small changes in inductance, if desired. In general, best results will be given with L1 at, or near, the centre of the rod.

Other ferrite rods of about the same dimensions may be employed, remembering that a longer rod will require fewer turns, as also will a thicker rod. The writer checked the receiver with a ferrite slab which was 4in. long, 1in. wide and ¼in. thick. This slab required 64 turns with a tap eight turns from the C2 end. The position of the tap in the coil is not very critical and acceptable results are given when the number of turns between the tap and the C2 end of the coil is approximately one-eighth of the total number of turns.

The beginner will find it quite easy to adjust the number of turns on L1. Provided that approximately the correct number are initially wound on, he will find it possible to receive stations near the middle of the medium wave band. He may then, later, search for stations at the high and low frequency ends. If stations at either of these ends are outside the tuning range, the number of turns can be adjusted accordingly.

The feedback coil L2 is also wound on the ferrite rod (or slab) and consists of three turns of 28 s.w.g. enamelled copper wire. It should be wound on a paper sleeve or former which is free to slide along the rod.

General construction of the receiver presents few problems, and the stages of either the 2-transistor or 3-transistor version may proceed along the board or chassis on which they are assembled in the same order as they appear in the circuit diagram. The wiring around TR1 and TR2 should be kept reasonably short. In the 3-transistor version, transformer T1 should be farthest away from the ferrite rod, and its laminations should be at right angles to the rod.

ADJUSTMENT AND OPERATION

When all wiring has been completed and checked, the battery should be connected with correct polarity and the receiver switched on. It should be possible, with either version, to receive at least one station by adjusting C1. If no station is received, adjust R2 towards its "maximum" position (minimum resistance in circuit) until oscillation occurs. Should there be no oscillation with R2 at "maximum", move L2 towards L1 until oscillation commences. If there is still no oscillation, even when L2 is very close to L1, reverse the connections to L2, whereupon the oscillation should commence.

If oscillations are too strong they may be reduced by adjusting R2 towards "minimum" and/or moving L2 away from L1. L2 should be finally positioned so that oscillation is available over all of the band at a setting in R2 which gives best performance with received signals. In general, oscillation should begin with R2 about a quarter of the way from the "minimum" end when a new battery is fitted. However, much depends on the specific transistor used for TR1, and final adjustments in the position of L2 should be for the best overall results, as adjudged on received signals. The sensitivity of the receiver is at its greatest when R2 is just below the oscillation point. If a howl is evident in the 3-transistor version when the receiver goes into oscillation, transpose the connections to T1 primary.

Should the constructor so desire, a short aerial may be coupled to the receiver via a 100pF trimmer as shown in dotted line at the left of Fig. 1. This trimmer and L2 positioning are then adjusted experimentally for the best compromise between sensitivity and selectivity. The external aerial can, incidentally, be the springs of the bed if the set is to be used as a bed-side receiver!

As a final point, R2 is adjusted to its optimum position for each station received. It will need to be advanced further towards its "maximum" setting as the battery ages and its voltage falls.

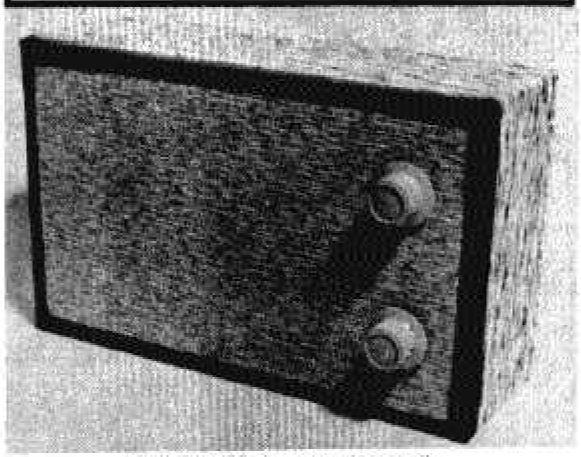
■

TAKE 20

JULIAN ANDERSON

No. 9
THREE TRANSISTOR RADIO

This month's special Christmas project describes a three transistor radio which is highly selective together with a good output level. By careful 'shopping around' among the advertisers the complete radio may be built for under 20s; as usual less than twenty components are used



The Take 20 three transistor radio.

A FEW months ago our project was a one transistor radio which did not require an external aerial and operated a loudspeaker; however this design did have limitations—especially volume which was mentioned in the text. With Christmas just around the corner there must be many readers who would like to take advantage of their interest in electronics and knock up something for the children, and it was with this specifically in mind that this month's project was planned.

First, the radio had to have decent selectivity and volume, and as it is intended primarily for children it had to be able to get Radio Luxembourg well. The circuit had to be reliable and quickly built. (To this end three prototypes were built to ensure the circuit was reliable.) Building of the prototype shown in the photographs took under three hours including the cabinet. Also the radio had to have a presentable but cheap case.

The Circuit

There is nothing particularly unusual about the circuit. The first transistor acts as an r.f. amplifier with VR1 as its collector load. Positive r.f. feedback (regeneration) is taken from the slider of VR1 and connected via VC2 to the top of the aerial coil.

The r.f. signal is fed to the base of Tr2 which is biased in such a way as to detect the r.f. signal, the output is smoothed by C3. The audio output is d.c. connected to Tr3, the output transistor. The emitter resistor is bypassed by C4, the base bias for Tr2 being taken from this circuit via R3, 100kΩ. The 200μF capacitor, C5, decouples r.f. and a.f. from the positive rail.

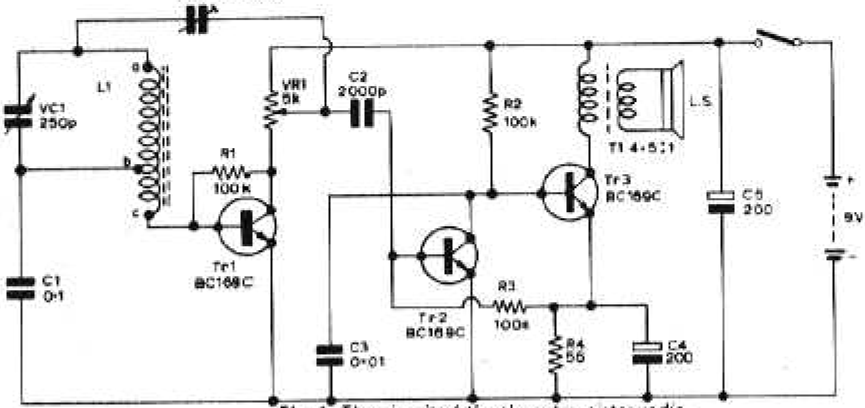


Fig. 1: The circuit of the three transistor radio.

Components

Care will have to be taken in the purchase of components to come within our 20s. maximum. Whereas aerial coils can be bought, it is far cheaper and very simple to wind your own. For this L1 should consist of about 70 turns and L2 of 5 turns on a four to six inch length of ¼in. or ⅜in. ferrite rod. VC1 may be any type of tuning capacitor between 200pF and 350pF. For economy the loudspeaker should be a 6 × 4in. size removed from old TV sets.

Construction

All components apart from the speaker, VR1, VC1 and the battery are mounted on an eleven-way minia-

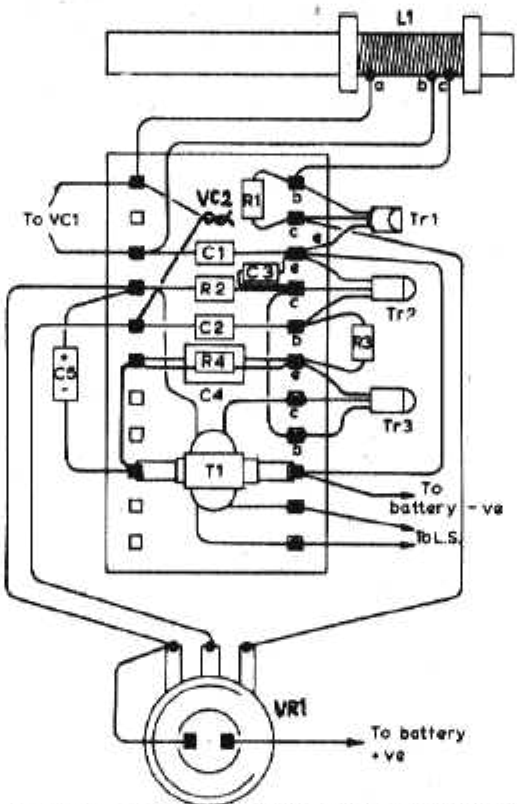


Fig. 2: The components are mounted on an eleven way tag-board. Compare this with the photograph.

ture tag board as shown in Fig. 2. The ferrite rod is secured to this board by tying one end to the top of the tag board as shown in the photograph.

The cabinet front is made from a piece of hard-board 9 × 5in. to which are fixed the sides made from 2¼ × ½in. planed softwood. These sides should be glued and nailed together and nailed with hard-board pins to the side framework. Holes must of course be drilled for the speaker and the two controls. The tag board is held inside the case by making a small bracket, one end of which is bolted to one of the holes in the tag board and the other screwed to the inside of the case ensuring that the ferrite rod is not too close to the speaker magnet.

The cabinet front can be covered with speaker fabric or any reasonably strong material. This should be cut exactly to size and glued. The sides and the back of the cabinet are covered in self-adhesive plastic covering such as Fablon. The junction of the speaker fabric and plastic covering may be hidden by using black plastic tape.

★ components list

Resistors:

R1	100kΩ	R3	100kΩ
R2	100kΩ	R4	56Ω

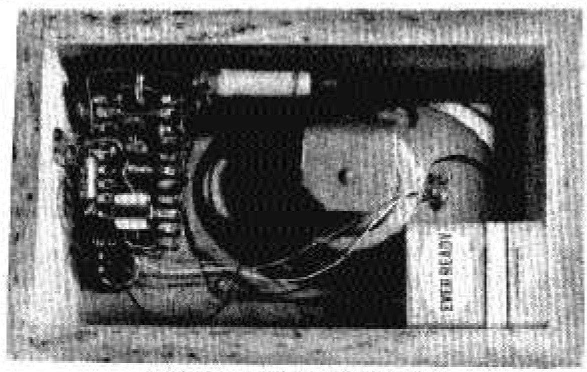
All ⅛ or ¼ watt, 10% miniature types
VR1 5kΩ log pot. with switch

Capacitors:

C1	0·1μF	C4	200μF 9V
C2	2,000pF	C5	200μF 12V
C3	0·01μF		
VC1	250pF variable—see text		
VC2	see text		

Miscellaneous:

Tr1, Tr2, T3r BC169C; Ferrite rod with windings—see text; T1, transistor output transformer, approx. 4·5:1; Loudspeaker 3Ω; Battery PP7 or equivalent; Eleven-way tag board; Hardboard and softwood for case—see text; Speaker fabric; Self-adhesive plastic covering.



An interior view of the prototype

Conclusion

Assuming everything has been wired up correctly the only adjustment is that of VC2 and this, being frequency selective, should be peaked so that the set just fails to break into oscillation on Radio Luxembourg. VC2 consists of two 1in. lengths of wire twisted together. Incidentally the gain of the first stage is so high that unless the general layout is carefully followed there is a danger of the set continually oscillating. Because of the fairly high capacitance of Veroboard it is not to be recommended for this particular project. ■


100 90 80 70 60 50 40 30 20 10 0

EXPERIMENTAL REFLEX RADIO

This simple reflex medium-wave receiver offers good sensitivity and selectivity, yet requires only a small quantity of components. It is a particularly attractive design for the constructor who wishes to experiment with a working receiver having a reliable circuit

WHENEVER THE AUTHOR WISHES TO BUILD A SIMPLE but efficient radio using transistors he always thinks in terms of the reflex principle, with which most amateurs and home constructors are familiar. The reflex receiver should never be confused with the superhet as the latter is a more efficient design. However, building a superhet can be difficult for beginners or home constructors who are not conversant with the superhet mode of operation.

The receiver described in this article gives good results so far as sensitivity and selectivity are concerned. After designing and experimenting with various forms of reflex receivers, improved detection and controlled regeneration was obtained with the circuit to be described. The output is in excess of 250mW, which is more than sufficient for normal listening.

THE CIRCUIT

The circuit of the receiver appears in the accompanying diagram. Signals are tuned in by the ferrite aerial coil and C1 and are amplified at r.f. by TR1, which then passes the signal to diodes D1 and D2 for detection. At the same time, the r.f. choke, L2, prevents the amplified r.f. signal being passed to the second stage. The detected a.f. signal is returned to the base of TR1, which then amplifies this also. In consequence TR1 functions as a reflex amplifier. It does the job of two transistors and a semiconductor is saved.

C2 is the feedback capacitor for regeneration, the main regeneration control being R2. A critical value in this stage is that of R1, which depends upon the diodes and transistor used for D1, D2 and TR1 respectively. To give an example of what is involved, R1 was 68kΩ when two Mullard OA70's were employed, but had to be increased to 150kΩ with two Philips or Valvo OA70's. Because of this, the best value for R1 has to be found by experiment.

Despite the lack of stabilising components in its emitter circuit, the first stage is quite satisfactory on its own for earphone listening. The stage can be checked by connecting a magnetic earphone having a resistance of 500Ω or more in parallel with R3. The omission of stabilising components saves a resistor and an electrolytic capacitor. Potentiometer R2 functions as a base bias potentiometer and, at its normal setting, causes the collector current of TR1 to be about 1mA.

A number of transistors were checked in the TR1 position, best results being given by an AF114. Its miniature version, the AF124, may also be used. No connection is made to the shield lead-out in either case.

The amplified a.f. signal at TR1 collector is passed, via L2 (which offers negligible impedance at audio frequencies), to the volume control R4 and, thence, to the base of TR2. TR2 is the driver transistor and provides the requisite signal for the two output transistors, TR3 and TR4. Its collector current is of the order of 2 to 3mA.

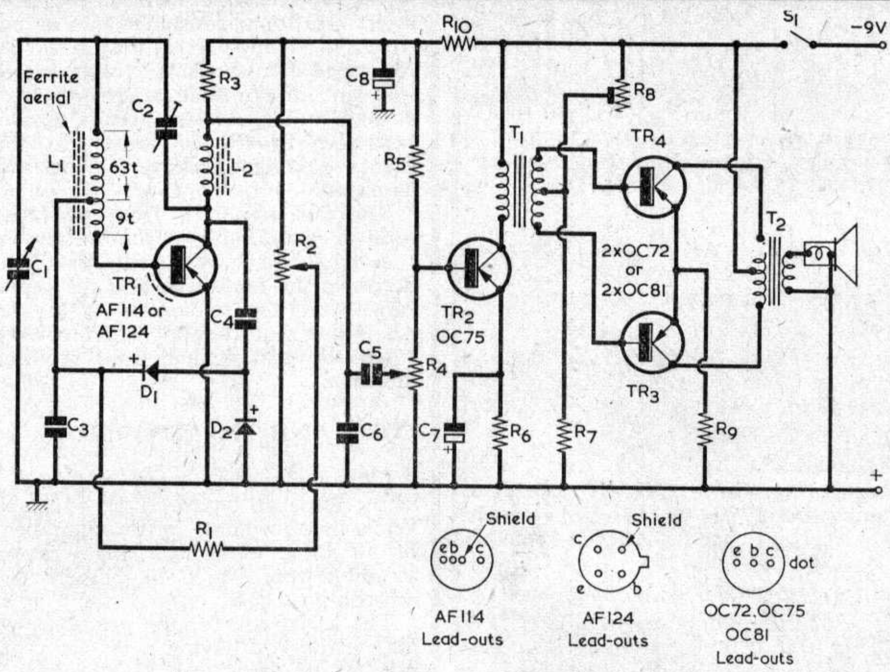
After checking a number of transistors of different type in the driver stage it was found that good results were given with an OC75, and this is specified in the Components List. The a.f. coupling capacitor, C5, may have any value between 0.25μF and 5μF, and should be paper or plastic foil, and *not* electrolytic. It was found that the use of an electrolytic capacitor affected sensitivity, although it resulted in an increase in a.f. output. (Experimenters may find it of interest to try a low-leakage tantalum electrolytic capacitor for C5.—Editor.)

The two output transistors should consist of a matched pair of the same p.n.p. germanium type, and a suitable choice is given by a pair of OC72's or a pair of OC81's. It is necessary to have a matched pair since the output stage operates in Class B, with each transistor amplifying alternate half-cycles of the applied signal.

The performance of the output stage depends upon the output of the first two stages. The latter may be checked, if desired, by temporarily connecting an earphone of around 100Ω across the primary of T1. The output in the earphone can be uncomfortably loud when tuned to a local station.

by

A. SAPCIYAN



The circuit diagram for the experimental reflex radio

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	68kΩ (see text)
R2	100kΩ potentiometer, linear
R3	2.2kΩ
R4	10kΩ potentiometer, log, with switch S1
R5	47kΩ
R6	330Ω
R7	33Ω
R8	5kΩ potentiometer, linear, preset, skeleton
R9	5.6Ω
R10	470Ω

Capacitors

C1	365pF variable, air-spaced
C2	15pF trimmer, mica
C3	10,000pF ceramic
C4	470pF ceramic
C5	0.25μF (see text)
C6	10,000pF ceramic
C7	100μF electrolytic, 6V wkg.
C8	100μF electrolytic, 10V wkg.

Inductors

L1	See text
L2	R.F. choke, 2.5mH (see text)
T1	Driver transformer type T/T1 (Radiospares)*
T2	Output transformer type T/T7 (Radiospares)*

*Radiospares components may only be obtained through retailers.

Semiconductors

TR1	AF114 or AF124	
TR2	OC75	
TR3	OC72 or OC81	matched pair
TR4	OC72 or OC81	matched pair
D1	OA70	
D2	OA70	

Switch
S1 s.p.s.t., part of R4

Loudspeaker
3Ω loudspeaker

Battery
9-volt battery

Miscellaneous
3 knobs (for C1, R2 and R4)
Connecting wire, etc.

R8 varies the quiescent current (i.e. the current under no-signal conditions) for the output transistors and is adjusted for minimum quiescent current consistent with lack of distortion. The quiescent current may be measured by inserting a meter between the centre-tap of T2 primary and the 9-volt negative line. A simpler approach is possible when the current drawn by the first two stages on their own is known, and consists of inserting the meter in series with the lead to the negative terminal of the battery. The current drawn by the output transistors will then be additional to the current for the first two stages, which is already known. R8 must always be initially set to insert *maximum* resistance into circuit when current checks are being carried out on the output stage. The resistance it inserts into circuit should then be carefully and *slowly* reduced until the required quiescent current and distortion level is obtained. Too low a resistance in R8 can result in the output transistors passing excessive current, with consequent damage.

The current drain from the battery when the receiver is operating at full volume is around 30mA.

A final circuit note concerns C8 and R10. These decouple the first stage and the input of the second stage from the remainder of the receiver, thereby preventing motorboating which could otherwise occur when the battery ages and its internal resistance increases.

COILS AND TRANSFORMERS

L2 can either be a standard 2.5mH r.f. choke (such as the Repanco type CH1) or it can be home-wound. When home-wound, the total number of turns is 400 of 34 s.w.g. enamelled single rayon covered wire scramble-wound on a $\frac{1}{4}$in. diameter former fitted with an iron-dust core.

The aerial coil for the prototype was wound on a 5in. ferrite rod having a diameter of $\frac{1}{2}$in. The total number of turns was 72 close-wound, these being tapped at the 9th turn to give 9 and 63 turns in each section. The wire was 30 s.w.g. enamelled single rayon covered. Slight variation of the turn numbers may be necessary for precise coverage of the medium wave band, this being done by adding or taking off a few turns at the C2 end of the coil. (A suitable alternative rod—which may also necessitate a slight readjustment in the number of turns—is the 6in. by $\frac{3}{8}$in. diameter rod available from Home Radio under Cat. No. FR2.—Editor.)

The a.f. transformers T1 and T2 are standard driver and output transformers respectively. Suitable types are listed in the Components List.

LAYOUT

Layout is not critical but it is necessary for the inductive components to be well spaced out. In particular, L2 and the two transformers should be at least $2\frac{1}{2}$in. to 3in. from the ferrite rod. The circuit does not lend itself to a miniaturised layout. Provided the spacing of inductive components is catered for, the actual dimensions of the receiver may be left to the wishes of the constructor.

The prototype receiver was wired up on an eyeletted insulated board with the stages proceeding along the board in the same general order as they appear in the circuit diagram.

SETTING UP

After wiring is completed and all connections have been checked, R8 is primarily adjusted to insert maximum resistance into circuit. The receiver is then switched on and R8 is *slowly* adjusted to produce a quiescent current in the output transistors of around 1mA, as already described. Again, it must be emphasised that R8 must *not* be allowed to insert into circuit too low a resistance or the output transistors will pass excessive current. The quiescent condition can be ensured by keeping R4 to minimum whilst carrying out the adjustment to R8. Also, the slider of R2 should be at the positive end of its track.

Volume control R4 is next set to maximum and the slider of R2 advanced from the positive to the negative end of its track until oscillation commences. The setting just below oscillation point corresponds to the receiver being at its most selective and sensitive. If no oscillation occurs, increase the capacitance inserted by C2. It should now be possible to tune in signals with C1. Finally set C2 so that regeneration is possible over all the band by adjustment of R2.

If oscillation occurs continually with C2 at its lowest capacitance, and cannot be controlled by R2, it will be necessary to increase the value of R1. This is carried out experimentally until satisfactory control is achieved with a new battery. The value finally chosen for R1 should enable regeneration to be maintained as the battery ages.

If, on the other hand, oscillation cannot be obtained with C2 at full capacitance and R2 slider at the negative end of its track, the value of R1 needs to be experimentally reduced until satisfactory regeneration is obtained. As was explained earlier, the value of R1 is critical and depends upon the particular transistors and diodes employed in the first stage.

Next, check that correct medium wave coverage is obtained and, if necessary, vary the number of turns in L1. Incidentally, if this coil is wound on a thin sleeve capable of sliding along the rod, quite a useful range of adjustment is available by merely changing the coil position.

The final process consists of setting up R8 for the desired quiescent current and distortion level, bearing in mind the precautions already mentioned with respect to this component. Normally, it is adequate to advance R8 slowly until distortion at low signal levels just clears.

The prototype gave good results on the medium wave band, with adequate selectivity and sensitivity for a receiver of this class. Also, there was no evidence of overloading, even with strong local signals. ■

TAKE 20

JULIAN ANDERSON

A series of simple transistor projects, each using less than twenty components and costing less than twenty shillings to build

No. 15
SHORT WAVE RECEIVER

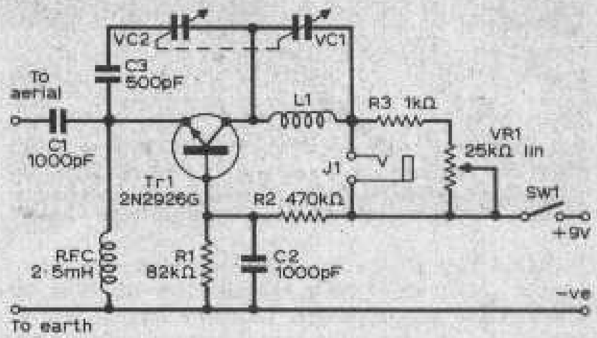


Fig. 1: The circuit of the one transistor short wave radio.

I CLEARLY remember the first project I ever tackled—a one valve short wave receiver; it took hours to build, especially the coil winding, but the final results were worth it. With the introduction of transistors things have become very much easier and the short wave receiver described here is the transistor equivalent of the frequently published "one-valve receiver" of a few years ago. The performance, though not comparable to a superhet, is quite good enough for the beginner and it will sort out the closely packed signals in the short wave bands with a 10ft. aerial. On the prototype 10 countries were logged in an hour and of course there were dozens of other signals that could have been identified with a little more patience.

In the published form the receiver should provide hours of fun but it is primarily designed as a starting point for experiments and at the end of the article I will give some clues on where to start.

THE CIRCUIT

The circuit may at first seem rather bewildering to the less experienced constructor. The transistor Tr1 is connected in the common base mode, an arrangement not often used outside v.h.f. tuners. The characteristics of this type of arrangement are low impedance input (about 50Ω), high output impedance (about 1MΩ), *no* current gain but high voltage gain. Additionally, the input and output are in the same phase and we make use of this in applying the regeneration.

The antenna is connected to the emitter via C1. The radio frequency choke (r.f.c.) connects the emitter to earth potential without losing any of the r.f. signal which cannot pass through it. The base of Tr1 is supplied with its bias by the potential divider R1 and R2, C2 smoothes the voltage. The tuned circuit comprises L1 and VC1. R3 and VR1 act as the audio load and the output is taken from across this to a crystal earpiece.

The unusual feature of this design is the method of feedback. Since the amount of feedback should be the same irrespective of frequency it must be arranged that the value of the capacitor gets less with the increase in frequency. This is usually done by using a separate variable capacitor but here we are using a double-ganged capacitor and we obtain the correct value of feedback level by padding it with 500pF. This will mean that the level of regeneration will be roughly correct whatever the frequency. However, since the level of feedback has to be *exactly* correct for maximum performance in this type of receiver, a fine adjustment is obtained by varying the collector load resistor, VR1 achieves this.

★ components list

R1	82kΩ 10%, ¼ watt	VC1, VC2	250pF + 250pF ganged
R2	470kΩ ,,	RFC	2.5mH choke, miniature
R3	1kΩ ,,	Tr1	2N2926G
VR1	25kΩ lin. pot with switch	L1	See text
C1	1000pF	J1	Earpiece output jack
C2	1000pF		
C3	500pF		

CONSTRUCTION

We are limiting ourselves to 20s. in this series and VC1 and VC2 will take a handsome section of this, so if we don't want to go over the limit we shall have to wind our own coil. This is a very simple business and all we need is the plastic housing from an old "Bic" ball-point and a couple of feet of wire. Two holes should be drilled through opposite faces of the hexagonal (six-sided) body and thirty turns of wire wound around it using the holes as terminal anchoring points. The type and gauge of wire matters very little, anything between 20 and 36 s.w.g. will do —even plastic covered hook-up wire will do for those without a supply of enamelled copper wire. Figure 2 shows the construction of this. Coverage with this coil will be from 5 to 15MHz but this will depend on the actual capacitor chosen.

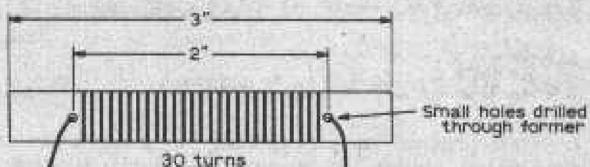


Fig. 2: The construction of L1.

Note that the common connection of VC1/VC2 is not at earth potential, it is connected to the collector and therefore it will have to be isolated if a metal chassis is used.

Layout should not be too critical but do not try crowding the components—construction on tag-strips would probably be the easiest.

continued on page 222

Take 20—*continued from page 203*

EXPERIMENTATION

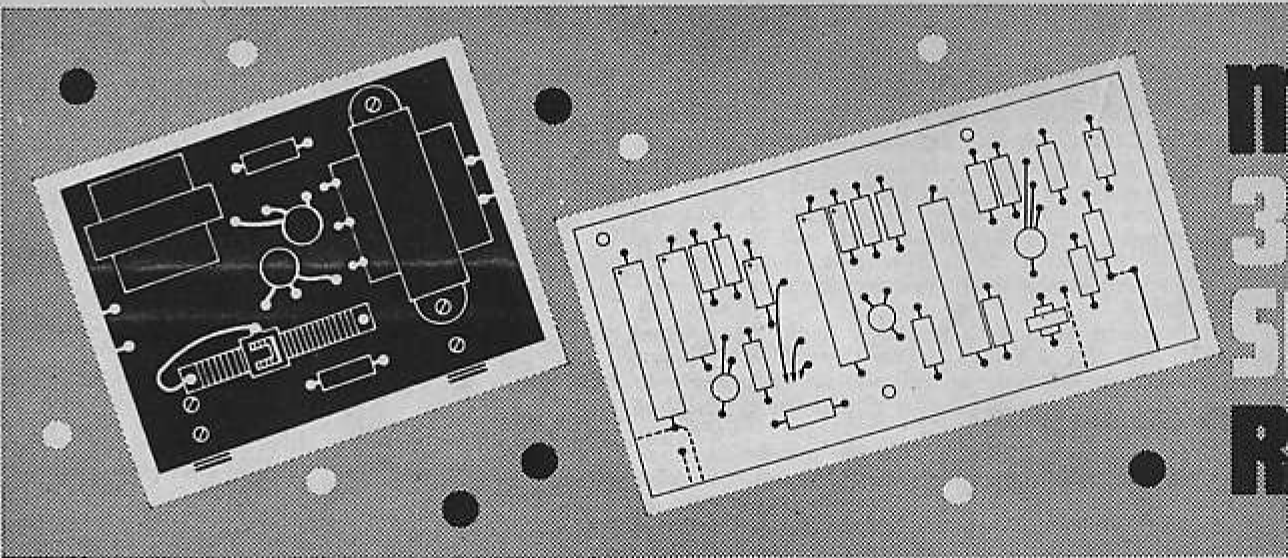
The value of C3 should be chosen so that the tracking of VC2 gives the best possible results over the band. It will also be found to vary with aerial length and if an earth is used. VC2 and C3 can be replaced by a separate control and various types can be tried; where this is done R3 should be made 2·2kΩ and VR3 omitted.

Since the coil should cost virtually nothing to wind there is plenty of room for experiment in this direction.

Also try varying R2 by replacing it with a 500kΩ pot. with 47kΩ in series.

The value of C1 also bears experimenting with and the optimum value may well be less than 20pF depending on aerial characteristics. Other transistors can also be tried but some will be found to be unsatisfactory in that it will be hard to control the regeneration—this was found especially with the BC109. The f_t of the transistor should be at least 50MHz for satisfactory operation.

It is not an easy matter to add an amplifier to this set—though of course it can be done, since the amplifier could affect the operation of this very simple circuit. In the near future I will deal with this by describing a suitable amplifier in this series. ■



AS is well known, a t.r.f. type receiver is capable of surprisingly good results, when correctly operated and circuit design is very much simpler than with a superhet.

The receiver described here covers approximately 1·3MHz to 20MHz or 230 to 15 metres, in three switch selected wavebands. The OC81D output stage gives very good headphone volume, from a large number of transmissions. Coverage includes the 160m and 80m amateur bands, ship and other frequencies, as well as the more usual short wave bands.

A push-pull output stage can be added to boost volume for loudspeaker reception. This stage is in the form of an optional module which can be plugged into the receiver output socket.

Circuit

This is shown in Fig. 1, with the coil for one band only. The remaining two coils are wired in the same way as that shown.

VC1 is the main tuning or band-setting capacitor and the small capacitor VC2 is for bandspreading.

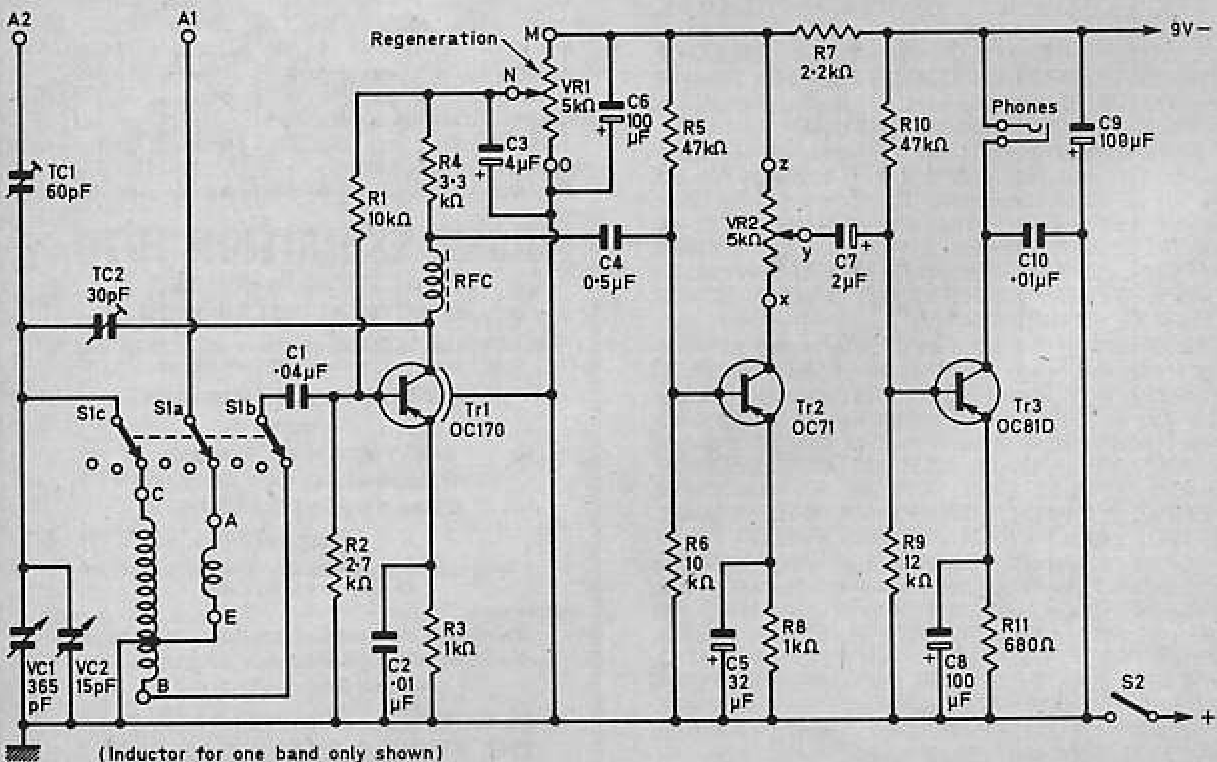


Fig. 1: Circuit of receiver. The circuit of the additional audio module is shown in Fig. 7.

MODULAR 3-Band Short Wave RECEIVER

R. F. GRAHAM

Its full rotation covers only a narrow band of frequencies. In use, VC1 is set for a band required, such as the 25m or 31m band, and this is tuned with VC2. The tuning "rate" with VC2 is about the same as that which would be obtained with a 20 : 1 reduction drive on VC1, and this method is inexpensive, convenient, and easy from the building point of view. These capacitors need not have the exact values shown.

Each inductor has a tuned section C to E, base coupling E to B, and aerial coupling A to E and 3-pole 3-way switch brings in the coil required. Alternative aerial sockets are fitted, A1 is better with a reasonably long aerial and when an earth is available. A2 is used in other circumstances, and has a small series capacitor TC1.

An OC170, Tr1, is used as a regenerative detector, with feedback through TC2 and regeneration control

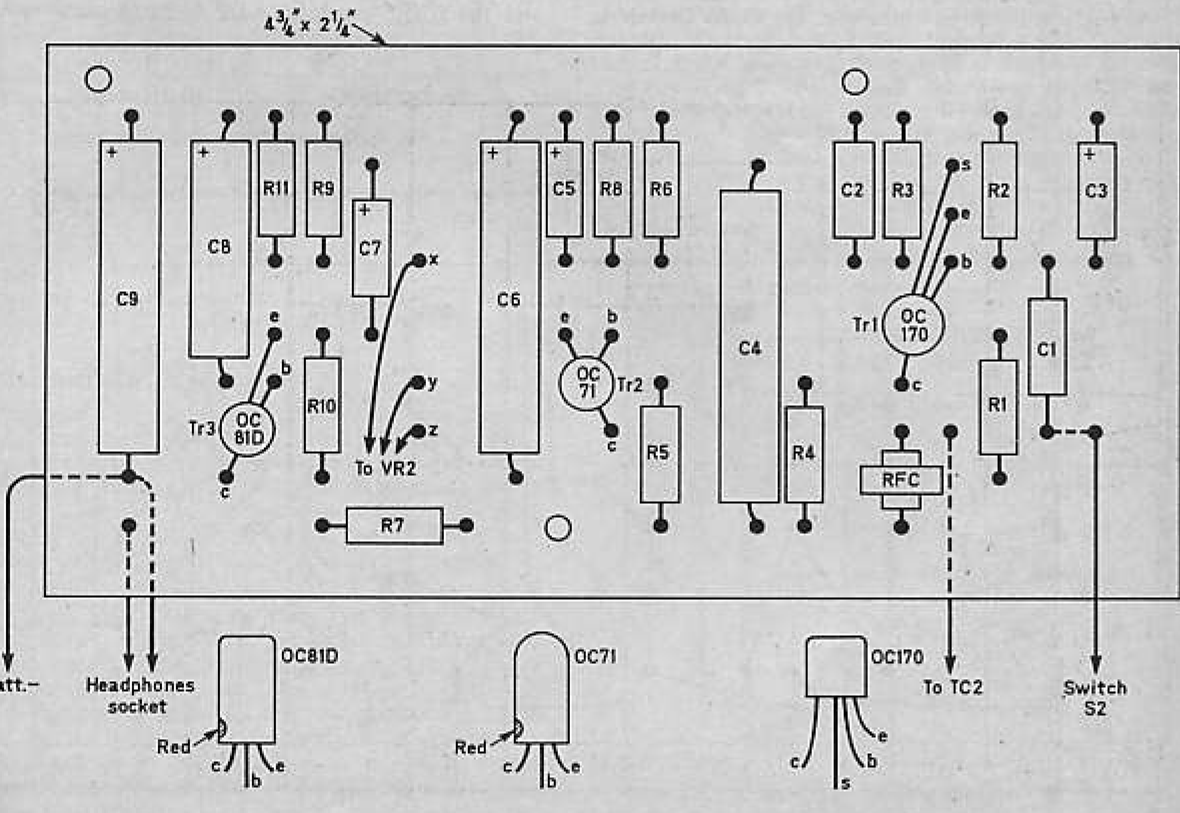


Fig. 2: Top view of circuit board and identification of transistor connections.

VR1. For proper results with a t.r.f. receiver, proper regeneration on all frequencies is absolutely essential, and this circuit was found to perform well.

The output of the detector is coupled to an OC71, Tr2, first audio amplifier, and VR2 is the audio gain control. Tr3, an OC81D, is intended for use with medium impedance (500Ω) headphones. A single earpiece or miniature personal earphone not being very suitable for regular s.w. listening.

Circuit Board Module

Most of the components are assembled upon a ready perforated insulated board about 4¾×2¼in. which is later fixed to the chassis by three bolts, two of which provide earth returns.

Fig. 2 is the top of the board. The easiest method is probably to insert the resistors and capacitors a few at a time, spreading the wire ends so that they do not fall out. The board is then turned over, and the leads are cut to suitable length, and soldered. Check all component values as they are fitted, and note that the larger capacitors have their polarity indicated, as shown.

Fig. 3 is the underside of the board. Where wire connections are necessary, some 22 s.w.g. tinned copper or similar wire is used. Insulated sleeving is put on all leads which may touch other bare wires or joints. Two tags are placed as in Fig. 3, and are common to the positive or earth circuit and chassis. These tags are tightly held by nuts or ¼in. long bolts.

When the circuit board is fixed to the chassis, put an extra nut on each bolt, so that the board is about ¼in. clear of the chassis. The bolts then pass through holes in the chassis, and further nuts are put on and locked tight. Bare joints and wires should be clear of the metal chassis, but a piece of card can be put under the circuit board, to avoid any possible short circuit.

Transistor connections are shown in Fig. 2, and it may be found helpful to put thin coloured sleeving on the wires to help identify them. Red may be used for the collector, black for the base, and some other colour for emitter leads. The wires are left at such a length that the transistors are about ½in. clear of the circuit board.

A number of flexible leads run from the circuit board, for connections to the volume control and elsewhere. It is helpful to identify these wires by using coloured sleeving, or by employing thin coloured flex.

A lead from C1 passes directly down through the chassis to the bandswitch, Fig. 4. Leads from VR1 go down through a common hole, as do leads from VR2. Take a flexible lead from C9, for battery negative, and solder on a negative battery fastener. Run leads from C9 and OC81D collector which go to the headphones socket.

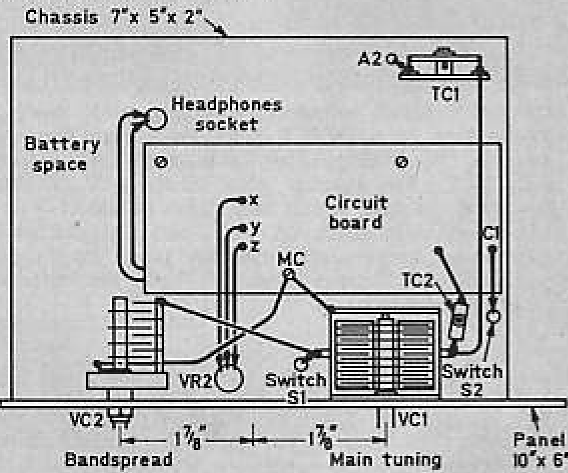


Fig. 4 : Top view of chassis and circuit board.

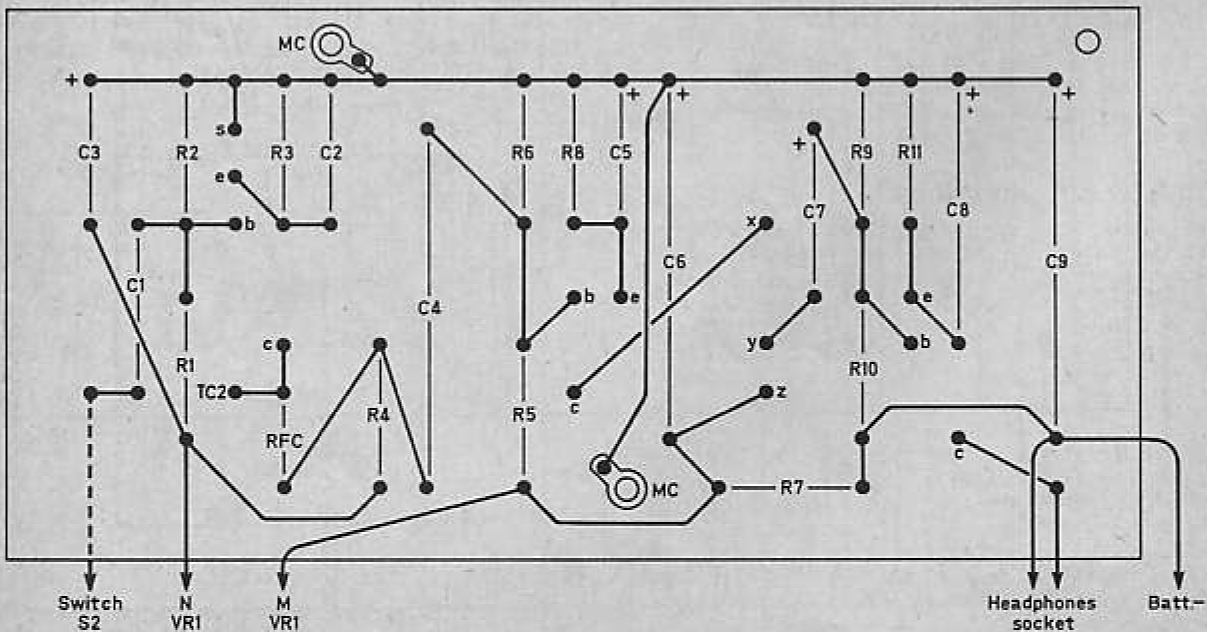


Fig. 3: Bottom view of circuit board showing interconnection of components.

Chassis

The chassis has flanges to which the panel is bolted as in Fig. 5, and Fig. 4 shows how the circuit board is fitted. The rotor connections for both VC1 and VC2 run to a tag MC, in Fig. 4. A further tag, under the chassis on this bolt, is the earth return point for the coils, Fig. 5.

TC1 is soldered to the insulated tags of a tag-strip, Fig. 4, and TC2 is soldered directly to one of the stator tags of VC1. A lead from the other stator tag passes directly down through the chassis to the bandswitch.

The tags of VR1 and VR2 are lettered, and must, of course, be correctly connected to the circuit board. The metal chassis is the common positive or earth return. A lead with a positive battery fastener is soldered to the switch incorporated in VR2, as in Fig. 5.

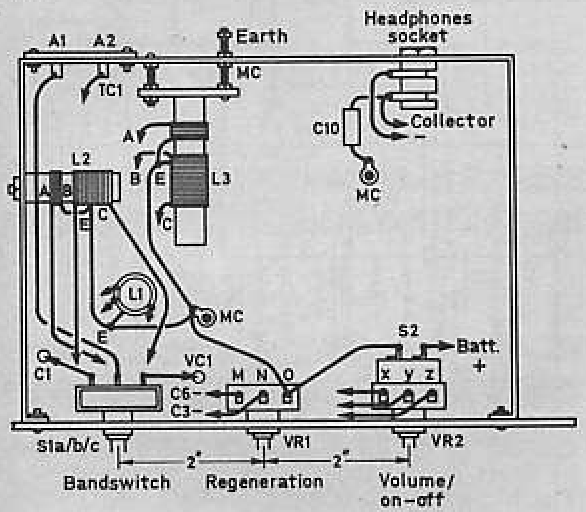


Fig. 5: Bottom view of chassis and wiring of coils and controls.

The cabinet listed has an inner flange, so the chassis has to be mounted a little high, as in Fig. 6, to clear this. With a receiver of this kind, a metal case is helpful in avoiding hand-capacity effects.

Coils and Calibration

The three coils are wound in the same way, except for the numbers of turns. L1 and L2 are on ¼in. diameter insulated formers, 1½in. long, and L3 is wound on a ferrite rod 2in. long and ⅜in. in diameter. Paxolin tubes can be mounted by cutting discs of insulating material, and cementing these in one end. A small bolt will then fix the coil to the chassis.

All windings for L2 are of 32 s.w.g. enamelled wire, turns wound side by side. Fix the wire at C, Fig. 5, near one end of the tube, by passing it through small holes, or cementing it. Wind on 34 turns. Bare the wire and form a loop E, continue for a further 4 turns in the same direction, and finish at B. Leave the wire ends long enough to reach the switch. Solder the wire on at E, leave about ⅛in. space, and wind 7 turns, finishing at A.

With all coils C goes to VC1 (via switch), E to chassis and earth line, B to transistor base (via switch and C1), and A to aerial, again via the switch.

The highest frequency coil L1 has 15 turns from C to E, and 3 turns from E to B, of 22 s.w.g. enamelled wire. E to A is 4 turns.

The lower frequency coil L3 is wound on a ferrite rod to reduce the number of turns required. C to E is 27 turns, and E to B is 1½ turns, of 24 s.w.g. double

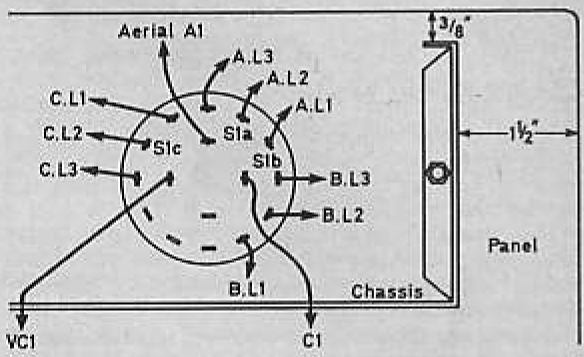


Fig. 6: Position of chassis relative to panel and bandswitch connections

cotton-covered wire. E to A is 7 turns of 32 s.w.g. enamelled wire. The end of the ferrite rod is a tight push fit in a hole in a strip of paxolin, and is cemented here. It is then mounted with two bolts, as in Fig. 5.

Fig. 6 shows the rotary switch connections, as seen from behind. (This is actually a 4-pole switch, with one pole unused. To avoid any chance of a mistake here, L2 only can be wired in, and the receiver tested with the switch in its central position. If the wrong tags are used for any coil or connection, the receiver cannot function.

VC1 and VC2 are fitted with large knobs and dials calibrated 0-100. VC1 is secured with three bolts, which must be very short to avoid fouling the plates. A small bolt was fitted above each dial, with its slot vertical and filled with paint, so that the dial numbers can be logged. Dial readings of VC1 for the various bands are given below. These are only a guide, because the home-wound coils and other factors will influence coverage.

	Freq.	*Dial*
Band 1.	20MHz	10
	15	20
	10	38
	8	55
	6	90
Band 2.	8MHz	12
	6	20
	4	40
	3	70
Band 3.	4MHz	15
	3	25
	2	50
	1·6	68
	1·3	95

Operation

With a t.r.f. receiver, adjustment of the regeneration is of the greatest importance. If there is little or no regeneration, almost no signals will be heard, and tuning will be very flat, but as regeneration is increased, a point is reached where sensitivity and selectivity improve enormously. This shows that the detector is approaching the point where it will begin to oscillate. Optimum results are with regeneration so adjusted that the receiver is *just* failing to oscillate. Advancing regeneration further will cause whistles when tuning through signals, and an almost complete loss of signals.

Initially, TC2 is almost wholly unscrewed. When VR1 is rotated slowly in a clockwise direction, background noise should begin to increase, and signals heard. If oscillation occurs when tuning through a signal back off VR1 very slightly. If regeneration up to the oscillating point cannot be obtained on some frequencies, screw down TC2 a little.

TC1 should normally be fairly well open, except for a very short aerial. If TC1 is screwed down, and a long aerial attached, the damping introduced may prevent regeneration, and may cause flat tuning.

Current drain is about 6-8mA or so, and any 9V battery is satisfactory.

Push-pull Amplifier Module

This amplifier, Fig. 7, can be plugged into the t.r.f. short wave receiver, to obtain speaker reception. No changes are needed to the receiver. The jack plug is put in the receiver headphones socket, audio signals being taken to the primary of the driver transformer T1. The plug also provides the supply voltage for the output stage.

★ components list

Resistors

R1	10kΩ	R8	1kΩ
R2	2·7kΩ	R9	12kΩ
R3	1kΩ	R10	47kΩ
R4	3·3kΩ	R11	680Ω
R5	47kΩ	R12	1·5kΩ
R6	10kΩ	R13	50Ω WW (Home Radio VR 101)
R7	2·2kΩ	R14	4·7Ω

All ¼W 10% except R13
VR1 5kΩ linear pot. VR2 5kΩ linear pot with switch.

Capacitors

C1	0·04μF 150V	C6	100μF 12V
C2	0·01μF 150V	C7	2μF 6V
C3	4μF 12V	C8	100μF 6V
C4	0·5μF 150V	C9	100μF 12V
C5	32μF 6V	C10	0·01μF 150V

VC1 365pF (Home Radio No. VC1A)
VC2 15pF (Home Radio No. VC26D)
TC1 60pF pre-set (Home Radio)
TC2 30pF pre-set (Home Radio)

Semi-Conductors

Tr1	OC170	Tr3	OC81D
Tr2	OC71	Tr4/5	OC81 matched pair

Miscellaneous

S1a-b-c, 3P3W rotary switch (Home Radio WSI7). Transformer T1 (Weyrad LFDT4). Transformer T2 (Weyrad OPT1). 2 Dials, 2¾in dia. (Home Radio KN2). Chasis components, aluminium plate 7 x 5in (Home Radio CU168), 2 sides 5 x 2in (Home Radio CU134), 1 side 7 x 2in (Home Radio CU136). Miniature R.F. choke 2·5 mH. Case 10 x 6 x 6in (Electroniques 'Dinkicase'). Headphones jack and plugs. Paxolin panel 3 x 2¼in. Eyelet board.

R12 and R13 set the base operating conditions for the pair of output transistors, and R13 is a miniature pre-set resistor. This allows easy adjustment for best results with any pair of output transistors of the type shown, or similar type.

The amplifier module is mounted on two small brackets which form the positive or chassis return. This connection is essential. If the amplifier is not fixed to the chassis in this way, a lead must be provided here to complete the circuit. In this case, the amplifier could be in the speaker cabinet.

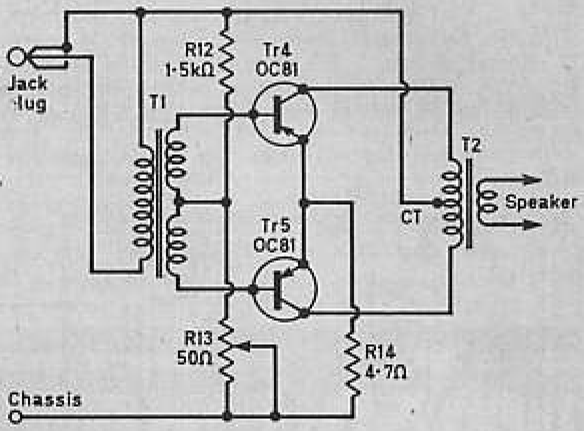


Fig. 7 : Circuit of amplifier module.

The components are mounted on an insulated board about 3×2¼in., Fig. 8. Provide a short flexible lead from the slider of R13, to one end, as shown. One tag of the driver transformer T1 is identified by a green dot, and this should be placed as in Fig. 8. Flexible leads run from the primary to the jack plug. Connect the plug is such a way that the negative circuit is correctly made when it is inserted.

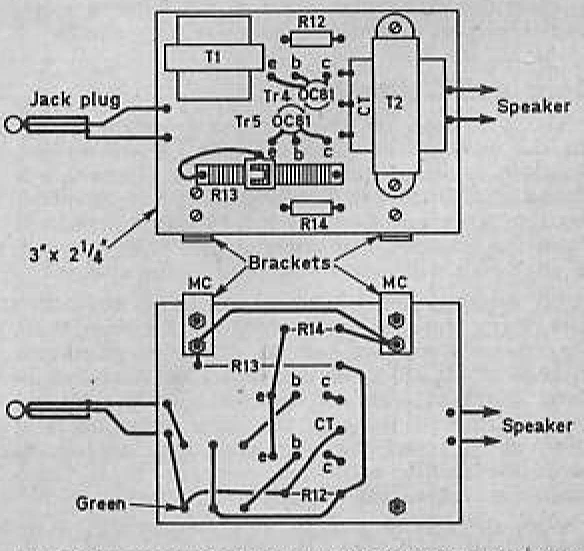


Fig. 8: Views of amplifier circuit board. Care must be taken to ensure correct wiring of jackplug.

Flexible leads from T2 run to the speaker, which should be a reasonably large 2Ω or 3Ω model, fitted in a cabinet, or attached to a baffle board. The amplifier is attached to the receiver by the two brackets, and stands vertically behind the receiver circuit board.

When the amplifier is in use, a PP9 or similar large 9V battery is more suitable. Temporarily, place a 100mA or similar meter in series with one battery lead. Set R13 to minimum resistance and plug the amplifier plug into the receiver headphones socket. When the receiver is switched on, the meter should show about 8-10mA. Move the slider of R13 to increase its resistance until the current rises about 2mA to 4mA above the original figure.

Subsequently R13 may be re-adjusted, if necessary, for best results with a signal tuned in. Current should not be over 15mA or so with no signal, rising to 30-40mA with good volume. The best setting for R13 depends somewhat on the individual transistors.

Headphones can be used as before, when wanted, by withdrawing the amplifier plug, and inserting the headphone plug. This puts the push-pull amplifier completely out of use. ■

SIMPLE F.E.T. REGENERATIVE RECEIVERS

by

A. S. CARPENTER, G3TYJ

Junction field-effect transistors are now available at quite low prices, and they are suitable for a number of receiver applications. In this article our contributor describes three simple f.e.t. receivers, concluding with constructional details for a 2-transistor receiver incorporating an f.e.t. and an a.f. amplifier stage

NOW THAT FIELD-EFFECT TRANSISTORS ARE available to constructors at reasonable prices it becomes possible to try out some interesting circuit configurations.

The junction field-effect transistor (JFET) is a three-terminal, solid-state device offering a high impedance input when connected in common-source form. In some respects a JFET can be compared to a triode valve: the transistor terminations are designated Gate, Source and Drain, and as shown in Fig. 1 may for a N-channel type be considered as comparable to the grid, cathode and anode respectively of a thermionic valve. Even tiny thermionic valves are physically enormous when compared to f.e.t.'s, the 'shells' of which are little larger than the 'hot' end of the familiar matchstick! Since f.e.t.'s are happy to work from quite low d.c. potentials – nine to 15 volts – they are obviously greatly to be preferred to valves in many instances.

Field-effect transistors may be used as oscillators, radio-frequency amplifiers, mixers, etc., and in Amateur radio circles they frequently feature in 'Two' and 'Four' metre converter designs; they also work well as regenerative demodulators.

The construction of simple regenerative receivers is in fact a pleasant and painless way of getting one's 'feet wet' with f.e.t.'s and some surprises may be in store for anyone who has not yet tried out the devices! Strong headphone signals can be obtained when using but a single f.e.t. and a handful of small components.

SOME 'LEAKY-GATE' CIRCUITS

An easily tried receiver circuit is shown in Fig. 2. Here TR1 performs both as signal demodulator and audio amplifier. Briefly, demodulation is effected by the gate and source acting as a diode, with the complete transistor functioning thereafter as a simple

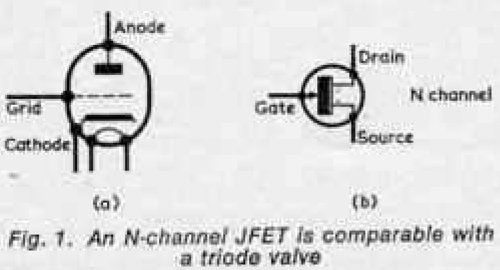


Fig. 1. An N-channel JFET is comparable with a triode valve

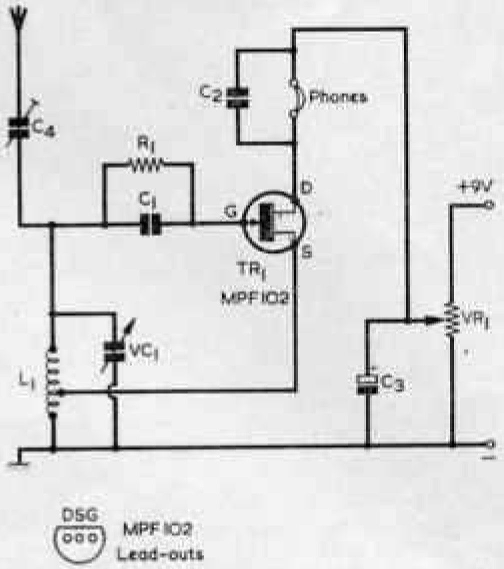


Fig. 2. A simple f.e.t. receiver with regeneration

COMPONENTS

(Fig. 2)

Resistors		
	R1	1MΩ 10% ¼ watt
	VR1	10kΩ potentiometer, linear
Capacitors		
	C1	100pF ceramic
	C2	5,000pF ceramic
	C3	100μF electrolytic, 15V wkg.
	C4	100pF trimmer
	VC1	200pF variable, air-spaced (Wavemaster)
Transistor		
	TR1	MPF102
Phones		
		2,000Ω headphones

audio amplifier. Signal selection is obtained by means of the tuned circuit, L1 and VC1, in the usual way.

Simple receivers of this sort need a regenerative peaking system to improve their performance and this may be accomplished by feeding some of the r.f. present in the output circuit back to the input. In Fig. 2 positive feedback from transistor drain to gate is effected by connecting the source not to the negative supply line but to a tapping on coil L1. Under certain conditions the circuit will oscillate continuously when switched on and in this state will be useless for the reception signals. However, by fitting a variable control, VR1, oscillation can be prevented from taking place and the system can be brought to the point of maximum sensitivity, i.e. to the brink of oscillation. Under these conditions tuning is sharp. Unfortunately, control VR1, cannot be made a preset item for it needs to be adjusted each time the vanes of VC1 are moved.

COMPONENTS

(Figs. 3 and 4)

Resistors

R1	220kΩ 10% ¼ watt
VR1	10kΩ potentiometer, linear
VR2	10kΩ potentiometer, miniature preset

Capacitors

C1	100pF ceramic
C2	5,000pF ceramic
C3	100μF electrolytic, 15V wkg.
C4	100pF trimmer
C5	0.47μF paper or plastic foil
C6	30-250pF trimmer
VC1	200pF variable, air-spaced (Wavemaster)

R.F. Choke (Fig. 4 only)

RFC1	2.5mH r.f. choke type CH1 (Repanco)

Transistor

TR1	MPF102

Phones

2,000Ω headphones

Nevertheless, by carefully manipulating both controls simultaneously the circuit may be kept at maximum sensitivity over the whole tuning range. Trimmer C4 is normally preset for best results in connection with the aerial used.

An alternative arrangement is depicted in Fig. 3, where a double-wound coil is employed. In this L1 and L2 are wound on the same former, the windings being placed close to each other. For improved selectivity the aerial may be tapped down the coil at the expense of received signal strength. Positive feedback is arranged by letting r.f. present at the transistor drain pass through coil L2, which is appropriately phased to produce regeneration. Feedback is then inductively coupled into the gate tuned circuit. The degree of feedback may be controlled coarsely by means of C6 which, if set to too high a capacitance, will pass all r.f. present to chassis. With C6 set up correctly, fine control of regeneration can be given by VR1. Preset control VR2 is fitted to ensure that the maximum transistor current does not exceed about 5mA.

Yet another variation is shown in Fig. 4 and here

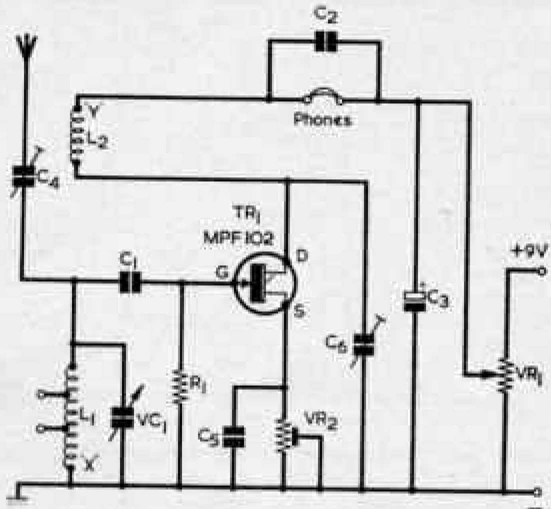


Fig. 3. An alternative design employing inductive feedback

r.f. is again coupled back inductively into the gate circuit; it is roughly controlled by trimmer C6, now placed in series with the feedback coil. Capacitor C6 must not be omitted or the d.c. supply will be short-circuited. Since r.f. is not wanted thereafter it is filtered out by means of choke RFC1 and capacitor C2.

REGENERATIVE PHASING

In circuits such as those depicted in Figs. 3 and 4 it is important to have the two coil windings correctly phased to provide the necessary positive feedback conditions. Since many experimenters like to try winding coils of their own it is always a good rule to consider the windings as a single coil. Thinking in terms of a single coil wound on a suitable former, if one end of the winding is connected to the gate circuit and the other to the drain circuit, phasing will be correct. The coil may then be 'snipped

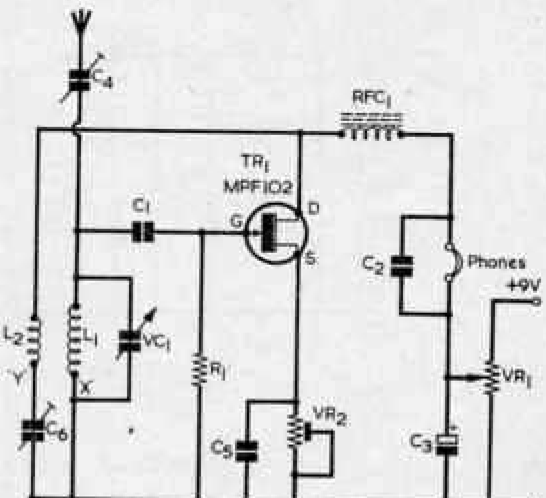


Fig. 4. A variation on the circuit of Fig. 3

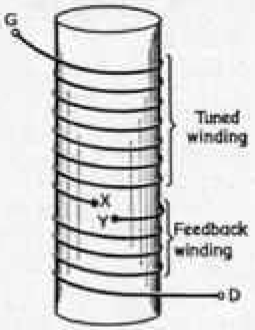


Fig. 5. Demonstrating the phasing required in coils L1 and L2

open,' as it were, a few turns from the drain end to provide the other two connections. Usually it is satisfactory if the regenerative winding turns are made approximately one-fifth of those used for the tuned winding. Remember: 'for positive feedback the coil outer ends go to gate and drain.' Fig. 5 shows the idea pictorially. What could originally have been a continuous winding has been opened at points 'X' and 'Y'; these points correspond to the similarly identified points in Figs. 3 and 4.

A 2-TRANSISTOR RECEIVER

A slightly more complex circuit is depicted in Fig. 6 and this may be used either as a headphone receiver providing good 'punchy' signals or as a simple tuner for use with a valve or transistor audio amplifier.

Using the components specified, the test model tuned over a frequency range of approximately 1.8 to 4 MHz, this embracing both the 80 and 160 metre Amateur bands plus shipping. A ready-made coil from the Denco Miniature Dual-Purpose (Valve) series simplified construction. The numbers alongside the coil in Fig. 6 apply to the pin numbers of the B9A valveholder into which this coil is plugged. As in the earlier circuits, controlled regeneration is incorporated to increase sensitivity and sharpen tuning.

The common-source connected f.e.t. performs as already described and audio signals filtered of r.f.

TABLE

Coil winding details using 30 s.w.g. enamelled copper wire, ⅜in (10mm) diameter dust-cored coil formers and a 200pF tuning capacitor.

Tuned winding turns	Feedback winding turns*	Approximate frequency range – MHz
17	4	5.2 – 23 dust-cored 7.6 – 32 air-cored
25	6	4 – 18 dust-cored 5.5 – 25 air-cored
32	7	3 – 16 dust-cored 4 – 24 air-cored

*Spaced approximately 1/16in. from 'earthy' end of tuned winding.

All turns should be closewound. For lower frequency ranges, use of a ready-made commercial coil is recommended.

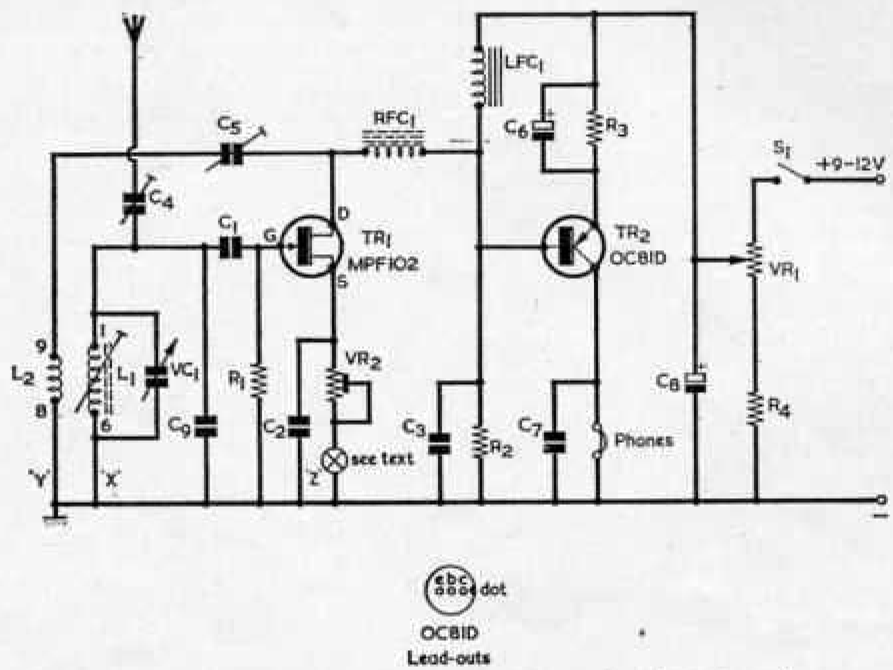


Fig. 6. A 2-transistor receiver incorporating an f.e.t. detector and an a.f. amplifier stage

are presented to the base of transistor TR2 for additional amplification. The audio frequencies are developed mainly across low frequency choke, LFC1, which additionally becomes part of the transistor base potential divider in conjunction with R2. Choke LFC1 may be the primary winding of a transistor-type driver-to-push/pull transformer and if its measured d.c. resistance is around 250Ω it will be satisfactory. The choke used in the test model was the primary winding of a Weyrad type LFDT4. Types JOT or JDT, available from Henry's Radio, are also suitable and are less expensive.

Transistor TR2 operates as a common-emitter amplifier and output is available at the collector. If phones are preferred they should be connected as shown; alternatively a resistor of approximately 3.9kΩ may be used in their place and, with capacitor C7 left *in situ* the output taken from the collector circuit to a suitable audio amplifier via a capacitor of 0.01μF. See Fig. 7. A p.n.p. OC81D works well in the TR2 position but other similar audio types may be used successfully. Regeneration can be smoothly controlled by means of VR1.

CONSTRUCTIONAL NOTES

The complete receiver can be constructed easily on 'breadboard' lines using a section of 6 by 6in. 18 s.w.g. aluminium sheet bent to provide a panel and base, each measuring 3 by 6in. It is essential to use a reduction drive for the shaft of VC1; the other panel controls will be VR1 and S1. A phone or audio outlet socket is required. Aerial and earth sockets may be placed at the rear.

To avoid making soldered connections to the coil spills, the coil may be mounted on the base plate via its threaded stem and polystrene nut with spills upward. A B9A valveholder can then be inverted and plugged on to the coil spills. This approach also allows spare tags to be used for anchoring components.

It is a good plan to obtain a pair of transistor holders which can be appropriately wired prior to plugging the transistors in to them; this affords complete protection for the transistors.

A suitable layout with some of the wiring included is given in Fig. 8; components not shown can be placed as is most convenient.

TESTING

Initially the slider of VR1 should be set to the end of the track connected to R4 and that of VR2 set to approximately half-travel. A testmeter switched to read 0–10mA should be inserted at point 'Z'. With phones and battery connected the receiver can next be switched on and the current at 'Z' checked; a reading of 5mA approximately is to be aimed at by adjustment of VR2. If the fixed vanes of VC1 are now touched with a penknife blade or similar piece of metal a healthy crackle should be heard in the phones, whereupon an aerial – and an earth if possible – should be connected up. Thereafter it is but necessary to adjust C4, C5 and the core of L1 in such a way that it is possible to bring the unit to the edge of oscillation at any setting of VC1 with control VR1. It will be found that as VR1 is advanced noise in the phones increases as sensitivity

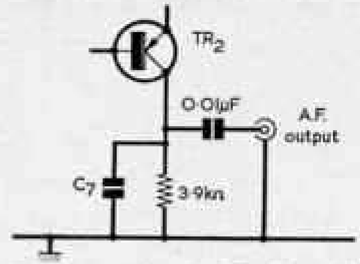


Fig. 7. The output circuit of Fig. 6 may be modified, as shown here, to enable the receiver to feed a subsequent a.f. amplifier

COMPONENTS

(Fig. 6)

Resistors

(All fixed values 10% ¼ watt)

R1	220kΩ
R2	15kΩ
R3	820Ω
R4	1kΩ
VR1	10kΩ potentiometer, linear
VR2	10kΩ potentiometer, miniature preset

Capacitors

C1	100pF ceramic
C2	0.47μF paper or plastic foil
C3	0.01μF ceramic
C4	100pF trimmer
C5	56pF trimmer, Mullard concentric
C6	100μF electrolytic, 6V wkg.
C7	5,000pF ceramic
C8	100μF electrolytic, 15V wkg.
C9	50pF ceramic
VC1	200pF variable, air-spaced (Wavemaster)

Inductors

L1	Two Miniature Dual-purpose (Valve) Range 3, Blue (Denco)
RFC1	2.5mH r.f. choke type CH1 (Repanco)
LFC1	See text

Transistors

TR1	MPF102
TR2	OC81D (see text)

Sockets

Two transistor holders type H14/15 (Henry's Radio)
B9A valveholder
Phone jack
Aerial socket
Earth socket

Phones

2,000Ω headphones

Battery

9-volt battery

Miscellaneous

Vernier drive type T502 (Eagle)
Knob
Tagstrip (See Fig. 8)
Aluminium sheet, 6 by 6 in., 18 s.w.g.
Connecting wire, nuts, bolts, etc.

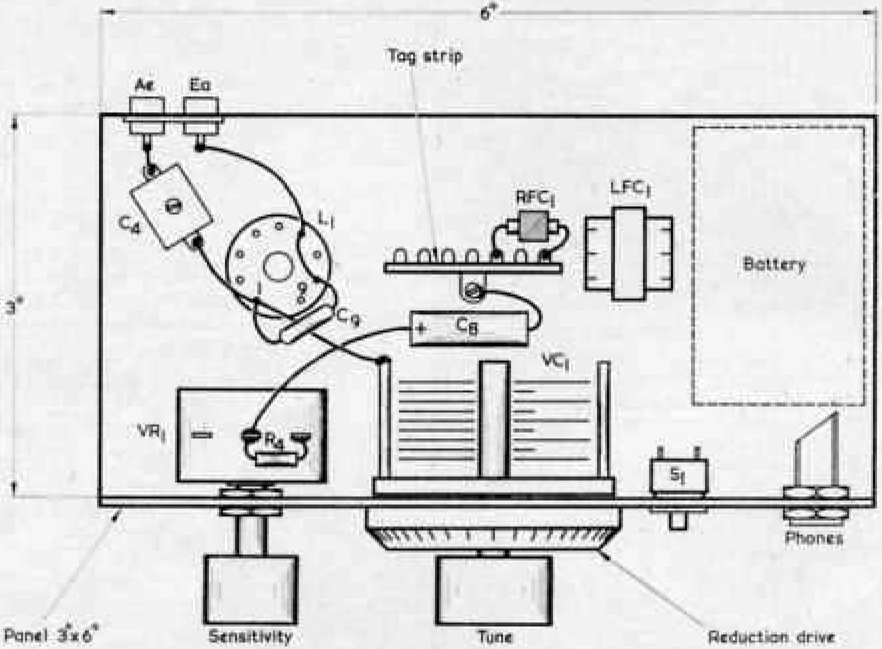


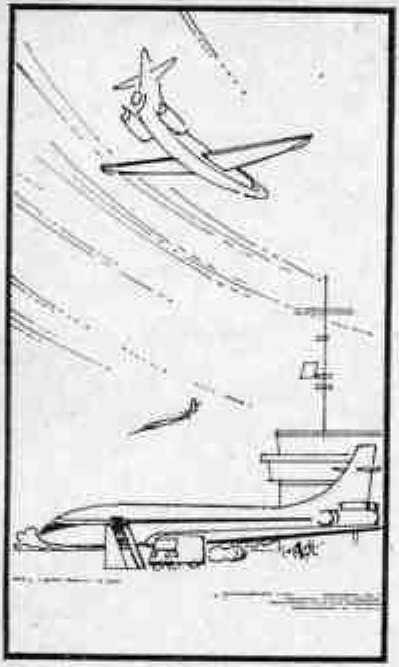
Fig. 8. A practical layout for the principal components in the 2-transistor receiver

improves, and any signals heard will rise dramatically in strength. If however VR1 is advanced overmuch signals will disappear completely and leave a sustained whistle; in this condition the receiver is useless and the control must be retarded immediately.

A short time spent experimenting with the controls will soon reveal the best method of operating – it will also be found that the various controls interact and that the aerial also has a large effect on performance. Control VR2 can be readjusted for enhanced performance as necessary compatible with a source current of approximately 5mA; once set it should need no further adjustment.

All regenerative receivers of the type described are apt to be temperamental and adjustments have to be made carefully if best results are to be obtained; this is the price that must be paid for simplicity. Nevertheless surprisingly good reception can be expected from what is, after all, but a handful of components!

If the reader wishes to try winding his own coils the accompanying Table will be useful as a guide. Precise frequency ranges obtained will, of course, depend a great deal upon the position of the iron dust core in the coil, the aerial employed, and stray capacitances, etc. ■



THE "AIRLANE" 7-TRANSISTOR AIRCRAFT BAND RECEIVER

by

C. H. G. MILLS

Intended for the more advanced constructor who is capable of working from a circuit diagram and general layout details, this article describes a super-regenerative receiver designed expressly for reception on the v.h.f. aircraft band. Coverage is from 108 to 140MHz. There is no necessity for padding and tracking adjustments, since tuning is carried out by a single variable capacitor

THE "AIRLANE" RECEIVER TO BE DESCRIBED WAS originally conceived to satisfy the demand of a younger member of the family for a simple set with which to listen-in on the Aircraft Band. The completed receiver was found to perform very satisfactorily and was, if anything, more suitable for its particular purpose than some of the superhets that are available. Its construction should be within the capabilities (and the purse) of young aircraft enthusiasts and, with slight modifications to the tuned circuit, could also be used on the 144MHz Amateur Band.

Using a 30in. whip aerial, at a location only some 200 feet above sea-level in the Midlands, aircraft can regularly be heard at about 100 miles range, and some ground stations are regularly heard at good strength although some 50 to 70 miles distant. The feature of variable band-width particularly facilitates station searching, so important when the transmissions are relatively transient, and the broad-tuned r.f. stage, coupled with careful screening, mitigates the problem of radiation from the super-regenerative detector.

Cover Feature

THE DETECTOR

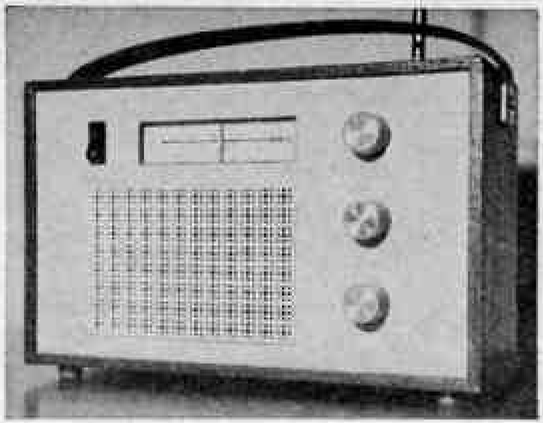
The choice of a self-quenching super-regenerative detector was dictated basically by the need for simplicity, but it does have certain positive advantages provided that it can be made stable and reliable. Extremely high sensitivity can be achieved using only one transistor and, although selectivity is inevitably not as good as with a superhet, it can be made quite adequate by keeping the quench frequency and the quench amplitude as low as is practicable. In fact, extremely high selectivity can make the task of searching for signals of short duration quite tedious. On the other hand, variable selectivity, giving a wide bandwidth for searching and adequately sharp tuning for adjacent channel rejection, can be achieved very simply by controlling the amplitude and frequency of the quench.

The super-regenerative detector also gives a level of amplitude limiting and thus exhibits some degree of a.g.c. action; some distortion of the signal is inevitable with this type of detector, but not such that intelligibility is impaired, and is of little consequence for the service for which the receiver is intended.

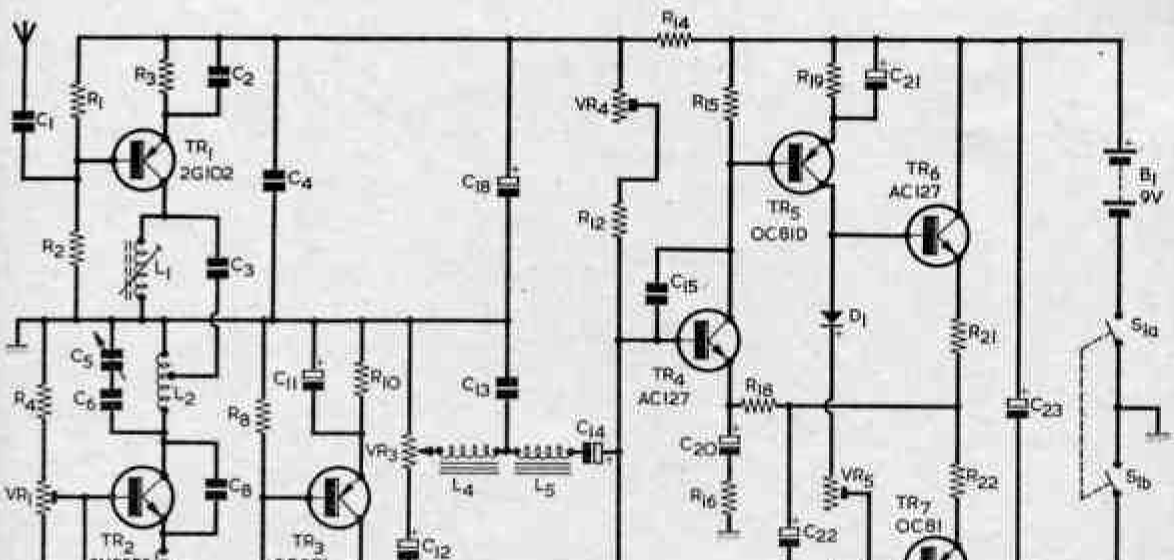
The transistor employed as the detector, TR2, is a Texas T1407, formerly 2N3983, an n.p.n. silicon planar device in encapsulated form, and with an f_t of 500 MHz. It is available from L.S.T. Electronic Components, Ltd. Much experimentation was carried out with various transistors in this stage, checking n.p.n. and p.n.p., silicon and germanium, and the particular type specified was found to be the most satisfactory. Using the T1407 no selection was found to be necessary, nor was any adjustment of the collector-emitter capacitance required to achieve oscillation. Since super-regenerative circuits have a reputation for being a little 'touchy' it is not recommended that an alternative type of transistor is used in this stage.

The circuit is basically a collector-emitter feedback oscillator, the tuned circuit consisting of L2, C5, and C6 in the collector circuit and positive feedback being applied by a small capacitor C8 connected between the emitter and collector. The r.f. choke L3 presents a high impedance at the frequency of oscillation, so that the feedback current flows into the emitter. Base bias is provided by the chain R4, VR1, and R5. By the correct choice of the time-constant of the emitter load, determined by VR2 and R6 in parallel with C9, the oscillator will be self quenched, the quench frequency and amplitude being adjustable by VR2. The audio signal appears at the junction of L3 and R6 and is fed to the a.f. pre-amplifier through C10.

The r.f. input is coupled to the detector at a tap close to the earthy end of L2 to avoid damping the tuned circuit. A padder capacitor C6 is provided in series with the tuning capacitor C5 to achieve the required coverage of 108—140MHz using a readily avail-



The exceptionally neat and symmetrical layout of the author's receiver is well demonstrated by this photograph. To the left of the tuning scale is on-off switch S1. The three controls to the right are (from top to bottom) tuning, regeneration and a.f. gain



The complete circuit diagram for the v.h.f. aircraft band super-regenerative receiver able tuning capacitor with integral slow-motion drive. C5 is, in fact, one gang of a two-gang unit currently used in many f.m. tuner kits.

The whole of the detector and the a.f. pre-amplifier circuit is contained within a screening box, which can conveniently be a metal socket outlet box, 3 by 3 by 1¼in. deep, as used in domestic electrical installations. The socket outlet box used by the author was an M.E.M. Type 7402.

THE R.F. STAGE

Complete screening of the detector and the addition of an r.f. stage is essential in order to minimise the radiation from the detector, but this does not significantly improve the signal to noise ratio. Broad tuning is achieved by L1 in the emitter of a germanium p.n.p. transistor with an f_t of 180MHz. The choice of r.f. transistor is not critical, a Texas 2G102 was employed in the original circuit but suitable equivalents such as the Mullard AF102 should be equally satisfactory. (Check results initially with the AF102 shield lead-out not connected to chassis.—Editor.) Although unconventional, the p.n.p. r.f. stage feeding the n.p.n. detector has the advantage of having the common earth line at the cold end of both coils, this overcoming problems of stability that had been experienced with other experimental configurations. It is also particularly convenient to use this arrangement with a conventional complementary power amplifier having a centre-earthed power supply .

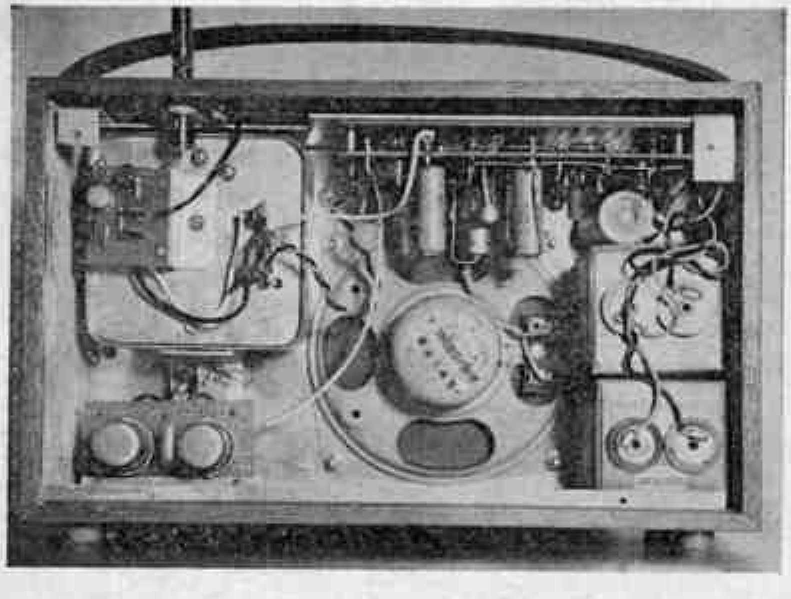
amplifier is attenuated by the gain control. A Texas 2G371 was employed in this stage, but any similar device could be substituted.

LOW-PASS FILTER

In order to reduce the detector noise in the absence of a carrier, the a.f. response of the receiver is limited to about 4kHz by a simple T-section L-C filter comprising L4, C13 and L5. The inductors employed originally in this filter were Fortiphone 470 mH iron cored chokes, C13 having a value of 0.001μF. However, these chokes may be difficult for the home-constructor to obtain and the writer has since redesigned the filter using the primary windings of Radiospares transformers type T/T6 for L4 and L5. No connections are made to the secondaries. With these new inductors, C13 has the value of 0.005μF shown in the Components List. (It should be noted that Radiospares components may only be obtained through retailers). The filter given by L4, C13 and L5 is a refinement rather than a necessity, and although the reduced noise bandwidth is well worthwhile, the filter could be omitted or replaced by a single R-C top-cut circuit.

OUTPUT STAGE

In the original receiver a conventional complementary power amplifier was incorporated, giving an output of 1 watt to drive a 35 ohm, 4in. circular loudspeaker.



Rear view of the prototype receiver. At top left is the screened box containing the detector (TR2) and a.f. amplifier (TR3) stages. Secured, on the outside, to the back cover of the box is the r.f. amplifier (TR1) and a 3-way tag-strip for negative and positive supplies. A.F. gain control VR3 is mounted on a bracket fixed to the bottom edge of the screening box, the a.f. output from the latter passing through an adjacent hole in the bottom edge. L4 and L5 are at bottom left (the photograph shows the Fortiphone chokes used originally) whilst the power amplifier is at top right. External a.f. leads prior to the power amplifier are screened

A.F. PRE-AMPLIFIER

The a.f. pre-amplifier stage, incorporating TR3, is conventional, being notable only because it is housed within the detector screening box, thus providing a compact front end with ample output voltage to drive any desired output stage. The a.f. gain control, VR3, is placed at the output of the pre-amplifier, rather than at its input, to allow the quench circuit of the detector to feed a constant impedance. This arrangement also ensures that any noise originating in the pre-

Additional top-cut is provided by feedback capacitor C15. This amplifier was described in more detail by T. Snowball in earlier issues of this journal.*

The type of construction which was adopted for the front end results in a virtually self-contained unit that can be used to drive any type of output amplifier; a very compact unit has, for instance, been constructed by employing a miniature packaged power amplifier driving a 3in. speaker. There is, however, much to be

* T. Snowball, "High Sensitivity Transistor V.H.F. Portable", *The Radio Constructor*, February and April 1967.

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1	10kΩ
R2	47kΩ
R3	1kΩ
R4	3.3kΩ
R5	2.2kΩ
R6	560Ω
R7	220Ω
R8	12kΩ
R9	39kΩ
R10	1kΩ
R11	2.7kΩ
R12	10kΩ
R13	22kΩ
R14	220Ω
R15	560Ω
R16	15Ω
R17	220Ω
R18	1.5kΩ
R19	56Ω
R20	1.5kΩ
R21	2.2Ω
R22	2.2Ω
VR1	10kΩ potentiometer, preset miniature
VR2	5kΩ potentiometer, linear
VR3	10kΩ potentiometer, log
VR4	10kΩ potentiometer, preset miniature
VR5	100Ω potentiometer, preset miniature

Capacitors

C1	0.001μF ceramic
C2	0.001μF ceramic
C3	0.001μF ceramic
C4	0.001μF ceramic
C5	One section of 15 + 15pF variable capacitor type 00 with slow motion drive (Henry's Radio)
C6	68pF ceramic
C7	10μF electrolytic, 6V wkg.
C8	4.7pF ceramic
C9	470pF ceramic
C10	2μF electrolytic, 6V wkg.
C11	50μF electrolytic, 6V wkg.
C12	2μF electrolytic, 9V wkg.
C13	0.005μF paper
C14	2μF electrolytic, 6V wkg.
C15	0.005μF ceramic
C16	0.001μF ceramic
C17	100μF electrolytic, 12V wkg.
C18	100μF electrolytic, 12V wkg.
C19	100μF electrolytic, 12V wkg.
C20	200μF electrolytic, 12V wkg.
C21	100μF electrolytic, 12V wkg.
C22	250μF electrolytic, 12V wkg.
C23	500μF electrolytic, 25V wkg.

Inductors

L1	See Table and text
L2	See Table
L3	See Table
L4	Radiospares transformer type T/T6 (see text)
L5	Radiospares transformer type T/T6 (see text)

Semiconductors

TR1	2G102 (or AF102)
TR2	2N3983 (TI407)
TR3	2G371
TR4	AC127
TR5	OC81D
TR6	AC127
TR7	OC81
D1	OA5

Switch

S1 double pole rocker switch (or toggle if desired)

Batteries

B1, B2 9-volt batteries type PP9 (Ever Ready)

Loudspeaker

35Ω 4in. round loudspeaker

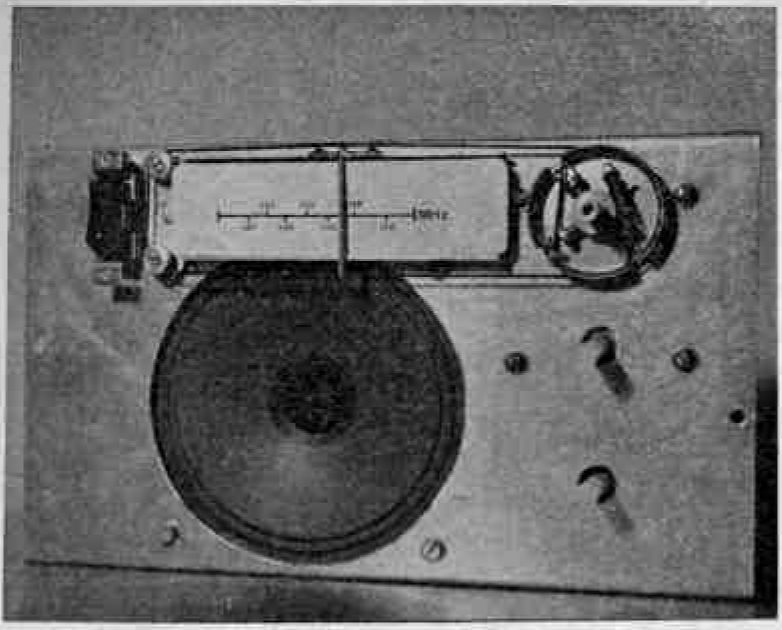
Miscellaneous

18 s.w.g. aluminium sheet
Plain Veroboard with terminal pins
3 knobs
Outlet socket box (see text)
Whip aerial (see text)
Dial drive components (see text)
Cabinet (see text)
Battery connector clips
Screened wire, etc.

said for the larger version described in this article; it allows room for batteries of ample capacity as well as a relatively large speaker, and it permits a tuning scale of reasonable length in a cabinet of well balanced external appearance.

CONSTRUCTIONAL DETAILS

A general view of the completed receiver is shown in the accompanying photograph. The cabinet measures 9½ by 6 by 3¾in. and is constructed from 5 mm plywood pinned and glued at the corners and finished in a wood-grain material (e.g. Fablon). The front panel is of melamine laminate, drilled to take the control spindles, and with rectangular holes cut for the on-off switch, the tuning scale and the loudspeaker fret. The plastic loudspeaker fret is simply glued to the front panel with Araldite; a piece of thin Perspex is glued behind the chamfered opening for the scale; and the whole front panel is glued to wooden strips, ¼in. square and fixed to the inside of the cabinet such that the panel is recessed slightly from the sides of the cabinet. The back of the cabinet is simply made from thin ply-wood or hardboard covered with wood-grain material; the handle is cut from a leather strap and fixed with woodscrews and bent aluminium finish plates.



The whole receiver is mounted on the aluminium sub-panel shown here. Switch S1, to the left, is a double-pole rocker component. The tuning drive drum is fitted over the rear section of the tuning capacitor shaft, this coupling directly to the moving vanes. The forward section of this shaft is coupled to the moving vanes by way of the integral slow motion drive of the capacitor

The melamine laminate just referred to may be Wareite or Formica plain silver grey, and is available from most do-it-yourself shops. The plastic speaker grille was obtained from a local retailer, and appears to be generally available. Also, a suitable plastic grille in black, cream, grey or white is listed in the Home Radio catalogue under Cat. No. LS1A.

The aerial may be any whip aerial having a length of 30in. The writer used a TA11 telescopic aerial obtained from Henry's Radio. This is swivel jointed, with a maximum extended length of 36in.

It is not intended to give dimensioned drawings since constructors may wish to use components differing from those specified, and may need to vary the dimensions accordingly. Little difficulty should be experienced in the construction of a cabinet with a pleasing finish if the accompanying photographs are referred to.

Also illustrated is a rear view of the receiver with the back of the cabinet removed. The screening box housing the detector and the a.f. pre-amplifier can be seen in the top left of the picture, with the r.f. amplifier mounted on the rear of the screening box. The coils of the low pass filter can be seen at the bottom left, these being the Fortiphone chokes in round cans which were employed originally. The a.f. gain control is immediately behind these coils. At the top right of the cabinet is mounted the power amplifier and the batteries are housed to the right of the loudspeaker.

The whole receiver is mounted on a sub-panel of 18 s.w.g. aluminium sheet as illustrated. The appropriate photograph also shows the assembly of the tuning scale and pointer drive mechanism. The scale is cut from a scrap of white melamine laminate and measures 4 x 1in.; lines can be drawn with indian ink and figures and letters applied by means of pressure sensitive stencils or transfers. The drive-cord pulleys can conveniently be made from the wheels of miniature toy motor-cars, with the tyres removed. Suitable pulleys, as well as a drive drum, may also be obtained from radio component sources, such as Home Radio.

A piece of 18 s.w.g. aluminium is bent into a shallow channel and screwed to the front of the sub-panel to house the scale. The top flange acts as a guide for a U-shaped runner bent from a piece of tin plate, to which a piece of 16 s.w.g. copper wire is soldered to form a pointer. The drive cable is fixed to a loop formed in the pointer wire above the guide, and the pointer proper is covered with red pvc sleeving.

The coils L1, L2 and L3 are home-wound. Winding details are given in the accompanying Table. It will be noted that 14/44 Litz is specified for L1, this being chosen for its mechanical, not electrical properties. The wire used by the author was taken from an old i.f. transformer. It is very flexible and makes the construction of L1 extremely simple, with the application of just a spot of wax to hold the winding in place. As an alternative, 36 s.w.g. tinned copper wire is perfectly satisfactory electrically, but is a little springy for a small diameter coil. Nevertheless, 36 s.w.g. wire could be used for L1 if the spares box does not yield a suitable Litz wire. A suitable coil former and core for L1 would be the Cat. No. CR26 and Cat. Z87 respectively, obtainable from Home Radio.

The socket outlet box, which forms the screening box for the detector stage, is first fitted with an 18 s.w.g. aluminium cover, cut such that it fits snugly in the box and rests on the four lugs which normally take the fixing screws of the socket outlet. 4BA clearance holes are drilled in the cover to mate with the tapped holes in the upper and lower lugs; the other two lugs are removed. The whole of the detector and a.f. pre-amplifier stages are built up on the cover plate as illustrated.

The tuning capacitor is first fitted to the cover plate by means of the three tapped holes in the rear of the capacitor frame; ¼in. spacers are employed on the 4BA fixing screws. Care must be taken in positioning the tuning capacitor to ensure that the moving vanes do not foul, but just clear, the top of the screening box. A bracket, bent from 18 s.w.g. aluminium, is fixed to the base of the capacitor frame by means of the two 4BA tapped holes provided here, to carry the regeneration control VR2. Clearance holes are cut in the screening box to take the tuning and regeneration control shafts.

A small piece of plain Veroboard (i.e. without copper strips) is cut to fit around the regeneration control and secured to the cover plate with a small bracket; this board carries most of the detector components, viz: R4, R5, R6, VR1, L3 and C9. Connections are made with the aid of terminal pins in the Veroboard. VR1 should be mounted on the underside of the Veroboard and a hole cut in the screening box to allow screwdriver access for adjustment. The tuning coil L2 is soldered between the tuning capacitor frame and a small stand-off insulator; the latter carrying the collector lead of TR2 and one side of C6 and C8. The lead from the r.f. stage to the tap on the coil is carried through a grommet in the cover plate.

The a.f. amplifier stage is also housed within the screening box and is constructed on a small piece of plain Veroboard, mounted on the side of the tuning capacitor. Again, terminal pins are used as required. The gain control, VR3, is mounted on a bracket beneath the screening box and feeds the filter incorporating L4 and L5 which is mounted on the base of the cabinet.

The r.f. amplifier is constructed on a small piece of plain Veroboard, about 1½ by 1in. and, after completion, is mounted on the back of the detector unit. The method of construction needs no special mention since it is obvious from the various photographs. All r.f. leads should be kept as short as possible and the earthy end of components taken to one earth point. It is of particular importance to keep

TABLE

COIL WINDING DETAILS

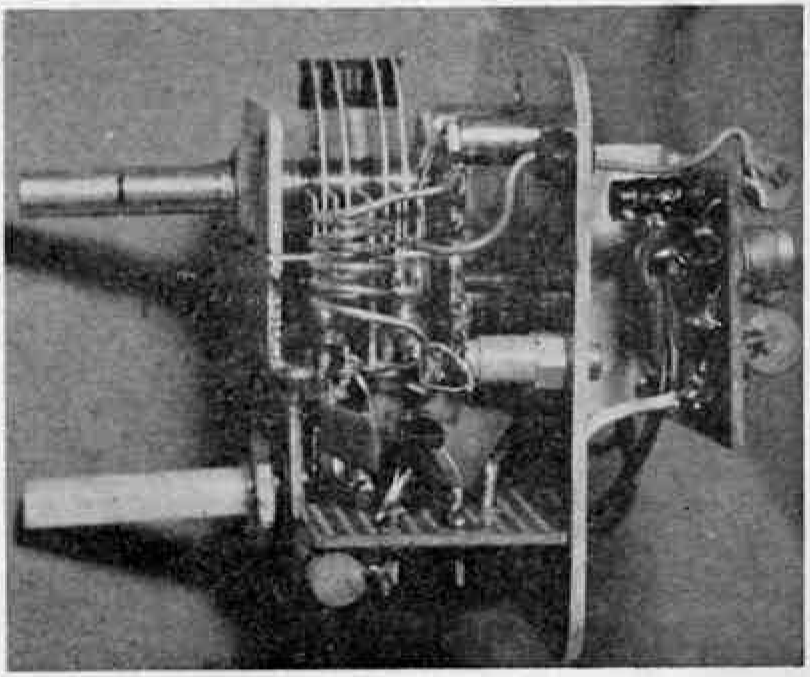
Coil	Turns	Wire	Former	Spacing or Length
L1	4	14/44 Litz (see text)	3/16in. former, with dust core (see text)	¼in. long
L2	5, tapped at 1½ turns from earthy end	16 s.w.g. tinned copper	Air cored, I.D. ¼in.	Turns spaced by wire diameter
L3	25	36 s.w.g. enamelled copper	¼in. former	Close-wound

the leads of the decoupling capacitors, C2 and C4, as short as possible. Terminal pins are omitted in view of the simplicity of the circuit.

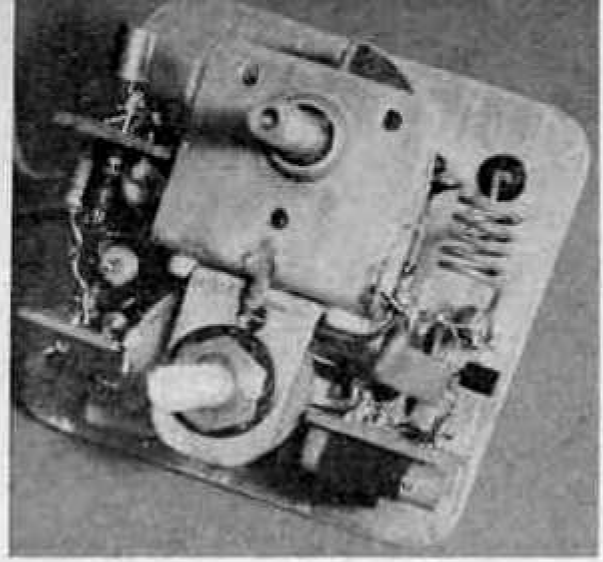
The power amplifier is assembled, using terminal pins, on a plain piece of Veroboard measuring 4 by 1½in., so as to fit in the top of the aluminium sub-panel. The layout of this section of the receiver is in no way critical and is left to the discretion of the constructor. As mentioned earlier, a small commercial amplifier, with an input sensitivity of about 100mV, could be used in place of the amplifier shown in the circuit diagram.

ALIGNMENT PROCEDURE

If the power amplifier shown in the circuit diagram is used, it is recommended that C14 be initially disconnected and the power amplifier adjusted first.



Side view of the components on the cover plate, illustrating in particular the r.f. amplifier stage. Coil L1 is visible affixed to the underside of the Veroboard (facing the cover plate). The upper disc capacitor is C3 and the lower C2, with TR1 between. Note the lead from C3 to the tap in L2



This photograph shows the general layout employed in the screened box containing the detector and a.f. amplifier stages. Directly below the tuning capacitor is regeneration control VR2, this being straddled by a piece of plain Veroboard. At top right is coil L2, with TR2 and C6 below. Underneath the Veroboard is choke L3. A second piece of Veroboard, to the left of the tuning capacitor, carries the a.f. amplifier components. Connection is made to the front fixed vanes only of the tuning capacitor

Check all connections, then connect a milliammeter in the collector circuit of TR6, and switch on. A current of not more than about 20mA should flow; if the current significantly exceeds this figure, switch off immediately and check for incorrect polarity of the battery supply and any other faults. Assuming a reasonable current flows in the output transistors, adjust VR4 until the voltage at the junction of R21 and R22 is exactly mid-way between the positive and negative supply rails, then adjust VR5 for a quiescent current of 5mA in the collector of TR6.

Reconnect C14 and connect the milliammeter in the negative supply line to the detector and a.f. amplifier stages. If the current exceeds 5mA, disconnect immediately and check wiring; if the current is less than 5mA, remove the meter and connect the supply line directly. Repeat the above procedure with the positive supply line to the r.f. amplifier.

Extend the aerial, set the tuning capacitor to a position in which the vanes are half engaged, set the regeneration control to its mid-position and advance the gain control slightly. Typical regeneration noise should now be heard as a loud hissing. Adjust VR1, if necessary, to ensure that regeneration occurs over the whole of the range of the regeneration control. Now tune to the high frequency end of the scale (minimum capacitance in C5) and check that regeneration occurs at all settings of VR2. If it does not, the tapping on L2 should be adjusted slightly until satisfactory regeneration occurs over the whole of the tuning range at all settings of VR2.

Tune in a signal at about the centre of the tuning band and, with VR2 in the high-selectivity position, adjust the core of L1 for maximum signal strength; this adjustment is not critical.

Calibration of the tuning scale and alignment can, of course, be more conveniently carried out with a suitable signal generator, but the procedure outlined above will yield good results with patience. Patience is necessary in order to calibrate the scale which, without a signal generator, must be done by listening to an aircraft announce a change of frequency and retuning to the same aircraft on the new frequency. ■

CQ2 VHF receiver

M.J.GORDON

WHEN it comes to v.h.f., most fixed amateur stations use either a transceiver, a crystal controlled superhet converter (with the s.w. receiver as i.f. and a.f. amplifier), or a de-luxe triple conversion receiver.

However, these units are usually quite expensive or difficult to build and align, unless one has considerable experience of v.h.f. techniques.

This super-regenerative t.r.f. design will satisfy the needs of many s.w.l.s and prospective G8s, as there is only one tuned circuit to adjust; it can be easily built in one evening and is not difficult to set up. Having only one tuned circuit, it is also very easy to change the frequency coverage.

The f.e.t. tuner is the heart of the device and if so desired could be used on its own with a jack plug to feed into the input socket of a ready-made amplifier. In this case the tuner could be made quite small. This set-up was in fact used by a local G8 for his first QSO. It will not do for DX, but at least it's a start. Many readers will have dabbled around with the regenerative t.r.f. type of receiver but in the super-regenerative design, feedback is introduced (via the source to drain capacitor C3 in the author's design) beyond the point where oscillation just occurs, and the stage is in continuous oscillation until this state is disturbed by an incoming signal. The super-regenerative state brings about a condition of extremely high sensitivity to the circuit; there is also a high level of circuit background noise, commonly referred to as "slush".

The complete circuit of the receiver is shown in Fig. 1. Even without an aerial the receiver has received good signals from aircraft, radio amateurs and other services up to a distance of approximately 6 miles. Because the prime purpose of building the receiver was to receive local amateur radio transmissions in the Taunton area, the extra encumberance of an elaborate aerial array has not been tried. It is suggested that for experimental purposes an 18in. length of 18 s.w.g. tinned copper wire is simply fitted to the centre of the coax socket. Vertical orientation of the aerial will normally bring forth optimum performance.

The author has built more than one version of this receiver, but that shown in the photograph was built into a wooden cabinet already on hand. This was approximately 8 × 8 × 4in. deep.

As an alternative to the loudspeaker, a low impedance (80Ω) earpiece could be used.

Layout and Construction

Although layout is important at v.h.f., and the effects of extra-long wires and inter-electrode capacitances undesirable, the circuit allows considerable latitude, even on 2 metres. The original mock-up was in fact, built up on a 1½ × 2½in. paxolin board. Layout will depend on the cabinet and components used, but VR1 should not be more than 6in. from the coil.

VC1 was actually an Eddystone 35pF variable with brass vanes in the prototype. All these were removed except for one stator and one rotor, but a 5pF C804 (Henry's Radio) is a suitable ready made

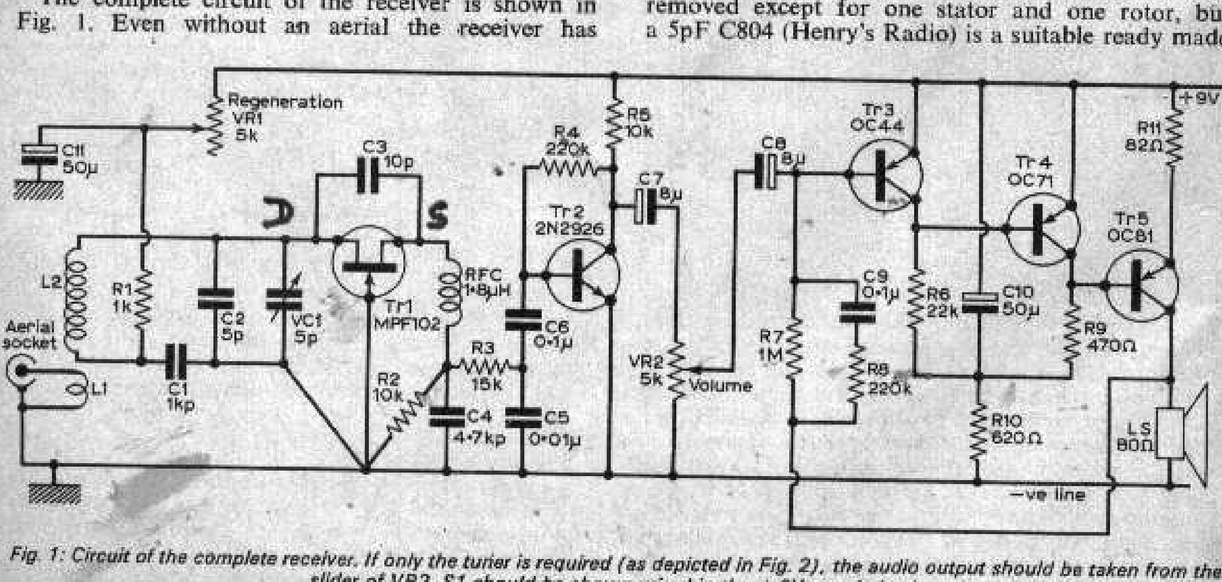


Fig. 1: Circuit of the complete receiver. If only the tuner is required (as depicted in Fig. 2), the audio output should be taken from the slider of VR2. S1 should be shown wired in the +9V supply lead.

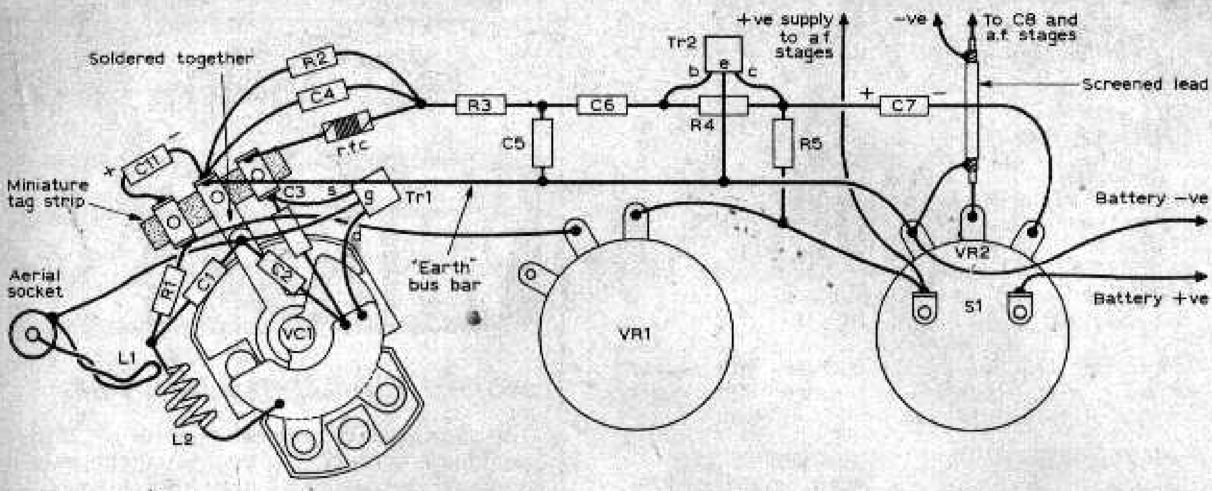


Fig. 2: Layout of the tuner section of the receiver. The audio amplifier stages are not shown. C3 may alternatively be of the "twisted wire" variety (see text). The leads of L2 should be kept as short as possible, one end being soldered directly to the fixed plate of VC1 (5pF type C804 shown in the above diagram).

component. The stator was cleaned and tinned, and direct soldered connections were made to it.

The coil L2 consists of 3½ turns of 18 s.w.g. tinned copper wire close wound to ⅜in. diameter. Tightly spaced this will get aircraft, and stretched over ½in. it will cover the 144MHz Amateur band. Naturally, the coil is sensitive to the effects of hand capacitance. The aerial coupling coil L1 should be a half turn of the same wire placed near to the earthy end of L2.

The 10pF feedback capacitor C3, if preferred, can be replaced by a conventional tubular variable type, which would also provide a good anchorage for the drain and source of the f.e.t. Alternatively, the unconventional variable "twisted wire" variety may be used. About ½in. is sufficient to get the circuit "started".

The 1·8μH r.f.c. in the prototype was filched from a turret-type v.h.f./u.h.f. tuner, but this may be difficult to obtain, and about 25 turns of very thin wire on a 1 megohm ¼ watt miniature resistor works equally well.

Wiring should be kept as short as possible, and the same tag should be used for all earth connections in the first stage.

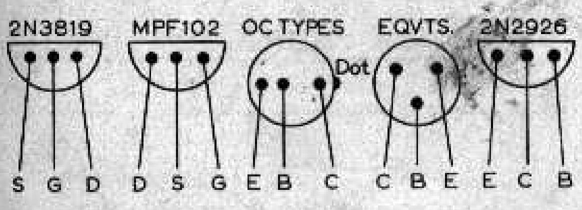


Fig. 3: Transistor lead connections.

Distinguish carefully the leads of the f.e.t. and if using the 2N3819 remember that the lead-out is different from that of the MPF102. Although the f.e.t. is silicon and should stand up to about 10 seconds heat from a 15 watt iron, it is best to use a heat shunt when soldering, such as long nosed pliers with a rubber band wound around the handles. An earthed soldering iron should be used, as the f.e.t. can be damaged by mains-derived capacitive

★ components list

Resistors:

R1	1kΩ	R7	1MΩ
R2	10kΩ	R8	220kΩ
R3	15kΩ	R9	470Ω
R4	220kΩ	R10	620Ω
R5	10kΩ	R11	82Ω
R6	220kΩ		

All 10% ½W miniature

Capacitors:

C1 1000pF ceramic
C2 5pF ceramic
C3 10pF (see text)
C4 4700pF ceramic
C5 0·01μF ceramic
C6 0·1μF miniature
C7 8μF 12V electrolytic
C8 8μF 12V electrolytic
C9 0·1μF miniature
C10 50μF 12V electrolytic
C11 50μF 12V electrolytic
VC1 5pF variable (see text)

Semiconductors:

Tr1 MPF102 or 2N3819
Tr2 2N2926
Tr3 OC44
Tr4 OC71
Tr5 OC81
(Tr2–Tr5) or equivalents

Inductors:

L1 ½–1 turn, near earthy end of L2, 22 s.w.g. insulated copper wire.
L2 3½ turns, 18 s.w.g. tinned copper wire, ⅜in. diameter, air cored.
r.f.c. 1·8μH r.f. choke (see text)

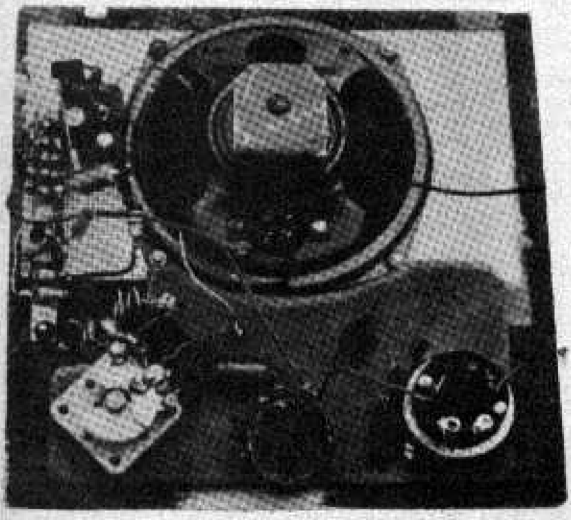
Miscellaneous:

VR1, VR2 5KΩ potentiometer, S1 single pole on/off switch (may be combined with VR2), 80Ω loudspeaker, paxolin board, tagstrip, coax socket, battery clips, PP9 battery, wire, solder, etc.

voltages. As a further precaution, all the f.e.t. leads could be shorted together by the "heat shunt" whilst being fitted.

Operation

Check the polarity of the battery, and the wiring before switching on. If the circuit of Fig. 1 is used the current drain on a 9V battery should be about 35-40mA. Check that none of the f.e.t. leads are shorting and switch on, with VR1 at minimum. A lively background hiss will indicate that the f.e.t. is oscillating. If it is not, advance VR1 towards maximum. The hiss should be extremely loud, much louder than ordinary background hiss with which it should not be confused. Experiment with various settings of VR1 to produce optimum results.



The photograph shows the author's prototype.

When a station is tuned-in there will be a reduction in the circuit background hiss, this depending upon the strength of the received signal. It is usually best to adjust L2 for the desired band on Sunday mornings or evenings as radio amateurs are usually more active on v.h.f. at these times.

The only likely cause of trouble may be C1 working loose or fracturing as a result of the manipulation of L2.

The amount of radiated interference, once the scourge of this class of receiver, appears to be negligible. ■

"MILLIWATT" SILICON REFLEX T.R.F. RECEIVER

by

G. W. SHORT

Power consumption in this simple but effective receiver design is reduced to less than 2 milliwatts by operating the transistors at the lowest practicable current. The result is greatly enhanced battery life

THE STARTING POINT FOR THE DEVELOPMENT OF THE receiver described here was an enquiry from a friend whose daughter is at a boarding school. Illicit listening to pop music in bed, after 'lights out', is very much the done thing at this school—and perhaps at many others. The trouble is, as my friend explained, that the listener tends to fall asleep, leaving the set switched on all night. Rather bad for the batteries, this, so could I suggest a way round the problem?

My first idea was to modify an existing set by adding a sort of 'dead man's handle' in the form of a push-button switch which would turn off the set when the sleeper's hand relaxed. This was rejected on the ground that the user was more than likely to find some way of keeping the button pressed by lying on it.

The allternative was to reduce power consumption so much that an occasional overnight run became tolerable. This approach was adopted, and the resulting circuit is shown in Fig. 1.

CIRCUIT DESIGN

Readers may recognise the circuit as a development of one of the writer's earlier designs, the 'Silicon Reflex T.R.F.' described in the January, 1968, issue.* This proved to be a very reliable design, and it seemed better to stick to a good thing for the present purpose rather than start on something quite different and possibly less satisfactory.

For the benefit of readers unfamiliar with the original, this type of circuit maximises overall gain by making all two transistors contribute to both r.f. and a.f. amplification. TR2 acts as an emitter follower to r.f. and presents a high input impedance to TR1, thus maximising the r.f. gain of the first stage and providing a relatively low impedance drive to the detector diode. TR2 can thus be regarded as an impedance matching device which, while it produces no voltage amplification itself, nevertheless serves to increase the overall r.f. gain.

The a.f. output of the detector is passed to TR1 and thence to TR2 in the usual way. At audio frequencies, therefore, the circuit is a straight-forward two-stage amplifier.

LOW-CURRENT OPERATION

The original circuit was not at all fussy about transistor types. Practically any silicon n.p.n. transistors worked in it, though naturally some worked better than others. In the present 'Milliwatt' version, the choice of transistor types is much more restricted. The gain and, more especially, the cut-off frequency of transistors fall off as the collector current is reduced below the normal operating value, but in this circuit the transistors must provide high r.f. gain and low r.f. and a.f. noise at collector currents of 100μA or less. Very few transistor types meet all these requirements.

Fortunately, the new epoxy encapsulated planar transistor type SF115 has the necessary characteristics. In particular, it has low internal capacitances, a prime need in circuits with high-value resistance loads operated as wideband r.f. amplifiers, as occurs here. The SF115 is equivalent to the metal type BF115, but is much cheaper. Its one disadvantage is that it will not work well at very low collector voltages. This is why the detector diode specified is a silicon planar type instead of the usual germanium point-contact diode. The voltage drop across a silicon diode when just biased to conduction is 0.5V, whereas the corresponding voltage for a germanium diode of the OA70 class is only about 0.1V. In the present circuit, the drop across the diode forms part of the collector-emitter voltage of TR1. (This point may not be very obvious at first, but a study of Fig. 1 will show that the collector-emitter voltage of TR1 is the sum of the base-emitter voltages of the two transistors and the drop in D1). Using a silicon diode raises the total from about 1.3V to about 1.7V, and this provides a useful margin for reliable operation. It is important to use a high-speed planar diode for D1. An ordinary silicon rectifier type will not do because it will not work at radio frequencies. (The specified IS44 diode and the SF115 transistors are available from Amatronix, Ltd.)

The receiver consumes about 170μA at 9V, and is not unduly dependent on the battery voltage, which can fall to 6V or less without impairing the performance badly.

EARPHONE

The set was designed for use with a crystal earpiece

*G. W. Short, 'Silicon Transistor Reflex T.R.F.', *The Radio Constructor*, January, 1968.

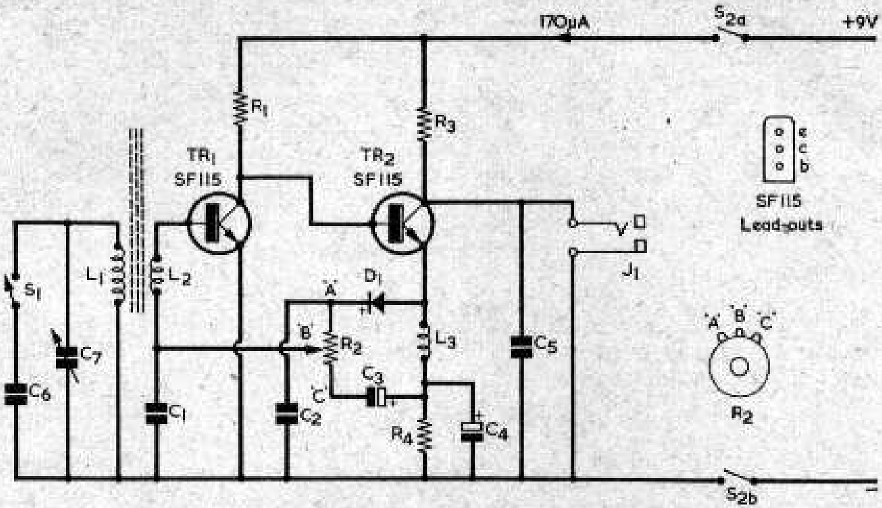


Fig. 1. Circuit diagram of the 'Milliwatt' Silicon reflex receiver

because these are suited to low-current high-voltage circuitry. It is, however, possible to use high-impedance magnetic earphones. The writer does not know of any miniature earpieces with the required impedance (4,000Ω or more), so for clandestine listening magnetic earpieces may be out. For normal purposes a good pair of magnetic phones, such as government surplus type CHR, with the earpieces connected in series can be connected in place of R3. It is also possible to use a step-down transformer to match low-impedance earpieces. For an 8Ω earpiece the turns ratio should be about 60 to 1. The primary inductance must be high (20H with 70µA d.c. flowing).

CONSTRUCTION

It is vital to keep the stray capacitance at the collector of TR1 and the base of TR2 as low as possible. This means that TR1, TR2, and R1 should be positioned close together so that leads can be kept short, and it also means that if a printed circuit or Veroboard base is used then the area of copper involved in joining the relevant three leads must be as small as possible. A pin-board base following the layout of Fig. 2 was used in the prototype, with all three leads on one small pin.

(For the benefit of readers who have not experienced the joys of this cheap and simple form of construction, here is a short description. The layout diagram is placed on a piece of dry wood. Ordinary domestic pins of the shiny plated type obtainable at office stationers are driven in at every junction point.

The heads are then cut off, leaving enough stem to act as solder tags for the leads. Perfectionists tin the stems first before attaching anything. The resulting wiring board is virtually self-checking and components are easily removed. Since everything is on one side of the board testing is easy, and the board can ultimately be made part of a case for the set.)

For reasons which are explained later, the lead-outs of choke L3 should be a little longer than is necessary for connection, in order that it may be orientated relative to the ferrite rod. Initially, its former should be at right angles to the rod.

In t.r.f. receivers, where the r.f. gain is always

COMPONENTS

(N.B.—Some of the components may have values differing from those listed here. Details are given in the text.)

Resistors

(All fixed values $\frac{1}{4}$ or $\frac{1}{8}$ watt 10%)

R1	68kΩ
R2	10kΩ potentiometer, log, with switch S2
R3	47kΩ
R4	10kΩ

Capacitors

C1	0.01µF
C2	1,000pF
C3	10µF electrolytic, 2V wkg.
C4	125µF electrolytic, 2V wkg.
C5	1,000pF
C6	see text
C7	see text

Inductors

L1, L2	see text
L3	1.5mH choke type CH5 (Repanco)

Semiconductors

TR1	SF115
TR2	SR115
D1	IS44

Switches

S1	s.p.s.t., rotary or toggle
S2	d.p.s.t., part of R2

Socket

J1	phone jack socket

Miscellaneous

Crystal earpiece with jack plug
9-volt battery
Knobs, as required

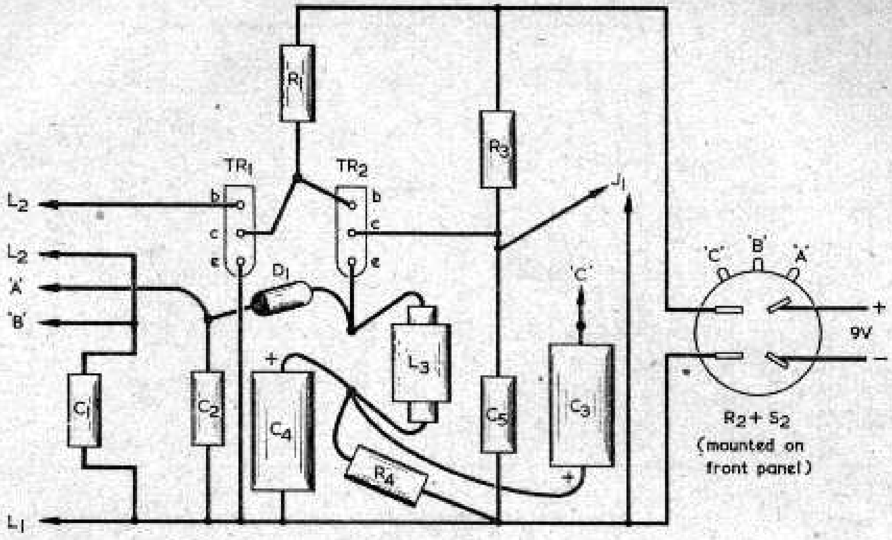


Fig. 2. Layout and wiring of the main components of the receiver. Identify the tags of S2 with a continuity tester before wiring to this component, as tag positioning with different switches may vary from that shown here

limited compared with superhets with their h.f., mixer, and i.f. stages, it is always advisable to keep the ferrite aerial rod well clear of everything else, in order to maximise signal pickup. In this design, the rod should also be kept at least 1½in. from L3. (See below under 'Reaction'.) The tuning capacitor and long-wave components S1 and C6 should be clear of the main circuitry, to reduce stray coupling which might cause instability. These considerations lead naturally to the sort of constructional layout sketched in Fig. 3.

The front panel and base dimensions are not critical, and the constructor may select these to suit the components he is employing. With the ferrite rod used in the prototype, the front panel may be some 5in. wide by 3in. to 4in. high. The base can be about 3in. deep, and could then accommodate a PP3 battery.

AERIAL CIRCUIT

The aerial tuned circuit should have a high Q, and a ferrite rod of reasonably large size should be used to provide a good input signal. In London, good results have been obtained with a 4½in. x ⅜in. round rod of Plessey NW25 ferrite (obtainable from Amatronix Ltd.).

The value of tuning capacitor C7 is not very critical and any standard air-space or solid dielectric variable capacitor offering a maximum value of about 200pF or more will be satisfactory. (A 300pF Jackson Bros. 'Dilemin' capacitor was employed in the prototype.) C7 tunes L1 over the medium wave band. Reception of one selected long wave station is provided by switching capacitor C6 across the tuning capacitor by means of S1. In the U.K., the long wave station is likely to be Radio 2 on 200kHz, and in this case C6 should normally be seven times the maximum capacitance of C7.

WINDING THE AERIAL ROD

Amateur constructors often have in their possession tuning capacitors salvaged from old sets. Unfortunately, the capacitance is not usually known, and even if it is the constructor is often discouraged from making his own ferrite aerial by the absence of information about the characteristics of the ferrite rod. Nevertheless, the winding of a rod for a set like the present design is not at all difficult if the constructor goes about it the right way. All that is needed is patience and a good supply of wire.

The method described here calls for no equipment other than the receiver itself, plus the usual tools, glue, and plastic sticky tape. To begin with, the rod is kept detached from the rest of the circuit, so that changes can easily be made. Only after the windings have been got nearly right is the rod installed and the final adjustment made.

First make up the rest of the circuit, providing in the process a pair of easily accessible tags for connections to L2 and one tag for making an 'earth' (i.e. supply negative) connection for L1 and C7. Check that the set is working by short-circuiting the L2 tags and listening in the earpiece with the volume control turned up. A gentle hiss should be audible. The constructor may then proceed with winding the coil for the rod.

First prepare the rod by wrapping a few turns of brown paper round the middle two inches or thereabout. Fix the paper with sticky tape or glue to prevent it unwinding, but if possible allow it to behave as a paper tube loose enough to be slid along the rod to provide fine adjustment of inductance. This paper tube is the coil former. Readers may have seen ferrite aerials in which the windings are directly on the ferrite. This is not good practice for all grades of ferrite; and some work better if the coils are spaced away from the surface. (The spacing reduces

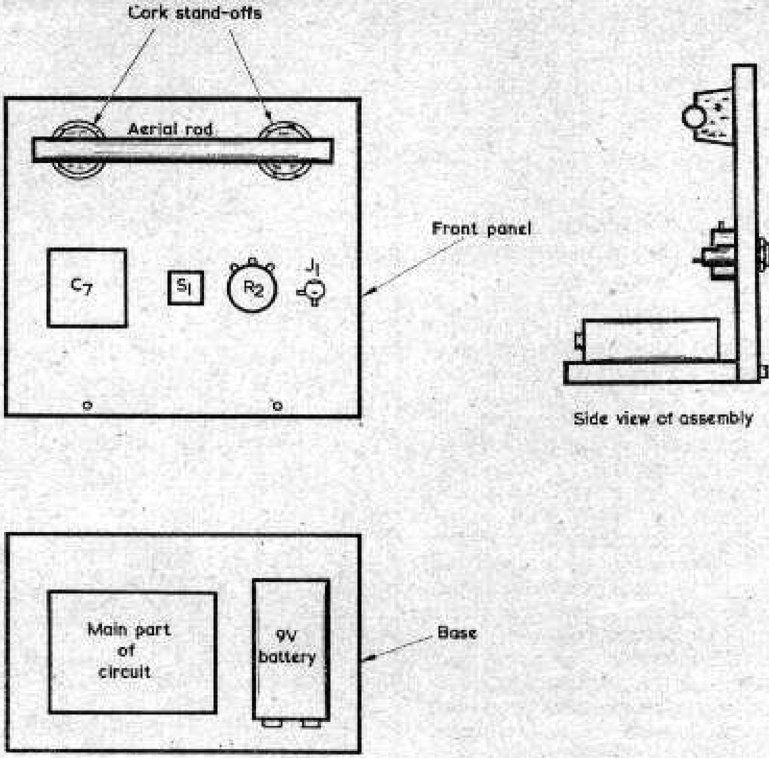


Fig. 3. A suitable layout for the front panel and base of the completed receiver. The rectangle designated 'main part of circuit' may enclose the components (apart from R2) shown in Fig. 2

certain r.f. losses.) L1 can be wound with any kind of litz wire (which can often be salvaged from old i.f. transformers) or with solid wire of around 30 s.w.g., silk or cotton covered. L2 can be wound with ordinary plastic covered hookup wire. Both coils are single-layer, close-wound. L2 can be wound on top of the earthy end of L1.

The number of turns needed depends on the capacitance and characteristics of the rod. As an indication, the rod just mentioned needs approximately 57 turns of 7/46 litz wire to tune over the medium wave band with a 300pF tuning capacitor. In finding the right number of turns by trial and error, it is best to begin with too many and then remove turns rather than to begin with too few and add them. If, on the other hand, plenty of wire is available, it may well be best to scrap the initial trial winding when the correct number of turns has been found, and then finally re-wind. In the latter case, it is a fairly safe bet that 50 turns will tune to some point in the medium wave band. If coverage down to the low frequency end at about 530kHz is not obtained, turns can be added. Should the set tune to lower frequencies than are needed, turns are removed. To make the initial trials, put on a temporary 3-turn winding for L2 with about 9in. of loose wire at each end. Twist the loose wire into flex and connect the ends up to the L2 tags on the circuit board, removing the short-circuit which was put on for the earlier test. The rod can now be kept well away from the circuit while L1 is adjusted. During adjustments, L1 and C7 may be connected with fairly long loose leads and the ferrite rod and variable capacitor can be placed on a wooden table top or other instulating support. It is not necessary to 'earth' the moving vanes of C7 to the negative supply line of the receiver at this stage.

Using a trial coil of 50 to 100 turns for L1, tune in and identify stations, and add or remove turns as required to tune to the low frequency end of the medium wave band. When the correct number required is beginning to become clear, slide the coil along the rod so that L1 is central. Readjust the turns slightly if necessary.

The ferrite rod and C7 can now be mounted. The best position for the rod is behind the top of a front panel of Formica or similar insulating board. Keep it away from metal, including the volume control and C7. If possible, mount the rod on stand-offs (pieces of cork or dowel) so that the winding can be easily adjusted *in situ*. Trim off excess leads and connect up again to the circuit. Also complete the 'earth' connection to C7 and L1. There should be no marked change in performance. If there is, adjust L3 as described later under 'Reaction'. A slight final adjustment of inductance, if required, can be made by sliding the coil along the rod. If it has to be put right at the end of the rod, remove a couple of turns and start again.

So far, nothing has been said about the tuning at the high frequency end of the medium wave band. In general, if the low frequency end is all right, so also is the high frequency end. The only exceptions are, first, that if the tuning capacitor has a built-in trimmer this may have to be set to minimum to obtain full coverage and, second, that if the tuning capacitance is too small the self-capacitance of the coil may be so large that it prevents full high frequency coverage. In the latter case there is nothing much to be done about it. As a guide, tuning capacitors of less than about 150pF maximum are in the 'danger area'.

The final job consists of fitting and wiring C6 and S1. If necessary, slightly alter the calculated value of C6 to bring in the Radio 2 transmission comfortably.

REACTION

Preset reaction is adequate to pep up the performance of this receiver. It is obtained in two simple ways, at no expense. Should L3 be near enough to L1 and L2 for there to be an appreciable amount of mutual coupling, then feedback is introduced between the input and output of the r.f. amplifier. If this feedback is negative, gain and selectivity both suffer. If it is positive, gain and selectivity are improved, and if the coupling is too high the circuit oscillates. The sense and magnitude of the coupling are adjusted by positioning L3. Initially, it should be placed so that it is approximately opposite the centre of L1 and at right angles to the rod; i.e. the former of L3 is pointing straight at a point near the middle of the rod. This is the position for minimum coupling. If L3 is now turned away from the right-angles position coupling with L1 is increased. There is no easy way of telling beforehand whether the result will be negative or positive feedback, but this becomes obvious when the receiver oscillates. L2 is finally positioned so that the set just fails to oscillate with a new battery.

The second method is to connect a short stiff insulated lead to the non-earthy side of L1 and place the free end near to or touching L2. If the sense of the windings on the rod is right, oscillation is obtainable. If not, reverse the connections to L2 and try again. Either or both of these methods of obtaining reaction may be used. There is some advantage in using both, since the L3 coupling method is usually most effective at the low frequency end of the band and the reaction wire method at the high frequency end. With both, the performance can be optimised over the band.

If necessary, an extra reaction wire can be connected to the non-earthy end of C6 to provide a separate adjustment of reaction for the selected long wave station.

GENERAL NOTES

The receiver is easily built, and a small battery lasts a long time. Apart from the tuning, there are no critical adjustments, and no critical component values. The volume control is a necessity in this low-consumption circuit, because it is essential to be able to turn down the volume on strong transmissions to avoid serious distortion caused by overloading on audio peaks; on the other hand its value is not critical and anything from 5kΩ to 100kΩ can be used. The electrolytic capacitors need not have the exact value specified. C3 can be 5 to 50μF and C4 50 to 500μF, both with any working voltage above the 2V specified.

■

THE MINI-3

R. F. GRAHAM

THIS receiver uses a well tested circuit employing three transistors and two diodes in a five-stage reflexed circuit which gives very good headphone volume. The receiver, with a miniature 9V battery, occupies a case having internal dimensions of only 1¾ × 2⅞ × 1¼in. External dimensions are of course a little greater depending on the thickness of material used. It could be accommodated in a box of different size and shape allowing something already to hand to be used: a metal box is unsuitable.

Figure 1 shows the circuit, with Tr1 acting as r.f. amplifier and also as audio amplifier after signal detection by D1 and D2. Tr2 and Tr3 are directly coupled audio stages, with Tr3 giving adequate output for all ordinary listening with a personal phone.

VR1 allows full control over regeneration which is very important for best sensitivity. The on/off switch is incorporated with VR1. VC1 is a compression type capacitor for small size. Its capacitance range is obtained over several turns of a small knob. A midget solid dielectric variable capacitor could be used instead.

Current drain is about 3mA from an ordinary miniature 9V battery, easily obtainable. The receiver also works satisfactorily with a 6V supply.

All the components except VC1, the aerial, L1, VR1 and C2 are assembled and wired on a small paxolin panel. When completed the panel is inserted in the case and connected with flying leads to VC1 and the other items just mentioned.

Ferrite Aerial

The aerial input winding L1 is wound with 34 s.w.g. enamelled wire on a ferrite rod aerial 1⅜in. long and ⅜in. in diameter. A single layer of paper is first wound on the rod. The wire is secured near one end at point A, using adhesive. Fifty-four turns are wound side by side and a small loop is then twisted for the tapping. A further 12 turns are wound, continuing in the same direction, and the wire is fixed at B. The loop and coil ends are scraped and tinned.

If the case is not as shown (Fig. 4) and a longer rod can be accommodated this will increase signal pickup. Ferrite rod material cannot be sawn by ordinary means but is brittle and snaps easily: it can thus be gripped lightly in a vice with a little padding at the point where the break is wanted.

Ready-made windings (for superhet receivers) can generally be employed. The existing base coupling winding usually has very few turns and is removed or ignored. The main winding then furnishes the section from A to the tap and some thin insulated wire is used to add the turns required for the tap to B section. These turns may if necessary be on top of the existing coil, but must be in such a direction that A to B is effectively one continuous winding.

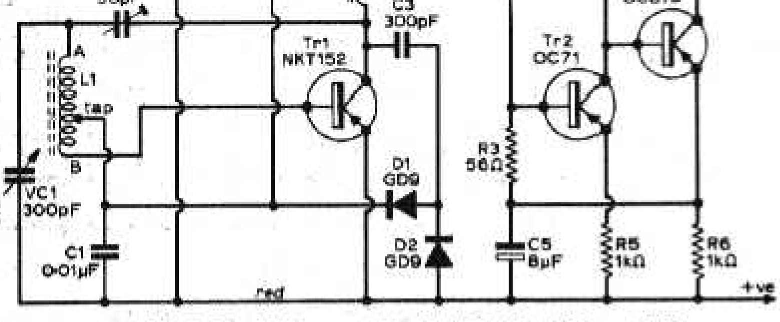


Fig. 1: Circuit diagram of the Mini-3. R3 is 56kΩ not 56Ω.

Receiver Panel

The paxolin panel is only 1⅞ × 1⅛in. so resistors etc. must be of the small size commonly used for small transistor receivers. The paxolin is 1/16in. thick and the holes for leads were made with a 1/16in. drill. The resistors, capacitors and diodes stand vertically. One lead passes down through a hole directly under the components, the other lead being covered with 1mm. sleeving and bent over to reach a second hole as shown in Fig. 2. D1, D2 and C4 are mounted with their positive ends on top so

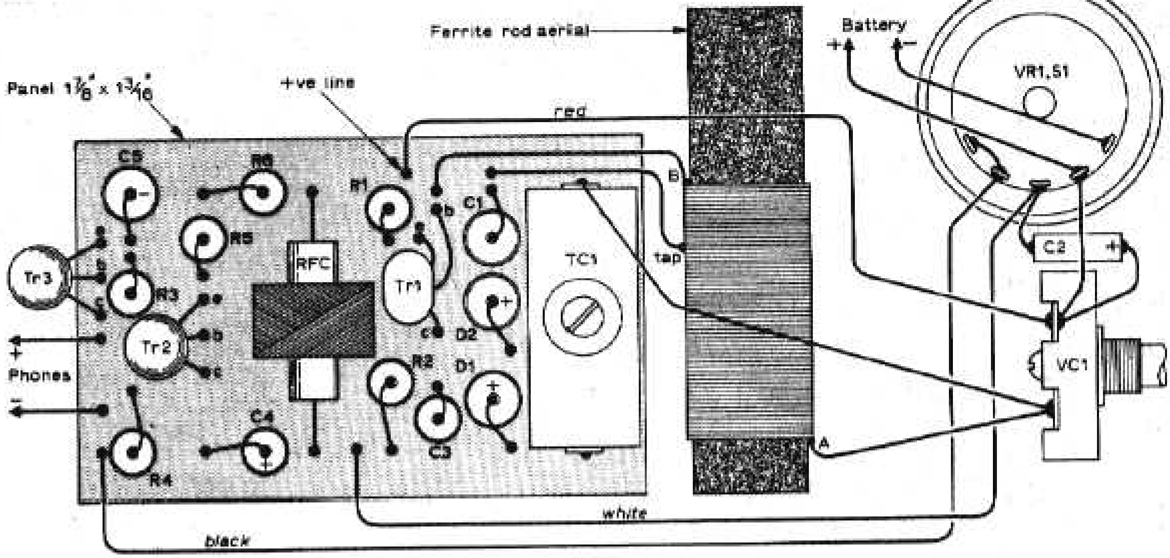


Fig. 2: Top view of paxolin board and connections to separately mounted components.

the negative ends emerge immediately under these components. C5 has its negative end uppermost.

Sleeving is also necessary on the transistor leads. The tops of the transistors are about ¼in. above the upper ends of the resistors etc. TC1 tags pass through slots made by drilling holes closely together, a central hole clearing the adjusting screw.

The panel is wired by turning it over and connecting as in Fig. 3. As there is little free space sleeving is used on nearly all wires. Transistor and diode connections must be soldered rapidly to avoid overheating. Unnecessary and lengthy heating of capacitors and resistors is also best avoided.

Pieces of thin insulated flex are soldered to the points indicated and will later be connected to VR1, VC1, and the aerial. If different colours are provided, as shown, this helps easy identification of the connections to be made later.

Phones

Excellent results are obtained with a full-sized headset but a miniature personal phone is easily carried in the pocket with the receiver. Short wire ends were left projecting at the phones points as shown in Fig. 2. When the receiver is in its case, pass the phone leads through a small hole and solder them to these points, covering the joints with sleeving.

If the phones may be changed from time to time a miniature jacket socket can be fitted to the case. The circuit is suitable for medium or high impedance phones, but not for crystal earpieces.

Other Components

VR1 is fixed to the outside of the box with an 8BA bolt, its five tags passing through holes. Should the material used for the box be too thick for the tags to pass right through, solder leads to the tags first, thread them through the holes, then fit VR1 in place.

VC2 is a compression type capacitor with fixing bush threaded for a 6BA bolt and is normally adjusted from the plates' side with a screwdriver. The bolt was removed and a longer one screwed in, the insulation and metal washers being kept as originally. A small disc or knob was then fixed on the free end of the bolt with lock nuts (a toothpaste tube cap can be used). Rotating the knob compresses or releases the plates of VC1 to alter its capacitance.

The ferrite rod was slightly shorter than the inside dimension of the box and was held with glue and a shaped slip of wood pushed between the box and one end of the rod.

The connections between the panel and other items in Fig. 2 can then be made. Figure 4 shows VC1 and VR1 in position: however, the various items could be rearranged to occupy different positions if this were more suitable for a box already available.

Leads were soldered directly to the battery. Alternatively the snap fasteners of an old battery

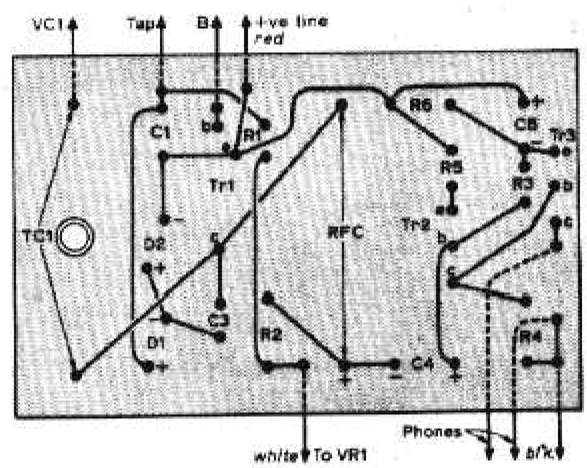


Fig. 3: Wiring on the underside of the panel.

could be used as connectors. If so remember to observe polarity as marked *on the battery itself*.

If a meter is placed in one battery lead the current drain should be zero with the receiver switched off and about 3mA when it is switched on, rising a little as VR1 is rotated. If a large current flows switch off at once and look for a wrong connection or short.

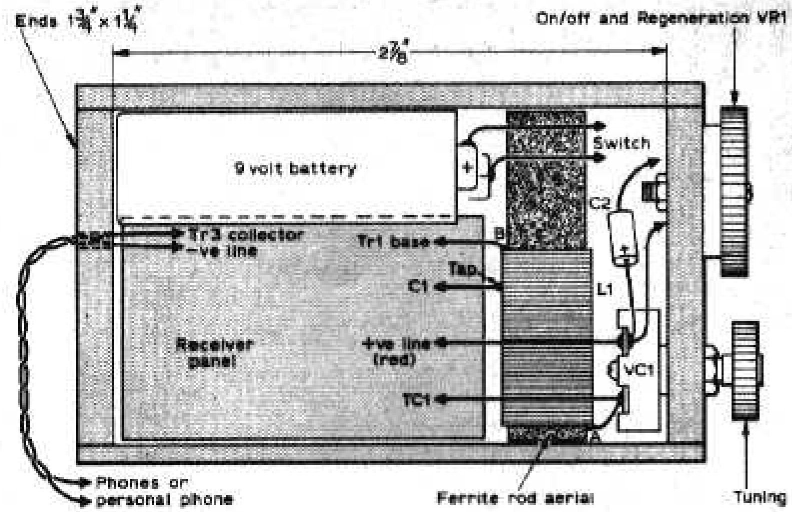


Fig. 4: Case dimensions and general assembly.

Adjustments

Regeneration arises more easily towards the high frequency end of the waveband but should be possible over the whole band when TC1 is suitably adjusted. Unscrew TC1, set VR1 about one-third from zero (off) and screw down TC1 slightly until oscillation arises on tuning through a station near the h.f. end of the band (VC1 near minimum capacitance).

If TC1 is screwed down too far oscillation arises with only a small rotation of VR1 and best volume is not obtained. But if TC1 is not screwed down sufficiently no regeneration can be obtained at the l.f. end of the band (VC1 at full capacitance).

For normal use only rotate VR1 as far as proves necessary for the volume required. Turning VR1 too far (as if it were a volume control) will cause oscillation or loss of signals. VR1 should not be rotated more than about one-half to two-thirds of its movement from the off position. If VR1 is used for critical control of regeneration, in the usual way for a t.r.f. receiver with adjustable reaction or regeneration, the receiver will be very sensitive to weak signals.

An external aerial should not normally be needed. However a few feet of thin insulated wire as a throw-out aerial can be clipped to A.

Case Construction

The box was made from clear Perspex, the ends being 1¾ × 1¼in. and ¼in. thick. The sides were ¼in. material, each 1¼ × 3⅜in. Top and bottom were both 3⅜ × 2in. This gives a case with internal dimensions of 2⅞ × 1¼ × 1¼in. The top was held with four small screws passing through clearance holes into the ends.

Tuning Range

With the ferrite-rod aerial described tuning covers the most important part of the medium wave band. Full coverage of this band is not achieved because the minimum capacitance of the 300pF compression capacitor is higher than the minimum capacitance of a conventional tuning capacitor.

In some parts of the country it may be felt desirable to tune to the low frequency end of the band. If so some turns should be added to the aerial winding. On the other hand should tuning to the high frequency end of the band be required a few turns can be removed from this winding.

★ components list

Resistors:			
R1	470kΩ	R5	1kΩ
R2	10kΩ	R6	1kΩ
R3	56kΩ	All miniature 10%	
R4	10kΩ	VR1	25kΩ with switch
Capacitors:			
C1	0·01μF miniature		
C2	2μF 9V electrolytic		
C3	300pF miniature		
C4	2μF 6V electrolytic		
C5	8μF 4V electrolytic		
VC1	300pF compression capacitor		
TC1	30pF trimmer		
Semiconductors:			
Tr1	NKT152	D1	GD9
Tr2	OC71	D2	GD9
Tr3	OC81D		
Miscellaneous:			
R.F.C.	5mH or similar		
L1	See text		
Paxolin board, wire, battery, etc.			

REFLEX-3 PORTABLE RECEIVER

by

ARMAN SAPCIYAN

IT IS QUITE EASY TO OBTAIN GOOD RESULTS FROM A SIMPLE receiver using 3 transistors only. The set to be described employs 3 transistors in an inexpensive and reliable circuit design, and it readily falls into this category. Like other home-constructor designs of similar type, however, it has one or two tricky points which affect the overall performance; but if these are properly catered for construction raises few difficulties.

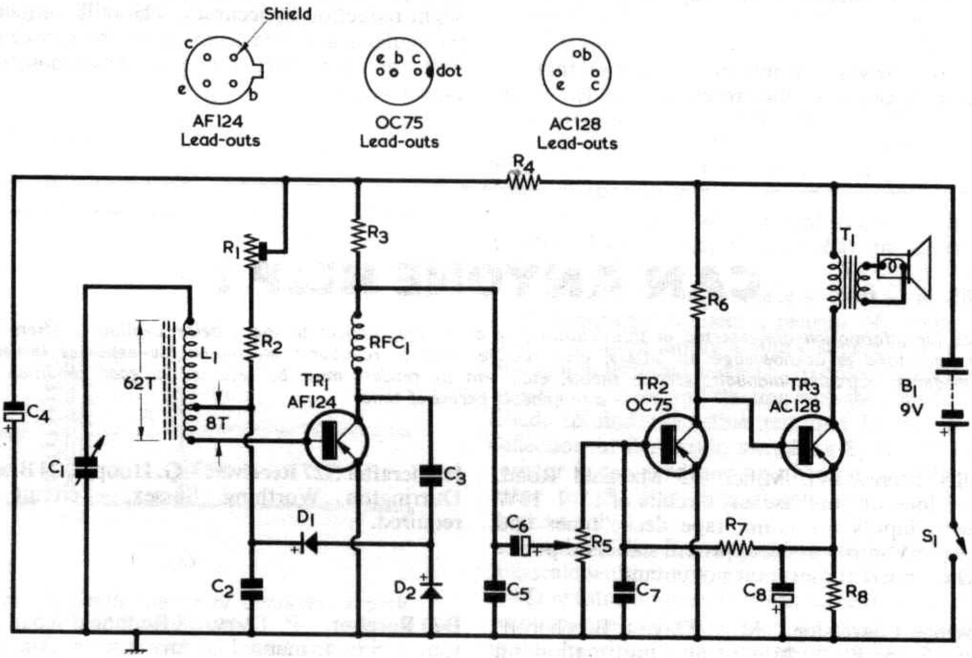
REFLEX CIRCUIT

The circuit of the receiver appears in the accompanying diagram. In this, L_1 is a medium wave ferrite aerial, with a coupling coil which feeds the base of TR_1. The aerial coil is tuned by C_1.

TR_1, in conjunction with diodes D_1 and D_2, functions as a reflex amplifier. It first amplifies the r.f. signal applied from the ferrite aerial to its base, the amplified signal appearing at its collector. The choke RFC_1 prevents this signal passing to the second stage and it is applied instead, via C_3, to the voltage doubler diode circuit given by D_1 and D_2. These detect the signal which is then re-applied, as a.f., to the base of TR_1 for further amplification. The amplified a.f. signal now passes through RFC_1 and is next fed via C_6 to the volume control R_5. Capacitor C_5 bypasses any residual r.f. that may still be present after RFC_1, whilst R_4 and C_4 decouple the TR_1 stage from the rest of the receiver.

Resistors R_1 and R_2 in series provide base bias current for TR_1, and it will be found that if this current is increased above a certain point the transistor oscillates. R_1 is in consequence adjusted so that TR_1 is just below the oscillation point over most of the band received, whereupon the resultant regeneration considerably improves the overall selectivity and sensitivity of the receiver. In some previously published designs using this type of reflex circuit it has been common practice to specify a single fixed resistor in place of R_1 and R_2, the constructor being advised to find the best value by experiment. Such an approach is time-wasting and can lead to the accidental damage of other components whilst different values of resistor are being soldered in. The present circuit is much simpler and enables the receiver to be set up without difficulty.

One of the incidental advantages given by this class of reflex circuit is that R_1 and R_2 provide a small forward bias for diodes D_1 and D_2, with the result that their detection efficiency is enhanced. Again, the rectified output from D_1 is positive-going, so that strong signals cause the base of TR_1 to go slightly positive whereupon its gain is reduced and it becomes partly removed from the state where it is just short of oscillation. The circuit therefore



The circuit of the Reflex-3 Portable receiver

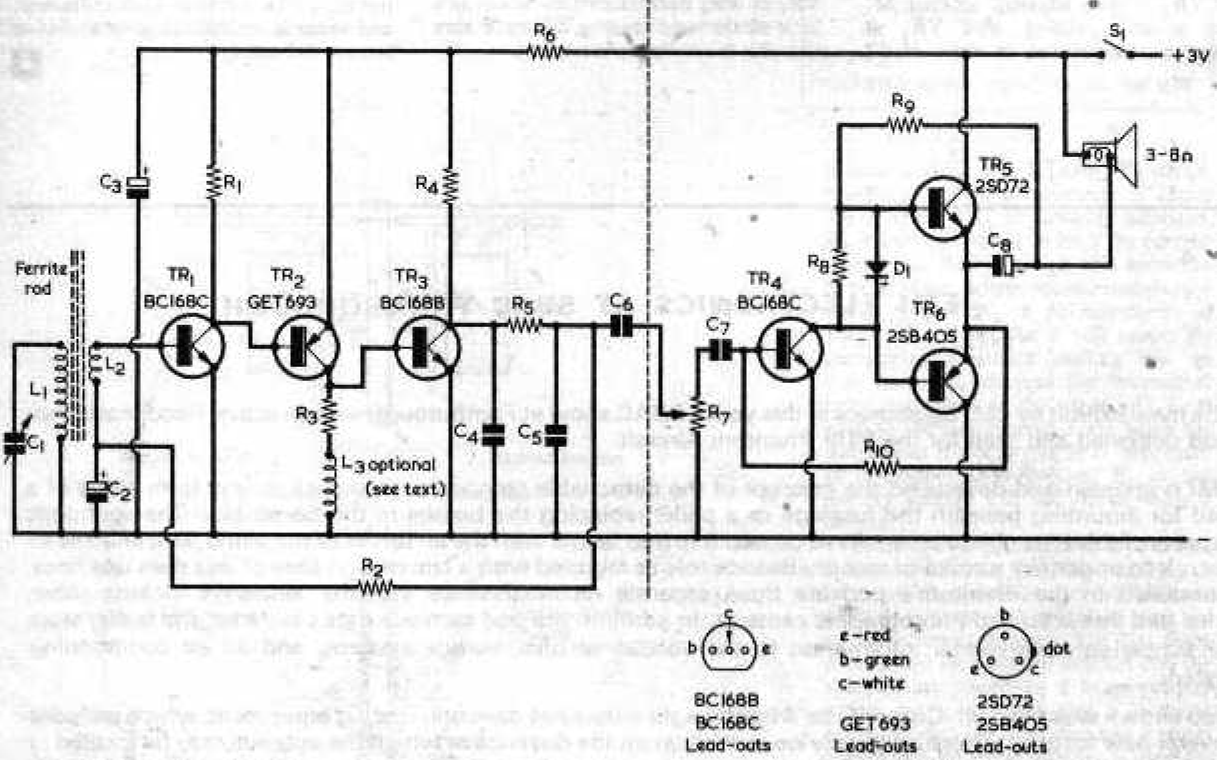


Fig. 1. The circuit of the 3 volt receiver. The ferrite aerial coils, L_1, L_2, are intended for medium wave reception only.

3-VOLT T.R.F. RECEIVER

by

G. W. SHORT

Operating from a 3 volt supply only, this neat receiver design offers loudspeaker reproduction either on medium waves only or on medium and long waves. It is assumed that the constructor is able to find the required turns on the ferrite aerial rod experimentally; this process is quite simple and detailed information is provided.

The main attraction of operating a receiver from a low voltage battery, as far as the writer is concerned, is simply that 1·5 volt cells are so cheap, compared with the usual 6 volt or 9 volt batteries. The logical conclusion to this argument would be to use a single 1·5 volt cell to power the receiver. However, it turns out that in this case, as in others, it is dangerous to take things straight to their logical conclusion. When loudspeaker reception is required, and one of the now-popular "transformerless class B" output stages is envisaged, the efficiency of a 1·5 volt circuit is too low. The receiver described here was therefore designed to operate from 3 volts. With pen-cells at less than sixpence each, compared with half a crown for the usual "transistor batteries", the economics is still very favourable. It is also possible, nowadays, to buy from component retailers neat little plastic holders which take a pair of pen-cells. By using one of these instead of a makeshift holder a significant increase in reliability is obtained.

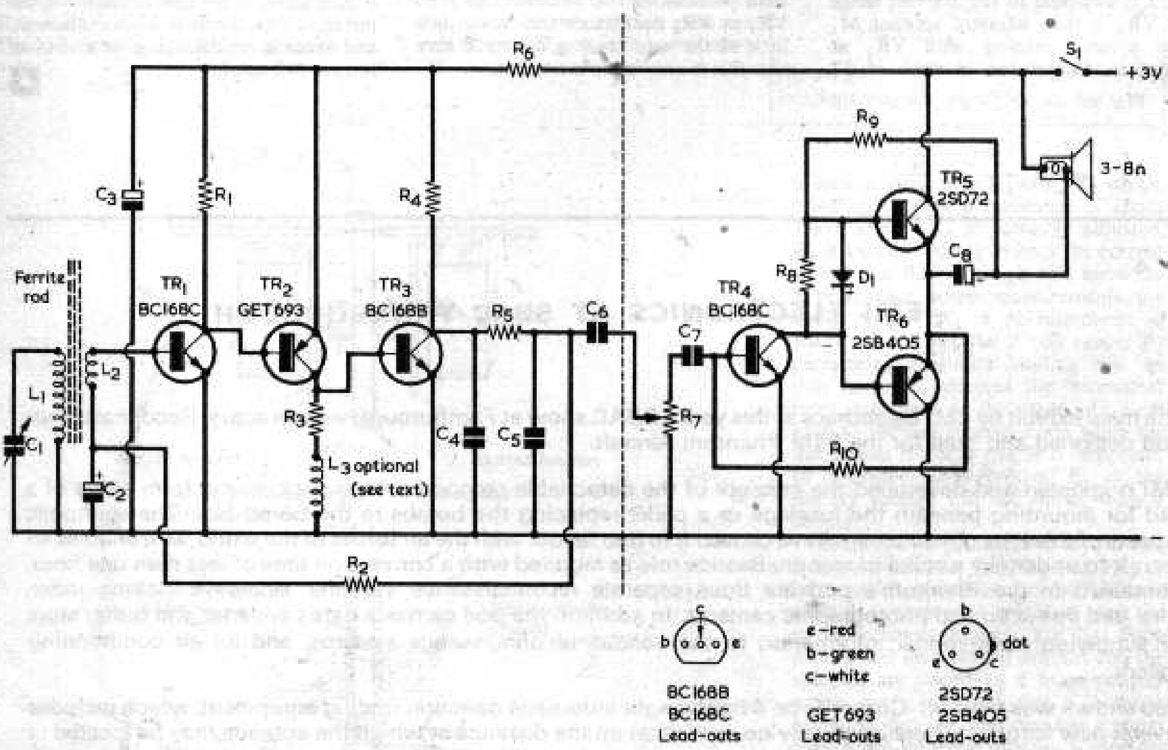


Fig. 1. The circuit of the 3 volt receiver. The ferrite aerial coils, L_1 L_2, are intended for medium wave reception only.

"CIRCUIT BLOCK" DESIGN

The design shown in Fig. 1 is really a combination of

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3-VOLT T.R.F. RECEIVER

(Continued from page 160)

two basic "circuit blocks" either of which may be used on its own. The first three transistors form a two-stage wide-band r.f. amplifier and detector; this part of the circuit (to the left of the dashed line) may be used as a radio tuner unit to drive an existing amplifier. The a.f. output is quite large (up to about 0·25 volt peak), and is sufficient to drive most types of amplifier. The remainder of Fig. 1 is a complementary class B transformerless audio amplifier, capable of being built into a small space, and of delivering 100mW into a speaker of 3 to 8Ω impedance.

The "tuner" part of the circuit consumes only 1mA, while the amplifier has a standby (no-signal) consumption of 3mA, and both will operate from fairly run-down cells.

TUNER SECTION

This is designed to give a good performance on medium or long waves even if "reaction" is not used. Many t.r.f. designs rely on reaction for their sensitivity, but good performance can then only be obtained at the price of critical adjustment of the reaction control. This circuit operates quite well without any reaction; selectivity on medium and long waves is quite good with a ferrite rod aerial, particularly if this is wound with Litz wire or fairly thick solid wire and the coupling to the first transistor is optimised. The only region in which better selectivity is then likely to be needed is the high frequency end of the medium-wave band, and a bit of preset reaction takes care of this.

The input stage uses a very-high-gain silicon planar transistor type BC168C. This is an epoxy-encapsulated transistor electrically identical to the metal-cased BC108, but selected for high gain (h_{fe} = 450 to 900). Use of a high gain input transistor means that, with a two-stage r.f. amplifier, the input impedance is high. This in turn enables the tuned circuit to be coupled to the base of the input stage with rather more turns than usual, which is equivalent to increasing the signal strength.

It should be noted that, in the case of a single-stage amplifier, the input impedance remains low even when a high-gain transistor is used. This effect is due to "Miller feedback"; i.e., voltage negative feedback from collector to base via the internal capacitance of the transistor. The higher the collector load, the lower the input impedance. In a two-stage r.f. amplifier like the present one, the Miller feedback in the second stage has the effect of presenting the collector of the first stage with a low-impedance load. This reduces the Miller feedback in the first stage and restores the input impedance to something like the no-feedback value. More turns can then be put on the coupling winding.

The use of "complementary cascade" circuitry (n.p.n. – p.n.p. – n.p.n.) enables the three transistors of the tuner section to be coupled directly, thereby saving a handful of coupling capacitors and bias resistors. D.C. negative feedback via the one bias resistor, R_2, establishes the correct operating conditions for the complete tuner, and also provides a certain amount of a.g.c. action. (The collector potential of the detector transistor TR_3 falls when a station is tuned in. This reduces the bias of TR_1 and the resulting fall in collector current reduces the drop across R_1, which causes the collector current of TR_2 to fall rather sharply.)

If desired, the gain of the r.f. amplifier can be increased by inserting an r.f. choke of around 1·5mH (not critical) in series with R_3, the collector load resistance of TR_2. This choke is shown in the diagram as L_3. (If L_3 is omitted, the lower end of R_3 connects directly to the negative supply line.) The inclusion of L_3 also adds one possible way of introducing "reaction". If L_3 is anywhere near the ferrite rod there will be enough inductive coupling between the two to cause an appreciable amount of feedback between the output and input of the r.f. amplifier.

COMPONENTS

Resistors

(All fixed values ¼ watt 10%)

R_1	2·2kΩ
R_2	1·5MΩ
R_3	1kΩ
R_4	10kΩ
R_5	4·7kΩ
R_6	470Ω
R_7	10kΩ potentiometer, log track
R_8	100Ω (see text)
R_9	680Ω
R_{10}	330kΩ

Capacitors

C_1	See text
C_2	2·5μF electrolytic, 3V wkg.
C_3	125μF electrolytic, 3V wkg.
C_4	0·01μF
C_5	0·01μF
C_6	0·1μF
C_7	0·22μF
C_8	320μF electrolytic, 2·5V wkg.

Inductors

L_1, L_2	See text
L_3	Optional, type CH5 (Repanco)

Semiconductors

TR_1	BC168C
TR_2	GET693
TR_3	BC168B
TR_4	BC168C
*TR_5	2SD72
*TR_6	2SB405
D_1	Germanium bias diode

*Complementary matched pair.

Switch

S_1 s.p.s.t. on-off (may be ganged with R_7)

Speaker

3 to 8Ω impedance

Miscellaneous

2 1·5-volt "pen-light" cells

1 Battery holder type BH2 (Eagle Products) or similar.

If this feedback is negative, sensitivity and selectivity are reduced. If the feedback is positive, sensitivity and selectivity are increased, very possibly to the extent that

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3-VOLT T.R.F. RECEIVER

(Continued from page 163)

the receiver oscillates. What governs whether the feedback is negative or positive is the relative direction of the windings, and reversing any one winding reverses the feedback. Rather than attempting to work out the appropriate directions of all the windings it is simpler in practice to connect L_3 with loose leads so that the choke can be twisted round through 180 degrees. It can then be oriented to produce just the right amount of feedback, whereupon it provides a preset reaction control.

An alternative simple way of introducing reaction does not require the presence of L_3. Connect a short stiff insulated wire to the base of TR_1, and bring the free end near R_3. This causes capacitive coupling, and it is always in the correct direction to produce positive feedback, irrespective of the direction of the windings on the aerial rod. (This is, incidentally, another advantage of two-stage r.f. amplifiers.) If simply placing the wire near to or touching the body of R_3 is insufficient to produce oscillation, wrap it round R_3 two or three times. If this does not do the trick then there is something wrong somewhere (e.g. not enough turns on the base winding, or of course a genuine fault in wiring or components). Oscillation occurs first near the h.f. end of the medium wave band, and the "reaction probe" wire should be positioned so that oscillation just fails to occur when the battery is new.

The last two paragraphs assume that reaction is needed. In many cases performance will be adequate without it.

DECOUPLING AND FILTERING

One very important item in the general circuitry of the tuner section has not so far been mentioned. This is the decoupling and filtering. In the collector supply line, R_6 and C_3 prevent a.f. signals from the output stage getting back to the tuner circuit, where they could cause instability or distortion. At the same time, the RC low-pass filter formed by C_4, R_5, and C_5 removes r.f. signals from the a.f. output of the detector. These signals might otherwise get back to the input and cause h.f. oscillation, a fault very common in home-made receivers but apt to be puzzling to the constructor since it usually shows up as violent a.f. oscillation of the "motor-boating" variety. (The circuit becomes a squegging oscillator, the r.f. oscillations choking themselves periodically at an audio or very low frequency.) This type of oscillation is apt to be expensive as well as puzzling, since it often destroys one of the transistors.

Another important part of the receiver – probably the most important – is the ferrite aerial. It is rather difficult to give precise winding instructions because the characteristics of ferrite vary somewhat, as do the size of commercial rods and the capacitance of the associated tuning capacitor. In general, with ferrite aerials as with boxers, a good big 'un is better than a good little 'un. Performance is always improved, barring some unpredictable effect caused by stray feedback, if the rod is well clear of all wiring and metal parts such as the loudspeaker magnet or tuning capacitor. As a guide, the rod aerial in the prototype was as follows (the data applying for medium waves):

$4\frac{1}{2}$ by $\frac{3}{8}$in round rod, in Plessey NW25 ferrite.
Tuned winding: 60 turns, 5/46 s.w.g. Litz, close-wound.
Base winding: 10 turns of thin hookup wire, close-wound.

This rod was used with a 300pF Jackson "Dilemin" tuning capacitor. (Some further points concerning the ferrite aerial appear in the Note at the end of this article.—Editor.)

Before winding the aerial coils, the rod was wrapped with two turns of thin cardboard (the kind used for postcards). The use of a cardboard wrapping under the windings means that the coils have a former which is capable of being slid along the rod, and this is very useful for fine adjustment of the inductance. For long wave operation any of the conventional arrangements may be employed. The best is to have a long rod with the medium wave coil near one end and the long wave coil near the other, each with its own coupling winding. A two-pole two-position switch with one moving contact connected to the live side of the tuning capacitor and the other to the base of TR_1 can then be used to switch the live sides of the appropriate coils into circuit. See Fig. 2. The presence of the long wave tuned winding on the rod, even when it is nominally switched out of circuit, affects the medium wave tuning. If the rod is too short (less than about 6in) it may be almost impossible to achieve two-band operation; the medium wave circuit will be pulled right off tune and the selectivity reduced. In this case it is better to dispense with full long wave coverage and settle for one long wave station only. Radio 2 on 200kc/s (1,500m) is the obvious choice in Britain. This can be tuned by switching a fixed additional capacitance across the medium wave coil after the latter has been satisfactorily set up for medium wave reception, the tuning capacitor being left in circuit to serve as a fine tuning control. The value of fixed capacitance required is approximately 7 times the maximum value of the medium wave tuning capacitance; in the case of a 300pF tuning capacitor the nearest standard value would be 2,200pF. A little experiment may be required to find the value which tunes the Radio 2 signal correctly. The additional fixed capacitor should be silver-mica, and not ceramic. A single-pole on-off switch is all that is required for switching the extra capacitance into circuit, as is shown in Fig. 3.

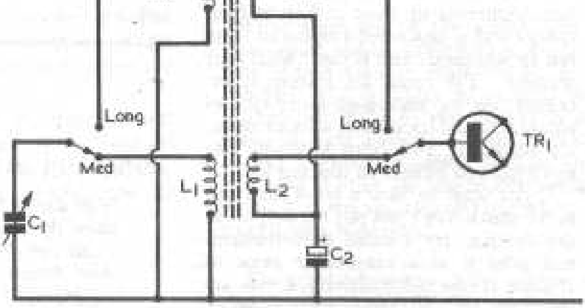


Fig. 2. If the ferrite rod is sufficiently long, tuned and coupling windings for long waves may be added. A double-pole double-throw switch is used for selecting wavebands

AUDIO AMPLIFIER SECTION

The audio amplifier section is quite conventional and the only point that needs watching is the biasing of the output pair. Diode D_1 is a germanium junction diode, or a gold-bonded diode (*not* a point-contact type). These diodes have a forward voltage drop of around 250mV at low currents. This is slightly greater than the base-to-base voltage needed to bias the output pair into conduction (I_c = 1mA), and it is reduced by shunting the diode by R_8. Variations in diodes and transistors may dictate values in R_8 slightly different from the nominal 100Ω quoted in the Components List, if the quiescent current of the output pair is to be set at exactly 1mA. Too low a resistance causes crossover distortion, and too high an excessive quiescent current. The current may be checked by a meter in series with TR_6 collector.

The collector current of the driver has the rather low value of 2mA in this circuit because the output transistors are high-gain types (h_{FE} at least 100 at I_c = 200mA), requiring only a small base drive current from TR_4.

Loudspeakers with impedances over 8Ω may be connected, but the output power will be reduced. The amplifier consumes about 30mA during loud passages of pop music when the peaks are lightly clipped.

CONSTRUCTION

Construction presents no special problems. The prototype was made up in "pin-board" form; i.e., the components were soldered to anchorage points made by driving ordinary bright new domestic pins into a wooden baseboard and then cutting off the heads, leaving about $\frac{3}{8}$in for use as solder tags.

Keep the r.f. wiring short and direct to reduce stray capacitance. Run the negative supply lead from the battery first to the collector of TR_6 and then to the tuner section. This reduces the risk of instability from stray coupling in the "earth" lead, a common fault in power amplifiers of this type where the large circulating currents in the output stage can set up appreciable voltages even across a few inches of plain wire.

It is a good idea to mount the ferrite rod, speaker, tuning capacitor, volume control, and any switches on a front panel, which can be made of Formica or other insulating board.

As a final point, this circuit is a variation on a design which has been in use in various parts of the world for some years now and it has proved to be simple to construct and reliable in use.

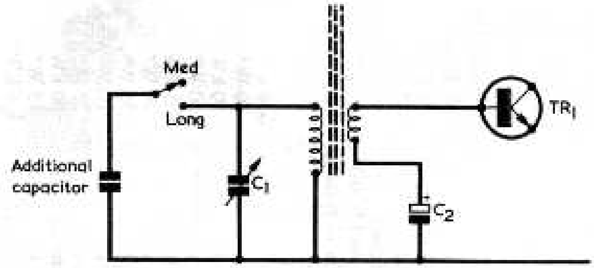


Fig. 3. With this simpler approach, the switch connects an additional capacitor across the tuned circuit for pre-tuned reception of Radio 2 on 1,500 metres.

EDITOR'S NOTE

As stated in the article, the number of turns on the ferrite rod depend on rod dimensions and ferrite grade. Any of the ferrite rods offered through home-constructor retail channels will be satisfactory here and it would be best to start with the medium wave band, using the 60 turns recommended by the author and reducing these if necessary until the desired medium wave coverage is obtained. Modern Litz wire is normally of the solder-through type and the soldering iron can be applied directly to the enamelled strands without previous stripping. A tuning capacitor, either air-spaced or with "Dilemin" insulation, of 300 or 310pF maximum capacitance will be satisfactory. The medium wave coupling winding (the author used hookup wire) can be of 20 to 16 s.w.g. in thickness. For maximum coupling it should be wound over the earthy end of the tuned winding, the end connecting to C_2 being over the end of the tuned winding connecting to the negative supply rail.

In general, the long wave tuned winding will require slightly less than 4 times the number of turns needed for medium waves. A suitable wire for both tuned and coupling windings on long waves is 36 s.w.g. double rayon covered enamelled copper, or similar. The tuned coil may be wound in a single pie, with the coupling winding close alongside. Again, it will be found easiest to wind on a few too many turns, then take these off until the desired range is achieved.

The coupling winding, on both medium and long waves, should have about one-sixth of the turns in the tuned winding.

A range of Litz wires, including 5/46, is available from Home Radio (Components) Ltd.

provides a degree of a.g.c. action and ensures that greatest regeneration is reserved for weaker signals.

The TR_1 stage is sufficiently sensitive to operate a pair of high resistance headphones connected across R_3.

A.F. STAGES

A.F. amplification is provided by TR_2 and TR_3. Direct coupling is employed from the volume control R_5 right through to the speaker transformer primary, thereby enabling a good performance to be obtained with a minimum of components. R_7 provides d.c. feedback and keeps the two stages stabilised. Capacitor C_7 functions as a bypass for the higher audio frequencies and, as is described later, may require adjustment to suit the particular speaker employed.

If a high impedance speaker, of around 150Ω, is available, this can be connected directly in place of T_1 primary, whereupon this transformer is not required. For lower impedance speakers, T_1 should present a primary impedance of around 150 to 250Ω to the collector of TR_3. (A suitable component for T_1 is the Radiospares Transistor Transformer type T/T4. This will match TR_3 to a 3Ω loudspeaker. The T/T4 transformer is readily available from component mail order houses.—*Editor*).

TRANSISTORS

The transistor specified for the first stage is an AF124, which is intended for v.h.f. operation. Alternative choices for TR_1 are AF126 or AF127, but the writer found that these did not provide quite as much gain as the AF124. When compared with a medium wave transistor like the OC44, the AF124 is much to be preferred. Its shield lead-out is ignored, and is *not* connected to chassis.

TR_2 is not very critical and a number of high gain a.f. types were tried with roughly equivalent results. An OC75 functioned well and this is specified in the Components List.

The output transistor, TR_3, should preferably be a high gain type also, although fairly adequate results would be obtained even with an OC72 or similar. (The author tried both an AC153K and an AC117, with equal results, in the prototype. These are not readily available in the U.K., and an AC128—"comparable" with the AC117—is quoted in the Components List.—*Editor*.).

The diodes D_1 and D_2 were OA70's in the prototype. Other germanium diodes should be satisfactory, but they may require changes in the value of R_2.

INDUCTORS

The aerial coil, L_1, is wound on a ferrite slab 3in long, $\frac{3}{4}$in wide and $\frac{1}{8}$in thick, and the total number of turns is 62, with the earthy tap 8 turns from the end which connects to TR_1 base. The coil should be close-wound on a paper sleeve which permits it to be slid along the slab for the required frequency coverage. Slabs of approximately the same dimensions as that used by the author (such as the $4\frac{5}{8}$ by $\frac{1}{2}$ by $\frac{5}{32}$in slab available from Henry's Radio.—*Editor*) will be satisfactory, although it may be necessary to add, or take off, several turns at the end which connects to C_1 to provide the requisite range. The wire is 26 s.w.g. enamelled copper.

In the prototype, choke RFC_1 consisted of the primary of a miniature transistor i.f. transformer with its internal parallel capacitor (200pF) disconnected. (Any internal capacitor across the secondary should also be disconnected.). The secondary winding and any taps in the primary are ignored, no connections being made to these. Some advantage was provided by the fact that the dust core position could be adjusted for best regeneration. The can was earthed to the positive supply line. However, the use of an i.f. transformer in this manner is put forward as an experimental approach only, and constructors may employ a standard r.f. choke instead. (A 2·5mH choke such as the Repanco CH1 would be satisfactory.—*Editor*.). A home-wound choke could also be made up by winding about 450 turns of 36 s.w.g. single rayon covered enamelled wire on a 1 watt 20% resistor of 1MΩ or more, the ends of the winding being soldered to the resistor lead-outs.

ADJUSTMENT AND OPERATION

With the prototype, current consumption was 10mA from the 9V battery, and the output power from the speaker was of the order of 50mW. A PP3 battery is satisfactory for running the receiver under these conditions. Output power may be increased by reducing the value of R_8 to 100Ω, whereupon the total current rises to 17mA. A PP3 battery is not recommended for this higher current since its life will be reduced by more than half, and a larger battery should be used.

The function of C_7 is to remove distortion at the higher audio frequencies, such distortion being most noticeable with small diameter speakers. With some speakers, it may be preferable to use 0·02μF or 0·03μF in the C_7 position or, even, to omit the capacitor altogether. The reader is advised to build the receiver and bring it up to worki

COMPONENTS

N.B. Some of the components listed below may require adjustment. Details are given in the text.

Resistors
(All fixed values $\frac{1}{4}$ watt 10%)

R_1	250kΩ variable, skeleton preset
R_2	100kΩ
R_3	4·7kΩ
R_4	1kΩ
R_5	10kΩ potentiometer, log, with switch
R_6	4·7kΩ
R_7	33kΩ
R_8	150Ω

Capacitors

C_1	365pF, variable
C_2	0·01μF, paper or plastic foil
C_3	330pF, ceramic
C_4	30μF, electrolytic, 10V wkg.
C_5	0·005μF, paper or plastic foil
C_6	5μF, electrolytic, 10V wkg.
C_7	0·05μF, paper or plastic foil
C_8	100μF, electrolytic, 6V wkg.

Inductors
All inductors are described in the text.

Semiconductors

TR_1	AF124
TR_2	OC75
TR_3	AC128
D_1, D_2	OA70

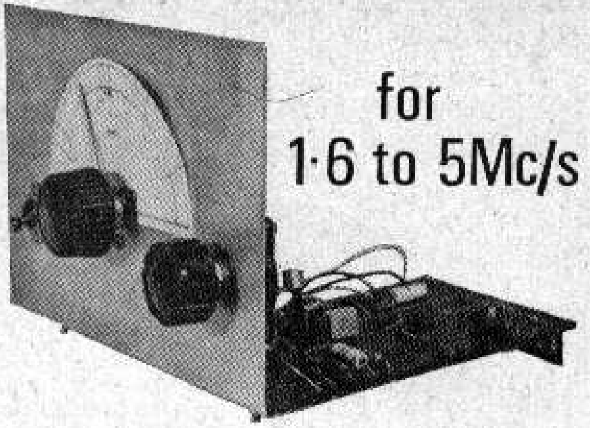
Switch
S_1 s.p.s.t., part of R_5

Battery
B_1 9 volt battery

Loudspeaker
See text

RÉFLEX FRONT END

for 1·6 to 5Mc/s



by V. S. EVANS

REFLEX circuits have a reputation for being gimmicky and unstable. This one has proved reliable in various applications and the unit described should present no difficulties provided the layout is strictly adhered to and the coil wound exactly as detailed.

The output can be fed into a conventional transistor a.f. amplifier with volume control, a four transistor push-pull type having proved adequate in sensitivity and gain. Space is available behind the panel for an additional paxolin board or veroboard on which an a.f. section can be mounted if desired.

Circuit Description

The aerial is fed via a 250pf trimmer capacitor to an aperiodic winding on the coil, loosely coupled to the tuned secondary winding, which in turn passes the tuned r.f. signal to the transistor base via a third inductive winding. The r.f. signal is amplified by the AF118 and then passed to the diode where the signal is demodulated and the resultant a.f. fed back to the base of the transistor via the 0·1μF capacitor.

The signal is again amplified and being a.f. passes through the 2·5mH choke and buffer capacitor to the output.

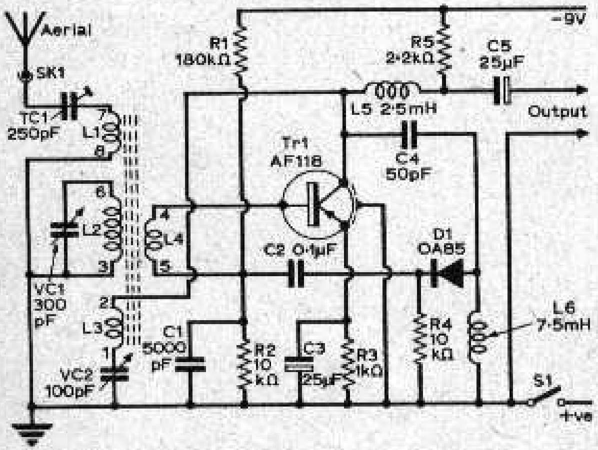


Fig. 1: Circuit of the reflex front end.

Regeneration is accomplished by a positive feedback loop (r.f.) from the collector to the tuned circuit and controlled by the 100pF variable capacitor.

The transistor is stabilised by the potential divider resistors in the base circuit and the resistor/capacitor network in the emitter line. A 10kΩ resistor gives bias to the diode.

It will be seen that the theoretical diagram coincides closely to the layout drawing showing the reverse side.

The tuning capacitor can for convenience be one section of a two gang, or the two sections in parallel provided this equals about 300pF. The one used by the writer was a surplus 196 +110pF having a slow motion spindle, thus avoiding an expensive slow motion dial. The panel is aluminium to minimise hand capacity effects.

The coil is made from a 2in. ferrite rod $\frac{5}{16}$in. diameter, around which is glued a sleeve of thin card. A further sleeve 1¼in. long is made to fit loosely over the previous one and is the coil former. The clear, quick setting glue sold in tubes is best for this job. The wire used may be 26 s.w.g. enamelled (or cotton covered) and the windings should also be

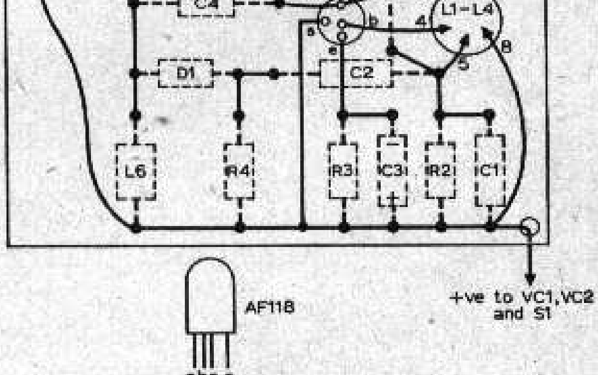


Fig. 2: Layout and wiring diagram. Components shown dotted, are on the reverse side.

★ components list

Resistors:

R1	180kΩ	R4	10kΩ
R2	10kΩ	R5	2·2kΩ
R3	1kΩ		

all 10% ½W

Capacitors:

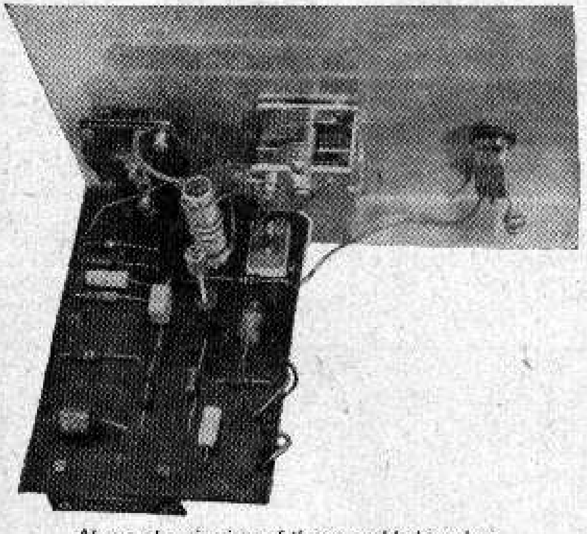
- C1 0·005μF
- C2 0·1μF
- C3 25μF 12V electrolytic
- C4 50pF
- C5 25μF 25V electrolytic
- VC1 300pF air spaced
- VC2 100pF solid dielectric
- TC1 250pF compression trimmer

Inductors:

- L1, L2, L3, L4 see text and Fig. 3 for winding details
- L5 2·5mH r.f. choke
- L6 7·5mH r.f. choke

Miscellaneous:

8 x 6in., 18 s.w.g. aluminium; 5 x 4in. $\frac{1}{16}$in. paxolin; AF118 transistor; OA85 diode; S1 on/off toggle switch; battery clips; PP3 9V battery; transistor holder.



Above chassis view of the assembled receiver.

smeared with glue to keep them in position. The ends are taken through holes made in the former to the inside and brought out through the ends as per diagram.

It will be seen that leads 1 and 2 are kept away from the others as they are "lively" and carry the r.f. feedback.

The usual precautions should be observed when soldering small components to avoid overheating. The layout ensures that all leads are kept short and direct. In most instances the actual component wire ends can be used for wiring up. Where extra lengths of wire are required it will be found that 18 s.w.g. tinned copper wire will meet all requirements. Before

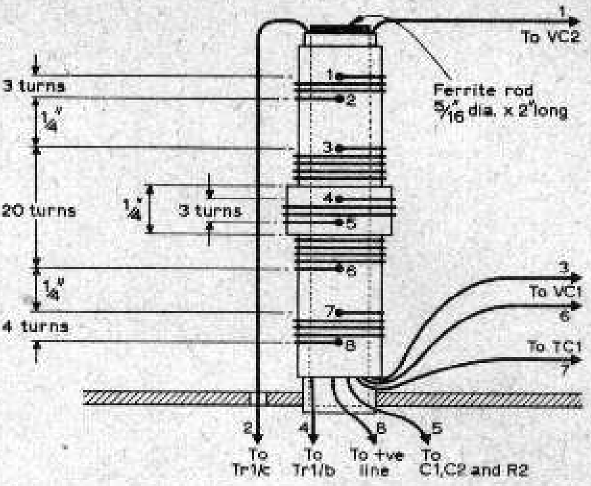


Fig. 3: Coil winding, see text for further details.

connecting the battery, make sure that all wiring is correct, as the transistor can become damaged.

Ensure that the collector is not in any way shorted to earth in connecting the regenerative capacitor. A solid dielectric type has been chosen as a protective measure, but if an air-spaced type is to hand it is as well to connect a 0·01μF capacitor in series as an added precaution.

Tuning Procedure

Tuning is best carried out by bringing the circuit to the threshold of oscillation, with the regenerative capacitor, and then rotating the tuning capacitor through the frequency range. It is important *not* to let oscillation actually take place (whistles or squeals from the loudspeaker) as in this condition the aerial is radiating and may cause interference to other listeners. The 250pF trimmer will help to match the aerial/earth system used and balance sensitivity with selectivity.

For the experimenter the range of frequencies covered may be altered to suit personal requirements by adding or subtracting to the number of turns on the main winding of the tuning coil. Up to ten turns off will bring in the 49 metre band whilst adding ten turns will bring in Radio Luxembourg. ■

order with C_7 at 0·05μF. The value of C_7 may then be changed experimentally, if necessary, to suit the particular speaker employed.

When the receiver has been completed it is first of all necessary to set up R_1. A new battery should be fitted for this process. Initially adjust R_1 such that the receiver is just below oscillation point over most of the band covered. If oscillation cannot be obtained, reduce R_2 to 68kΩ. With the prototype it was found that the 100kΩ value specified for R_2 was satisfactory for a wide range of transistors in the TR_1 position. Remember that if RFC_1 is unscreened the onset of oscillation will depend to some extent upon any inductive coupling it may have to the ferrite aerial coil. RFC_1 should be mounted several inches away from L_1 and with its axis at right angles to that of L_1. Some control of the oscillation point may then be given by orientating it relative to the ferrite aerial coil, and this factor may be helpful in some cases. After R_1 has been initially set up it does not need to be touched again.

A suggested alternative method of using R_1 is to fit it to the front panel as a normal 250kΩ linear potentiometer and employ it as a sensitivity control. It may then be adjusted for optimum sensitivity on each received station. In this instance, R_5 is not required in variable form and may be replaced by a fixed resistor of the same value, with C_6 connecting direct to its upper end. The on-off switch may then be provided by a separate slide or toggle switch. However, this alternative scheme is offered as a suggestion only, since the circuit gives excellent results as it stands.

As a final point there is a very slight risk of inductive a.f. feedback coupling between the output transformer and the ferrite aerial. If this occurs the connections to the output transformer primary should be reversed. There was no trouble on this score at all with the prototype, and it is only mentioned in case the constructor encounters the snag and does not know how to deal with it.

HIGH PERFORMANCE T.R.F. TUNER UNIT

by

J. MORLEY

The simple medium and long wave tuner unit incorporates an unusual r.f. amplifier circuit to obtain a high level of selectivity and sensitivity

THE MAIN DISADVANTAGE OF SIMPLE "STRAIGHT" receivers is their lack of selectivity. The inherent low input impedance of a transistor in the normal common emitter configuration loads the preceding tuned circuit and reduces the effective "Q" of its coil. The result is poor selectivity and, at worst, the overlap of signals. Tertiary windings on the coils help but are not, at any rate in the writer's experience, a successful answer to the problem.

LONG-TAILED PAIR

In order to produce a simple high performance tuner that could really separate stations without the use of field effect transistors, the writer looked again at the long-tailed pair configuration. Its basic use in the present application is illustrated in Fig. 1.

In this diagram the first transistor, because of current feedback, has a reasonably high input impedance—enough, anyway, not to drastically load the type of coils the writer would use. The second transistor is effectively in grounded base, being driven by the common emitters, and the output impedance would also be reasonably high.

With these factors in mind some experiments were carried out, these culminating in the complete tuner unit circuit shown in Fig. 2. Here, TR_1 and TR_2 are the long-tailed pair, these appearing between standard Denco Miniature Dual Purpose Transistor coils. The coils are Range 1T for long waves and Range 2T for medium waves, and may be plugged into B9A valveholders as required. The numbers alongside the windings in the circuit diagram indicate the valve pins to which connections should be made. The two coils should be screened from each other.

The coils are tuned by the 2-gang capacitor C_1C_2, with trimmers C_3 and C_4. Normally the trimmers may be set up for best results at the high frequency end of the medium wave band.

The output from the second tuned circuit is fed into transistor TR_3, which is biased back on the lower part of its characteristic curve to work as a detector in rather a similar manner to the old anode-bend type. The a.f. output is obtained via L_{11}.

In practice, the circuit works extremely well, with very effective selectivity and good audio quality.

Before concluding, some points need to be made concerning components. An OC170 is specified for TR_3, and it was found that this was the only type that would function as an efficient detector with the component values given for the circuit. Its shield lead-out can be left unconnected.

It may be found of advantage to experiment with R_5 to meet the requirements of specific transistors in the long-tailed pair. The value of R_5 may be raised or lowered until the selectivity and sensitivity are at best proportions. TR_1 and TR_2 may be OC44, GET874 or OC170. If the last, the shield lead-outs, should preferably, be connected to chassis.

The value specified for C_{11} is applicable if the tuner output feeds into a subsequent transistor stage. If the following amplifier has a high impedance input, as would occur with a valve amplifier, C_{11} may have a value of 0.05μF.

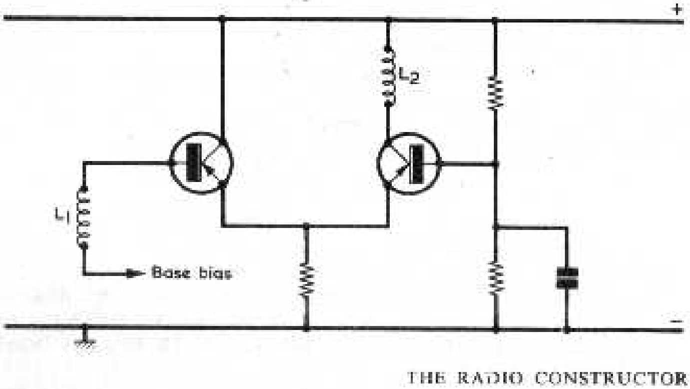


Fig. 1. The basic long-tailed pair r.f. amplifier

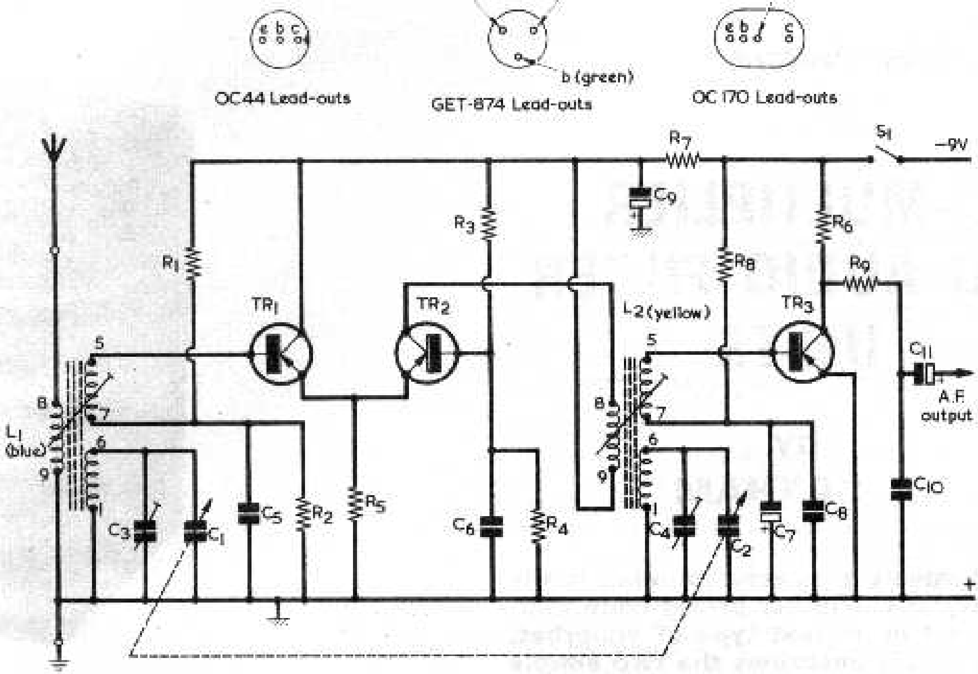


Fig. 2. The complete a.m. tuner incorporating the long tailed pair. TR_3 is the detector

COMPONENTS

Resistors
(All ¼ watt 10%)

R_1	47kΩ
R_2	5.6kΩ
R_3	47kΩ
R_4	5.6kΩ
R_5	270Ω (see text)
R_6	33kΩ
R_7	470Ω
R_8	2.2MΩ
R_9	1kΩ

Capacitors

$C_{1,2}$	2-gang variable, 310+310pF
C_3	30pF, trimmer
C_4	30pF, trimmer
C_5	0.1μF
C_6	0.1μF
C_7	100μF electrolytic, 6V wkg.
C_8	0.04μF
C_9	4μF electrolytic, 10V wkg.
C_{10}	1,000pF
C_{11}	50μF electrolytic, 10V wkg. (see text)

Inductors

L_1	Miniature Dual Purpose Transistor Coil, Blue, Range 1T and 2T (Denco)
L_2	Miniature Dual Purpose Transistor Coil, Yellow, Range 1T and 2T (Denco)

Transistors

TR_1, TR_2	GET874, OC44 or OC170
TR_3	OC170

Switch

S_1	s.p.s.t. on-off

Battery
9-volt battery

POCKET REFLEX RECEIVER

by
ARMAN SAPCIYAN

Arman Sapciyan is resident in Istanbul, and regular readers may recall his previous design, "Short Wave Three", which appeared in our February 1968 issue. He now presents a neat and simple 2-transistor medium wave receiver which combines good sensitivity with low battery consumption.

TRANSISTOR RADIOS STILL CONTINUE TO BE ONE OF THE most interesting constructional projects for the home constructor. However, a great variety of transistor radios described in the home constructor magazines use a.f. transformers to couple the first stage to the second and this can make them rather bulky, as it is not possible to find subminiature transformers in every country in which these magazines are read.

The present design has only one a.f. transformer, between the output stage and the speaker. With a high impedance speaker it is possible to dispense even with this, whereupon the design represents a radio using no transformers at all.

Today, the reflex principle is widely in use with cheap Japanese portables which are sold in most countries. These incorporate at least one a.f. transformer. The receiver described here is not only simpler than these radios but provides a better performance. With the prototype it is possible to tune in at least ten foreign stations after dark in addition to two strong local ones in the medium wave band.

THE R.F. STAGE

The circuit of the receiver is given in the accompanying diagram. It employs two transistors, and the first stage, TR_1, consists of a reflex amplifier. A reflex amplifier is one that amplifies at two frequencies, usually at r.f. and a.f. Any home constructor who is familiar with this sort of receiver knows very well that in such a circuit everything depends upon the gain of the first transistor. Therefore, it is necessary to get maximum gain from the first stage, since the second stage will only amplify the signal received from the first stage. If the reader fails to get a satisfactory result from the first stage it is obvious that the performance will be disappointing (so far as sensitivity and selectivity are concerned) no matter how efficient the output stage is.

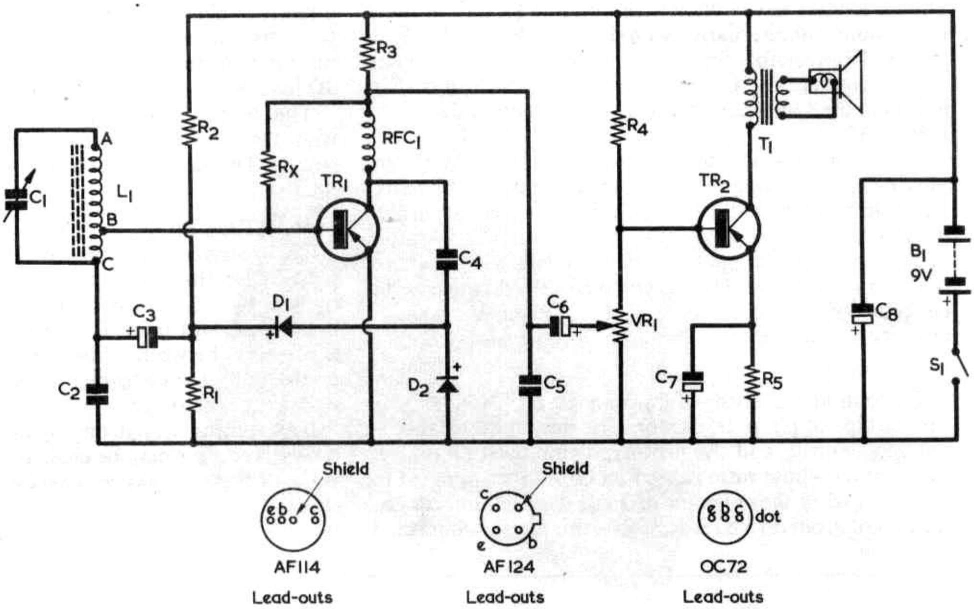
In the TR_1 stage, L_1 is a medium wave coil wound on a ferrite slab and tuned by C_1. The base of TR_1 couples into this coil by way of the tapping at "B", and it initially amplifies the received r.f. signal. This signal is detected by D_1 and D_2 and re-applied, as a.f., to TR_1 base. TR_1 amplifies once more and the amplified a.f. signal appears across R_3, being passed to TR_2 via C_6 and volume control VR_1. Resistor R_x has a value which ensures that TR_1 is just below oscillation point over most of the band covered, without actually breaking into oscillation at any point.

Constructors may find it of advantage to initially build the first stage on a relatively large chassis so that the process of experimentally finding the value of R_x can be carried out more easily. This value should be between 1MΩ and 150kΩ, and will vary for different transistors. Regeneration increases as the value of R_x reduces.

(*Continued on page* 27)

POCKET REFLEX RECEIVER

(Continued from page 24)



The simple circuit of the pocket reflex receiver

In the prototype, R_x had a value of 220kΩ when used with an AF124. It is necessary to use a new battery when finding the required value of R_x, and C_8 should be in circuit across the supply lines. (As some experimenting with coil turns may be needed, this could also be carried out at this stage.—EDITOR).

The writer checked a number of transistors in the TR_1 stage, including AF114 to AF117 and AF124 to AF127. In general, the AF114 and AF124 gave best results, particularly at the high frequency end of the band, and these types are specified here. No connection is made to the shield lead-out.

If desired, the TR_1 stage can be employed as a complete receiver on its own, an earpiece with a resistance of about 100Ω being connected between the positive side of C_6 and the positive supply line, and all components after C_6 (including C_8 in this case) omitted. It will then be possible to tune several foreign stations in addition to local ones with good volume. The total battery consumption of the first stage will be around 2.5mA from a 9 volt supply. The earpiece can also be used for checking the performance of the TR_1 stage whilst finding the value needed for R_x. The first stage will make a good front-end, incidentally, for any r.f. amplifier.

THE AERIAL COIL

Coil L_1 is close-wound on a ferrite slab measuring 6cm by 1.5cm by 4mm, the wire being 28 s.w.g. enamelled copper. The tuning capacitor may have a value lying between 250pF and 365pF, a 260pF component being used in the prototype. With this capacitor the total number of turns, from "A" to "C", should be 73 tapped at 8 turns ("C" to "B"). In the prototype this number of turns gave a coverage of 540 to 1,900 kc/s. With a 365pF capacitor in the C_1 position, the number of turns from "A" to "C" may be reduced to 63, the tap again being at 8 turns ("C" to "B"). (The metric figures for the ferrite slab correspond, approximately, to $2\frac{3}{8}$ by $\frac{5}{8}$ by $\frac{3}{16}$in.

COMPONENTS

Resistors
(All fixed values $\frac{1}{4}$ watt 10%)

R_x	See text
R_1	22kΩ
R_2	220kΩ
R_3	2.2kΩ
R_4	33kΩ
R_5	100Ω
VR_1	5kΩ potentiometer, log track, with switch

Capacitors

C_1	260pF variable, air-spaced (see text)
C_2	0.01μF, paper or plastic foil
C_3	50μF, electrolytic, 6V wkg.
C_4	470pF, ceramic or silver-mica
C_5	0.01μF, paper or plastic foil
C_6	5μF, electrolytic, 12V wkg.
C_7	100μF, electrolytic, 6V, wkg.
C_8	100μF, electrolytic, 12V, wkg.

Inductors

L_1	Ferrite aerial (see text)
RFC_1	2.5mH r.f. choke
T_1	Output transformer (see text)

Semiconductors

TR_1	AF114 or AF124
TR_2	OC72 or similar
D_1	OA70
D_2	OA70

Switch

S_1 s.p.s.t., part of VR_1

Battery

B_1 9-volt battery type PP3 (Ever Ready)

Speaker

Miniature moving-coil (see text)

Should readers have difficulty in obtaining a slab of these dimensions, an alternative would be the $4\frac{5}{8}$ by $\frac{1}{2}$ by $\frac{5}{32}$ in ferrite slab available from Henry's Radio. Slightly fewer turns from "A" to "C" would be required with this slab, although the 8 turn tap, "C" to "B", need not be altered.—EDITOR.).

Some variation in the regeneration effect is given by moving coil L_1 along the ferrite slab although, normally, it should be in the middle. Should the constructor wish to provide a physical feedback path, a small adjustable "capacitor", made up of two insulated wires twisted together over a short length, could be added between the collector of TR_1 and end "A" of L_1. From the writer's experience, this addition should not be necessary.

TR_2 STAGE

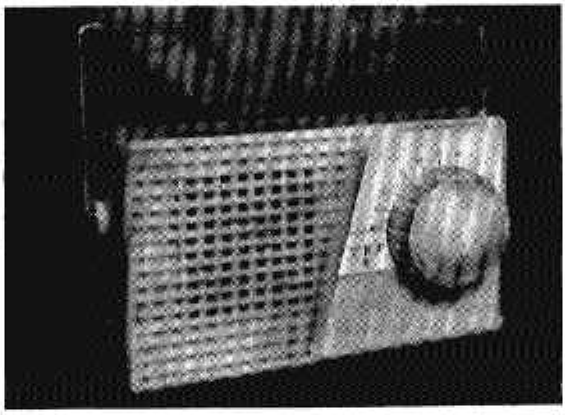
The output transistor, TR_2, may be an OC72 or any similar type of p.n.p. transistor. The output impedance is not very critical, and the prototype employed an output transformer whose ratio caused an impedance of 600Ω to be presented to the collector of TR_2. If a high impedance speaker of around 150Ω is available, this may be connected directly in place of T_1 primary, causing the whole receiver to be transformerless. (For a 3Ω speaker, T_1 may be any output transformer intended to match an OC72 to a 3Ω load, such as the Radiospares T/T4.—EDITOR).

The battery consumption of the complete receiver, with TR_1 and TR_2, is approximately 9mA from a 9 volt supply. This is quite reasonable, and a PP3 battery can be used.

CONSTRUCTION

The receiver may be finally assembled in a small plastic case, that used by the author measuring only 11cm by 7cm by 3.5cm (approximately $4\frac{1}{2}$ by $2\frac{3}{4}$ by $1\frac{3}{8}$in). The most important point is to ensure that adequate spacing is provided between all inductors. Thus, neither the r.f.c. or the output transformer should be close to the ferrite slab or to each other.

If, on tuning very strong signals, a motor-boating effect is observed, this may be cleared by slightly increasing the value of R_3 to 2.7kΩ or 3.3kΩ as required to remove the effect.



TRF5 POCKET PORTABLE

COVER SUBJECT

R. F. GRAHAM

THE t.r.f. type of receiver avoids the more complicated circuits and alignment difficulties of the superhet, yet will normally give good loudspeaker volume plus a reasonable selection of stations. This circuit has five transistors in a 6-stage reflexed arrangement which is sensitive, easy to build, and provides excellent volume from an economical single-ended push-pull output stage.

Figure 1 shows the circuit, and a personal phone or headphones may be used to test it in three sections, during construction. This ensures that progressive wiring is correct. Tr1 acts as r.f. amplifier, with regeneration through TC1 controlled by the potentiometer VR1. R.F. is blocked by the r.f. choke and passes to diodes D1 and D2, the demodulated signal passing through L1 to Tr1, which furnishes audio signals across R1, taken through C6 to Tr2. When the circuit is wired as far as C6, phones from C6 to battery positive give moderate phone volume from some local stations, while tuning and regeneration will be found in order if this section is working correctly.

Tr2 and Tr3 are audio amplifiers, connected to obtain d.c. stabilisation of their working conditions. For example, assume Tr2 collector current is too high. The voltage drop across R4 rises, moving Tr3 base positive and Tr3 emitter current falls, reducing the voltage drop across R6, and moving Tr2 base positive through R3, to restore working conditions. Should Tr2 collector current be too low, the reverse arises. With Tr3, excess collector and emitter current increases the voltage drop across R6, shifting Tr2 base negative, increasing Tr2 collector current and the voltage drop across R4, which in turn moves Tr3 base slightly positive, to restore conditions.

With Tr2 and Tr3 added, phones from Tr3 collector to battery negative should give more than enough volume, with good quality of reproduction, thereby showing this section is in order. Transformer T1 drives Tr4 and Tr5 in a popular and economical push-pull circuit, operating directly into a 75Ω speaker.

Components

There is some latitude in transistors and some other items, but miniature transistor receiver type components have to be used throughout. All resistors are 10% (silver band) except R7, R8, R9 and R10, which *must* be either 5% (gold band) or selected with a reliable meter for accuracy. VR1 is a midget pot with switch and actual results are the same with 10kΩ or 20kΩ. VC1 is a midget solid-dielectric (300pF) but there is space for a midget air-spaced capacitor, if to hand, and 365pF or other larger value can be fitted.

Various transformers for single-ended push-pull, for use with OC71 and 2xOC72, or OC81D and 2xOC81, or similar transistors, are satisfactory for T1. The ratio is generally about 7:1+1, to 3·5:1+1. Tags are

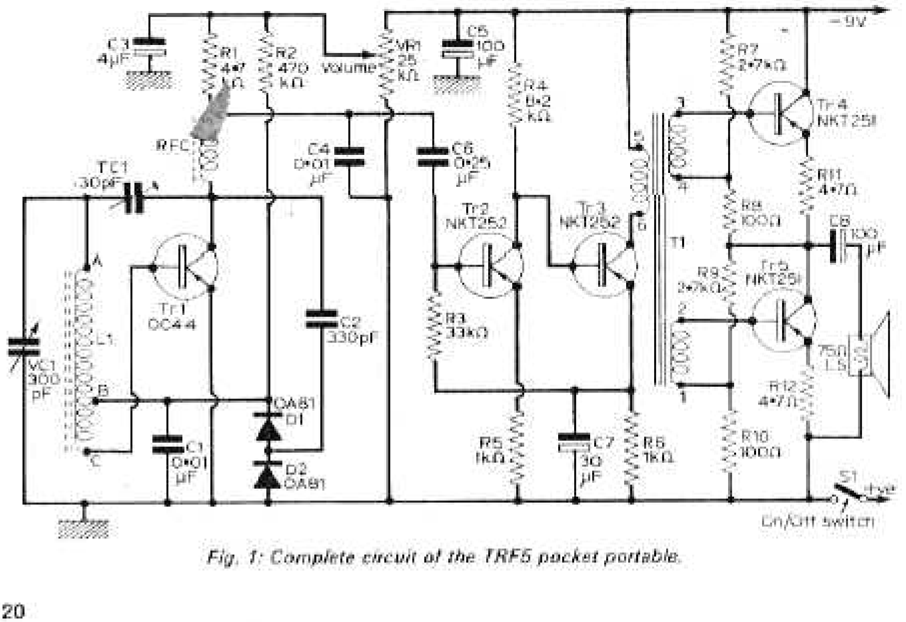


Fig. 1: Complete circuit of the TRF5 pocket portable.

numbered in Fig. 1 and a wiring plan shows location of tags or pins and must of course be for the actual transformer, if different from that listed.

The speaker is a 75-80Ω 2in. or similar unit, but 35Ω units are also in order, while a 25 or 35Ω speaker is particularly suitable for 2xOC81 or similar transistors. The receiver is easily accommodated in a plastic case which is approximately 5½ x 3¼ x 1¾in. external dimensions.

Chassis and Case

This is 5 x 3in., 1/16in. paxolin, with all components except VR1 and the speaker mounted on the back as in Fig. 2. Cases of the type mentioned have three projections inside, tapped 6 B.A. Bolts in holes X, Fig. 2, secure the finished receiver in its case. These three holes can be positioned by cutting thin card 5 x 3in., placing it in the case, piercing over the tapped holes, then using the card as a template for drilling the paxolin. Should any holes be inaccurately placed, they can be elongated with a small round file. The two holes marked S are for bolts with extra nuts, which secure the speaker. Somewhat similar cases are made with tapped holes to fix a speaker inside, and two flexible leads can then run from speaker to receiver.

The speaker opening, Fig. 2, is about 1¾in. in diameter, to clear the speaker. As many holes as possible should be drilled before fitting any components to the panel.

Ferrite Rod Aerial

This has 88 turns of 26s.w.g. enamelled wire, side by side on a 5 x ¼in. ferrite rod. Glued paper is wound round the rod, and the wire fixed at A with tape, adhesive, or cotton. After winding 76 turns, the small loop B is made, and winding continued in the same direction for a further 12 turns, the wire being fixed at C.

A loop of some insulating material, such as cardboard, leather or plastic is cut to go round the rod, and drawn tight with a bolt, which also goes through the panel. Extra nuts or a spacer lifts the rods so that the winding clears the trimmer TC1. Note that a wire also passes from the moving plates of VC1 through the panel to the "earth" or battery positive circuits the other side.

If the receiver is to be tested in sections as mentioned, insert components up to C6.

The underside of the panel (or front when the receiver is in its case) is shown in Fig. 3. VR1 is fixed with a small bolt. The simplest method of wiring is to use 26s.w.g. or similar bare tinned copper wire, with 1mm red sleeving for "earth" and black sleeving for negative line. Joints (especially for transistors and diodes) are soldered rapidly, the iron being removed immediately the joint is formed.

To test the first stage, connect phones from the free end of C6 to battery positive and unscrew TC1. Set VR1 at about half its travel. Tune in a signal with VC1 and screw down TC1 until the receiver just begins to oscillate, backing off VR1 slightly should then control regeneration. A meter in one battery lead should show a current of about 1—1·5mA, falling

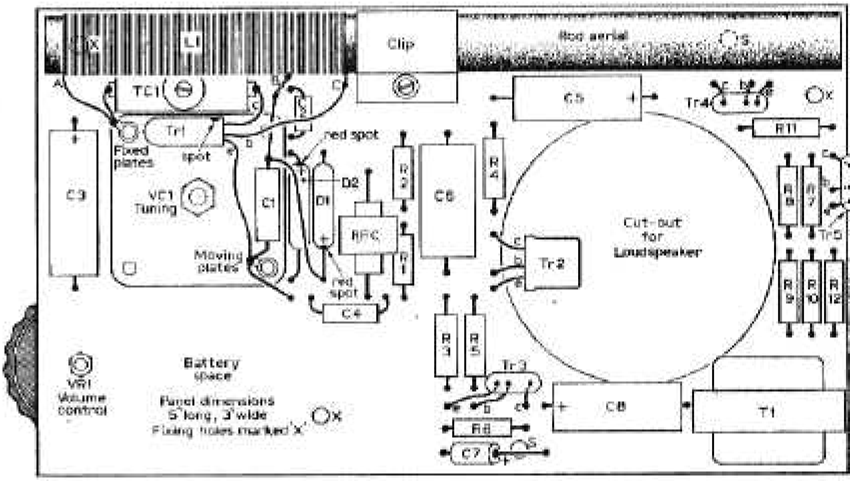


Fig. 2: Component layout. The volume control VR1 is mounted on the reverse side (see Fig. 3).

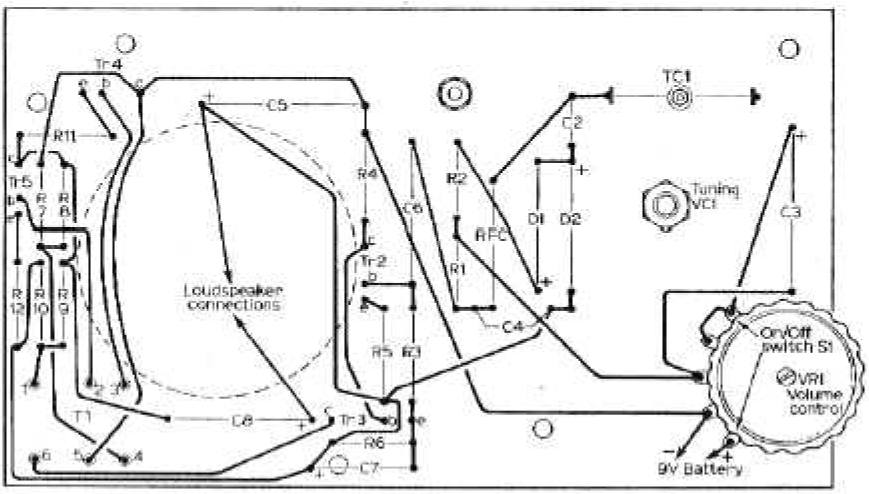
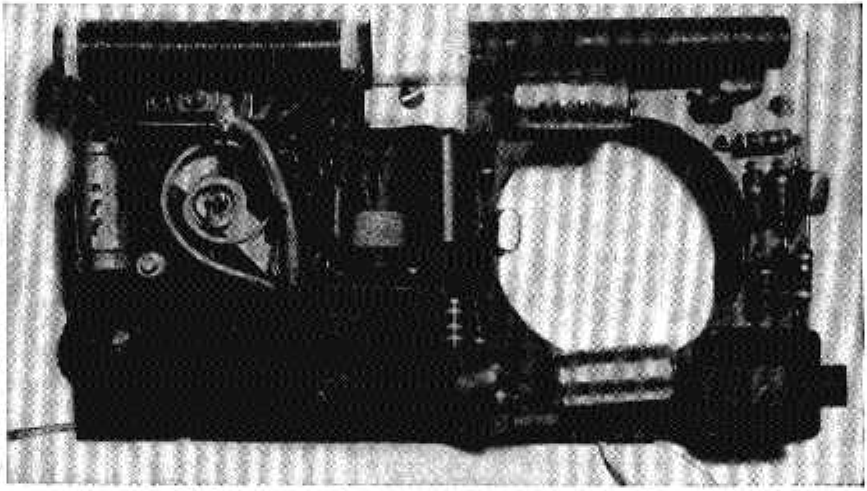


Fig. 3: Underside wiring of the paxolin panel.

by about 0·2mA on tuning in a strong signal, due to increased base bias from the diodes. Regeneration becomes less easy towards the low frequency end of the waveband, so TC1 can be readjusted slightly later, for best over-all reception.

During normal use, VR1 *must* be adjusted as a regeneration control, *not* as a simple audio volume control. Rotating VR1 towards maximum builds up volume, until oscillation begins. Sensitivity is very high just below this oscillating point. Should no results be obtained, connections in this part of the circuit should be checked.



Internal view of assembled receiver (less loudspeaker).

When Tr2, Tr3, and associated components have been added, it is worth checking results by connecting phones between the collector of Tr3 and the battery negative line. This corresponds to points 5 and 6, Fig. 1. Volume on local signals should be very great, and more stations may be heard. There should be no audio distortion. If results are poor or distortion has arisen since adding Tr2 and Tr3, check resistor values and connections here.

Current drain with Tr1, Tr2 and Tr3 in use depends somewhat on transistors, but can be expected to be around 3—4mA. Should there be any fault, correct this before wiring the output stage.

★ components list

Resistors:

R1	4·7kΩ	10%
R2	470kΩ	10%
R3	33kΩ	10%
R4	8·2kΩ	10%
R5	1kΩ	10%
R6	1kΩ	10%
R7	2·7kΩ	5%
R8	100Ω	5%
R9	2·7kΩ	5%
R10	100Ω	5%
R11	4·7Ω	10%
R12	4·7Ω	10%
VR1	25kΩ pot. with switch	

Capacitors:

C1	0·01μF 150V
C2	330pF 150V
C3	4μF 25V electrolytic
C4	0·01μF 150V
C5	100μF 12V electrolytic
C6	0·25μF 150V
C7	30μF 6V electrolytic
C8	100μF 12V electrolytic
VC1	300pF miniature variable
TC1	30pF trimmer

Inductors:

L1	see text
RFC	miniature 7·5mH r.f. choke
T1	Single-ended push-pull transformer 7:1+1 (Fotiphone L442 or similar) see text

Semiconductors:

Tr1	OC44	
Tr2	NKT252	
Tr3	NKT252	
Tr4	NKT251	matched
Tr5	NKT251	matched
D1	OA81	
D2	OA81	

Miscellaneous:
Ferrite rod, wire, solder, paxolin 5 x 3 x $\frac{1}{16}$in., 75Ω speaker, case to suit, knob, dial, 9V battery.

Output Stage

As mentioned, connections to T1 in Fig. 3 are for the listed transformer, and tag 1 is red. Other transformers have tags in different positions, but are equally suitable.

Resistor values R7 to R12 are suitable for OC72's, OC81's, and many similar transistors, in addition to those listed. The output transistors are best purchased as a matched pair. It should then be found that the voltage at the junction of R8 and R9 is about half the supply voltage. This will not be so with unmatched transistors in Tr4 and Tr5 positions or with an error in value in R7, R8, R9 or R10. In practice, it is usually found that results are satisfactory if transistor voltages lie within about 20% of each other, if the transistors are otherwise matched.

Current taken by the whole receiver should be about 8—10mA, rising to 12—20mA peaks with good volume. Should current be around 8—10mA but extreme distortion spoil results after adding the output stage, check connections to T1. In particular, leads to one half secondary may need to be reversed. Should current be much under 8mA, with weak, distorted reception, check that a mistake is not made in reading the values of R7—R11. Should current be much over 10mA, with no signals tuned in, but reception nevertheless good, R8 or R10 may be too high in value, or R7 or R9 too low. This is not expected with 5% resistors.

Loudspeaker Mounting

There is space for the usual 9V miniature battery, and receiver leads should have correct positive and negative clips. If the speaker is bolted to the paxolin panel, a piece of thin felt, thick blotting paper, or similar material with a central hole can be placed between speaker and cabinet, to prevent vibration sounds. The tuning scale is drawn on card, afterwards cemented to the case front. A knob of fairly large diameter is most suitable for tuning. ■

SHORT WAVE THREE

by Arman Sapciyan

Our contributor, resident in Istanbul, gives details of a simple but efficient 3-transistor reflex receiver capable of operating from a telescopic aerial 3ft 9in long when extended, and without an earth connection. The design is based on the "Two + Two Receiver" described by Wallace Studley in our January 1966 issue

THE SIMPLE RECEIVER DESCRIBED HERE IS AN ideal design for those who want to get satisfactory results with the minimum number of components. If this receiver is carefully built the constructor will be able to tune in many distant short wave stations, as well as local ones, with a good level of volume.

The Circuit

The circuit appears in Fig. 1 and consists of a reflex design in which TR_1 functions both as r.f. and a.f. amplifier. Detection is given by diodes D_1 and D_2. TR_2 and TR_3 are a.f. amplifiers.

R_2 is the sensitivity control, whilst C_4 is a trimmer providing regeneration. A fixed capacitor of 30pF

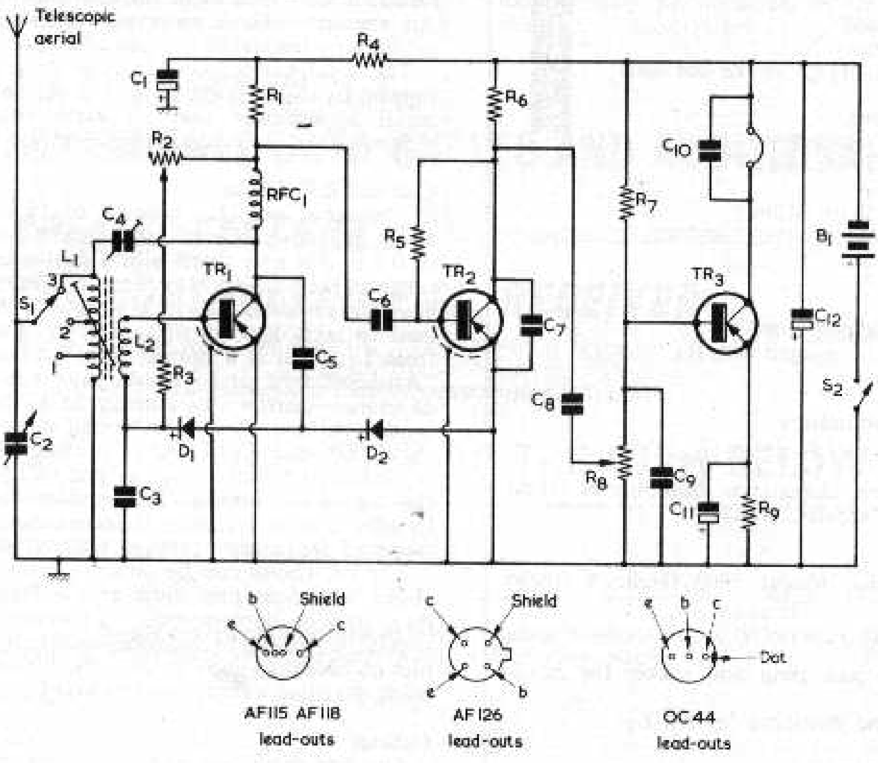


Fig. 1. The circuit of the Short Wave Three

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

- R_1 3.9kΩ
- R_2 100kΩ potentiometer, linear track
- R_3 150kΩ (see text)
- R_4 1kΩ
- R_5 100kΩ
- R_6 5.6kΩ
- R_7 68kΩ
- R_8 10kΩ potentiometer, log track, with switch
- R_9 1kΩ

Capacitors

- C_1 100μF electrolytic, 6V wkg.
- C_2 165pF variable, air-spaced (Wavemaster 160pF, Cat. No. VC75, Home Radio, will be suitable)
- C_3 0.02μF
- C_4 40pF mica trimmer
- C_5 220pF ceramic
- C_6 0.1μF
- C_7 0.01μF
- C_8 0.1μF
- C_9 0.01μF
- C_{10} 0.005μF
- C_{11} 50μF electrolytic, 6V wkg.
- C_{12} 100μF electrolytic, 6V wkg.

Inductors

- L_1 see text
- L_2 see text
- RFC_1 2.6mH r.f. choke (see text)

Semiconductors
(*See text for alternatives*)

- TR_1 AF118 or AF115
- TR_2 AF126
- TR_3 2SA30 or OC44
- D_1 OA70
- D_2 OA70

Switches

- S_1 single-pole 3-way
- S_2 s.p.s.t., ganged with R_8

Battery

- B_1 6-volt battery

Headphones

1 pair low impedance headphones (total resistance approx. 100Ω)

Drive

Vernier dial, Model T502 (Henry's Radio Ltd.)

Miscellaneous

Miniature jack plug and socket for headphones
Former and dust-core for L_1, L_2
Knobs
Telescopic aerial

could be employed for C_4, but the trimmer is more convenient since it allows a regeneration level to be obtained which gives best overall results. The tuning capacitor is C_2, and this is connected across the section of L_1 which is selected by range switch S_1. The nominal coverage is from 4.7 to 18 Mc/s with the dust core centrally in the coil but this can, if desired, be changed to 5.5 to 22 Mc/s with the dust core some way out of the coil.

After experimenting with a wide range of transistors it was found that an AF118 gave best results in the TR_1 position. An AF115 may also be used, with R_3 altered to 120kΩ, although the performance is slightly inferior to that offered by the AF118. (Since the AF118 is listed as a video amplifier, the performance of different transistors of this type in the present circuit may vary. We would class its use here as experimental, as compared with that of the AF115 which is specifically intended to give r.f. amplification up to v.h.f.—EDITOR.) For TR_2 an AF126 provided best results, whilst nearly as good a performance was given by AF116, AF117, AF127 and AF115.

Although TR_3 is only a simple a.f. amplifier, by far the best performance was given here with a 2SA30, this being a near-equivalent to the OC44. Since it may be difficult to obtain the 2SA30 in the U.K., an OC44 may be employed in its place.

The performance of the receiver also depends on the type of headphones used and it is highly recommended that these be low impedance types. An earpiece with a resistance of 70Ω also gave satisfactory results.

The total battery consumption from the 6-volt supply is about 1.8mA only. Since a telescopic aerial is sufficient and no earth connection is required, the receiver can be carried anywhere.

Coil and R.F. Choke

The aerial coil, L_1, consists of 18 turns of 34 s.w.g. silk covered wire close-wound on a former of 0.3 in diameter fitted with a dust-core. Taps are taken at the 4th and 11th turns, as shown in Fig. 2. The former should have 6 eyelets or tags at the base to take the ends of L_2 and the 4 connections from L_1. (This is a normal Bakelite former of the "Aladdin" type, and it could have a length of 1in or more.—EDITOR.) L_2 consists of 1¾ turns of the same wire and should be wound close to L_1. L_2 should be wound first and L_1 second, coil positioning being such that the upper end of L_1 is close to the top of the former. This enables the dust-core to offer a wide variation in inductance, giving the range of frequency coverage referred to earlier.

The r.f. choke can be either a standard 2.6mH choke with four pies, such as the Denco RFC.5, or it may be home-wound. The writer obtained a satisfactory choke by random-winding four separate pies of 200 turns each on an 820kΩ 2 watt resistor, using the same wire as was employed for L_1 and L_2.

Cabinet

The prototype was constructed on an eyeletted board fitted in a cabinet measuring 8 x 4½ x 3in.

This may seem rather large for a receiver of this nature. However, the panel has to accommodate two potentiometers, a switch and a variable capacitor with its drive, and it is desirable to mount these components so that a reasonable amount of space exists between them. Since an aerial is always necessary it is best to screw the panel to the cabinet.

Setting Up

After the components are mounted and soldered, double check all connections and battery polarity, then switch on. First, check to see whether the set is oscillating or not by turning the knob of R_2 towards maximum (minimum resistance in circuit) and adjusting C_2 if necessary. If it is not possible to obtain oscillation, reverse the connections to L_2. Apply a signal generator set to 4.7 Mc/s and very loosely coupled to the aerial, and tune in this signal with C_2, adjusting the dust-core if necessary. S_1 should be in position 3. Next, put S_1 to position 1 and check whether 18 Mc/s from the signal generator may be tuned in by C_2. C_4 has a noticeable effect on the frequency of reception and it may be necessary to adjust this component to enable the 18 Mc/s signal to be received. When C_4 is at its final position it should be possible to obtain oscillation on all ranges with a frequency coverage of the order specified earlier. It should be noted that the 4.7 and 18 Mc/s frequencies just quoted apply to the extreme ends of the coverage given by the prototype coil for one setting of the dust-core. Other coils may offer a similar coverage but with the end frequencies slightly shifted.

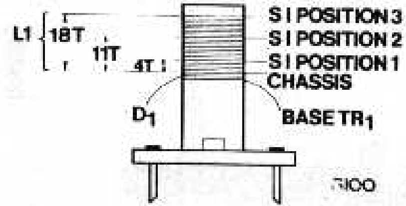


Fig. 2. Details of the coil. L_2 is immediately below L_1

If a signal generator is not available, adjust C_4 so that it is about three-quarters towards maximum capacitance. Obtain the desired coverage by finally adjusting this capacitor and the dust-core, working from received signals.

R_2 will require different settings for each band selected by S_1. As is to be expected, adjustment is more critical at the higher frequencies, and a little skill is needed at first to obtain optimum results.

Performance

The writer has found that this receiver gives very satisfactory reception. At Istanbul he can tune in B.B.C., V.O.A., Kol Israel, Cairo, Moscow, Vatican, Prague, Deutsche Welle, and a lot of other distant stations at a very high volume. Even Peking comes in at satisfactory level. Although not an extraordinary performance, this still represents a remarkable achievement for so simple a receiver.

Silicon Transistor Reflex T.R.F.

by G. SHORT

By taking advantage of the properties of silicon transistors this circuit offers a high performance with an extremely small quantity of components. The design is not critical and a number of modifications can be incorporated

THE TWO-TRANSISTOR REFLEX RECEIVER WHOSE circuit is given in Fig. 1 was designed with simplicity and component economy in mind, but performance has not been sacrificed. In fact, the sensitivity is much greater than that of most two-transistor receivers. The measured sensitivity of the prototype, *without using any reaction*, was about 20dB better than the sensitivity of a conventional two-transistor reflex receiver using an OC44 and an OC71. The current consumption is low—about 1.5mA.

Exploiting Silicon Transistors

This good performance is obtained by making use of the characteristics of modern high-frequency silicon planar transistors. These transistors work well as r.f. amplifiers at low collector currents.

In the usual type of reflex circuit, TR_1 feeds the detector, often of the double-diode type. The impedance presented by such a detector to low-level r.f. signals is typically about 1.5kΩ. This rather low impedance severely limits the gain of TR_1; and increasing the value of its collector resistor is of

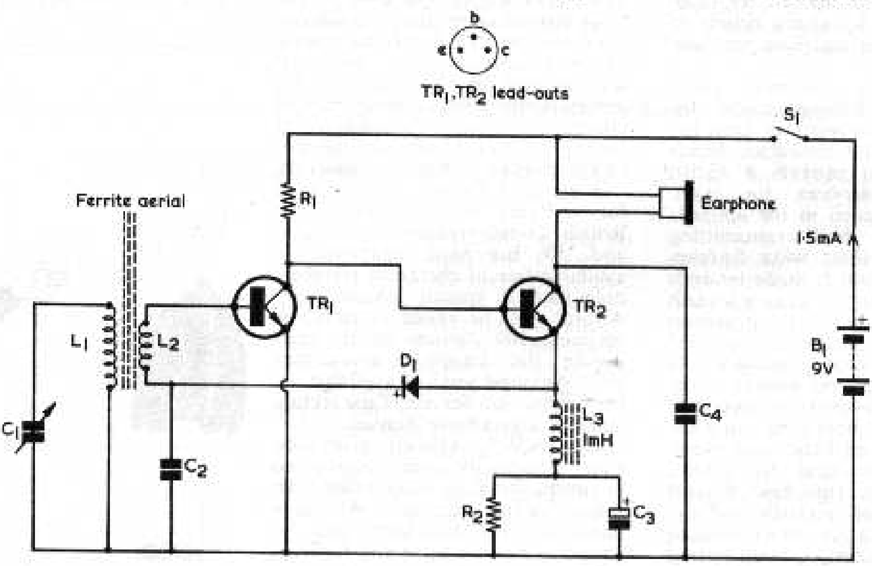


Fig. 1. The basic circuit of the reflex transistor receiver. A magnetic earphone is used. Note the economy in components

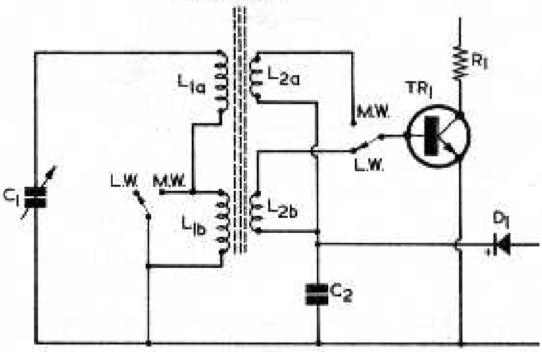


Fig. 2. Suggested modification for a medium and long wave version of the receiver

very little help. In the present circuit, however, TR_1 does not feed the detector directly. Instead, TR_2 acts as a unity-gain buffer. TR_2 is an emitter-follower as far as the r.f. signals are concerned, and its input impedance is high. The full advantage of using a high value for R_1 (the collector resistor for TR_1) is thus obtained.

Direct Coupling

A further feature of silicon transistors which is put to good use in this circuit is their relatively high base-emitter voltage. This is about 0.65V in the present case. How this is useful can be seen by working out the collector emitter voltage of TR_1. This is made up of the sum of three voltages: the base-emitter voltage of TR_2 (0.65V), the drop across the forward-biased detector diode (0.1V), and the base-emitter voltage of TR_1 itself (0.65V). The total is 1.4V, and is well above the "bottoming" voltage of TR_1 which is about 0.5V in the present instance. If germanium transistors, with base-emitter voltages of about 0.2V had been used, the collector voltage of TR_1 would have been only 0.5V. Good r.f. germanium transistors such as the AF117 will not work well with such a low collector voltage, and in consequence the simple form of direct coupling from the detector used here is not practicable with germanium transistors.

COMPONENTS

(N.B. Some of the components listed below are altered if the modifications described in the text are made.)

Resistors
- R_1 15kΩ, ¼ watt, 20%
- R_2 680Ω, ¼ watt, 20%

Capacitors
- C_1 Tuning capacitor, to suit L_1
- C_2 0.01μF
- C_3 125μF electrolytic, 3V wkg.
- C_4 0.01μF

Inductors
- L_1 Ferrite aerial for medium or long waves
- L_2 See text
- L_3 R.F. choke (see text)

Semiconductors
- TR_1 HK301
- TR_2 HK101, HK301 or HK601
- D_1 Any germanium diode

(The transistors are available from Amatronix, Ltd.)

Switch
- S_1 s.p.s.t. switch

Battery
- B_1 9-volt battery

Earphone

Magnetic earphone, resistance 250Ω to 4kΩ

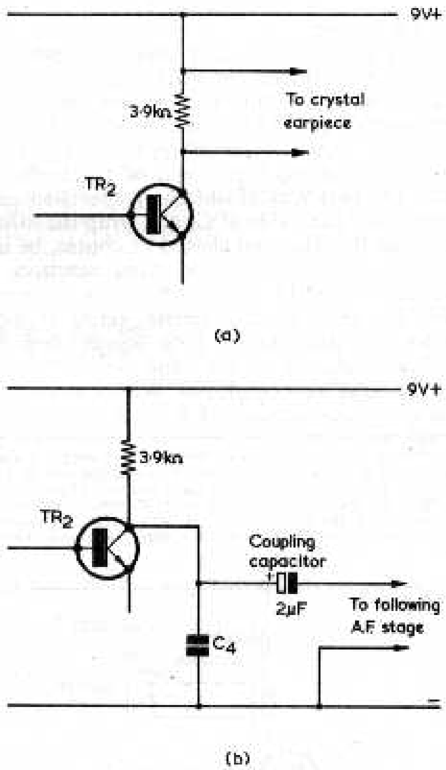
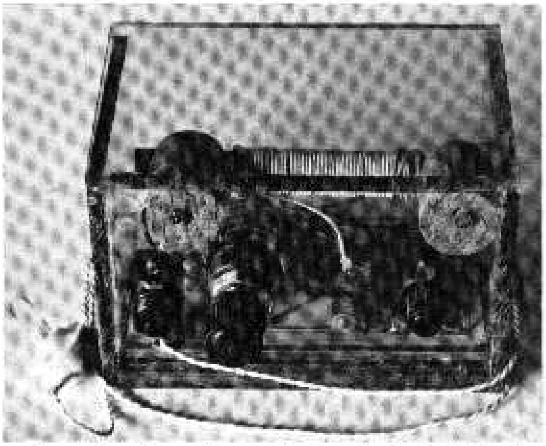


Fig. 3 (a). If a crystal earpiece is used, an additional 3.9kΩ resistor is fitted between the collector of TR_2 and the positive supply line
(b). An additional 3.9kΩ resistor is also required if the receiver is to feed a following a.f. amplifier



Front view of a receiver made up to the circuit of Fig. 1 and incorporating a volume control

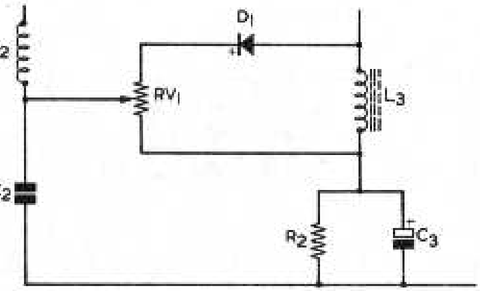


Fig. 5. Showing how a volume control may be added to the circuit

Audio Circuit

The a.f. circuit is perfectly straightforward. The detector D_1, which can be almost any type of germanium diode (a gold-bonded "computer diode" was used in the prototype) feeds the base of TR_1, and TR_1 is direct coupled to TR_2.

Adding Reaction

If L_3 is parallel to L_1 and close to it, positive r.f. feedback is produced, provided that the turns in L_1, L_2, and L_3 are in the appropriate direction. Alternatively—or additionally—reaction can be obtained by capacitive coupling between the collector of TR_1 and the "hot" end of the aerial tuned circuit. The best way of obtaining this is to connect a wire to the "hot" side of C_1 and wrap the other end of it round R_1. This end should of course, be insulated. With correctly adjusted fixed reaction, quite weak stations can be received.*

Coil L_1 may be any ferrite aerial tuned coil intended for medium or long waves, and tuning capacitor C_1 should have a value to suit the particular ferrite aerial coil employed. With a medium wave ferrite aerial, L_2 consists of 5 turns of wire around 22 s.w.g. wound over the earthy end of L_1 or on the ferrite rod close to the earthy end of L_1. The gauge of wire and its positioning are not critical. With a long wave ferrite aerial, L_2 should consist of 15 turns of the same wire wound on the ferrite rod close to the tuned coil. The prototype was made for single waveband working only. However, should the reader desire to use a medium and long wave ferrite rod aerial, two coupling coils may be fitted, with wave-change switching along the lines suggested in Fig. 2. In this diagram, $L_{2(a)}$ is the medium wave coupling coil and $L_{2(b)}$ the long wave coupling coil. The two switches in Fig. 2 are ganged.

The r.f. choke L_3 has an inductance of approximately 1mH. It may be made by scramble-winding 100 turns of 36 s.w.g. single silk covered wire on a ½in length of ¼in diameter ferrite rod.

Modified Second Stage

As it stands, the receiver will operate a magnetic earpiece or headphone with a resistance between 250Ω and 4kΩ. If it is desired to use a crystal earpiece, substitute a 3.9kΩ resistor for the magnetic earpiece and connect the crystal earpiece across it. See Fig. 3 (*a*). If it is desired to use the receiver as a radio feeder or as a "front end", to be followed by an audio power stage, similarly fit the 3.9kΩ resistor and couple to the following stage via a capacitor,

*For regeneration to occur with the capacitive coupling, the upper end of L_1 in Fig. 1 should be in anti-phase with the end of L_2 which connects to TR_1 base. This differs from the coil phase relationship apparent in the diagram, which is primarily intended to illustrate the basic operation of the receiver circuit. If satisfactory regeneration does not occur at the first attempt, try reversing the connections at L_2.—Editor.

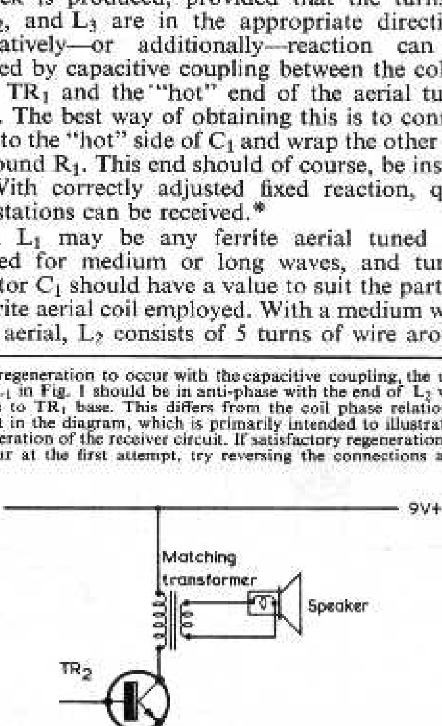
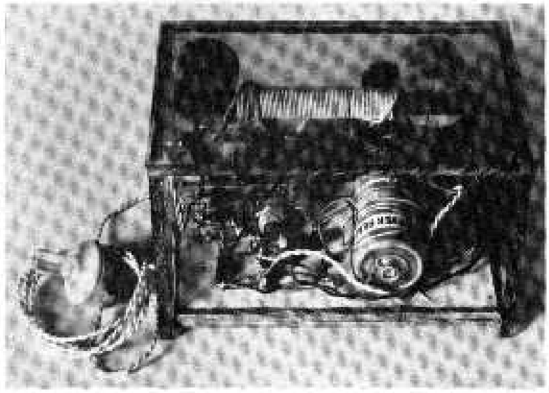


Fig. 4. Coupling a loudspeaker to the receiver



Rear view of the receiver. Component details are discussed in the text as shown in Fig. 3 (*b*). If the following stage employs a transistor the coupling capacitor may have a value of 2μF electrolytic (as in the diagram); if it employs a valve the coupling capacitor may be 0.02μF.

In favoured localities it may be possible to obtain enough power from TR_2 to drive a sensitive loudspeaker. To increase the power, the collector current of TR_2 may be increased, within reason, by using a lower value for R_2. The voltage across R_2 is about 0.7V, and is more or less independent of the value of R_2. Thus with $R_2 = 680\Omega$, the collector current of TR_2 is about 1mA. Reducing R_2 to 100Ω makes the current rise to about 7mA, and so on. If this modification is made, TR_2 should have a current amplification factor of 90 or more. With the earphone output, transistors from any of the available gain groups may be used, though the sensitivity of the receiver will, of course, be increased somewhat if high-gain transistors are employed in either or both stages. (The question of gain in available transistors is covered in the Note at the end of this article.)

For maximum output to the speaker a matching transformer is required. The optimum turns ratio is

$$\frac{V_{CE}}{I_C.R_L}$$

where R_L is the loudspeaker impedance. For example, if $V_{CE} = 8V$, $I_C = 10mA$ and $R_L = 4\Omega$, the required turns ratio is 14:1. The maximum output is theoretically $\frac{V_C.I_C}{2}$, but in practice it is nearer $\frac{V_C.I_C}{4}$, which in this case is 20mW. The speaker is connected as in Fig. 4.

Volume Control

There is no means of turning down the volume in the circuit of Fig. 1 except of course, by orienting the ferrite aerial so that less signal is picked up. A volume control may be added as shown in Fig. 5. It is placed immediately after the detector. This is the best circuit position from the point of view of signal-handling capacity, since the a.f. input to the transistors can be minimised. The resistance of the volume control is not critical, but it should not be too high or the d.c. working conditions of the transistors will be disturbed at intermediate settings. On the other hand it should not be too low or sensitivity may be impaired. A potentiometer with a log track and a value of 5 or 10kΩ is suitable, and it may, if desired, be combined with the on-off switch.

Built-Up Circuit

The accompanying photographs show two views of a receiver built up in a perspex case to the circuit of Fig. 1 (with the exceptions that a crystal earpiece is employed, as in Fig. 3 (*a*), together with a volume control, as in Fig. 5). Regeneration is obtained by way of an insulated lead from the "hot" side of C_1 to R_1, as described earlier. The ferrite aerial covers the medium-wave band and is home-wound on a 4in length of ⅜in ferrite rod, and consists of 46 turns of 20 s.w.g. insulated wire close-wound. It is tuned by a variable capacitor of the type used in TV timebases, although any normal variable capacitor of around 300pF could be used instead. The battery is an Ever Ready PP4.

Note: Transistor Gain

The HK101 and HK301 transistors available from Amatronix Ltd. are in the following grades for h_{fe}. HK101: 30–60 (red); 50–100 (purple); 90–180 (blue); 150–450 (green). HK301: 20–60 (black); 50–100 (purple); 90–180 (orange); 150–450 (green). The HK601 is available with a minimum h_{fe} of 20 at 50mA.

O-BAND REFLEX RECEIV

By S. Short

This neat miniaturised receiver, which can be fitted in a case measuring only 2 x 2 x ¾in, obtains a high performance by reflexing two r.f. transistors and by incorporating a fixed regeneration circuit which is operative at all frequencies. It gives full coverage of medium waves, together with switched reception of the Light Programme on 200 kc/s

COMPONENTS

Resistors
(All resistors ¼ or ⅛ watt 10%)

R_1	1.8kΩ
R_2	4.7kΩ
R_3	1kΩ
R_4	470Ω
R_5	1kΩ
R_6	1kΩ
R_7	22Ω (see text)

Capacitors
(N.B. The Radiospares trimmer may only be obtained through retail sources)

C_1	250pF, single compression trimmer (Radiospares)
C_2	1,000pF silver mica
C_3	0.1μF paper
C_4	220pF silver mica
C_5	50μF electrolytic, 3V wkg.
C_6	0.1μF paper
C_7	0.02μF ceramic disc
C_8	50μF electrolytic, 3V wkg.

Inductors

$L_{1,2,3}$	Aerial assembly on ferrite slab (see text)

Semiconductors

TR_1	OC44
TR_2	OC44
TR_3	OC139 or OC140
D_1	OA70 or OA81

Switch

S_1	s.p.s.t. wavechange switch

Miscellaneous

Earphone with jack plug (see text)
Jack socket, modified (see text)
3-volt battery, type as required
Veroboard 0.15in matrix, 1 x 1⅜in (see Fig. 3)

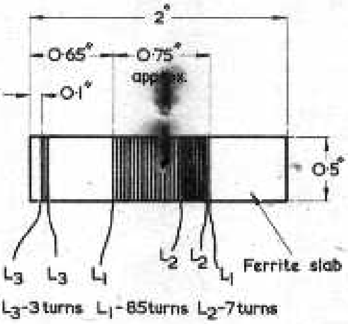


Fig. 2. How the coils are wound on the ferrite slab. The earthy end of L_1 is wound over L_2. The position of L_3 should be adjusted for optimum reaction

I N CONSIDERING THE DESIGN OF VERY small transistorised reflex receivers many factors must be taken into account, and the result is always a compromise depending on the requirements of the constructor and user. In the design discussed here the most important requirement, after obtaining adequate sensitivity and selectivity on medium waves, was that the instrument should be capable of receiving the Light Programme on 200 kc/s. Normally, adding a long wave band to this type of receiver adds substantially to the size and complexity, but the method used here solves the problem in a simple manner and results are good.

Other important aspects of the design were that the circuit should be simple and reliable, using only easily obtained components. Also, to keep down size and weight and to improve stability, chokes and transformers were precluded.

Circuit Analysis

The circuit finally evolved is shown at Fig. 1. The tuned r.f. signal is amplified by TR_1 and TR_2, developed across R_3 and passed via C_4 to the diode detector, which is loaded by R_2. After demodulation the audio signal is fed back to the base of TR_1 via L_2, decoupled by C_3 and amplified again by TR_1 and TR_2. The audio signal developed across R_6 is fed direct to the base of the n.p.n. transistor TR_3. Use of an n.p.n. transistor in this position enables one to dispense with the normal coupling and bias components that would be required if a p.n.p. type were used. This effects a useful saving in cost, as well as improving stability and efficiency. It will be noted from the circuit that, with the exception of C_4 the receiver is entirely direct coupled. R_7 is used to bias TR_3 and, since it is not decoupled, generates a small amount of negative feedback. Further

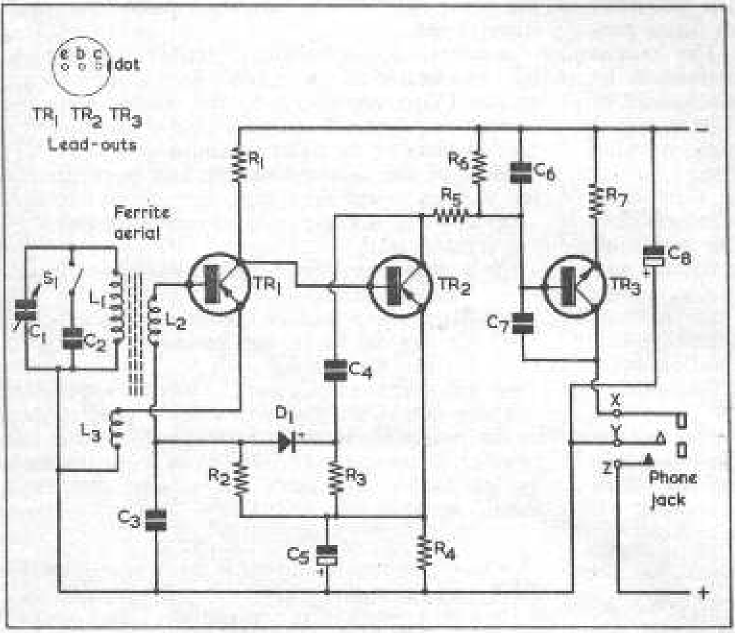


Fig. 1. The complete circuit of the two-band receiver

negative feedback is introduced by C_7. This reduces transistor hiss, which may otherwise be rather annoying due to the very high gain of the circuit, and improves the bass response.

For best results it is essential that the diode be connected with the polarity shown. If incorrectly wired in there will be a marked loss of gain. It may be necessary to reverse the connections to L_2 for maximum signal; the best way will be immediately obvious in terms of gain.

Long wave reception is obtained by switching in an additional capacitor across L_1 and the values shown enable the Light Programme to be received in about the middle of the swing of the tuning capacitor. The L/C ratio is not the optimum and the Q suffers somewhat, but nevertheless output is similar to that from a local medium wave station

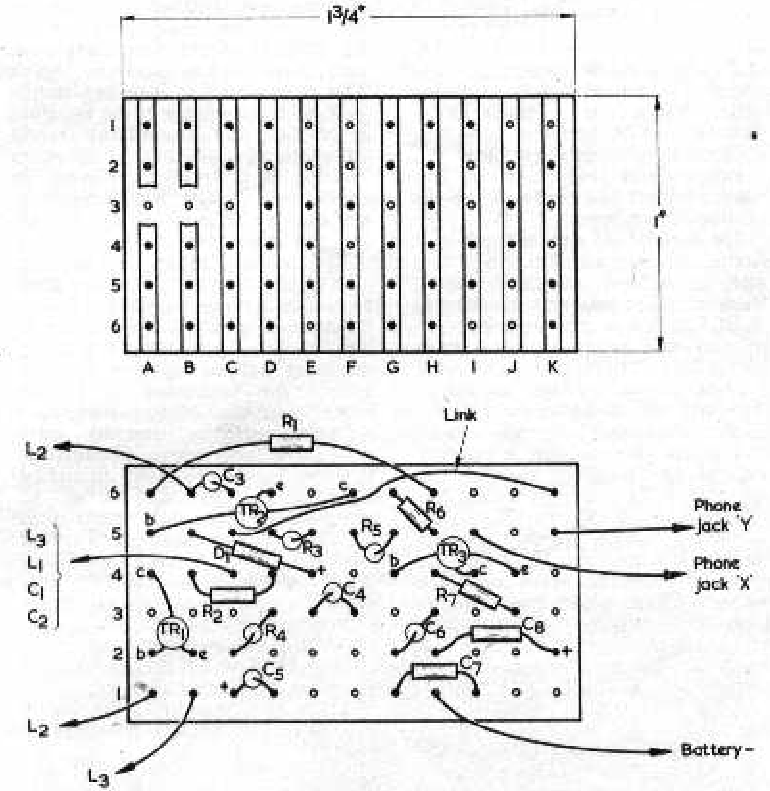


Fig. 3. The copper and component sides of the Veroboard used by the author. Note that one lead of C_3 and one lead of L_2 share the same hole. Components are not drawn to scale and some of those shown flat here may need to be mounted vertically. The wires designated X and Y connect to the similarly lettered contacts of the phone jack illustrated in Fig. 1. Contact Z of the jack connects to the positive terminal of the battery. The circuit around S_1 is external to the board

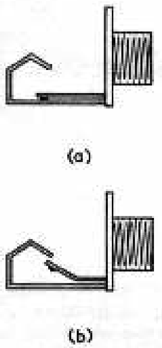


Fig. 4 (a). Showing, in simplified form, the phone jack before modification. The contacts are normally closed, opening when the jack plug is inserted
(b). The jack is modified by bending the centre contact upwards. Inserting the plug then pushes the top contact down on to the upper surface of the centre contact

and selectivity is adequate. The use of this method greatly simplifies aerial design. On a small ferrite slab interaction between coils for different wavebands is a problem, and a switched-out long wave coil can cause damping and dead spots on the medium wave band.

The aerial coils were wound on a ferrite slab measuring $2 \times \frac{1}{2} \times \frac{3}{16}$in and, to achieve maximum signal transfer whilst retaining reasonable selectivity, the turns ratio between primary and secondary was made about 12:1. The actual turns were 7 close-wound for the secondary (L_2) and 85 close-wound for the primary (L_1). The latter was wound in a single layer so that the earthy end of the winding covered the secondary. The gauge of wire is not important and 30 to 32 s.w.g. enamelled single rayon covered was found convenient. This winding gave full medium wave coverage with the 250pF trimmer used in the C_1 position. Approximate dimensions are given in Fig. 2. The reaction winding, L_3, is discussed in the next section.

Reaction

With small receivers of this type it is advantageous to introduce some form of reaction to improve sensitivity and selectivity. Any surplus gain can be used up by negative feedback in the audio stages to improve quality. Capacitive coupling was tried between collector and base of TR_1 by connecting short lengths of insulated wire to the collector and the "hot" end of L_1, and these were twisted together forming a small variable capacitance. This was not very satisfactory as, being frequency dependent, different capacitances were required to produce reaction on each medium wave station for optimum gain and no significant gain was produced on long waves.

The best results were obtained by winding a coil of two or three turns round the ferrite slab and inserting it in series with the emitter of TR_1. By sliding the coil up and down the slab an optimum position could be found and the coil fixed. This coil is shown as L_3 in Figs. 1 and 2, and it will be noted that it appears at the non-earthy end of L_1. The type of reaction employed here was virtually independent of frequency and provided substantial gain on both bands as well as improving station separation on medium waves. Ensure that the regeneration winding is connected into circuit right way round; the incorrect way will, of course, result in no reaction being obtained. In the author's model three turns were used, positioned as shown in Fig. 2. This positioning is intended purely as a guide to what is to be expected in practice, and constructors should adjust the position of L_3 for optimum reaction in their own receivers. In some cases, it may be necessary to use only two turns for L_3. It may use the same wire as L_1 and L_2.

The receiver proved to be very stable in operation, giving good reception over all the medium wave band and on long waves around 200 kc/s. Good results were obtained on local stations using a 1.5 volt supply, but increasing to 3 volts livened up the performance considerably on the medium wave band, enabling many Continental stations to be received including Luxembourg. No adjustment to component values was necessitated by this voltage increase. Current consumption at 3 volts was 11mA (using an OC140 in the TR_3 position). This may seem rather high but it gives a reasonable earphone output with good quality. As an economy measure, and if the constructor is prepared to accept a lower output, R_7 could be replaced by a resistor of 56Ω. Consumption at 3 volts is then 5mA.

Mechanical Detail

The layout was not critical, the components being mounted on Veroboard of 0.15in matrix, and details are shown in Fig. 3.

The earphone used was a magnetic type having a resistance of approximately 100Ω. However, the set functioned satisfactorily with earphones having resistances varying from 30 to 250Ω. A crystal earpiece could be used by connecting a resistor of suitable value between TR_3 collector and the positive supply rail with the earpiece in parallel.

The set is switched on by inserting the earphone plug in the jack. Most miniature phone jacks have contacts which open when the plug is inserted, but it is a simple matter to modify them so that the contacts close on insertion and open when the plug is withdrawn. See Fig. 4. A 2mm plug and socket were used.

The tuning capacitor is a Radiospares trimmer modified by removing the adjusting screw and replacing with a longer screw which protrudes beyond the ceramic base of the trimmer. Lock nuts were then fitted which formed a "knob" for hand adjustment. The modification is shown in Fig. 5.

The case used by the author was a plastic box measuring approximately $2 \times 2 \times \frac{3}{4}$in, but other suitable arrangements could be used to fit any box of convenient dimensions. As may be seen from the photograph, C_1 and wavechange switch S_1 were mounted on one side of the case, the switch being a small slide type. The author's receiver is powered by two U16 cells, connected in series.

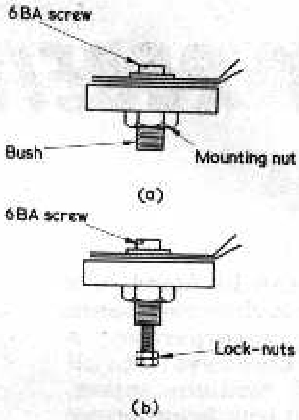


Fig. 5 (a). The Radiospares trimmer before modification
(b). The trimmer after modification. A longer 6BA screw is fitted, this projecting beyond the mounting bush. Lock nuts are then fixed on this to make a hand control

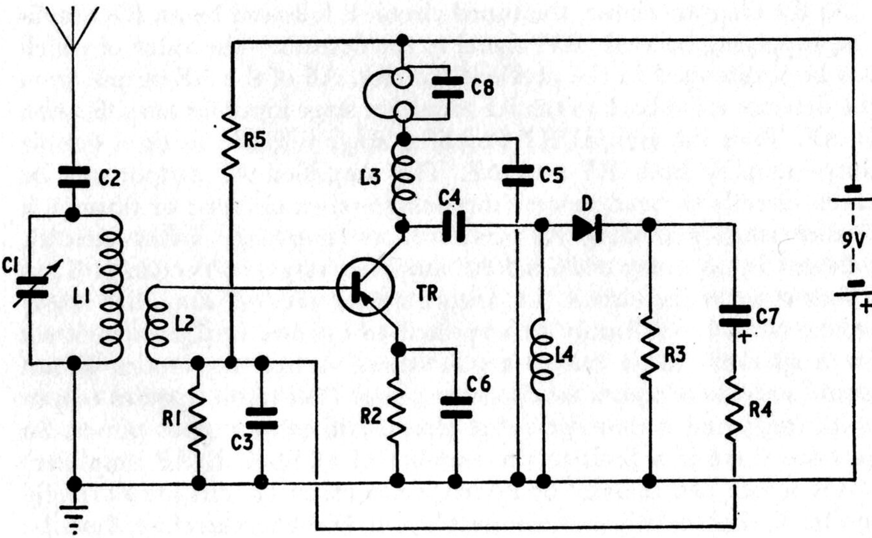


Fig. 36. *A three-stage reflex circuit which uses only one transistor—a simple and easy to construct receiver capable of excellent performance in areas of moderate to high signal strength*

L1, L2—transformer coupled aerial coil
C1—0–250 pF tuning capacitor
C2—220 pF (may be omitted and direct coupling of aerial tried)
C3—0·01 μF
C4—47 pF
C5—0·005μF
C6—32μF (15 volts D.C.) electrolytic
C7—10μF (6 volts D.C.) electrolytic
C8—0·009 to ·01 μF
R1—4·7 kilohms
R2—3·3 kilohms
R3—22 kilohms
R4—1 kilohm
R5—22 kilohms
L3—RF choke (*see* Fig. 37)
TR—Mullard OC44, OC45 or equivalent
D—Mullard OA81, OA91, or equivalent

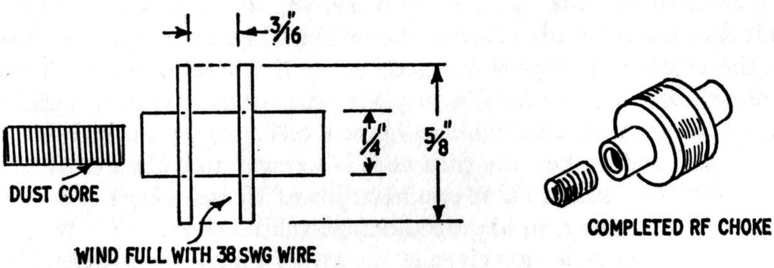


Fig. 37. *Construction of an RF choke (L3 in the circuit of Fig. 35)*

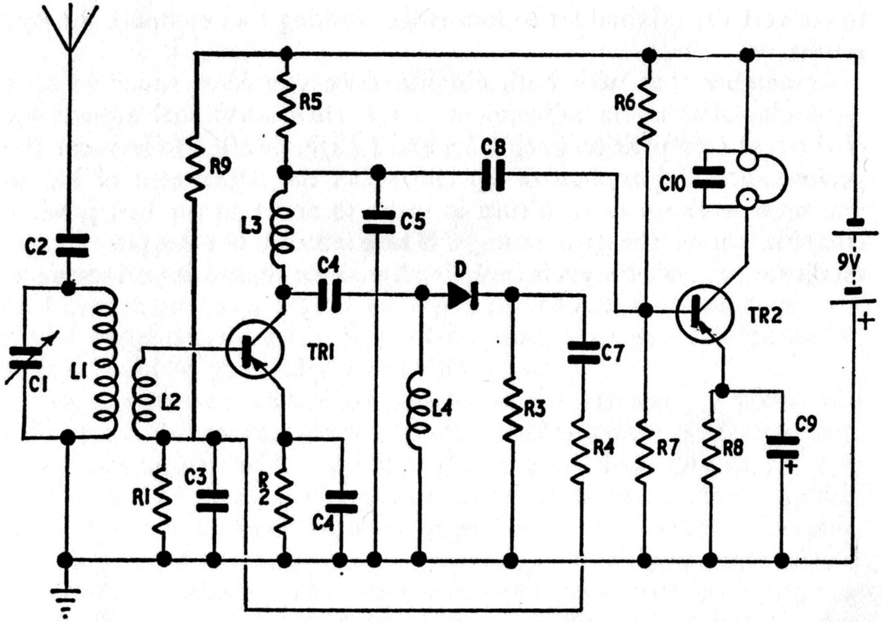


Fig. 38. *A four-stage reflex circuit. This should have enough output to operate a loudspeaker via a step-down transformer (replacing the phones); or an additional stage of amplification could be added for loudspeaker reproduction*

I1, L2—as Fig. 32
L3—as Fig. 37
L4—as Fig. 37
C1—0–250 pF tuning capacitor
C2—220 pF (may be omitted)
C3—0·01 μF
C4—47 pF
C5—0·005μF
C6—32μF (15 volts D.C.) electrolytic
C7—10μF (6 volts D.C.) electrolytic
C8—8μF (15 volts D.C.) electrolytic
C9—8μF (19 volts D.C.) electrolytic
C10—0·005 to 0·01μF

R1—4·7 kilohms
R2—3·3 kilohms
R3—22 kilohms
R4—1 kilohm
R5—4·7 kilohms
R6—22 kilohms
R7—10 kilohms
R8—4·7 kilohms
R9—22 kilohms
D—Mullard OA81, OA91, or equivalent
TR1—Mullard OC44, OC45, or equivalent
TR2—Mullard OC71, or equivalent

THE explorer

AM/FM VHF RECEIVER

By W.E.BARDGETT

COVER SUBJECT

A Four Transistor unit covering 65-170 Mc/s

A NUMBER of readers have indicated in recent correspondence an interest in constructing receivers which will explore the v.h.f ranges, including the 2 and 4 metre amateur bands. A valve receiver employing inexpensive surplus valves was described in the June, 1964 issue, and one advertiser offers a simple kit for a mains valve super-regenerative receiver employing the Flewelling circuit which requires few components, yet provides a means of exploring the v.h.f. bands at low cost. These receivers are, however, dependent upon mains power supplies. Very high frequency transistors are now available at reasonable cost which permit the construction of a tuner/receiver which can be entirely portable or can be used in a motor car feeding into the amplifying stages of a car radio. The receiver described may be fitted with coils of various sizes allowing coverage of the 2 and 4 metre amateur bands, the B.B.C. Band II f.m. transmissions and many others. The v.h.f. Explorer is a detector of amplitude modulated signals but can also receive f.m. transmissions although not at hi-fi quality.

SKILL REQUIRED

The construction of the receiver described should not be attempted by the absolute beginner, as the building requires a certain amount of skill. V.H.F. circuits must be leadless in the signal circuits, so that the components have to be soldered directly to each other with the shortest possible connections. The layout of the components must facilitate this lead-less construction and the proximity of the components concerned must take precedence over any

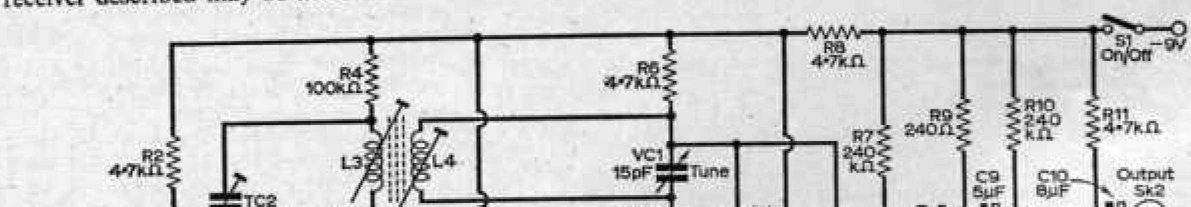


Fig. 1: Circuit diagram of the "Explorer" receiver.

claims for symmetry, or even accessibility. The need for this ultra short wiring cannot be too strongly stressed: without it, the losses in the signal circuits would be so great that the receiver would not work at all. To achieve successful results demands intricate construction, good soldering, patience and persistence, as well as an electric soldering iron with a small bit and pair of tweezers. On the other hand, the sense of achievement when results are finally obtained at v.h.f. is akin to that experienced by earlier generations when it was an event to receive radio transmissions at all.

V.H.F. transmissions have a relatively short range, and the amount of traffic picked up on a receiver of the type described will vary considerably between different parts of the country.

These are the two main warnings to those considering the construction of the receiver.

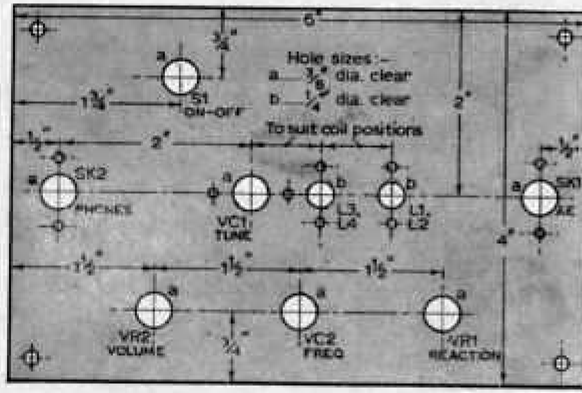


Fig. 2: Drilling dimensions of front panel.

THE CIRCUIT

The receiver circuit is shown in Fig. 1. It consists of a tuned r.f. stage Tr1, with a neutralising capacitor and a self-quenching super-regenerative detector (Tr2); both employing alloy diffused transistors capable of operation up to 200Mc/s in the circuits shown. These two stages are followed by two conventional stages of audio amplification with an output capable of driving headphones. This is also suitable for feeding into a transistor or valve amplifier for loudspeaker reproduction. Whilst a sensitive pair of headphones may be driven directly, much improved results are obtained if the output is fed into a package transistor amplifier such as many advertisers offer, or into the amplifying stages of a car radio. The author has fitted a jack and socket before the amplifier section of his *Practical Wireless* "Autocrat" car radio (described in the November 1964 issue), so that the v.h.f. tuner can be fed into this.

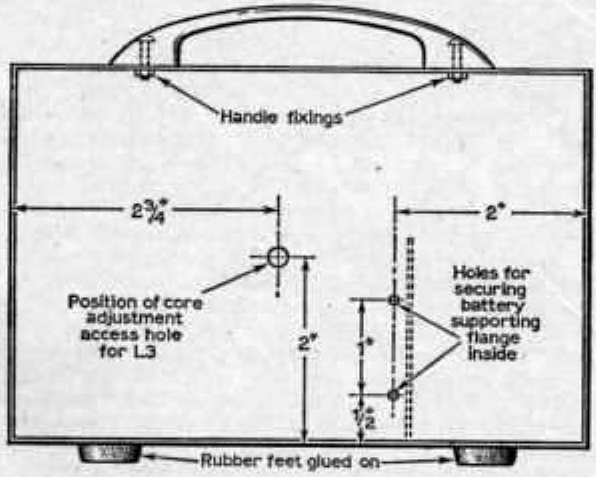


Fig. 3: Rear view of screening box.

CONTROLS

The aerial input socket Sk1 is a television-type co-axial socket for use with a dipole aerial. The second socket Sk2 is the output to headphones or amplifier. The on/off switch is of the toggle type. This was preferred to the type incorporated in the volume control as it is possible to see at a glance whether the tuner is switched on or not. The main tuning capacitor requires a 180° scale and knob/pointer, but as tuning is fairly broad a reduction drive is not necessary. The other controls consist of a volume control VR2, especially important if the output is to be fed into a transistor package amplifier without its own volume adjustment, a base bias potential adjuster VR1 which controls the regeneration of the super-regenerative detector and a quench frequency control VC2.

Note:- Transistor Tr2 holder is secured to fixed plates of VC1,VC2

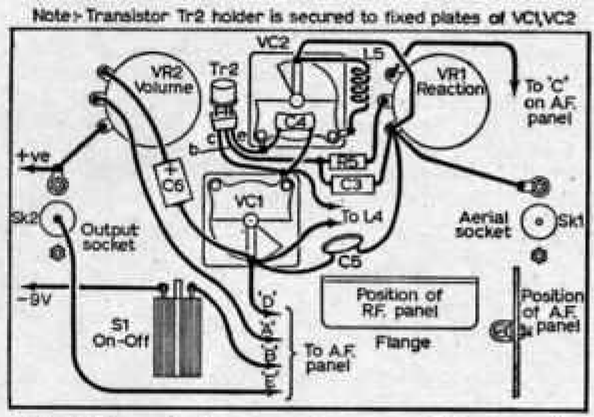


Fig. 4: Layout of components on rear of front panel.

CONSTRUCTION

As super-regenerative detectors are radiators which would cause illegal interference if connected directly to an aerial or operated unscreened, an r.f./buffer stage must be used and the receiver must be contained in a metal case. All components, controls and sockets are fitted directly or by means of flanged panels to the front panel; of aluminium measuring 6 x 4in. This is then housed in a commercially produced metal screening box measuring **6 x 4 x 2¼in**, being attached to it by four self-tapping screws which go into the corner flanges on the box. The layout of controls and sockets on the front panel is shown in Fig. 2. The r.f. stage is not merely a buffer: it improves the signal/noise ratio sufficiently to make listening pleasant and makes selective what would otherwise be very broad band reception.

COILS

Details of the coils are given in Table 1. They are positioned and permeability tuned by two Aladdin plastic coil formers with dust cores. Coils L3 and L4, although on the same former, each have a separate dust core entering the former from opposite ends. A hole may be drilled in the rear of the screening box opposite the coil former of L3 and L4 as shown in Fig. 3, to permit adjustment of L3 core by means of a plastic trimming tool. The cores of L1, L2, and L4 may be adjusted in a similar way through the holes opposite the Aladdin formers on the front panel.

The positioning of the main components at the rear of the front panel is shown in Fig. 4, which also shows the wiring of the super-regenerative detector stage. The r.f. stage is constructed on a 2 x 1½in. paxolin shelf, held at right angles to the front panel by a narrow aluminium flange. The wiring and connection of components for the r.f. panel is shown in Fig. 6. All wiring should be completed on the shelf before it is fitted close to the Aladdin formers mounted on the front panel. The coils on these formers should be cut to give, by trial, the shortest and most direct connections to the transistor holder of Tr1 and to the variable capacitor VC1. Thick wire is highly desirable for v.h.f. and 16 s.w.g. is suggested. As the v.h.f. signals flow on the outer surface of the wire, tinned copper wire should be chosen. The tuned choke L5 is space-wound and self supporting being mounted directly on the quench frequency variable capacitor VC2. It should be at right angles to the other coils. The usual v.h.f. practice is followed of bringing all earth connections of each signal stage to a common point.

The a.f. stages are constructed on a 12 position tag board (two lines of 6 tags), which in turn is mounted on the front panel by means of an aluminium bracket in the position shown in Fig. 4. The wiring of the a.f. panel is shown in Fig. 5. Transistors Tr3 and Tr4 mounted on the tag board are bent back on their leads (which should be covered in p.v.c. sleeving), so that they are close to the board, and so permit the easy insertion of the receiver into its screening box. A heat sink must be used when soldering leads of transistors Tr3 and Tr4 to their tag connections: a pair of pointed nosed pliers will suffice. Transistors Tr1 and Tr2 should not be inserted in their transistor holders until all soldering is completed, and they must be removed when any subsequent soldering (e.g. for coil changing) takes place.

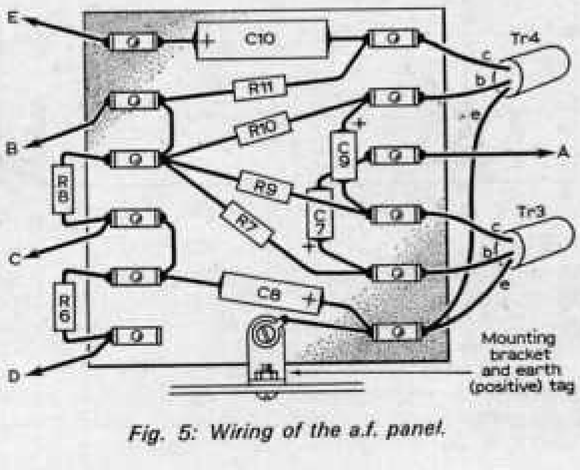


Fig. 5: Wiring of the a.f. panel.

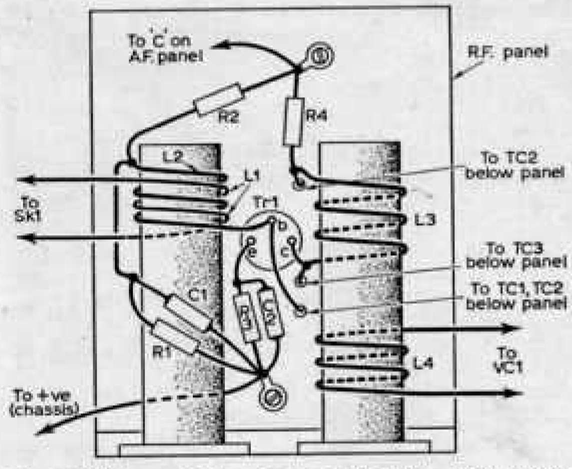


Fig. 6. Wiring of the r.f. panel. Below—Coil winding data.

Table I—Coil Details

Range 1 110 to 170Mc/s	L1. 2 turns 22 s.w.g. tinned copper p.v.c. covered on ¼in. Aladdin former with dust core (without screening can) interwound with L2.
	L2. 3 turns 16 s.w.g. tinned copper on same ¼in. Aladdin former with dust core and interwound with L1.
	L3 and L4. 3 turns each of 16 s.w.g. tinned copper adjacent to each other on same ¼in. Aladdin former with 2 dust cores, 1 to each coil, without screening can.
	L5. 28 turns 30 s.w.g. enamelled copper, self-supporting wound in screw thread of 0BA bolt and then removed
Range 2 65 to 120Mc/s	L1. As in Range 1.
	L2. 5 turns 16 s.w.g. tinned copper on same ¼in. Aladdin former as L1 and interwound with L1 with dust core, without screening can.
	L3 and L4. 5 turns each of 16 s.w.g. tinned copper adjacent to each other on same ¼in. Aladdin former with 2 dust cores, 1 to each coil, without screening can.
	L5. As in Range 1.

AERIAL

The usual long wire domestic aerial is virtually useless at v.h.f. Plugging in the home television aerial will probably give some results, but it is advisable to construct a half-wave dipole aerial for the frequency range to be explored. The length across both arms of the dipole in inches is found by dividing 5616 by the frequency in megacycles. A telescopic quarter wave whip aerial may be connected as an alternative to a tapping point about the centre of L2.

TESTING AND OPERATION

All wiring should be checked carefully against the theoretical circuit diagram before a battery is connected to the receiver. A PP7 battery supplying 9 volts fits neatly into the case and is held in position by an aluminium flange bolted to the rear. Ensure that the correct battery connectors are fitted to the appropriate leads, as reversal of the battery polarity could ruin all the transistors.

Connect a dipole aerial to the aerial socket and a pair of headphones to the output socket or alternatively connect the output, preferably by a short length of co-axial cable, to the input of an amplifier. Switch on the receiver and advance the volume control VR2 as required. Rotate the regeneration control VR1 until the characteristic super-regenerative hiss is heard. If regeneration does not take place, adjust VC2 and/or move coils L3 and L4 a little further apart. Search for signals with the set just regenerating. The dust core of L3 and L4 should at first be well out towards opposing ends of the coil former in order to avoid increasing the the coupling and damping the regeneration. Set the trimmers and cores initially as follows, and adjust for best results when a signal is heard.

TC1 just fully out; TC2 just fully out; TC3 quarter closed; L1 and L2 core fully into coil; L3 core almost fully into coil; L4 core end just entering coil.

All final adjustments should be made on signals found by rotating VC1 slowly, and if necessary adjusting the core of L4.

By installing the coils for L1, L2, L3 and L4 of the size given for Range 1 in Table 1, it is possible on the prototype to pick up taxis and other mobile transmissions in the 165 to 174Mc/s allocation and even Band II television sound transmissions, but at this height in the frequency scale the receiver is approaching its limit and regeneration may be difficult to obtain over the full range of tuning of VC1. In appropriate areas there should be no difficulty, however, in hearing on Range 1 coils, the air to ground transmissions between 118 and 136Mc/s as well as the 2 metre amateur band (144Mc/s). Range 2 coils as described in figure 7 will allow the BBC f.m. band to be heard with mobile radio allocations on either side of it. The lower one between 71 and 87Mc/s is easily recognisable by the frequent Motoring Association transmissions about vehicle breakdowns. Not far from this on Range 2 is the 4 metre amateur allocation. Initial success is more likely if Range 2 coils are tried first.

★ components list

Resistors:	**Capacitors:**
R1 33kΩ	C1 0·001μF ceramic
R2 4·7kΩ	C2 0·001μF ceramic
R3 1kΩ	C3 200pF ceramic
R4 100Ω	C4 2·2pF ceramic
R5 120kΩ	C5 0·01μF ceramic
R6 4·7kΩ	C6 8μF electrolytic
R7 240kΩ	C7 2μF electrolytic
R8 4·7kΩ	C8 100μF electrolytic
R9 240Ω	C9 5μF electrolytic
R10 240kΩ	C9 5μF electrolytic
R11 4·7kΩ	C10 8μF electrolytic

Variable Capacitors:

VC1 15pF air spaced bolt fixing insulated from panel
VC2 5pF air spaced spindle fixing

Transistors:	**Trimmer Capacitors:**
Tr1 ADT140 (Sinclair)	TC1 3-8pF beehive trimmer
Tr2 ADT140 (Sinclair)	TC2 3-8pF beehive trimmer
Tr3 OC71 (Mullard)	TC3 3-8pF beehive trimmer
Tr4 OC71 (Mullard)	

Potentiometers:

VR1 50kΩ   VR2 5kΩ

Miscellaneous:

6 x 4in. aluminium front panel, 6 x 4 x 2½in. metal screening box, 2 x 1½in. paxolin panel, 1½ x ¾in. aluminium for panel flange, 2 x 2in. aluminium for battery flange, 1½ x 1½in. 12 position tag board, 1 single pole toggle switch, 1 aluminium bracket, wire, nuts, bolts, etc., 2 co-axial sockets, 2 transistor holders (Eagle Products), 2 battery connectors, 2 coil formers ¼in. Aladdin, 3 dust cores for formers, 3 small knobs, 1 tuning pointer knob with scale, 4 rubber feet, 1 carrying handle.

Rear of front panel, showing Range 1 coils fitted.

CONCLUSION

When signals are tuned, they should quench the super-regenerative hiss, so that the background is clear of noise. Super-regenerative receivers have the advantage of possessing built-in automatic volume control and noise limiting action, whilst the relatively broad tuning characteristics make band spread or reduction drives unnecessary. The gain of this type of receiver appears to be proportional to the frequency, so that at v.h.f. levels its performance can be quite phenomenal. ■

Correction: The Explorer VHF Receiver

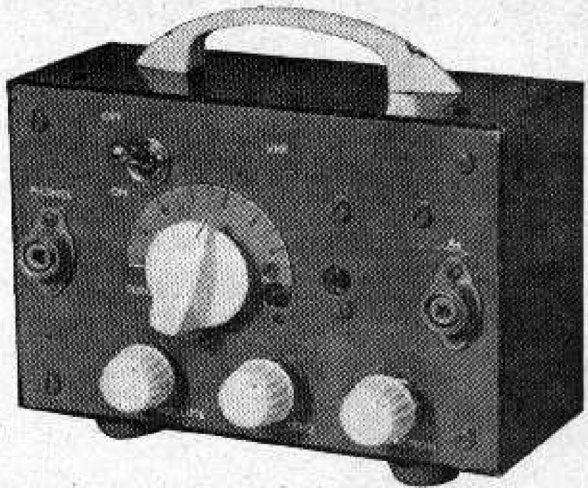
It has been brought to our attention, by the author, that four of the component values given in the circuit diagram and one of the items in the components list for The Explorer (January 1967 issue) are incorrect. To put matters right, the circuit diagram (page 646) should be amended as follows: R4 should read 100Ω, C4—2·2pf, TC2—3 to 8pf, and R9 should read 4·7kΩ. To correct the components list (page 649), the value of R9 should read 4·7kΩ.

more about

THE explorer

AM/FM VHF RECEIVER

By W.E.BARDGETT



Published in the January 1967 issue

THE V.H.F. Explorer, a four transistor a.m. and f.m. receiver employing a self-quenching super-regenerative detector and covering 65 to 170Mc/s in the v.h.f. band, was described in the January 1967 issue of this magazine. It occasioned considerable interest and was built successfully by a number of readers, although some had difficulty with the r.f. stage adjustments. More recently several constructors have been unable to make the receiver work at all, and this has now been traced to the fact that the Sinclair transistor marketed currently as the ADT140 is different from the ADT140 marketed by the same firm about a year ago, when the prototype V.H.F. Explorer was built. The early type of ADT140, which works outstandingly well in this receiver, has the same gold-coloured capsule and leads of the later type, but may be identified by the off-white or polythene colour of the insulation through which the leads pass into the capsule. The later ADT140, which works in many applications for which it was designed but which will not, unfortunately, operate in the super-regenerative circuit of the Explorer, has a brownish-red insulating material, but is otherwise similar to the earlier type.

Transistor equivalents

With the help of a number of readers who have built the Explorer, it has been ascertained that the circuit will work with the following Mullard transistors in place of the ADT140's for positions Tr1 and Tr2: AF118—AF117—AF115—OC171—OC170. The only essential change to the original circuit is an adjustment of the base bias control VR1, which initiates regenerative action at quite a different setting from that required by the early ADT140.

A transistor which might have been expected to work well at v.h.f. but which does not appear to function at all in the super-regenerative circuit described is the AF183.

Circuit improvements

As was explained in the April 1967 issue of PRACTICAL WIRELESS, four of the component values in the original circuit diagram and one in the component list were incorrect. To put matters right R4 should be 100Ω, C4—2·2pF, TC2—3 to 8pF and the value of R9 should be 4·7kΩ.

The values of R1 and R2 should also be transposed so that R1 is 4·7kΩ and R2 is 33kΩ. Whilst the above are the only necessary corrections, further experiment with the receiver has shown that its functioning may be improved by a number of other circuit variations.

Firstly, the feedback capacitor C4 on the super-regenerative detector stage Tr2 may be replaced with advantage by an adjustable 3 to 8pF beehive trimmer. This is mounted from the fixed vanes of VC1 to the fixed vanes of VC2 across which the transistor holder for Tr1 is soldered as well. Adjustment of this trimmer allows an optimum setting to be found which is something which will vary slightly when different transistors are employed.

Secondly, the use of a single battery to energise both the r.f. stage and detector and the audio stages has resulted in some interaction between VR2 and VR1 so that, particularly when a battery is partly discharged, the increase in volume for the audio stages by VR2 may stop the super-regenerative detector operating at all. This can best be overcome by employing two separate batteries for the audio section and the r.f. and detector section. If both these are 9 volt batteries the negative lead to the detector stage should continue to be fed through a 4·7kΩ resistor. Both a PP7 battery and a PP4 battery (the latter for the r.f. and detector stage) may be housed within the original case but improved results have been obtained from having two PP7 or even two PP9 batteries in a separate case fixed to the back of the receiver screening box.

Thirdly, performance is improved by including a second choke in the super-regenerative detector circuit. This is inserted between the 4·7kΩ resistor coming from the negative supply line to this stage and the end of L4 and side of VC1 which are remote from the collector of Tr2. The choke should be the same size as L5, i.e. 28 turns of 30 s.w.g. enamelled copper wire wound in the screw thread of an 0BA bolt and then removed. Alternatively, as with L5, it may be wound around a short length of plastic tuning spindle and the ends fixed with cellulose tape.

Fourthly, a modification which may improve working consists of the replacement of C3, the 200pF capacitor linking the base of Tr2 with the positive line, by a 47pF ceramic or disc capacitor linking the base of Tr2 with the end of L4 and side of VC1 which are remote from the Tr2 collector. If the original physical layout is followed this is a connection with very short leads. It appears to introduce a measure of neutralisation to Tr2 in the same way as this is provided by TC2 for the r.f. transistor Tr1.

Loudspeaker operation

A number of readers have fed the output of the Explorer into transistor amplifiers to provide loudspeaker reception. Most have used English or Japanese package amplifiers for this purpose, the author having used a $1\frac{1}{2}$ watt transformerless package amplifier. With most such amplifiers the audio stages included in the original receiver circuit will be unnecessary and the input to the amplifier may be taken from either C9 (dispensing with the last audio stage Tr4) or from C7 (dispensing with both audio stages Tr3 and Tr4). The volume control VR2 should, of course, be retained.

Getting the receiver going

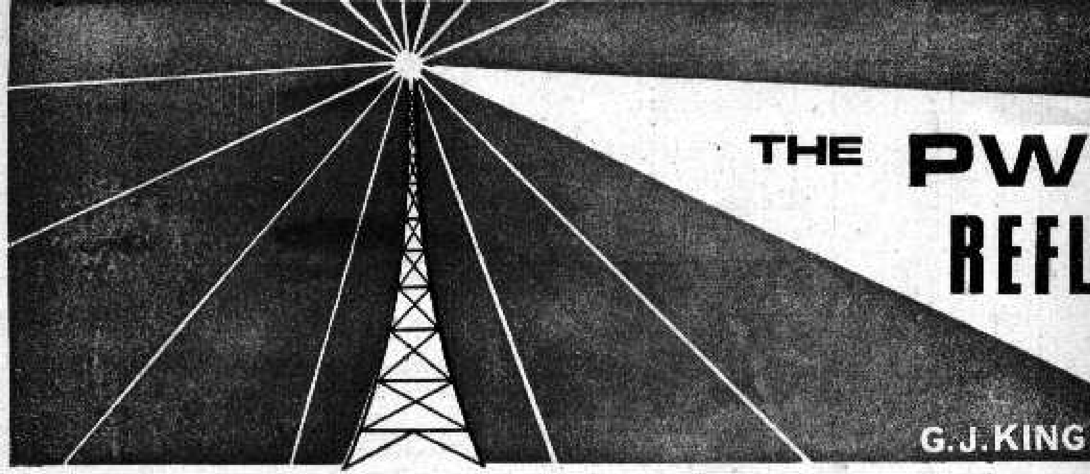
For those who have made the essential circuit corrections mentioned earlier, the following procedure should be used to get the receiver going. It is based on the experience of a number of readers.

Ensure that the proper size of v.h.f. half-wave dipole or $\frac{1}{4}\lambda$ whip aerial is attached to the aerial socket. The length in inches is found by dividing 5616 by the frequency in megacycles. This gives the dipole length across both elements: the appropriate quarter-wave whip aerial would be half this length. A long wire aerial is quite useless, but some results may be obtained from a TV or f.m. aerial array.

Having connected an amplifier or headphones, advance the volume control VR2 and then adjust the super-regeneration control VR1 until a fierce fairly high-pitched hissing noise is heard. There may be some other less fierce hissing at other settings of VR1. If the fierce hissing is not heard, unbolt the r.f. panel, maintaining a lead to chassis for the positive power supply, and move L3 away from L4. If regeneration then commences at some setting of VR1 bring L3 close to L4 until it just fails to quench the oscillations. Alternatively, dead spots in the regenerative action may possibly be eliminated by adjusting VC2—this is its main function.

Tuning by VC1 should then resolve some signals but if this does not happen several readers have overcome the difficulty by temporarily cutting out the r.f. stage and connecting the aerial coil L1 directly to the super-regenerative detector tuning coil L4. It must be emphasised, however, that this will cause at least some local radiation and possibly interference. Builders of the set who have done this have brought L1 close to L4 until it quenches the super-regenerative hiss and have then moved it away again until the hiss just begins. The set is then most sensitive to signals. By tuning in a fairly strong signal and leaving the detector stage tuned to it some builders have found that the r.f. stage may then be re-inserted and the trimmers and cores adjusted on the signal which is breaking through.

A number of experimenters have tried other r.f. stage circuits including those employing the common base configuration—often considered more suitable for v.h.f. work. These have included the circuit of the 70cm preamp described by J. L. Oliver in the July 1967 issue of this magazine, and the pre-amplifier described by J. W. Thompson in the July 1967 issue of PRACTICAL TELEVISION, both with appropriate adjustments in the size of the coils. It has to be admitted, however, that there is relatively little improvement obtainable from any r.f. stage in the Explorer circuit, but it is essential to retain it as a buffer stage to prevent radiation from the super-regenerative detector via the aerial. ■



THE exercise was to create a pocket-sized two-transistor local-programme m.w. radio with an internal ferrite rod aerial, suitable for working a crystal earpiece, and that could be built easily from readily obtainable parts.

While the set could have been made somewhat smaller than the final version, measuring about 2½ x 2½ x ¾in., including the battery, this represents about the smallest size that can be achieved by the use of easily obtainable components.

A smaller overall size could probably have been obtained by the use of a PP5 battery instead of the PP3 used, but the latter was eventually decided on because this is obtainable anywhere.

Moreover, for fair performance the ferrite rod aerial should not be too short, and the dimensions referred to above allow the use of a 2½in. length of 5/16in. dia. ferrite rod upon which the m.w. aerial coil is wound. The pick-up efficiency and the "Q" (goodness factor) of a ferrite rod aerial deteriorate as the length and the diameter of the rod are reduced.

Most pocket-sized sets use a single-gang tuning capacitor, sometimes with a stage of "untuned" r.f. amplification. The set to be described uses two-ganged tuning, one section for the ferrite rod aerial and the other for the r.f. stage. This improves the efficiency a little above that possible by the use of an untuned stage.

The Circuit

Before the construction of the set is described, let us have a look at the circuit, which is given in Fig. 1. It will be seen that two transistors and two diodes are used, marked (Tr1, Tr2, D1 and D2 respectively).

Now, the first transistor Tr1 is arranged in a "reflex" circuit so that it performs two functions. Firstly, it acts as an r.f. amplifier. That is, it has coupled to its base signals from the ferrite rod aerial L1, tuned by VC1 section of the tuning gang. These signals are developed in amplified form across the collector coil L2, tuned by VC2 section of the gang. From the collector of TR1 they are coupled to the detector circuit through C2. The detector comprises the two diodes D1 and D2 in conjunction with the input impedance of Tr1.

Thus, audio signal acts in the base-emitter junction of Tr1, and this is how the transistor does its section job. That is, it acts as an audio amplifier. This time, however, the amplified audio signals are developed across the collector resistor R2. From the audio aspect, L2 and its associated components have virtually no effect while from the r.f. aspect R2 is isolated by the low impedance presented to these signals by C4 and the base circuit of Tr2. We thus get audio at the junction of R2 and L2 yet very little r.f. signal.

At the collector proper of Tr1 we get both audio and r.f. signal. The audio is somewhat attenuated by the r.f. coupling to the detector diodes, but there occurs a certain degree of negative feedback which tends to reduce the efficiency of a single transistor circuit so reflexed below that possible by the use of separate transistors and properly isolated circuits. Nevertheless, the extra gain possible

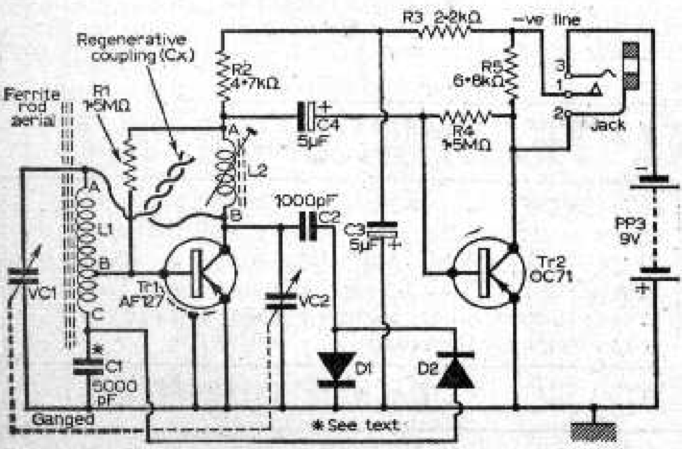
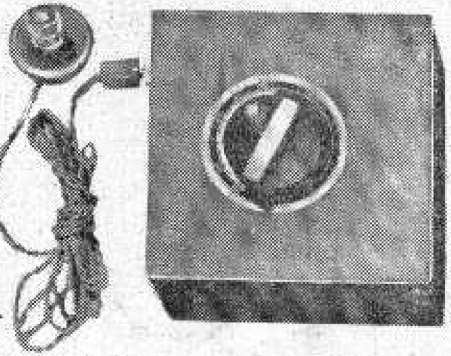


Fig. 1: Circuit of the Reflex 2.



by the reflexed action is well worth while in small receivers.

Now, the audio signal at the junction of R2 L2 is applied to the base of Tr2 through the electrolytic coupling capacitor C4. Tr2 is arranged as a low-level second audio amplifier for working the crystal earpiece. The audio signal is developed across the collector load R5 and is directly coupled to the earpiece via the jack socket, at terminals 1 and 2. Terminal 3 on the jack socket serves as a switch, so that a switch contact in the jack makes when the jack plug is inserted, thereby connecting the battery supply circuit from battery negative to the negative line of the circuit, via jack socket terminals 3 and 1.

Switched Jack

Miniature "switched" jacks are available, but those investigated by the author are arranged so that the switch *opens* when the earpiece jack is inserted. This action can be reversed, so that the switch *closes* when the jack plug is inserted, by easing the spring switch contact so that it is above the jack contact (contact 3) which is activated by the plug. Fig. 2 shows at (a) the jack socket in its ordinary state and at (b) the socket with the contact rearranged in the manner described above.

Both transistors run with very small emitter current, and this current is determined by the values of R1 (for Tr1) and R4 (for Tr2). R3 and C3 serve to decouple the two stages and improve the stability margin.

Tr1 is a Mullard AF127, which is a smaller version of the AF117. The latter can be used but its larger size takes up most of the room between the tuning gang and the ferrite rod aerial. Tr2 is a medium gain OC71. The diodes D1 and D2 are miniature Mullard OA91's or equivalents. It is important to make sure that they are connected round the right way in the circuit otherwise the sensitivity will be impaired.

The receiver is built on a laminate or bakelite panel of approximately 2¼ x 2½in. Most of the components are secured to the panel and connected in circuit by the use of small eyelets fitted in holes drilled in the panel. In addition to the eyelet holes, the panel carries a ⅜in. diameter hole for mounting the tuning gang, two holes for L2 coil former, two holes for the rubber band that fixes around the ferrite rod aerial mounting grommets, two holes for the battery securing rubber band.

Drilling details for the panel are given in Fig. 3, and the holes marked with "Y" are those to accommodate the eyelets, of which there are twenty-four. These holes should be of a size that provides the eyelets with a fairly tight fit, the actual size, however, being determined by the type of eyelet employed. A *ready drilled* chassis board is available plus twenty-four push-fit eyelets (see components list). A No. 48 drill is used for the former fixing holes of L2, while a ⅛in. drill is used for the rubber band holes that are used for securing the ferrite rod grommets and battery.

Fig. 4 shows how the holes in the panel are employed, and this also incorporates a point-to-point wiring diagram. The eyelets, it will be seen, carry the capacitors and resistors on the left-hand side of the panel, also the lead-out wires of Tr1 and Tr2 (the latter in the top left-hand corner) in addition to the two diodes and capacitor C1 (near the ferrite rod aerial). The broken lines on this diagram correspond to point-to-point connections made beneath the panel, while the full-line connections are those made on the top of the panel.

When the holes are drilled in the panel and the eyelets fitted, the next move should be to solder the components to the eyelets, after which the larger components can be more easily fitted. As each component is soldered to the appropriate eyelet the above- or below-panel interconnecting wire or wires should also be soldered. These wire interconnections can either consist of thin, flexible p.v.c. covered stranded wire or about 26 s.w.g. tinned copper wire covered with insulated sleeving. Stranded miniature p.v.c. wire was found to be the best for the job by the author.

The eyelet-connected components on the left-hand side of the panel are mounted vertically, and it is this kind of mounting that enables all the components (of "standard" size) to be accommodated on the board. The idea is to dress one of the lead-out wires from resistor or capacitor back along its length, so that the two ends can then be pushed into the adjacent eyelets. It is a good plan to put a short length of insulated sleeving over the wire running by the side of the component to prevent any possibility of short-circuiting.

A miniature soldering iron will greatly facilitate the various joins and prevent burning the insulated sleeving and components. It is important, though,

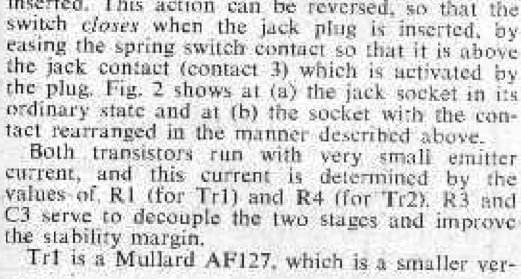


Fig. 2: Modifications for the phone socket.

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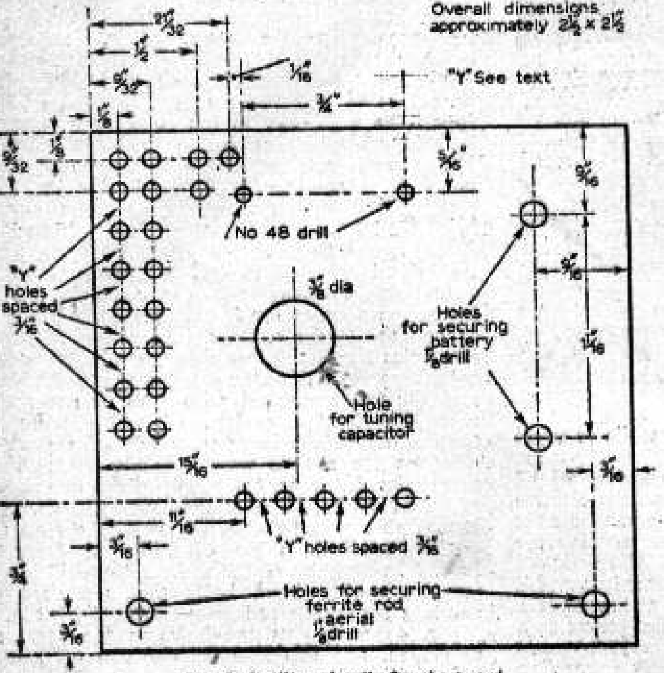


Fig. 3: Drilling details for the panel.

that the tip of the iron be clean and nicely tinned and—of course—as hot as possible. When soldering to the eyelets, the author found it best first to fill the eyelet holes with solder, to cut the component lead-out wires to the correct length, tin the ends and then plug them as it were, into the eyelets after making the solder molten with the tip of the soldering iron. This technique also makes it simple to change components and to experiment with components of different values.

After the eyelet components have been soldered in position and the interconnecting wiring completed as far as possible, the two-gang tuning capacitor should be fitted. The large centre thread of the gang spindle bearing fits in the ⅜in. diameter hole on the panel, and the gang is secured to the panel by the large brass nut. At this stage, make sure that the protruding 6BA thread on one of the gang bolts appears at the top left-hand side of the chassis board.

The next item to position is the former for L2. This is an ordinary bakelite or polythene type of component. It is secured in position by two "self-tapping" or "binder" screws from the top of the panel. The coil winding is put on later.

It then finally remains for the ferrite rod aerial to be wound and mounted, for L2 to be wound and put on to the former and for the wiring to be completed.

Aerial and Coil Windings

The ferrite rod winding is made on top of a piece of thin brown paper or card itself wound round the rod. The card should be cut to 1½ x 1¼in., allowing for two turns round the rod, giving a winding length of 1¼in.

The winding is made of a total of 72 turns of 28 s.w.g. enamelled-covered copper wire, tapped at ten turns from one end. Close spaced, the turns occupy almost the whole length of the card leaving a little margin at each end, as shown in Fig. 5. The turns are finally secured in position by means of Sellotape. The card former allows the winding easily to be slid along the ferrite rod to provide a small adjustment of inductance, maximum inductance being with the winding midway along the rod.

The coil (L2) is also made on a paper or thin card former but this time it is cut to measure 7/8 x 1¼in. with two turns round the former. It is best to hold the former in position with Sellotape before commencing the winding, and this technique can also be used for the aerial winding.

L2 consists of a total of 136 turns of 39 s.w.g. enamelled-covered copper wire in four layers of 34 turns, each layer being separated from its partner by two thicknesses of Sellotape.

COMPONENTS LIST

Resistors:

R1 1·5MΩ R4 1·5MΩ
R2 4·7kΩ R5 6·8kΩ
R3 2·2kΩ
All 20% miniature.

Capacitors:

C1 0·005μF (5000pF)
C2 0·001μF (1000pF)
C3 5μF 12V. electrolytic
C4 5μF 12V. electrolytic
All miniature types.

Semiconductors:

Tr1 AF127 Mullard (or AF117, larger size)
Tr2 OC71 Mullard
D1 OA91 D2 OA91 (Mullard)

Miscellaneous:

Miniature 300pF twin gang. PW/01. Drilled chassis board with 24 push-fit eyelets, rubber band for battery, PW/02, 2½ x 5/16in. dia. ferrite rod—paper former—quantity of 28 s.w.g. enam. wire—mounting grommets—rubber fixing band, PW/03.

0·3in. coil former—dust core—paper former—two binding screws (self-tapping)—quantity of 39 s.w.g. enam. wire, PW/04.

Miniature battery clips, PW/05.

Ready drilled case and back—dial—knob, PW/06.

Crystal earpiece with lead, 3·5mm. jack plug and socket.

PP3 battery or equivalent.

Small quantity of wiring wire.

Items: PW/01—PW/06 may in cases of difficulty be ordered directly from R.C.S. Products Ltd., 11 Oliver Road, Walthamstow, London, E.17.

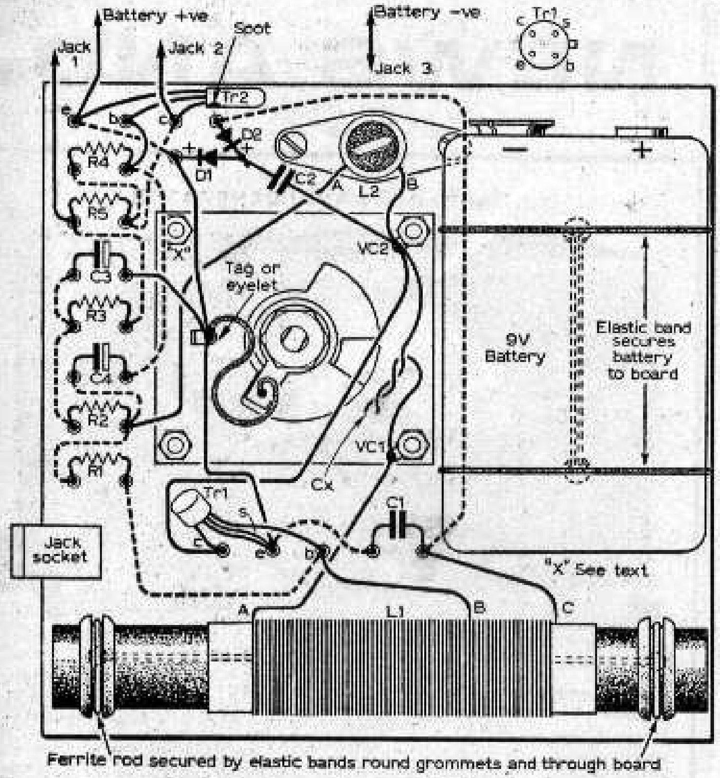


Fig. 4: Component layout and wiring details.

It is best to produce this winding either on a separate former or on the former to be used *before* it is finally fitted to the panel. The card former can then easily be slid over the former once the latter is in position and screwed down.

The ferrite rod is held clear of the panel by two ¼in. rubber grommets, one at each end. These are also used for securing the rod a thin rubber band passing round them and through the holes at each side of the panel. A similar rubber band is used to hold the PP3 battery to the panel (see Fig. 3).

Finally, a thin flexible two-conductor lead should be made up for the battery connections, the ends of the conductors terminated in suitable connectors for the PP3 battery and a three-conductor flexible lead should be processed for connecting from the panel at the various points indicated in Figs. 3 and 4 to the jack socket. Extreme caution should be taken over this latter exercise to ensure that the conductors are terminated to the correct tags or terminals on the jack socket (see Fig. 2). It is also very important, of course, to avoid reversing the battery polarity, for while this may not completely ruin the transistors it could reduce their efficiency and alter their characteristics.

There is sufficient room to accommodate the jack socket between the ferrite rod aerial and R1 (see Fig. 4, for instance), but since the jack socket terminals carry the full negative voltage of the battery, inadvertent contact between one of these terminals and the base end of R1 could immediately destroy Tr1. For this reason, *an insulating sleeve* should be dressed over the terminal end of the jack socket.

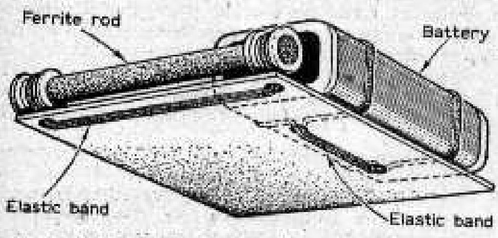


Fig. 5: Method of connecting battery and ferrite rod.

Tuning Up

L2 former should be fitted with a dust-iron core and initially this should be adjusted so that it embraces the whole of the winding width. With L2 so adjusted and with the aerial winding in the centre of the ferrite rod, there should be no difficulty in receiving the local m.w. station. To peak reception on this programme, L2 core should be re-adjusted while slowly turning the tuning gang a little either side of the station for optimum gain.

While it is impossible for a receiver of this kind to track accurately over the whole dial, reasonable tracking is achieved owing mainly to the flat tuning of L2. However, if the set is required to be peaked to a more distant station the station should be tuned as near as possible on the gang and then L2 should be re-adjusted at this new setting for optimum gain.

A degree of feedback occurs in the r.f. stage, especially towards the higher frequency end of the band automatically due to stray capacitance. However increased feedback can be applied simply by flexing a pair of thin, insulated conductors between the two "live" terminals of the tuning gang. This is shown as the "regen coupling" on the circuit (Fig. 1) and the coupling in physical form is clearly shown in Fig. 9. On no account should a d.c. connection exist between the two flexed conductors, for their purpose is simply to provide a small variable capacitance. In the prototype, the five

—continued on page 1081

—continued from page 1059

twists on this coupling were sufficient to put the r.f. amplifier in oscillation over the entire band. It was found that just a single twist is sufficient for most purposes, depending upon the nature of Tr1.

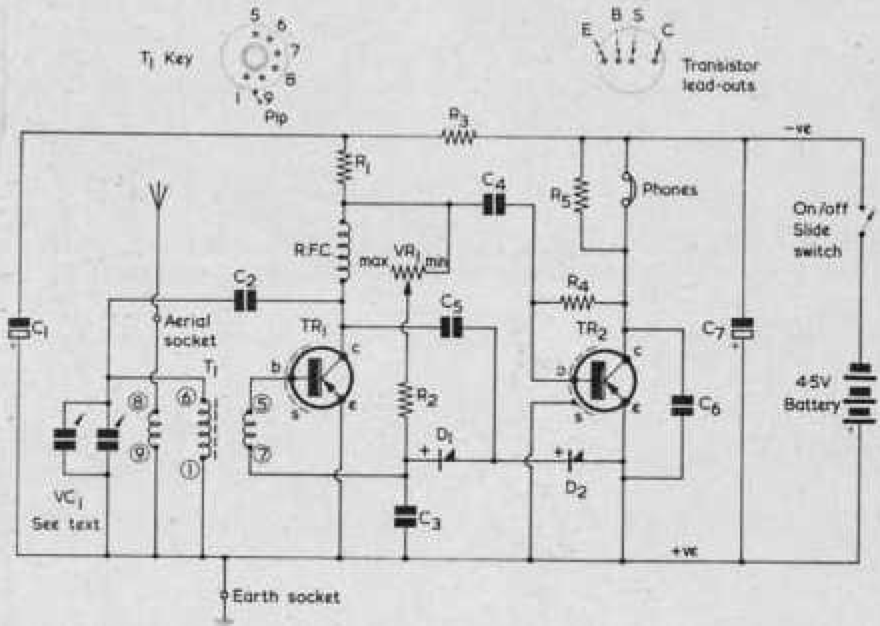
Capacitor C1 in the tuned circuit of L1 constitutes a form of padding capacitor, as well as serving as an r.f. bypass. Thus, the tracking can be influenced by varying the value of this component. Unfortunately, there is not available a miniature preset capacitor of sufficiently high value to permit easy adjustment here. The author found that an 0·005μF fixed capacitor satisfied the tracking for his reception area, but values above or below this could be tried since C1 is not difficult to change.

It is as well to remember that a simple set of this kind employing a sub-miniature ferrite rod aerial and only two transistors cannot be claimed to have super-sensitivity! Nevertheless, the prototype gave good volume on local stations, while after dark the more powerful European stations were received.

Housing the Receiver

The complete receiver is fitted in a small ready drilled plastic case as shown in the photograph which comes with back, tuning knob and paper dial. The gang retaining nut being used to lock the assembly to the front panel and a hole in the side of the box to cater for the jack socket which, again, is held secure by its locking nut. The long 6BA bolt on the rear of the tuning gang is used to hold the back of the case in position.

The battery will have many months of useful life provided the earpiece jack plug is removed from the socket when the set is not in use ■


T1 Key
5
6
7
8
1
9
Pip
E
B
S
C
Transistor lead-outs
R3
-ve
R1
C4
R5
Phones
On/off Slide switch
R.F.C.
max
VR1
min
C2
R4
C1
Aerial socket
C5
TR1
TR2
C7
T1
c
b
e
4.5V Battery
C6
D1
D2
VC1 See text
C3
+ve
Earth socket

Cover Feature

THE "TWO + TWO" RECEIVER

By WALLACE STUDLEY

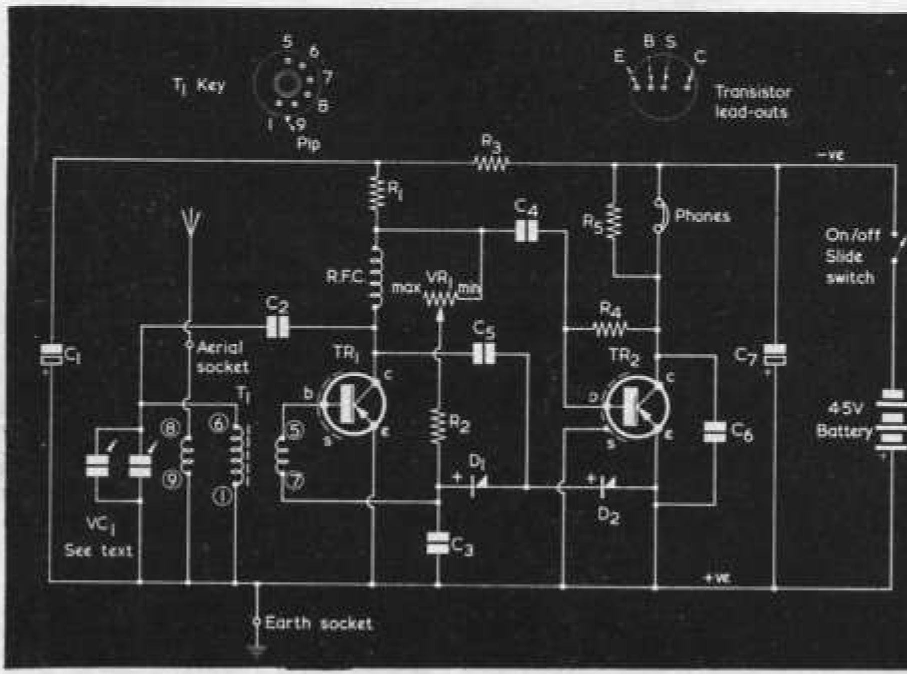


Fig. 1. The circuit of the receiver. The screen of TR_1 is left disconnected

A miniature short and medium wave receiver which fits into a cabinet measuring some 6 x 3¼ x 2⅜in, and which draws a current of only 1mA from an internally fitted 4.5 volt torch battery, represents an attractive proposition. Tuning is carried out by a twin-gang capacitor and maximum frequency coverage is offered by connecting its two sections in parallel. If, however, there is a particular interest in part of a band only, it is possible to obtain reduced coverage by using either the front or rear section of the capacitor on its own

THIS RADIO RECEIVER USES FOUR SEMICONDUCTORS and is capable of tuning over a frequency range of 480 kc/s to 15 Mc/s whilst drawing a current of only 1mA from a 4.5V supply! Two transistors, two diodes and a handful of small components make it possible; and the circuit of the simple receiver is illustrated in Fig. 1. Here, TR_1 provides r.f. and a.f. amplification simultaneously, whilst diodes D_1 and D_2 give demodulation. Transistor TR_2 gives additional audio amplification and any signals initially presented by the aerial may be clearly heard in high impedance headphones connected in the collector circuit of the transistor. The receiver is easily duplicated and no alignment problems whatsoever present themselves. Ready-made plug-in aerial transformers are used, three in all being required.

Frequency Coverage and Band Changing

The actual frequency coverage obtained depends partly upon the wishes of the contructor, for not only is it possible to vary within limits the inductance values of the aerial transformers but it is also possible to utilise the tuning capacitor VC_1 in different ways.

The tuning capacitor is, in fact, the popular Jackson "00" twin-gang unit, the front section of which has a maximum capacitance value of 208pF. The other section has a value of 176pF and either section may be used alone. Alternatively, the two sections may be strapped to provide a maximum capacitance of 384pF. Considering these three values and allowing some 40pF for circuit "strays" we can calculate coverages. These are detailed in the accompanying Table.

Band changing is effected by plugging the required transformer into a B9A valveholder and since each transformer is fitted with an inbuilt "pip" (see inset diagram and key in Fig. 1) incorrect positioning is unlikely. Each transformer carries three windings and these are identified in Fig. 1 by circled numerals corresponding to their pin numbers.

Sensitivity, and Some Circuit Considerations

Simple receivers of this type can never approach communications receiver sensitivity; they can, however, be "pepped up" somewhat. In the present circuit, enhanced sensitivity is achieved by returning part of the r.f. present at TR_1 collector to the base circuit, in order to provide regeneration. Fixed capacitor C_2 performs this duty and effectively connects the tuned winding between collector and base. The degree of regenerative feedback depends partly on the setting of VR_1 which can be adjusted for maximum sensitivity by maintaining the transistor at the brink of oscillation. To assist in the regenerative action the screen lead-out of TR_1 is left open-circuit.

Both transistors derive the necessary bias potentials from resistors which are simply connected between base and collector. In the case of TR_1 the value of the appropriate resistor (R_2) is made rather low to increase collector current sufficiently for oscillation to take place when VR_1 is set to "Min". By moving the slider of VR_1 towards "Max", however, additional resistance is effectively added to R_2 and a point is eventually reached where oscillation just ceases. At this "peak point" sensitivity is at its greatest but will fall off rapidly if VR_1 slider is further adjusted in the direction of "Max". Keeping VR_1 set to the "peak point" is of great importance, and it must be emphasised here that if "Min" is approached excessively signals will be replaced by whistling, whilst if "Max" is approached excessively no signals whatsoever may be heard. Unfortunately, VR_1 cannot be pre-set and left; it must be reset whenever tuning is varied for the circuit constants are then being changed. This

Components List

Resistors
(All fixed values $\frac{1}{8}$ watt 10%)

R_1	3.9kΩ
R_2	68kΩ
R_3	1kΩ
R_4	100kΩ
R_5	5.6kΩ (see text)
VR_1	100kΩ, potentiometer, linear track

Capacitors
(All capacitors modern miniature types)

C_1	100μF, electrolytic, 6V wkg.
C_2	6pF, ceramic or silver-mica
C_3	0.02μF, paper
C_4	0.1μF, paper
C_5	220pF, silver-mica
C_6	0.01μF, paper
C_7	100μF, electrolytic, 6V wkg.
*VC_1	208+176pF. Type "00" twin-gang (Jackson Bros. Ltd.)

Semiconductors

TR_1	AF115
TR_2	AF117 (see text)
$D_{1,2}$	OA70

Coils

T_1	Aerial transformer. Transistor Dual Purpose Coils, Blue, ranges 2T, 3T and 4T (Denco)
RFC	R.F. choke type RFC5 (Denco)

Sockets
1 B9A socket
1 Aerial-earth socket strip
1 Phone jack

Miscellaneous
29 hole x 9 strip (including end strip—see text and Fig. 3) piece of Veroboard, 0.2 x 0.2 in hole matrix
Paxolin, 6 x 3¼ x $\frac{1}{16}$in
Vernier dial, Model T502 (Henry's Radio)
Miniature slide switch, s.p.s.t.
4,000Ω headphones with jack plug
¼in knob
4.5 volt battery type 1289 (Ever Ready)

* If supplied with trimmers, these should be set to minimum capacitance.

feature is common to all such simple circuits. Please note that the terms "Min" and "Max" refer to the amount of resistance in circuit. Note also that, due to its very low d.c. resistance, the r.f. choke plays no significant part in the bias arrangement for TR_1. To clarify this latter point it can be said that TR_2 receives base bias simply from R_4, whereas base bias for TR_1 base is provided via R_2 and VR_1, the choke having negligible d.c. resistance.

The prime purpose of the r.f. choke is to obstruct the passage of the received radio frequency signals

TABLE

Approximate frequency coverages obtainable in Mc/s using "00" twin-gang tuning capacitor

Maker's range No.—T_1	L(μH) Tuned winding	Coverage—Rear section, VC_1	Coverage—Front section, VC_1	Coverage—Both sections strapped
2T	271.0	0.65– 1.5	0.615– 1.5	0.48– 1.4
3T	27.2	2.10– 5.0	1.90 – 5.0	1.50– 4.3
4T	2.9	6.50–15.0	6.0 –15.0	4.50–13.5

Note: An approximate ±15% variation of tuning inductance is obtainable via core adjustment.

appearing at TR_1 collector. These can more readily pass via C_5 to the diodes where demodulation takes place. The audio frequency resulting from demodulation is then re-introduced to TR_1 via the low impedance winding of the aerial transformer (pins 7 and 5) and reappears amplified at the collector. The audio signals now see C_5 as a high impedance and the choke as a low one and are thus able to pass via C_4 to the base of TR_2 for further amplification. The fact that TR_2 is a type normally employed for r.f. work is of small consequence; it could, perhaps, be exchanged for a OC71. Use of the specified types is recommended, however, and this applies particularly to TR_1.

Re-considering the demodulation process momentarily, it is interesting to observe that due to the way the diodes are connected a d.c. potential is developed across C_3 that is dependent on the strength of the received signal. Slight irregularities are smoothed out by C_3 to leave a potential which tends to drive the base of TR_1. The result is that a simple automatic gain control system is set up which assists to some extent in counteracting fading; at the same time the need for a blocking capacitor is removed.

Since the receiver is to be used mainly for short

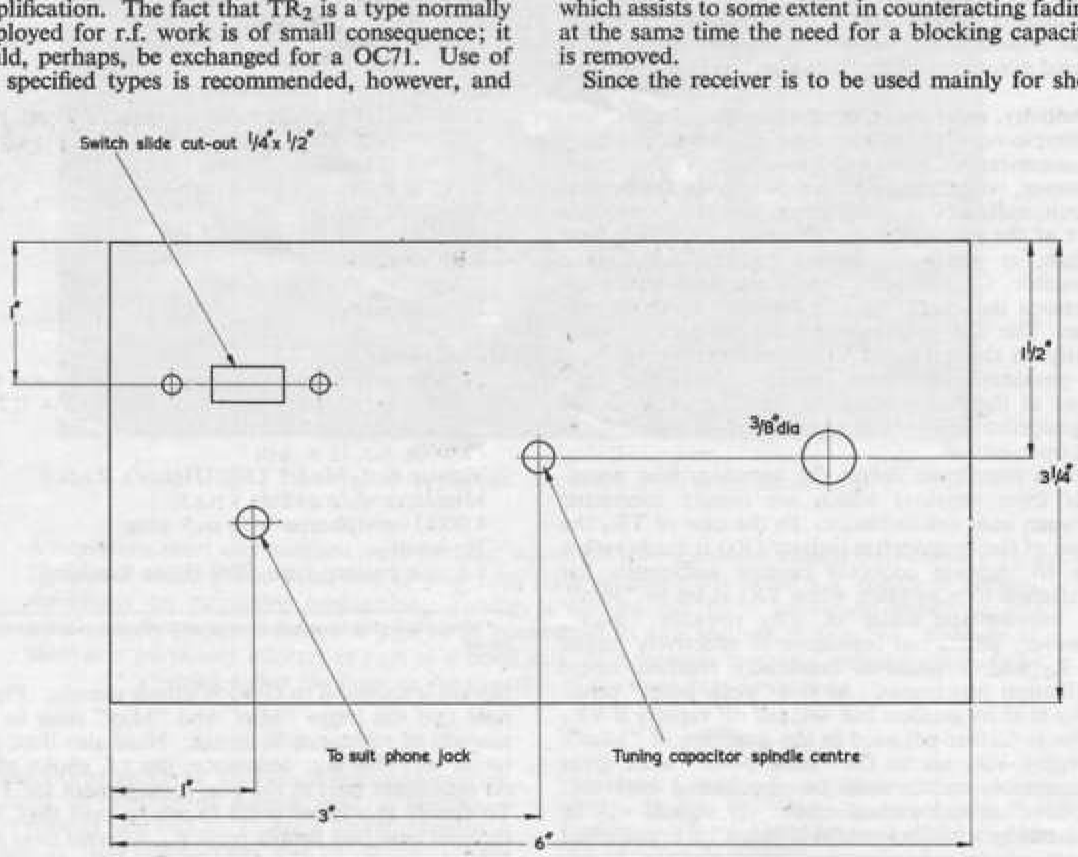


Fig. 2. Essential drilling dimensions for the front panel. Extra mounting holes will be required for the tuning drive, and these may be marked out from the drive itself. The dimensions shown for the slide switch may vary with some types, and this point should be checked before drilling and cutting out. The material is $\frac{1}{16}$in polished Paxolin

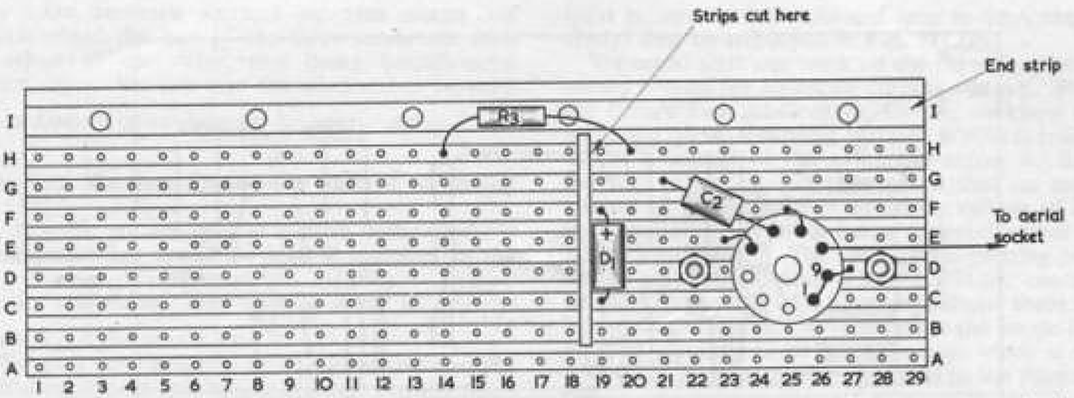


Fig. 3. Wiring on the conductor side of the Veroboard. Note that a connection from D28 to D19–22 is carried over by the metal frame and mounting nuts of the coil holder. The nuts should not short-circuit against strips C or E

wave listening an aerial is essential. An earth is also beneficial but not absolutely necessary. It should also be noted that a direct tuning drive is entirely unsatisfactory—hence the inclusion of a vernier reduction drive unit. Decoupling is adequate and the test model is 100% stable. Simple t.r.f. receivers do, nevertheless, tend to be temperamental, and this point should be borne in mind. Resistor R_5 is not really essential but it is interesting to note that, if it is retained in circuit, the receiver can be used to drive a separate transistorised audio amplifier merely by removing the headphones and lifting the "cold" end of C_6, connecting this to the amplifier input. In this case R_5 is left *in situ*; an additional lead is also used to interconnect the positive supply lines of the two units.

Construction

Mechanical details are given in Figs. 2 to 5. Briefly, a piece of $\frac{1}{16}$in thick Paxolin forms a front panel (see Fig. 2) which carries the various controls and to this is affixed a rectangle of Veroboard. Veroboard is made of pre-fabricated Paxolin which is fitted with parallel copper conductor strips on one side and is plain on the other. The strips are pierced with small holes in a regular pattern and enable low voltage circuits to be rapidly constructed to form what are virtually "printed circuit" assemblies.

The section of Veroboard required, together with all details relating to the conductor side, is shown in Fig. 3. As may be seen, twenty-nine holes over each of the nine strips are needed. These have been given imaginary letter and numeral designations to

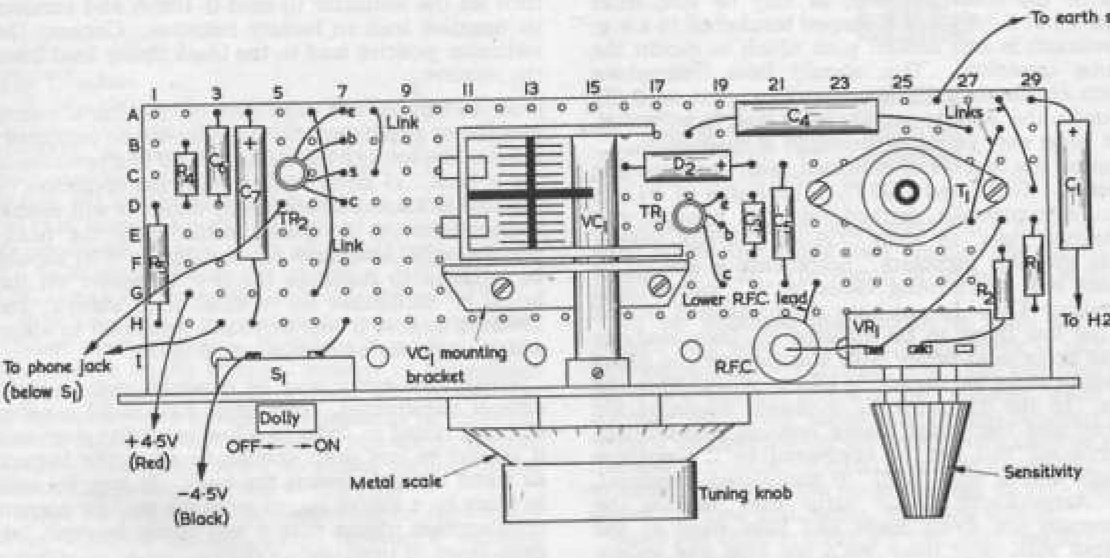


Fig. 4. The layout above the board. The tuning capacitor frame is earthed via its metal bracket and mounting nuts and bolts to strip G. Ensure that the mounting bolts pass through the board at positions G12 and G17 and that the nuts do not contact strips F or H

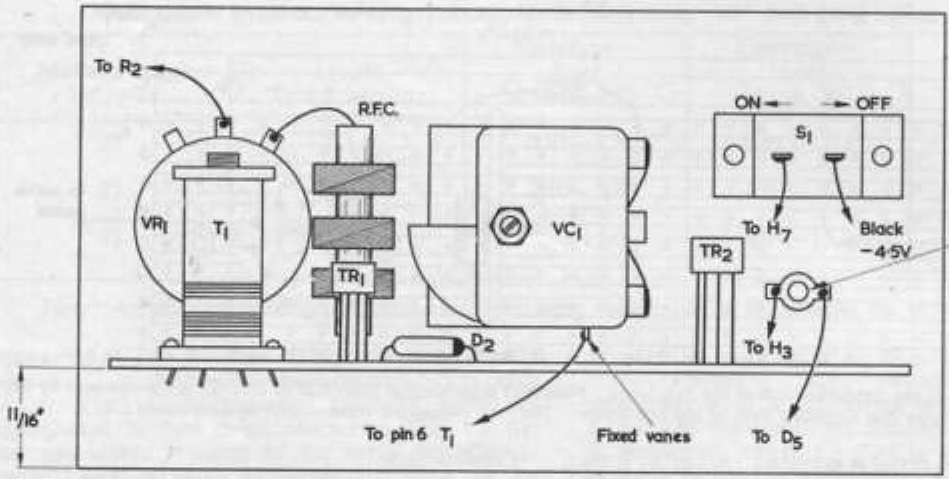


Fig. 5. A rear view above the chassis. The layout of switch tags may vary from that shown here, according to the type of switch employed. As is explained in the text, the connection from VC_1 fixed vanes may be taken from the first section, the rear section, or both sections connected together

aid construction. Strip "I" is slightly wider than the others and is found at the edge of a new section of the board. The holes in strip "I" are larger and if two thin "butts" of wood are glued firmly to the inside of the front panel small screws may be passed through these holes to provide a rigid assembly. A cut-out for the B9A valve-holder is made as shown and a slit made across seven of the strips (to break their continuity) as indicated. Two resistors and a diode are also soldered to this side of the board.

The majority of the items are fitted to the plain side of the board however as may be seen from Figs. 4 and 5. A small L-shaped bracket of 16 s.w.g. aluminium is also needed with which to mount the tuning capacitor. This should have dimensions which enable the capacitor spindle to pass centrally through the appropriate hole in the front panel, and these may be taken from the component itself. Position the bracket as indicated, with the mounting holes at "G12" and "G17". The frame of VC_1 is then automatically earthed, via the bracket and mounting nuts, to strip "G1–18". Four linking wires are also necessary. Some care is needed to ensure that the moving vanes of VC_1 cannot foul transistor TR_1. In any case the transistors should be the last items to be soldered in, their lead-out wires being held firmly with stiff tweezers or pliers to shunt away the damaging effects of heat from the iron. In the diagrams C_1 is shown displaced for clarity and the metal casing appears unconnected —although this can be connected to the positive supply line at hole "D21" if considered beneficial. An Aerial/Earth socket strip may initially be connected via flying leads and later fixed to the cabinet side. For these leads use blue and yellow wires, or any other colours *except* black or red.

Completing and Testing the Receiver

After connecting a flying lead with red insulation to hole "G2", solder a similar lead, but with black insulation to the tag of S_1 as indicated in Fig. 4. To prevent accidental damage, check with a meter set to read 0–10 volts d.c. the polarity of the 1289 battery terminations, whereupon it should be found that the long one represents negative and the short one positive.* Label these clearly then fashion a pair of clips from brass or tin which will slide over the terminations. Keeping them free of the battery, solder one each to the red and black flying leads already fitted. Fit the positive one to the battery then set the testmeter to read 0–10mA and connect its negative lead to battery negative. Connect the testmeter positive lead to the black flying lead from the receiver.

At switch-on and with one of the transformers plugged in approximately 1mA should be indicated; if much higher, say 10mA, switch off and investigate for a fault. If all is well, careful manipulation of the tuning knob and sensitivity controls will enable transmissions to be heard immediately the headphones, aerial and earth are connected. VR_1 should be adjusted to maintain the first transistor on the brink of oscillation for normal a.m. signals; for listening to c.w. it will be found beneficial to allow a small amount of oscillation to occur.

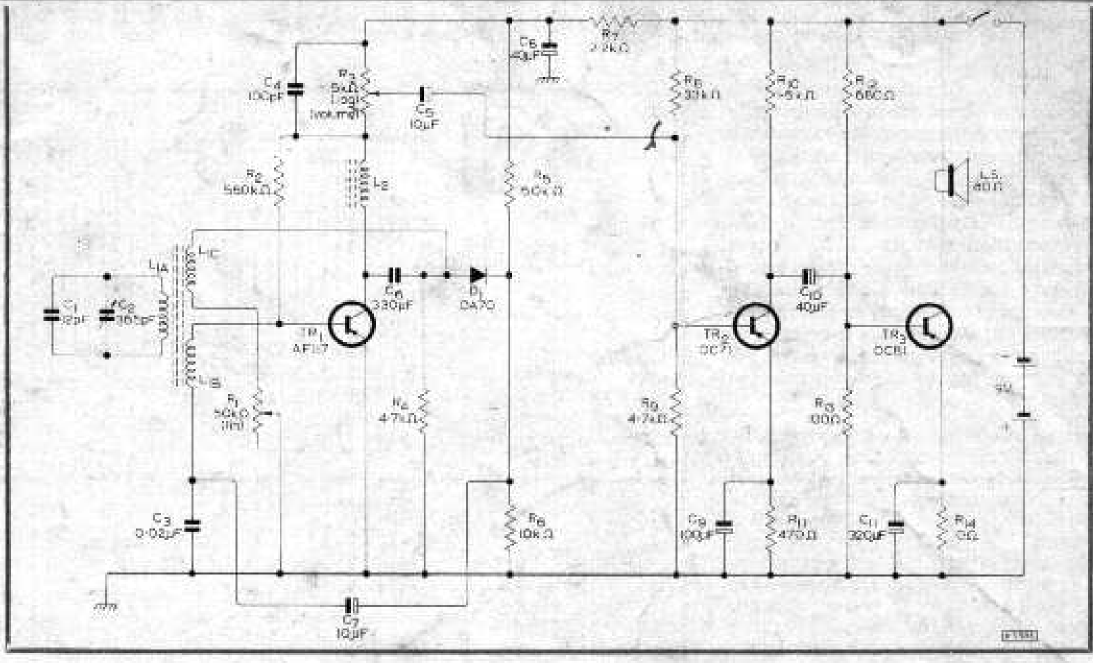
Finally the meter may be removed and a simple cabinet constructed. This must have a lid capable of being raised in order to allow bandchanging, and it should be just deep enough to allow the battery to stand upright against the back. It may be held in place by a simple clamp or, since the low current consumption means that it will rarely be replaced, even glued in position!

* The polarity is normally marked on the seal of a new battery. —EDITOR.

Mullard OUTLOOK

TECHNICAL SECTION

THREE-TRANSISTOR RADIO



The accompanying circuit was published at last year's Radio Show, and is for a simple three-transistor radio suitable for construction by students and experimenters. It is an improved version of the circuit described in the November 1962 issue of OUTLOOK: the biasing arrangement now adopted for the audio output stage affords better stability against changes in temperature.

A full description of the circuit was given in the earlier article. Briefly, in this circuit the first transistor operates in an arrangement that acts as a regenerative r.f. amplifier and an audio pre-amplifier simultaneously. The output from the aerial coupling winding L_{1B} is amplified by the transistor and developed across the choke L_2. Part of the amplified signal is returned to the aerial circuit via C_6 and L_{1C}, causing regeneration. The r.f. signal output is applied to the OA70 detector diode, which is slightly forward-biased to improve efficiency, and the resulting a.f. signal is fed back to the AF117 base via C_7 and L_{1B}.

At audio frequencies, the volume control R_3 is the load in the collector circuit of the AF117. The amplified audio signal is fed via C_5 to the OC71 driver stage. This is a low-current audio amplifier which drives a class A output stage.

To reduce the cost of the set, a high-impedance loudspeaker is used to form the load in the collector circuit of the output stage, thereby eliminating the need for a transformer.

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COMPONENTS LIST

Resistors

R_1	50kΩ lin. pot.	R_8	33kΩ
R_2	560kΩ	R_9	4·7kΩ
R_3	5kΩ log. pot.	R_{10}	1·5kΩ
R_4	4·7kΩ	R_{11}	470Ω
R_5	150kΩ	R_{12}	680Ω
R_6	10kΩ	R_{13}	100Ω
R_7	2·2kΩ	R_{14}	10Ω

Capacitors

C_1	12pF	
C_2	365pF	Jackson type 01
C_3	0·02μF	Mullard C296AA/A22K
C_4	100pF	
C_5	10μF, 16V	Mullard C426AM/E10
C_6	330pF	
C_7	10μF, 16V	Mullard C426AM/E10
C_8	40μF, 16V	Mullard C426AM/E40
C_9	100μF, 4V	Mullard 426AM/B100
C_{10}	40μF, 16V	Mullard C426AM/E40
C_{11}	320μF, 2·5V	Mullard C426AM/A320

Inductors

L_{1A}	60 turns of 12 x 46 s.w.g. Litz
L_{1B}	3 turns of 3 x 46 s.w.g. Litz
L_{1C}	4 turns of 3 x 46 s.w.g. Litz

L_{1B} should be interwound with the earthy end of L_{1A}, and L_{1C} should be interwound with L_{1A}, ¾in from the earthy end.

The Ferrite aerial slab should be Mullard FX2367.

L_2 consists of 100 turns of 3 x 46 s.w.g. Litz wound on a tuning slug from a 470kc/s i.f. transformer.

Transistors and Diode

Tr_1 Mullard AF117	Tr_3 Mullard OC81
Tr_2 Mullard OC71	D_1 Mullard OA70

Copies of the leaflet describing this circuit, and other leaflets describing the home-construction circuits that have appeared in recent issues of OUTLOOK, are available free of charge from Central Technical Services, Mullard House.

TOP POCKET TRANSISTOR RADIO

By G. Jeffries

THIS LITTLE TRANSISTOR RADIO IS INTENDED FOR fitting into the top pocket, and it was designed after most of the bus and coach companies had barred the use of loudspeaker sets.

The circuit employs the minimum number of components to obtain the desired performance, and its overall dimensions are only 4¼in long by 2⅜in wide with a cabinet depth of approximately 1in. The receiver incorporates two transistors, operates over the medium waveband, and drives a high impedance earphone. It can also be used to feed a push-pull amplifier when operated at home, thereby giving loudspeaker reception.

The Circuit

The circuit diagram of the two-transistor receiver appears in Fig. 1. In order to achieve the desired sensitivity with a ferrite rod whose length is limited to 2¼in, the first stage is a reflexed r.f. and a.f. amplifier with regeneration.

The required signal is tuned in by the ferrite rod aerial, L_1, in conjunction with C_1, and is fed to the base of TR_1 via C_3. An amplified r.f. signal appears at the collector of TR_1, and is prevented from being passed to the following a.f. stage by the r.f. choke, L_2. A portion of the amplified signal is fed back to the ferrite rod winding by C_2 in order to provide regeneration.

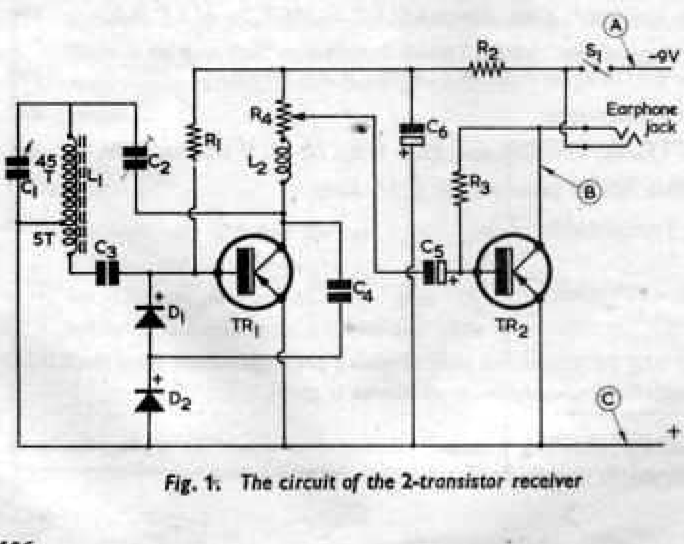


Fig. 1: The circuit of the 2-transistor receiver

The collector of TR_1 is coupled via C_4 to the detector circuit given by the diodes D_1 and D_2. These allow the detected signal to appear at the base of TR_1 which then carries out its secondary function of a.f. amplifier. The polarity of the two diodes is such that the base of TR_1 tends to go positive with increase in signal strength, with a result that a rudimentary form of a.g.c. is obtained.

Components List
(Fig. 1)

Resistors
(All fixed resistors ¼ watt 10%)

R_1 390kΩ
R_2 1kΩ
R_3 270kΩ
R_4 5kΩ potentiometer, log track, miniature, rim adjust. (May be ganged with S_1—see text)

Capacitors

C_1 500pF variable, miniature, solid dielectric
C_2 2—8pF concentric trimmer
C_3 0.01μF
C_4 500pF
C_5 8μF electrolytic, 12V wkg.
C_6 100μF electrolytic, 12V wkg.

Inductors

L_1 Ferrite rod aerial (see text)
L_2 R.F. choke, 2.5mH (Elpico)

Semiconductors

TR_1 OC44
TR_2 OC71
D_1 OA81
D_2 OA81

Switch

S_1 s.p.s.t. on/off (see text)

Earphone

500Ω to 1kΩ impedance

Battery

9V, type PP3 (EverReady)

Miscellaneous

Groupboard, eyelets, cabinet, etc.

Components List
(Fig. 2)

Resistors
(All resistors ¼ watt 10%)
R_5 100Ω
R_6 4.7kΩ
R_7 10Ω

Capacitor
C_7 0.1μF

Transistors
TR_3 GET114 } Matched pair
TR_4 GET114 }

Transformers
T_1 Driver transformer type LT44 (Henry's Radio Ltd.)
T_2 Output transformer type LT700 (Henry's Radio Ltd.)

Switch
S_2 s.p.s.t. on/off switch

Battery
9 volt (see text)

Loudspeaker
3Ω impedance

The amplified a.f. at the collector of TR_1 passes through the r.f. choke L_2, and is applied to the volume control R_4. The slider of R_4 taps off the desired a.f. level, which is then fed to the base of TR_2. The latter functions as a high gain common emitter stage, driving the high impedance earphone. A small amount of feedback is applied via R_3.

There is no stabilising circuit for TR_2, which passes a relatively low current of about 1.5mA. In the writer's experience, and after a considerable period of use, there has been no evidence of thermal runaway using the circuit shown.

Fig. 2 gives the circuit of the additional a.f. amplifier. This is quite optional and is only employed when loudspeaker reception is required. The circuit is quite conventional and consists of two transistors in push-pull offering an output of the order of 300mW. The amplifier couples to the receiver circuit of Fig. 1 by way of the terminal points indicated as A, B and C.

Construction

A very convenient method of construction for the Fig. 1 circuit is given by the Paxolin groupboard technique, and the layout employed in the prototype is illustrated in Fig. 3. This diagram also shows the outside dimensions of the groupboard.

The groupboard should initially be marked out and all the holes drilled. Holes required for connection points may then be fitted with eyelets. With the exception of R_4, the components are all mounted on one side of the board and take up the positions shown in the diagram. Capacitor C_5 is omitted from this diagram for ease of presentation, and it connects between the centre tag of the volume control R_4 and the base of TR_2, the positive end connecting to the transistor.

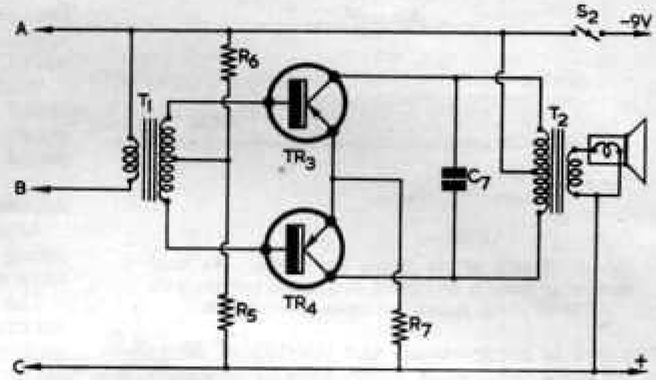


Fig. 2. The optional power output stage. This enables the receiver to operate a loudspeaker

The on/off switch, S_1, is not shown in Fig. 3. This component is inserted between the negative supply terminal on the groupboard and the negative terminal of the battery. S_1 may be a miniature slide type fitted to the side of the cabinet, or a switch which is incorporated in R_4. In the latter case, the wiring to R_4 may vary from that illustrated in Fig. 3, which shows the connections applicable to a potentiometer without a switch.

The Ferrite Rod Aerial

Details of the ferrite rod aerial are given in Fig. 4.

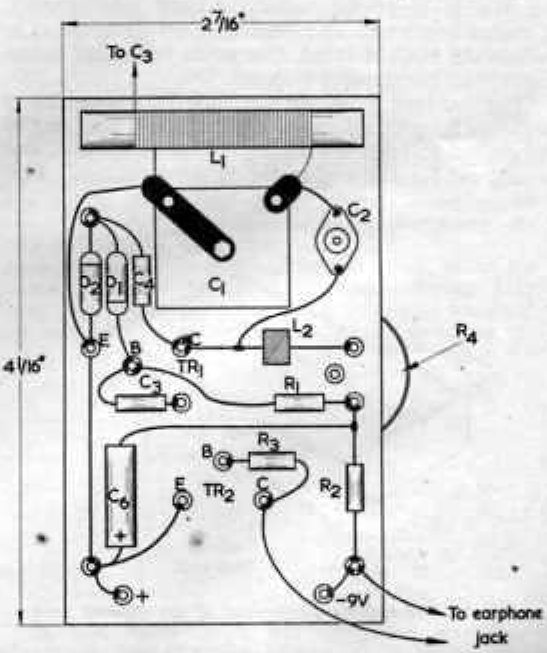


Fig. 3. The layout employed with the prototype

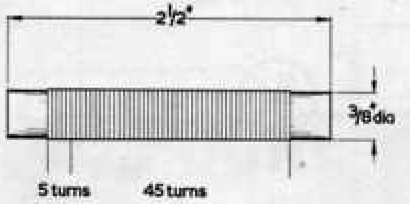


Fig. 4. Details of the ferrite rod aerial. The total number of turns is 50 tapped at 5 turns, and the wire is 36 s.w.g. enamelled rayon-covered wire

The coil is home-wound and consists of 50 turns of 36 s.w.g. enamelled rayon-covered copper wire with a tap of 5 turns. The ferrite rod is 2½in long with a diameter of ⅜in. The ferrite rod assembly may be secured to the groupboard by clips or, more simply, by tying it in place with suitable thread. It is important to ensure, when clips are used, that these do not cause an effective "shorted turn" to be formed around the rod.

The Cabinet

The prototype cabinet was made from ⅛in Perspex, made up to the outside dimensions shown in Fig. 5. These allow a clearance of 1/16in on all four sides of the groupboard. The depth of the cabinet, shown provisionally as 1in, depends partly upon the clearance required on the non-component side of the board by the volume control, and on the size of the components around TR_2. It is necessary to fit the PP3 battery at the TR_2 end of the board, and the cabinet depth must be sufficient to enable it to be accommodated comfortably. Cabinet depth will also depend upon the manner in which the back is fitted, this point being left to the individual constructor's ideas.

The cabinet is glued together by means of a suitable Perspex adhesive, after which a hole has to be drilled to take the tuning capacitor spindle, and a slot cut for the rim of the volume control. Also required are a hole for the earphone jack, and an aperture for the on/off switch (if this is not ganged with the volume control).

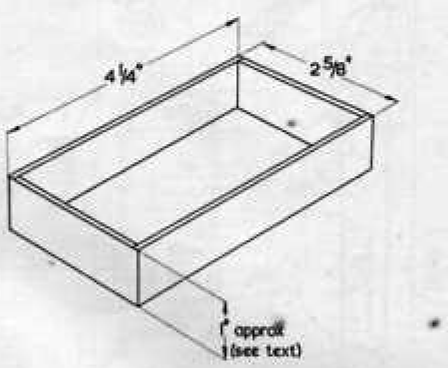


Fig. 5. The outside dimensions of the cabinet used with the prototype. The depth, shown here as approximately 1in, may vary according to the components employed in the receiver

With the prototype, the groupboard was secured in the cabinet by a single nut fitted over the tuning capacitor bush. The final appearance of the completed receiver in its cabinet is shown in Fig. 6.

Adjustment

After the receiver has been completed and the wiring carefully checked, the regeneration level has to be adjusted.

The receiver should be switched on and the volume control set to maximum. A strong local station is then tuned in and the receiver oriented for maximum pick-up by the ferrite rod aerial. Trimmer C_2 is then adjusted until the receiver is just short of going into oscillation. This procedure is then finally repeated at the high frequency end of the band, working preferably with the Radio Luxembourg signal.

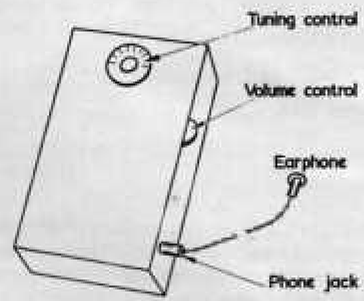


Fig. 6. The appearance of the completed receiver

Using the Additional Power Stage

If desired, the receiver may be employed from time to time with the optional power output stage shown in Fig. 2. In this instance, it is necessary to provide a simple means of interconnection between the two sections. It is also desirable to disconnect the small receiver battery and to employ a larger battery installed in the power amplifier unit.

A simple means of interconnection for terminals A and C consists of fitting battery clips at the power amplifier, whereupon the battery leads in the receiver may be clipped to these. Connection to terminal B may be achieved by inserting a jack plug having a single wire soldered to its appropriate contact.*

In the writer's case, the additional power unit was built into an extension speaker cabinet, and fed to a 3Ω 10in loudspeaker.

* Although, as stated by the writer, there was no evidence of thermal runaway in TR_2 with the prototype, the theoretical risk of damage to TR_2 is increased when the circuits of Fig. 1 and 2 are used in combination because the primary of T_1 will have a much lower resistance than is offered by the earphone. If this risk is considered sufficiently high it may be reduced by inserting a 470Ω resistor between the negative supply line and the upper end of T_1 primary, bypassing the junction with a capacitor of around 8μF.—EDITOR.

'high compressio

THE mathematical approach to a practical problem can be extremely elegant, but there are occasions when incomplete data can lead to a discouraging conclusion. In particular, much of the available information about transistors suggests that they do not make efficient simple "front ends" for receivers, and perform best as superhets. Having tried out many published circuits, the writer must sadly agree that, despite considerable ingenuity in their design, reflex circuits tend to be unstable and to lack sensitivity in weak signal areas.

By prolonged trial and error, the writer has evolved a simpler circuit which is stable, smoothly controllable and gives excellent sensitivity over the medium wave-band. It may seem to fly in the face of accepted transistor practice, but its efficiency has been confirmed by several specimens giving consistent performance over a period of four years, throughout freezing and summer conditions alike.

Perhaps it should here be explained that the writer's principal interest in this field lies in really tiny receivers, driving an earpiece and working off a single cell, yet providing good volume with easily adjusted and *stable* controls. Using the basic circuit in question, the smallest complete set (so far) fits in a case considerably smaller than a matchbox. Yet with its ferrite rod aerial just over an inch long, it can get as many stations and as clearly as a typical commercial superhet.

Probably the most striking feature of this circuit is that its aerial does *not* have a step-down tapping into the base: the entire winding is used. This—contrary to expectations—provides a much stronger signal than the conventional tapped winding (which is designed for the different function of feeding into crystal, reflex or superhet circuits).

However, when the whole aerial is shunted in this way, tuning can be completely upset by changing transistor characterics; especially those due to thermal drift or variations in the supply voltage. This is very marked with the early types of r.f. transistor—such as the familiar red and yellow spot—but much less so with the more recent surface-barrier or micro-alloy types (e.g. SB 305 or MAT 101).

However, with direct coupling, even these last give far more thermal drift than is tolerable in a practical receiver. Not only does tuning alter; the gain varies so the regeneration ("reaction") cannot be set with any degree of stability.

The immediate essentials therefore are: (a) thermal compensation, and (b) voltage constancy. The first can be provided by a thermistor in a suitable voltage-dividing circuit to control the base bias. Thermal compensation is probably the most vital necessity for a "high compression" set to be carried in the pocket. Supply voltage can be kept adequately constant either by using an ordinary dry cell with capacity large in relation to the load, or by using a mercury cell.

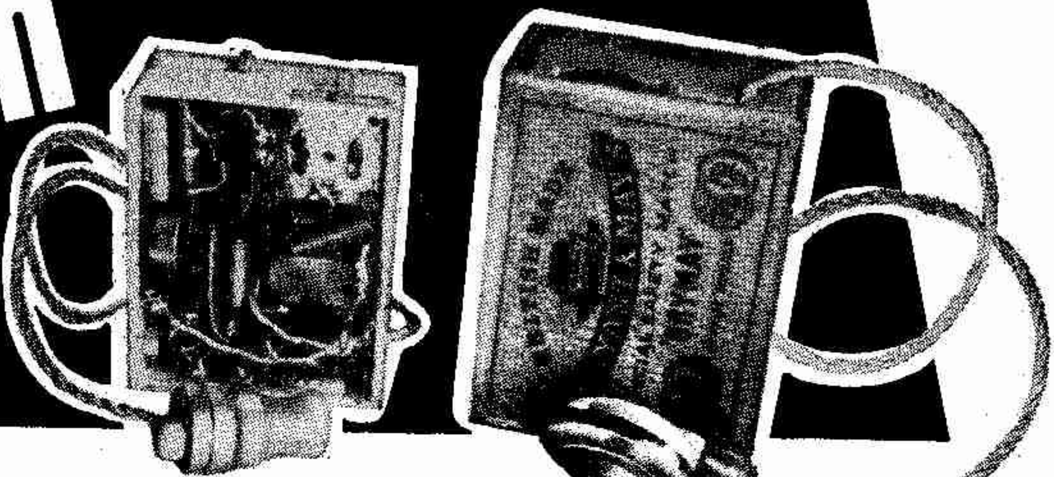
To obtain adequate sensitivity, without recourse to complex circuitry or to a second tuned stage, old-fashioned "reaction" proved to be far and away the most rewarding. It gives at the same time enormously increased gain and ample selectivity.

The reported failure of other experimenters to obtain useful degrees of regeneration with transistors may well be due to their use of step-down coupling of aerial to base. The writer has found a variety of control circuits, either using a variable resistor or a variable capacitor, to give excellent gain and thoroughly practical performance.

The regeneration characteristics can be varied over a wide range by adjusting and balancing the values of the components; the most important desiderata being "non-ploppy" action and uniform setting over at least the greater part of the tuning range. In addition, there should be no detuning as the reaction is varied.

The stronger the signal that can be obtained from the "detector" stage, the less the a.f. amplification necessary, and the less the background noise. However, if the "front end" is too complex, the bulk of the components makes a compact construction difficult or impossible, and stray capacity and induction effects make placing much too critical. This is especially true if more than one tuned circuit is involved, or if r.f. chokes are used.

This brings us to the next essential feature of the circuit—a transformer output. This provides an adequate impedance to r.f. signals, so allowing these to be by-passed into the reaction coil. It also effectively blocks the passage of r.f. into the amplin'



by C. Leslie Thomson B.Sc.

fier stages and allows one to reverse polarity so that a.f. feed-back can be kept negative overall, no matter how compact the set. (This eliminates the need for decoupling in multi-stage amplifiers, so keeping the number of components to a minimum.)

By no means least of its virtues, a transformer gives a much stronger a.f. signal than resistance capacity coupling with limited supply voltage. A suitable transformer—such as the Ardente D 1001—is only slightly bulkier than the smallest effective r.f. choke, which would otherwise be an essential component.

Regeneration control can be provided in two ways, depending on the particular needs. For maximum compactness, and combining on-off with volume control, a sub-miniature potentiometer with switch seems to be ideal. Taking a little more space, a variable capacitor (e.g. a 30pF trimmer) and a separate switch should give greater freedom from crackle over the years!

The process of adjusting the base bias and the reaction capacitors for optimum performance must be set about in a methodical fashion. It is well worth the seeming delay of assembling the entire circuit on a "bread board" (or should one say "biscuit block"?) before attempting to fit it into the eventual case. It takes only minutes to do so, and it is quick and easy to substitute various values of resistor or capacitor—with full-length wires and using tag-boards as anchorages—but tedious and wasteful to perform the same operation with trimmed and shaped component wires inside a tiny box.

The resistors shown are a good starting point, but individual transistors may give even better performance with slightly different values. The degree of thermal stabilisation is controlled by the shunting resistor R3; without it, the thermistor would "overcompensate". If, with the values shown, regeneration is stronger in a warm room than in the cold, R3 should be increased in value: if the converse, reduced. The thermistor—a Brimar CZ 10—has a resistance of about 15kΩ at room temperature; when colder the resistance is higher, and when warmer it is lower, thus altering the bias voltage. If R3 has to be less than half or more than double the value shown, R1 may also have to be altered correspondingly to maintain the same average value of bias.

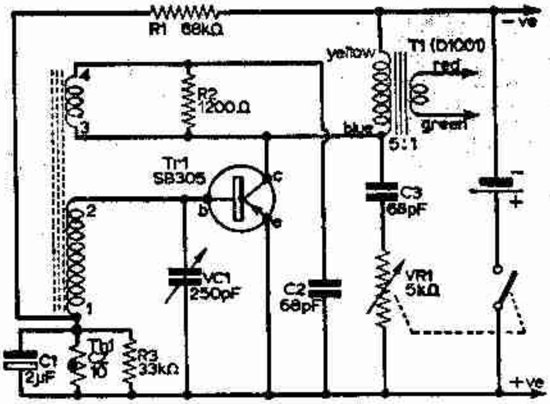
When the bias is correct, regeneration is free from "ploppiness" and sensitivity is at a maximum. For sensitivity, the voltage is not critical, but for *smoothness* of control it is well worth spending a little time on preliminary checks.

The next requirement for practical regeneration is that it should be substantially uniform over the tunable range. This makes it possible to bring in all stations at the same setting of the gain control, near to the oscillation point.

Incidentally, one need have no fear of oscillation being a nuisance to neighbours: the very low power involved and the tiny size of the aerial limit the range of possible interference to a few feet.

It is usually enough to make regeneration equal on Light and Home, although local conditions may make a different arrangement preferable. For example, if Light—or Luxembourg—has a much weaker signal than Home, a greater sensitivity at the high-frequency end will give similar volume on each station without re-setting the control. With an SB 305 or MAT 101, uncompensated regeneration is stronger at the high frequency end, and this is reduced by the shunt resistor R2; if too high in value, Home will require a higher setting than Light or Luxembourg; if too low, the converse.

Depending on individual layout, it may be found that the regeneration coupling capacitor C2 may have to be larger or smaller than shown—due to stray feedback. This will be indicated by harsh control if it is too large, and inability to produce oscillation if too small. The thermistor should be mounted close to the transistor, so that they are warmed or cooled together. If there is a *rapid* change in temperature, the thermistor responds the



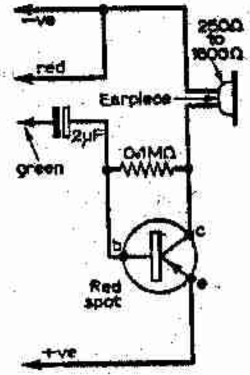


Fig. 1 (left): Windings 1-2=70-80t. 36s.w.g. enamelled wire; 3-4=25t. 36s.w.g. or 30t. 40s.w.g. depending on rod length. Fig. 2 (centre): Temperature-compensated regenerative receiver. With a good signal, it will drive a high-resistance magnetic earpiece, or it may be fed into an a.f. amplifier. Fig. 3 (right): Single-stage a.f. amplifier.

more quickly. This is most noticeable when soldering in trial components: radiant heat from the iron can knock the balance out for a full minute.

Patience is particularly called for in making adjustments to resistors R1 and R3, which have metallic links with the thermistor, and it may take two or three minutes for thermistor and transistor to drop back to the general temperature of the set.

The aerial is in no way critical as to dimensions or the placing of its windings, other than that they must be in the relationship shown in Fig. 1. With the smallest aerial rod—$\frac{3}{16}$in. x $1\frac{1}{8}$in.—the windings occupy the full length, in the form of a single layer, close wound, of enamelled wire.

The aerial winding consists of 80 turns of gauge 36, and the reaction of 30 turns of gauge 40. With a rod of between 2 and 3in. in length, about 70 and 25 turns, respectively, of gauge 36 are suitable. These cover a range of at least 200 to 500 metres with a 250pF tuning capacitor.

The a.f. requirements depend upon locality and the volume required. The basic unit will happily feed into any form of amplifier, whether with one "earthed" input terminal or with both terminals "live". For most needs, a single stage is ample; that shown in Fig. 3 adds only a transistor, one capacitor and one resistor to the basic circuit. Using an earpiece of 250 to 1600Ω, good quality and volume to spare can be obtained with less than half a milliamp of battery current.

Audio negative-feed-back is provided by biassing the base through a high resistance from the collector, as shown. This is probably the simplest practical circuit for an amplifier, and gives an excellent performance.

In favoured localities, fair volume can be obtained from the basic circuit alone, with a 250 to 1600Ω earpiece across the transformer secondary. The consumption then is only about one fifth of a milliamp, and this naturally limits the undistorted power output.

For really generous reserve—giving a daylight signal which is clearly audible even in high wind, and at many miles from the station—a two stage amplifier (Fig 4) takes about one milliamp. A 250Ω earpiece takes a little more current and gives rather less volume than a 1600Ω.

The physical size of the finished set depends mostly on the components one can obtain (or make) for tuning, switching and reaction control. The writer's three models are: Mk I, occupying the popular black-and-white plastic case measuring 2in. x 3in. x $\frac{3}{4}$in. with $\frac{3}{4}$in. square tuner and trimmer reaction control; Mk II, literally in a matchbox, with a compression-trimmer for tuning and resistance reaction control; Mk III, in a plastic box as sold for storing watchmakers'

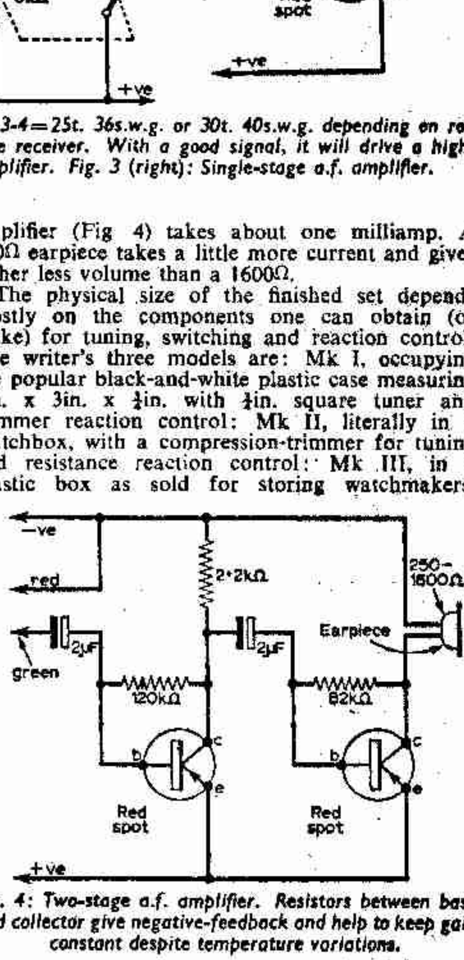


Fig. 4: Two-stage a.f. amplifier. Resistors between base and collector give negative-feedback and help to keep gain constant despite temperature variations.

materials, measuring $1\frac{1}{4}$in. x $1\frac{3}{4}$in. x $\frac{3}{4}$in. ($\frac{1}{2}$in. square tuner, "pared down", and hearing-aid volume-control-and-switch). The first is powered by single pencil cell, the second by a Mallory 625 and the third by a 675.

As an alternative to the variable resistor gain control VR1 shown in Fig. 2, the fixed capacitor C2 may be replaced by a 30pF variable, and both capacitor C3 and VR1 omitted. ■

EXPERIMENTAL BATTERY RECEIVER

By C. MORGAN

PERHAPS ONE OF THE MOST ABSORBING HOBBIES and probably the most interesting is the construction of miniature radio receivers for broadcast band reception. Many younger (and not-so-young) members of the fraternity spend countless hours constructing and discussing the various merits of performance of their handywork.

Another interesting field of experiment lies in the construction of the power supply that operates the receiver. Construction of a battery or cell is simplicity itself, and when one can boast that Radio Luxembourg was received with a home-made cell offering 1 volt at a current of 30μA (although the cell is capable of a far greater current) then prestige rises.

The Receiver

Reference to Fig. 1 shows the very simplest of crystal-transistor receivers. In the writer's home this is capable of reception of the Home and Light frequencies, together with shipping broadcasts and several Continental radio stations.

The aerial was slung round the picture rail, and consisted of about 35ft of 30 s.w.g. copper wire. An earth connection was found to be very essential, and was taken from a 3-way mains socket.

No layout diagram is given, and it is possible that the experimenter will want to try various other circuits. The transistor in the circuit of Fig. 1 was interchanged with other types, but little difference was noticed.

The Cell

Cell construction should present no problems, and the one in use at the time of writing has been in constant operation, day and night, for several months without any sign of deterioration or loss of voltage.

It was constructed with the following items. (1) A medium sized glass test tube, (the flat bottom type is ideal), together with a tight-fitting cork. (2) A small piece of thin (0.01in) copper foil. (3)

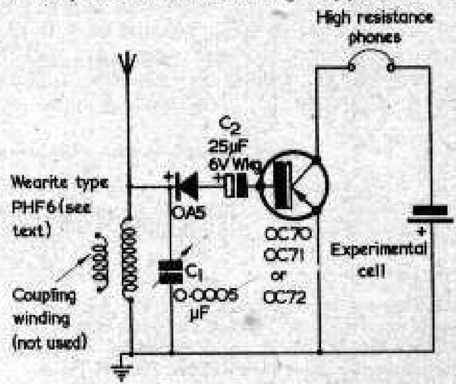


Fig. 1. The circuit of the experimental receiver and cell. Most germanium diodes should function satisfactorily in place of the OA5 shown. Several further points concerning the circuit are discussed in the text

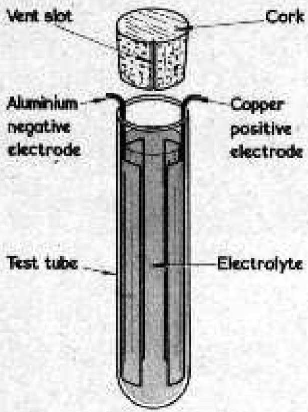


Fig. 2. The assembly of the cell

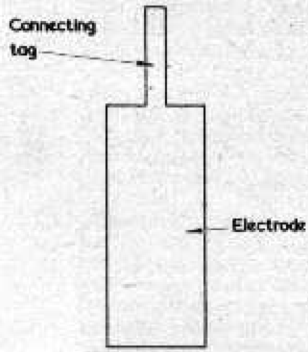


Fig. 3. The shape of each electrode. The lower section is bent round to fit the inside of the test tube employed

A similar piece of aluminium of the same thickness. (4) A quantity of vinegar, sufficient to three-quarters fill the test tube.

The cork should have a "V" slot cut in one side of it to allow the gas which the cell gives off to escape. However, the amount of gas is so small that it will never be evident. The test tube can be of any size, and no increase of voltage will result from having a larger volume, although there will be an increase of available current directly proportional to area if the electrodes are increased in size also.

Reference to Fig. 2 and 3, which show the shape of the electrodes, will assist in the construction of the cell. No dimensions are given as this is left to individual experiment. It is important to make sure that the two electrodes do not come into contact with each other, or this will cause a short-circuit.

If after several weeks of continual use the electrodes show signs of corrosion, all that is required is to remove the cork, take out the plates, give them a gentle clean with a piece of soft rag, and replace them in the tube again. If the vinegar has evaporated slightly it can be "topped up" with a little water, whereupon it will be once again ready for several more months' use. The battery will also operate if a mixture of water and salt is used instead of vinegar, and the results are almost as good.

It might be thought that several of these cells could be linked in series to form a battery of higher voltage. A small amount of advantage will result from two cells so joined, but the internal resistance becomes so high that there is no great improvement when used with the circuit of Fig. 1.

If the resistance of the circuit driven by the cell is kept high, the cell will continue to function indefinitely.

It should be noted that the copper electrode is the POSITIVE, and that the aluminium is the NEGATIVE connection of the cell.

EDITOR'S NOTE.—The writer's original prototype employed a Wearite PHF6 coil, which covers 91 to 261 metres. He has since checked reception with a PHF2 coil, which covers the medium wave range of 200 to 557 metres, with satisfactory results. There would be less dampling and capacitive loading of the tuned circuit if the aerial and earth were applied to the coupling coil instead of the tuned coil.

No bias is applied to the base of the transistor (apart from any small bias current which may flow, due to leakage in C_2, if a strong signal is received) and the writer states that he has found no improvement in performance if C_2 is short-circuited, or if a bias resistor is connected between the base and the negative supply line.

Kit Review

The Sinclair "Slimline" Micro-Radio Receiver

THE MOST POPULAR CONSTRUCTIONAL PROJECT amongst amateurs is the small pocket radio and, as long as there is no loss of performance, the smaller the receiver is the more popular it will be. In the past, the design of really small high performance receivers has been hindered by the lack of sufficiently small components and by the expense of high grade transistors. These problems have been overcome in the "Slimline", which is the result of an intensive effort to produce the smallest possible radio design with full scale performance and still to retain simplicity of construction.

Circuit Description

The high performance of the "Slimline" has been made possible by the introduction of Micro-Alloy transistors on to the amateur market. These transistors are the first to combine excellent a.f. performance with cut-off frequencies in the region of 100 Mc/s. The r.f. power gain of a conventional r.f. alloy transistor in a reflex circuit is only about 20dB or 100 times whilst a micro-alloy transistor (MAT) can provide a gain of 40dB or 10,000 times. Furthermore the a.f. gain of a MAT is much higher than that of an ordinary alloy type.

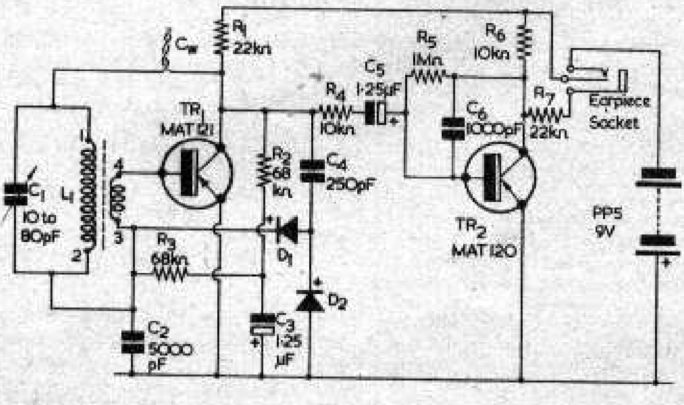
By combining MAT's with careful design it has been found possible to achieve really remarkable performance with only two transistors and relatively few associated components. The sensitivity compares well with that of many superhets and the volume is sufficient to enable the set to be used in a car or train. The "Slimline" is free from noise or distortion and gives excellent fidelity of reproduction.

The "Slimline" circuit is shown in the accompanying diagram. L_1 is a miniature ferrite rod aerial which picks up the signal and, with C_1, tunes to the required station. A secondary winding on L_1 couples the signal to TR_1, MAT 121, which then amplifies at r.f. The r.f. output from TR_1 is fed to a voltage doubling detector via C_4. D_1 and D_2 demodulate the signal and feed an a.f. voltage back to the input of TR_1. Any residual r.f. voltage is removed by C_2.

In addition to detecting the signal, D_1 and D_2 provide an automatic gain control voltage for TR_1. This prevents overloading on strong stations and is an important feature not normally found on simple receivers.

The base bias for TR_1 is provided by resistive feedback from the collector via R_2 and R_3. Taking

Circuit of the "Slimline" transistor receiver



the bias from the collector ensures adequate d.c. stabilisation but would normally result in unwanted negative feedback at a.f. This is prevented by decoupling the junction of R_2 and R_3 with C_3, an electrolytic capacitor. The addition of C_3, another novel feature of the circuit, results in a considerable increase in the a.f. gain of the stage.

The r.f. gain of TR_1 is increased by positive feedback or regeneration applied via C_w from the collector to the top of L_1. C_w consists simply of two short lengths of insulated wire twisted together. Its main purpose is to enhance the performance of the radio at the high frequency end of the band, where Radio Luxembourg is situated, thus overcoming the poor sensitivity in this region which is a feature of many reflex sets.

Once the set is constructed C_w does not have to be adjusted because the r.f. gain is automatically controlled by the a.g.c. system.

TR_1 provides about 35dB gain at a.f. and the output is fed to TR_2, and MAT 120, via R_4 and C_5. The circuit around TR_2 is designed to obtain the maximum possible voltage gain from the transistor because the earpiece used, a piezo-electric crystal type, requires a voltage drive for good quality. Crystal earpieces normally give higher sensitivity at high frequencies than they do at low frequencies. This is compensated for by C_6 which provides frequency selective negative feedback from the collector to the base of TR_2.

The total current consumption of the circuit is only 1mA making the battery life several hundred hours with the type specified.

Practical Details

The "Slimline" receiver uses a printed circuit board and the case employed, besides being remarkably small, is both elegant and carefully designed. The case and the dial are both made specially for this receiver.

Particular attention was paid to small details when the layout of the "Slimline" was considered.

This illustration shows the extremely small size of the "Slimline" receiver

For example battery clips are provided making it unnecessary to solder the battery into the circuit. The receiver is automatically switched on when the earpiece plug is inserted and switched off again when the plug is removed. Thus it is virtually impossible to leave the set on unintentionally.

The "Slimline" operates in the vertical position with the dial at the top. The tuning capacitor provided gives full coverage of the Medium wave band and may be detuned slightly to give control over the volume. Alteration of the volume may also be achieved by rotating the receiver, because the aerial is directional.

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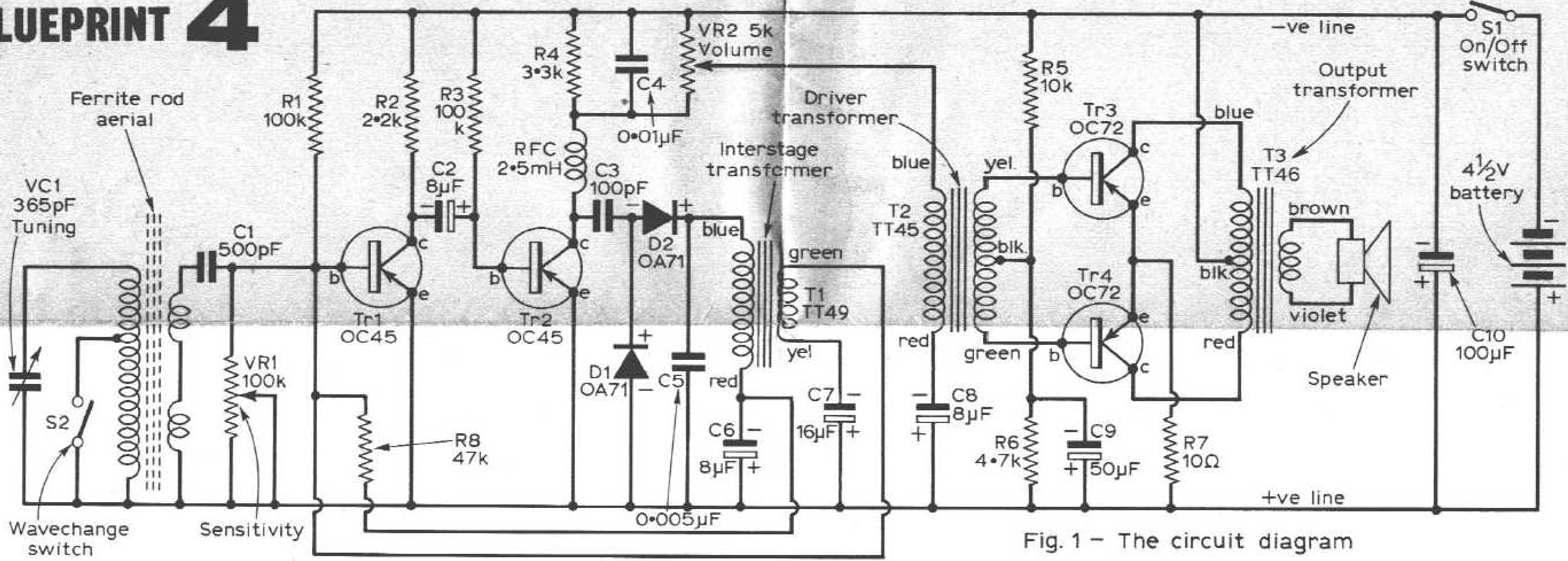
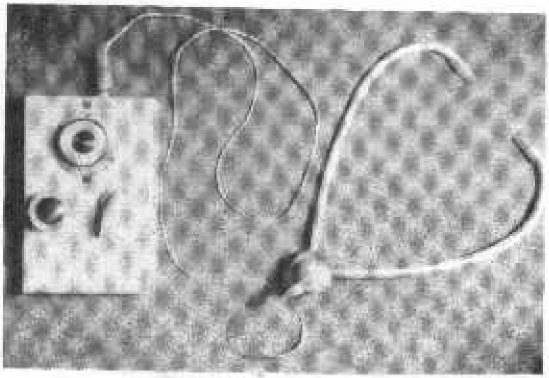


Fig. 1 – The circuit diagram

MODIFYING THE SUPER 3

By

J. C. FLIND



Front panel view of the modified "Super-3" receiver with headset attached

UNTIL THE "SUPER-3" DESIGN WAS FEATURED IN the May 1961 issue of *The Radio Constructor*,* the writer had for a long time been looking for a pocket transistor receiver to meet a special need. What was wanted was a really personal set employing a deaf-aid type earpiece, so that it could be used in bed or in a deck-chair without annoyance to others, and with sufficient sensitivity to ensure a worthwhile signal of good entertainment value on both long and medium wavelengths. Several published t.r.f. circuits had been tried but only with moderate success, usually because of instability or poor sensitivity, while superhets were "out" because of high cost and complexity.

The "Super-3", whose circuit is shown in Fig. 1, looked more hopeful, as it featured two r.f. transistors in a regenerative circuit which seemed to promise adequate pick-up from the internal ferrite aerial. Accordingly the very reasonably priced kit was purchased and assembled. Assembly was an easy proposition, thanks to the printed-circuit chassis, which offered a great help towards neatness and small size. First trials came up to expectations, so the next step was to modify the design to meet the requirements stated above, at the same time taking the opportunity which the use of an earphone output offered to improve certain features of the original kit.

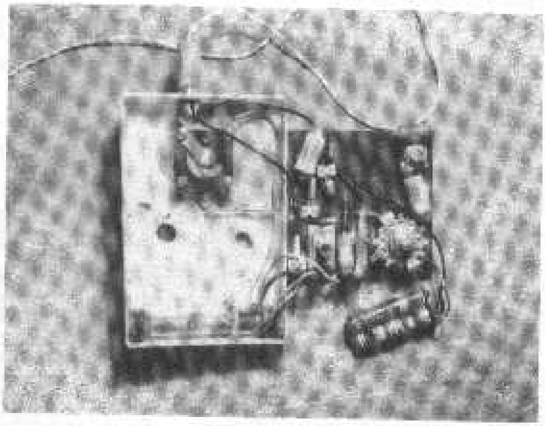
New Tuning Capacitor

Removal of the loudspeaker unit left a space large enough to accommodate a standard Radiospares 500pF solid-dielectric tuning capacitor—this type, while inexpensive and not an ultra-miniature component, occupies only a little over a square inch of area. A piece of thin aluminium sheet cut to 3 x 2in—a useful protection against hand-capacity effects while tuning—was bolted inside the lid, using the two holes already drilled for fixing the discarded speaker, and a central hole drilled in it to take the capacitor bush. The bush itself and the ¼in spindle were trimmed down to the minimum possible length.

The use of a rotary tuning capacitor instead of the compression-type trimmer supplied with the kit, is an important improvement. Not only does the rotary capacitor make for easier handling but it also makes it possible to provide a tuning scale, thus greatly simplifying searching for the desired programme.

Experiment now showed that the tuning range had shifted towards the low-frequency end of the scale, so that Luxembourg and the Medium wave Light Programme were no longer tuneable. To put matters right some turns were cautiously removed, a few at a time, from the primary or aerial coil of the ferrite rod—in all about 18 turns has to be taken off, and the coverage then extended from just under 200 metres to around 600 metres. The removal of so many turns affected the ratio between the aerial and the coupling coil, with the gratifying result that signal transfer noticeably improved. A less happy effect was that the B.B.C. Long wave transmitter now lay outside the tuning range. A new value for C_1 had to be found by experiment, and this turned out to be 2,500pF.

It should be noted here that in the Long wave position of the control switch the tuning capacitor operates more as a trimmer than as a true tuner: C_1 and TC_1 are in parallel so that their total capacit-



Rear view of the receiver showing the new tuning capacitor and regeneration control

* "The Super-3, A 3-Transistor Pocket Receiver", described by R. A. Langis, *The Radio Constructor*, May 1961.

Components List

Resistors

R_1 2.2kΩ $\frac{1}{8}$ watt
R_2 4.7kΩ $\frac{1}{8}$ watt
R_3 680Ω $\frac{1}{8}$ watt
R_4 1kΩ $\frac{1}{8}$ watt
R_5 4.7kΩ $\frac{1}{8}$ watt
R_6 10kΩ $\frac{1}{8}$ watt
R_7 2.2kΩ $\frac{1}{8}$ watt

Capacitors

C_1 1,500pF ceramic
C_2 0.1μF tubular, 150WV
C_3 16μF, electrolytic, 6WV
C_4 2μF, electrolytic, 6WV
C_5 560pF, ceramic
C_6 0.1μF, tubular, 150WV
C_7 2μF, electrolytic, 6WV
TC_1 250pF variable trimmer

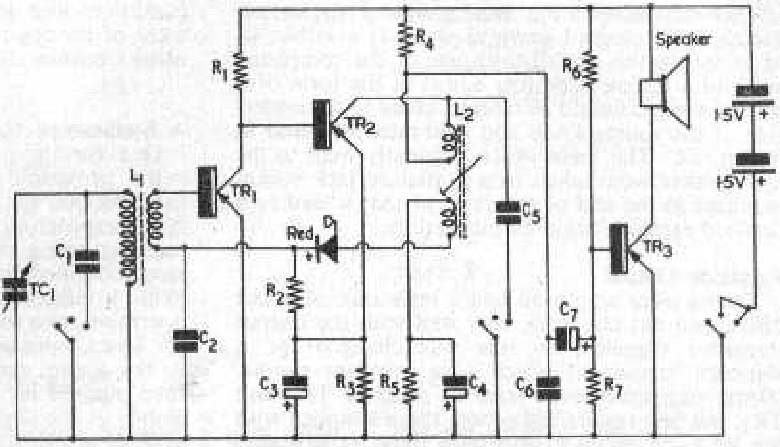


Fig. 1. The original "Super-3" circuit M264

Batteries

Ever Ready U16 (2)

Transistors

TR_1 Surface barrier r.f. type (R & TV Components Ltd.)
TR_2 Surface barrier r.f. type (R & TV Components Ltd.)
TR_3 V10/15 (R & TV Components Ltd.)

Miscellaneous

Case, 3-way 4-pole switch, balanced armature insert, printed circuit board, ferrite rod aerial assembly, coil L_2, germanium diode, knob, nuts and bolts, etc. (R & TV Components Ltd.)

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ance can be varied approximately only from 3,000pF to approximately 2,500pF, a ratio of 1.2/1. (In the original design the capacitance range was 1,800pF to 1,500pF.) Accordingly the tuning range is limited to a few kc/s, but as few listeners on this waveband will be interested in anything other than the B.B.C. on 200 kc/s this is not a matter of great importance.

Variable Regeneration

The tuning dealt with, there remained available the vacant space occupied in the original design by TC_1, and it was decided to incorporate a variable regeneration control: the designer's idea of paralleling the leads to the base of TR_1 and the collector of TR_2 proved rather tricky, and the optimum setting was not the same for all frequencies. The most satisfactory method found was to join these leads by the smallest postage-stamp type trimmer that could be purchased (3–30pF) and to mount this in such a way that it could be controlled by a knob outside the case. The trimmer was fixed to a small square of thin plywood, drilled so as to allow the adjusting screw to project downwards, the plywood then being mounted, with contact glue, on to the printed circuit board between TR_1 and C_2 in such a way that the head of the adjusting screw came directly under the small hole already drilled in the case for the original tuner. A short length of $\frac{1}{8}$in brass rod (or preferably, for greater strength, tube) soldered to the head of the adjusting screw will project through the case ready to accept a suitable knob.

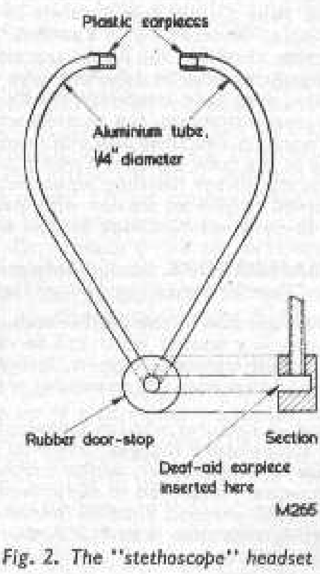


Fig. 2. The "stethoscope" headset

This spindle and the one operating the on-off switch were trimmed down as short as possible, so as to reduce the overall thickness of the completed set, and a tuning scale was added in the form of a disc of white celluloid or ivorine, glued to the underside of the tuning knob and calibrated by hand in indian ink. The leads which originally went to the loudspeaker were taken to a miniature jack socket mounted in the end of the case, so that a lead to a deaf-aid earpiece could be plugged in.

Earphone Output

The earpiece employed had a resistance of about 250Ω, and did not work very well with the output transistor supplied, so this was changed for a standard "red-spot" which gave excellent results. (Other transistors were tried in place of TR_1 and TR_2, but best results came from those supplied with the kit.) In order to facilitate these experiments none of the transistors were soldered directly into the circuit, but transistor holders were used, so that they could be plugged in. Not only does this procedure make experimenting easier, but it protects the transistors from accidental damage by heat.

The set was now operating really well—in the Greater London area all the B.B.C. transmissions could be made loud enough to be uncomfortable to the ear (control of volume is easily obtained by tilting or rotating the whole set so as to reduce aerial pick-up). After dark under good reception conditions and with careful orientation and adjustment of the regeneration control, Luxembourg and other Continental stations came in at good strength.

A Stethoscope Headset

One further improvement seemed worth while—the provision of a "stethoscope" headset for listening over long periods or in noisy surroundings. An inexpensive but highly satisfactory unit was made up using as a basis an ordinary rubber doorstop, obtained for a few pence from Woolworths. With a tubular cork-borer, kept wet during the operation, two radial holes, ¼in diameter and about 75° apart, were bored from the circumference down to the centre, and short lengths of soft aluminium tube plugged in. These were then bent by hand as shown in the illustration, a piece of spring curtain-rod threaded inside preventing the bores from collapsing during bending. The two radial holes and the inner ends of the tubes, of course, connect with the axial hole thoughtfully left by the manufacturers of the doorstop, and the deaf-aid earpiece is plugged into this. The whole outfit weighs just an ounce, and can be taken to pieces in a moment for carrying in the pocket. The improvement in quality of the sound, coupled with the absence of interference from extraneous noise, has to be experienced to be believed. As an additional refinement, plastic earpieces can if desired be shaped and fitted over the ends of the tubes.

CHAPTER IX

SUB-MINIATURE RECEIVERS

WHILST the circuits described in the previous chapters can be described as "miniature" in that the complete receiver, with its batteries, can be accommodated in quite a small case, transistor circuits also lend themselves to further compacting and space reduction resulting in the sub-miniature receiver, which is smaller in size than a box of matches. The use of a loudspeaker is precluded in such a small volume, so receivers of this type invariably utilize a deaf-aid type earpiece for listening, plugging into a matching jack on the side of the receiver case. Also, again to save space and reduce the number of components to a minimum, fairly simple circuits are usually employed and the smallest sizes of Mallory-mercury batteries.

The main limitation with such circuits is the rather low aerial efficiency which can be realized in a necessarily small size of aerial coil and ferrite rod or slab. Nevertheless, well-designed sub-miniature receivers are capable of providing satisfactory listening in areas of good reception and good sensitivity over a wide range of broadcast frequencies. In less favourable areas reception may be marginal and variable with conditions. In particular the final signal volume may be quite low with a suitable level for listening dependent on fairly precise alignment of the aerial relative to the source of signal. Such circuits, however, are readily adaptable to a further stage of a.f. amplication for working a speaker, although the combined volume of basic receiver, amplifier and speaker no longer conforms to the conception of a sub-miniature receiver.

In order to achieve minimum spacing of components together with a practical method of mounting and wiring up, sub-miniature receivers are invariably built on a printed circuit board. The original design of such a circuit is tricky and demands some experience to tackle successfully. For this reason the sub-miniature receivers are normally best built from kits which include a printed circuit board ready prepared and drilled for the mounting of components. Building the receiver then becomes a matter of simple assembly, locating each component in its correct position on the printed board and

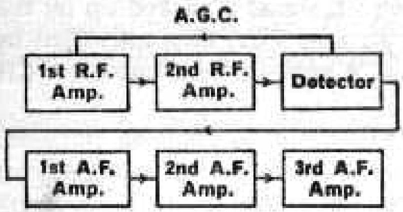


Fig. 57.

soldering the leads in place to the copper lands. Since the positioning of components can be quite critical—one component assembled in the wrong order may interfere with the mounting of a subsequent component—a definite sequence is usually specified for building. Certain precautions may also have to be observed, specific to the design. Thus, building from kits, the main point to remember is to follow the instructions for that kit specifically and not attempt what may appear to be "short cuts."

An outstanding example of a sub-miniature receiver of this

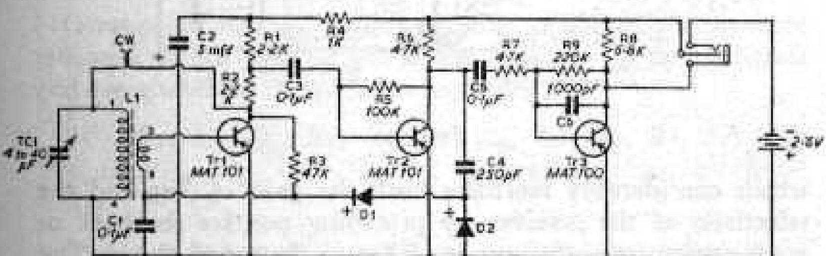
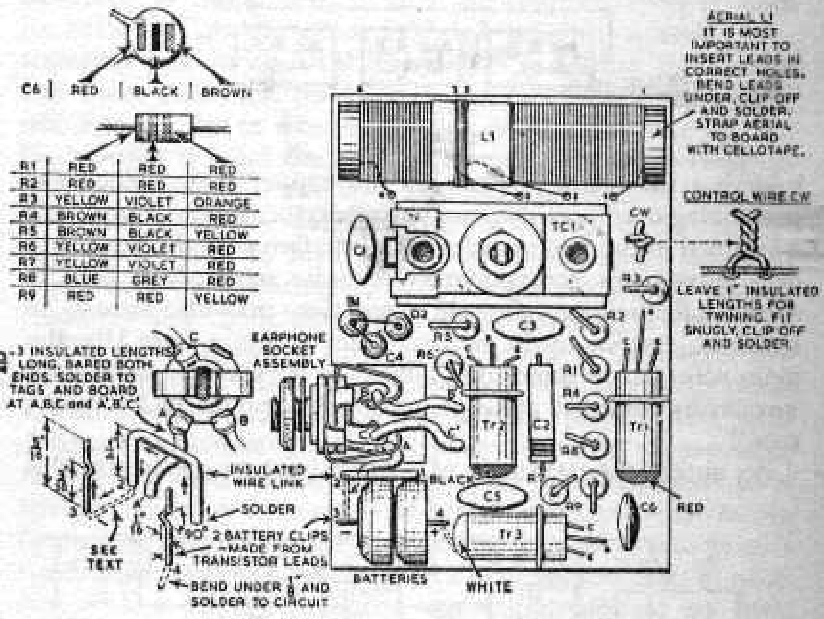


Fig. 58.

type is the Sinclair Micro-6. This is designed to fit into a case measuring only 1·8 × 1·3 × 0·5 inches and weighs less than one ounce, complete with batteries. The circuit is ingenious in that although only three transistors are employed the performance is generally comparable to that of a six-transistor superhet. This is achieved by reflexing both the first and second transistors so that each amplifies successively at both a.f. and r.f, in the block diagram Fig. 57.

A circuit diagram of the Sinclair Micro-6 is shown in Fig. 58. The incoming r.f. signal is picked up by the aerial coil *L1* and selected by *L1* and *TC1*, then amplified by *Tr1* and *Tr2* prior to detection. A semi-variable capacitor *CW* is introduced



R1	RED	RED	RED
R2	RED	RED	RED
R3	YELLOW	VIOLET	ORANGE
R4	BROWN	BLACK	RED
R5	BROWN	BLACK	YELLOW
R6	YELLOW	VIOLET	RED
R7	YELLOW	VIOLET	RED
R8	BLUE	GREY	RED
R9	RED	RED	YELLOW

FIG. 59.

which considerably increases both the gain of *Tr1* and the selectivity of the receiver by providing positive feedback or regeneration from the output of *Tr1* to the tuned circuit. The level of regeneration is automatically controlled by the a.g.c. circuit. In practice, *CW* is simply two pieces of single stranded insulated wire twisted together, adjusted for best performance merely by twisting or untwisting the "coupling" until best performance is achieved.

The r.f. output from *Tr2* is coupled directly to the double diode detector *D1* and *D2* by capacitor *C4*. The output from the detector stage consists of three parts:

(i) a D.C. voltage which is proportional to the signal strength and which controls the collector current and thus the gain of *Tr1*.

(ii) an a.f. signal which is fed to the base of *Tr1*. This a.f. signal is then amplified in turn by *Tr1*, *Tr2* and *Tr3*.

(iii) an unwanted residual r.f. signal which is removed by capacitor *C1*.

The three transistors used are of micro-alloy type, enabling a satisfactory performance to be realized on a low battery voltage with very low current consumption. The batteries are

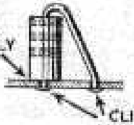


FIG. 60.

Mallory ZM312 or RM312 mercury cells of 1·2 volts each. In areas of strong signals a single cell (1·3 volts) may be satisfactory but for most areas two batteries (2·6 volts) are required for working.

Component assembly is shown in Fig. 59. All components are mounted on the opposite side of the board to the copper lands and are assembled in the following order:

TC1, *C1*, *R5*, *C3*, *R2*, *R3*, *R1*, *R4*, *R8*, *R9*, *R7*, *Tr1*, *C6*, *Tr2*, *C2*, *C5*, *Tr3*, *R6*, *D2*, *D1*, *C4*, battery clips, earphone socket, *CW*, *L1*.

It is very important that all the components used to build this set are mounted as close to the board as possible. The leads must be clipped to within about $\frac{1}{32}$ inch from the board and then soldered. The solder must not protrude from the board more than absolutely necessary. To ensure a good joint the solder should be held against the wire and the copper and the joint made quickly with the iron at full heat. The transistors can be damaged by excess heat and it is wise to grip the transistor lead being soldered with tweezers or pliers to act as a heat sink. It is not essential to hold the solder to the joint in the case of the transistors as the leads are gold plated.

Remove any insulation from the leads of *C*1, *C*3 and *C*5 as shown in Fig. 61.

The assembly of *D*1, *D*2, and *C*4 is shown in Fig. 62. Take

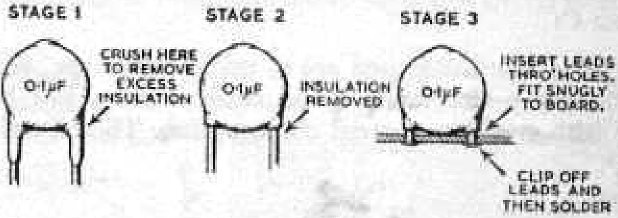


Fig. 61.

care to ensure that the diodes are inserted the correct way round. The positive end is that which looks like a tiny front arrow inside the glass body of the diode. *C*4 (250 *pF*) is mounted flush to bring the top to the level of *D*1 and *D*2. The top lead of *C*4 is wound round the top leads of *D*1 and *D*2 as shown in Stage 3. Solder *C*4 to *D*1 and *D*2 as quickly as possible to avoid damaging the diodes and then clip off the rest of the diode leads

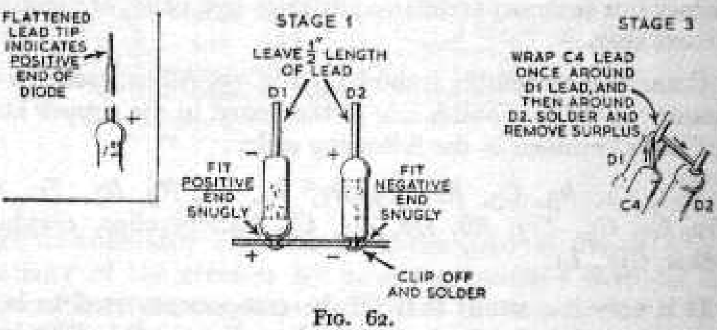


Fig. 62.

as close to the diodes as possible. Unless the leads are clipped close to the diodes the final assembly might not fit into the case.

Bend the transistor leads so that they can be assembled on to the board as shown in Fig. 63. Clip off the leads after mounting and keep them, as two are required to make the battery clips. Remember to make the solder joints quickly and to use a heat sink if possible to avoid damaging the transistors.

TC1, the tuning capacitor, must lie flat on the board as shown in Fig. 59. The eyelet and the bush protrude slightly into holes provided on the board. It may be necessary to bend the leads slightly so that they coincide with the copper on the board to which they must be soldered. The leads, when clipped, must not extend more than $\frac{1}{16}$ inch from the board and should be soldered as in Fig. 64.

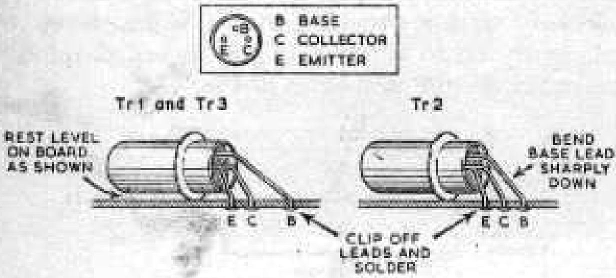


FIG. 63.

Mount *L1* on to the board as shown in Fig. 59 and then fix it to the board carefully with clear cellotape so that it cannot move. If wished, the aerial may further be glued to the board for extra security.

For *CW* use two pieces of the single stranded, plastic insulated wire just over 1 inch in length. Bare one end of each and solder into position as shown in Fig. 59. It is not necessary to twist these wires together at this stage. The single stranded wire is only required for *CW*.

The assembly of the battery clips is shown in Fig. 59. These are bent from the transistor leads you will have saved. The positive clip (numbered 4 on the diagrams) requires about $\frac{1}{2}$ inch of lead. The negative lead (numbered 3) extends under the board, up through the hole numbered 2, across and down again through hole 1. The section between 1 and 2 must be covered with $\frac{3}{4}$ inch of plastic sleeving taken from the 4 inches length of single strand wire. This insulated wire link helps to keep the batteries in position. The clips must be soldered very firmly under the board to ensure sufficient rigidity. They must be clean at all times. Corrosion or dirt must be removed by gently filing or scraping.

Solder the earpiece socket to the board using three $\frac{3}{4}$ inch lengths of the multi-stranded, plastic insulated wire as shown in Fig. 59. Be careful to join the tags to the correct holes.

Remove the nut and washer from the earpiece socket and fit the entire assembly into the case passing the threaded neck through the hole on the side. Now replace the washer and nut of the socket on the outside of the case and tighten the screw firmly but carefully.

Remove the screw and two washers from *TC1* and screw in the dial from the front of the case until the spindle projects through *TC1*. Replace the paxolin washer and fit the specially shaped locking washer provided over this and screw the nut provided tightly on to the end of the threaded spindle. The whole assembly should now be as in Fig. 64.

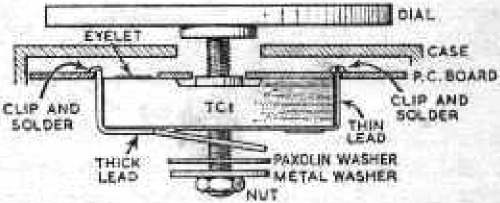


FIG. 64.

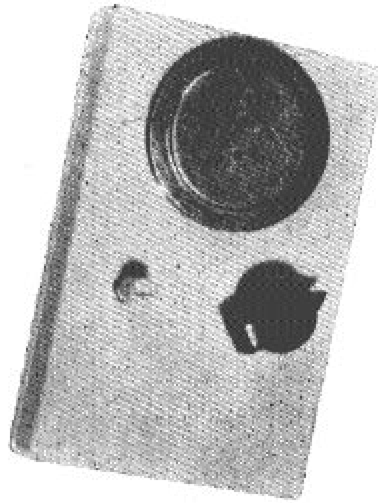
The Micro-6 uses two Mallory ZM312 (or RM312) mercury cells. These may be obtained from Boots the Chemists, or from most radio shops. Fit the cells between the battery clips, being very careful to insert them the correct way round as shown in Fig. 59. You will probably need to bend the battery clips inwards to ensure that they grip the cells tightly enough. Make sure the clips are always clean.

Plug the earpiece into the socket. This automatically switches the set on and you should now be able to tune in a station or two. Tune to the high frequency end of the band, that is with the dial turned clockwise as far as it will go, and twist the wires of *CW* tightly together until you hear a rushing or whistling noise. Now untwist them slightly so that the noise just stops. *CW* may be adjusted slightly for best performance and then bent over so that the lid can be fitted. Two lids are provided; one in white plastic and one in clear to give you a choice. The lid slides into place from the end of the box.

The kit for the construction of the Sinclair Micro-6 is produced by Sinclair Radionics Ltd, Comberton, Cambridge.

The "SUPER-3"

(A 3-Transistor Pocket Receiver)



described by **R. A. LANGIS**

THE PERSONAL POCKET RECEIVER ABOUT TO be described is an ideal design from many points of view. First—it can be completely constructed in about an hour or so; second—it is comparatively inexpensive; third—it is completely portable and has "pocketability", its dimensions being only some 3½ x 5 x ⅞in; fourth—it has a "speaker" output; fifth—the few components required are mounted on a printed circuit board; and sixth—it may be built with ease by the veriest beginner.

Using two r.f. surface barrier transistors and one a.f. transistor together with a germanium diode, only seven ⅛ watt resistors and seven condensers (plus TC_1) as well as a balanced armature insert and the printed circuit board are required to complete the whole circuit. This, together with the batteries and the case, provides the complete assembly.

Circuit

This is shown in Fig. 1 from which it will be seen that it is a five stage reflex design. The primary winding of the ferrite rod aerial assembly L_1 is tuned by the variable trimmer TC_1. On the Long wave position C_1 is brought into circuit by the 3-pole 3-way Yaxley switch. This functions as the on off control also, as well as bringing C_5 into circuit on the Long wave position. The signal induced in the secondary of L_1 is then applied to the base of transistor TR_1, the amplified r.f. at its collector being passed to the base of TR_2. The resultant further amplified r.f. at the collector of TR_2 is then transformer coupled to the germanium diode D_1 via L_2. D_1 rectifies the signal and passes it, as a.f. back to the base of TR_1. TR_1 and TR_2 now function as a.f. amplifiers, the amplified a.f. signal being fed, via C_7, to the base of the audio transistor TR_3, from the collector of which the audio signal is finally applied to the balanced armature insert.

Construction

Construction of the "Super-3" receiver should commence with modifications to the tuning condenser TC_1. As supplied, this is a standard compression-type trimming condenser. Remove the 6BA adjusting screw completely and replace this with the 1-in 6BA bolt provided. Ensure that this operation is carried out without losing any of the mica leaves and washers that are sandwiched between the metal plates. Screw in the bolt until the condenser plates are firmly compressed. Fit the condenser to the plastic receiver case and then, over the bolt, slide on a washer, a coil-spring and a second washer—in that order (see Fig. 2). Having done this, screw on a 6BA nut until it *just begins* to compress the coil-spring. Using a spanner, hold the 6BA nut in position and screw on the white plastic tuning knob supplied up to the nut, finally tightening the nut against the knob and locking it in position. Providing this operation has been done correctly, it should be possible to obtain about three complete turns of the knob, and this will be found to give an adequate tuning range when the receiver is completed.

Next, the balanced armature speaker unit should be fitted to the receiver case, its

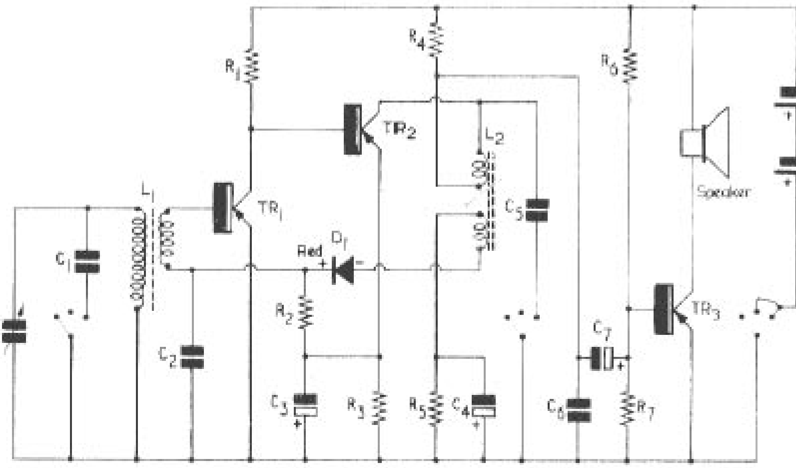


FIG.1
Circuit Diagram

M974

Components List

Resistors

- R_1 2.2kΩ ⅛ watt
- R_2 4.7kΩ ⅛ watt
- R_3 680Ω ⅛ watt
- R_4 1kΩ ⅛ watt
- R_5 4.7kΩ ⅛ watt
- R_6 10kΩ ⅛ watt
- R_7 2.2kΩ ⅛ watt

Transistors

- TR_1 Surface barrier r.f. type (R & TV Components Ltd.)
- TR_2 Surface barrier r.f. type (R & TV Components Ltd.)
- TR_3 V10/15 (R & TV Components Ltd.)

Condensers

- C_1 1,500pF ceramic
- C_2 0.1μF tubular, 150 w.v.
- C_3 16μF, electrolytic, 6 w.v.
- C_4 2μF, electrolytic, 6 w.v.
- C_5 560pF, ceramic
- C_6 0.1μF, tubular, 150 w.v.
- C_7 2μF, electrolytic, 6 w.v.
- TC_1 250pF variable trimmer

Batteries

Ever Ready U16 (2)

Miscellaneous

Case, 3-way 4-pole switch, balanced armature insert, printed circuit board, ferrite rod aerial assembly, coil L_2, germanium diode, knob, nuts and bolts, etc. (R & TV Components Ltd.)

position being exactly as shown in Fig. 3. Of the four 8BA bolts holding the brass front plate in position, two should be removed and replaced with the two longer 8BA bolts provided. *On no account must the other two remaining bolts be disturbed.* Having firmly screwed in the two longer bolts, the balanced armature unit may now be placed into position on the receiver case and two 8BA nuts used to secure it firmly into position. This completes the assembly of the receiver case for the time being, and it should be placed to one side whilst the remaining components are soldered into circuit on the printed circuit board.

Note that all the following components are fitted such that their bodies appear on the blank side of the printed circuit board, their connecting wires protruding through the holes provided. The wires which project from the printed side of the board should be cut to a length just sufficient to allow for soldering to the respective copper conductors. The wire ends should be tinned, bent flat upon the board and then soldered using a hot iron applied briefly to the joint. The order of component assembly on the board is as follows:

On/Off Wavechange Switch

This is a 4-pole 3-way component, only three poles of which are used in the present circuit. Having first checked that all the tags are perfectly straight and clean, carefully feed them through the holes in the board (see Fig. 3). The ends of the tags which, after pressing the switch body home, project from the circuit side of the board are then trimmed down to leave about ⅛in clearance from the board. When all the tags have been so trimmed, their remaining stubs should be lightly pressed outwards on to the board and the appropriate tags soldered. The pressing operation must be done with care, using the plastic handle of a screwdriver or knife as the pressing tool. A sharp metal instrument should, *on no account*, be used—an accidental slip would almost certainly result in damage to the thin copper surface of the printed circuit board. With the switch tags now correctly in place, solder these tags to the copper pattern. Note here that it does not matter which way round this switch is pressed into the circuit board—any section or pole can occupy any position. When soldered it will be noted that one complete section of the switch is not used in the circuit.

R.F. Transformer L_2

This should be fitted to the board next. The orientation of the coil terminal ring must be that shown in Fig. 3, correct orientation being given when the gap in the terminal ring aligns with the pilot hole in the board. The tags of L_2 should be bent over, as in the case of the switch, and then soldered. Some care should be exercised here in order to avoid damage to the extremely fine wires of the coil.

Resistors

Collect together all seven of the resistors and bend their respective lead-out wires at right angles to the component body; then clip off surplus wire and tin the ends before insertion through the respective holes in the board. Before finally soldering, ensure that the resistors are laid flat against the plain side of the board. When positioning the resistors, note that they must be kept clear of the two areas shown in Fig. 3.

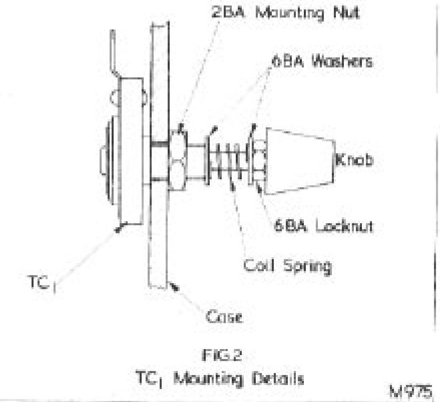


FIG.2
TC_1 Mounting Details

The positions which the resistors occupy are shown in Fig. 3. Resistor identification, together with that of the transistors and germanium diode, is given in Fig. 4.

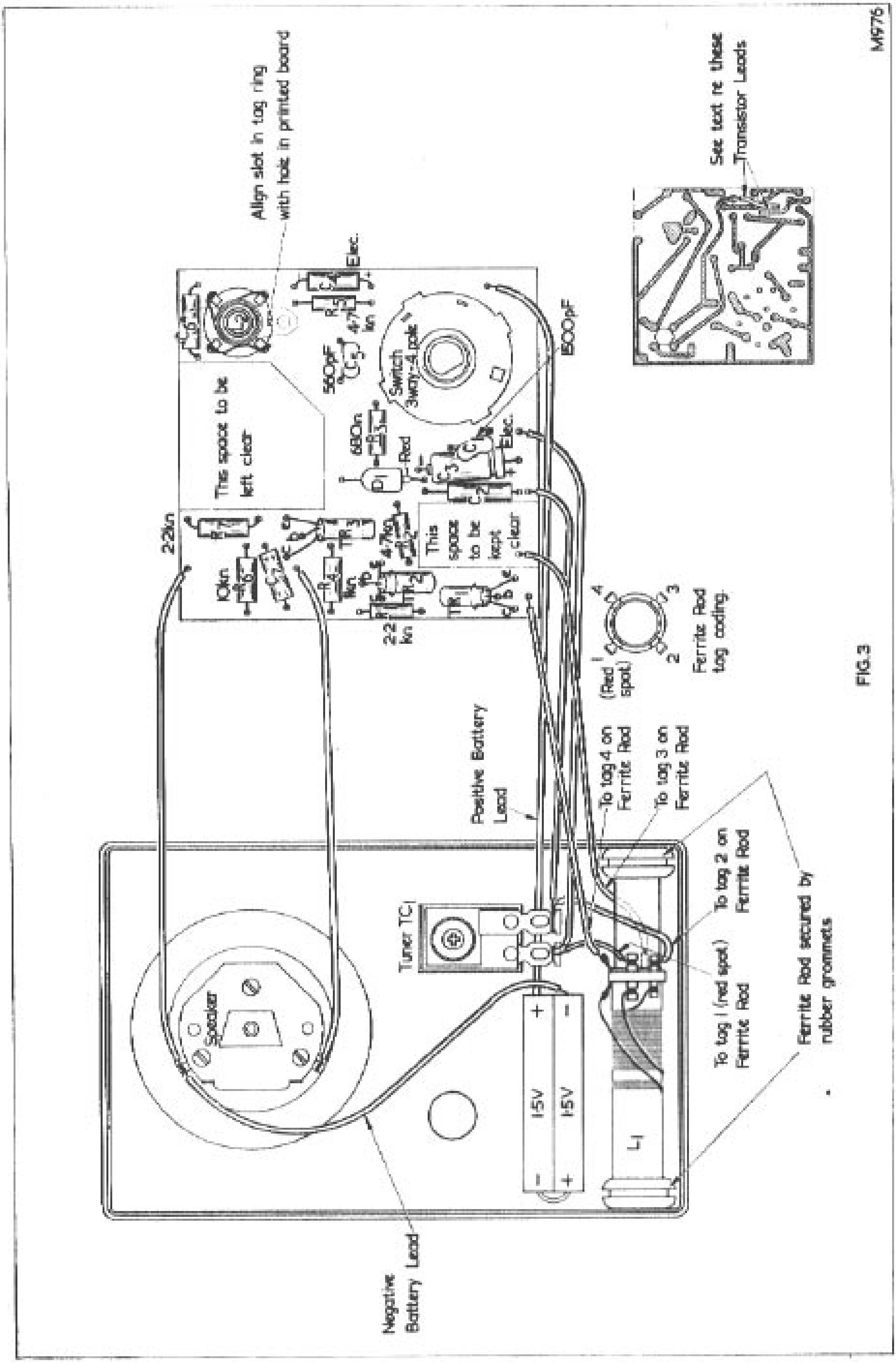
Condensers

Having soldered all the resistors into circuit, deal next with all the condensers —except, of course, TC_1. Deal with these components in the same manner as was described above for soldering the resistors into circuit. Electrolytic condensers must be connected with due regard to their polarity and this is shown not only in the circuit of Fig. 1 but also in the layout diagram of Fig. 3. In most instances the negative pole of the electrolytic condensers is identified on the case, but where this is not so the metal can of the condenser should be taken as the negative (−) connection—the positive wire being that which enters the condenser through an insulating bush. When positioning the condensers, note again the two clear areas of Fig. 3. Also, mount the electrolytic condensers such that they are clear of the printed circuit board edges; these components must not protrude over the edge of the board.

With a short length of wire, connect the metal body of the switch to the outside edge copper strip which traverses three sides of the printed circuit board. This provides a chassis connection.

Transistors and Germanium Diode

It is most important to carefully study the diagram showing the transistor lead-out connections (Fig. 4) before attempting to fit these components. Note particularly that the r.f. transistor lead-out wires are quite different from those of the a.f. transistor. Should a transistor be connected into circuit incorrectly, immediate damage will almost



Align slot in tag ring with hole in printed board
Elec.
4·7kΩ
560pF
C_5
Switch 3way-4 pole
1500pF
This space to be left clear
680Ω
Red
Elec.
2·2kΩ
10kΩ
This space to be kept clear
4·7kΩ
1kΩ
2·2 kΩ
Ferrite Rod tag coding.
(Red spot)
Positive Battery Lead
To tag 4 on Ferrite Rod
To tag 3 on Ferrite Rod
To tag 2 on Ferrite Rod
Ferrite Rod secured by rubber grommets
To tag 1 (red spot) Ferrite Rod
Tuner TC1
Speaker
1·5V
1·5V
L_1
Negative Battery Lead
See text re these Transistor Leads
M976

FIG.3

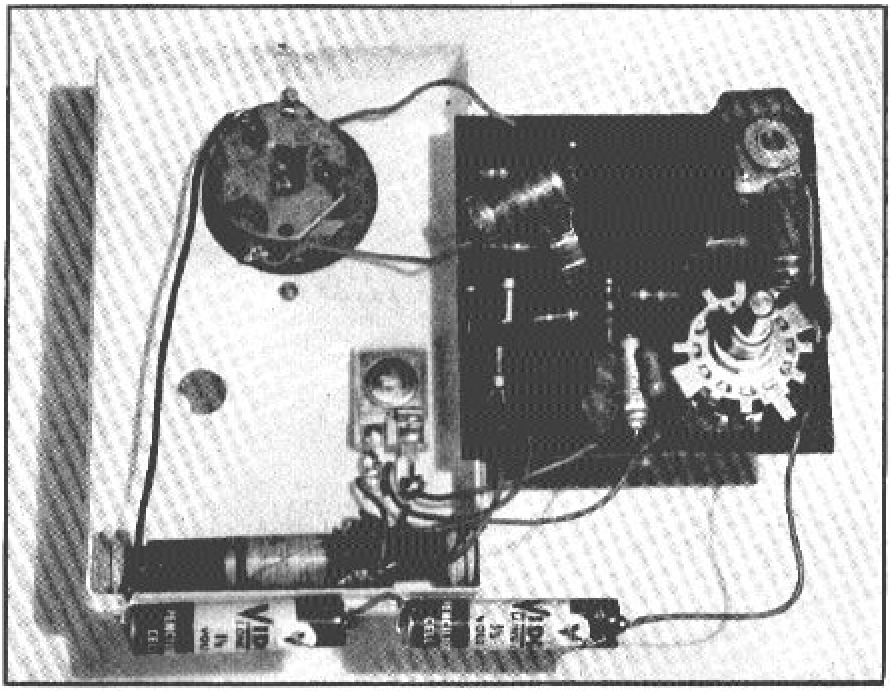
certainly result. For the beginner, it should be mentioned here that damage can also be occasioned to transistors from two other causes when soldering them into position. There is, firstly, damage due to excessive heat from the iron. To avoid this, grip the lead-out wire being soldered with a pair of pliers so that most of the heat is conducted away from the transistor—the application of the iron bit to the joint being made as briefly as possible. The second cause of damage is especially applicable to surface barrier transistors because these transistors can be immediately damaged by any electrostatic or resistive leakage voltages which may exist on the bits of mains-operated soldering irons. The most convenient method of avoiding this risk is to disconnect the iron from the mains during the actual soldering process, re-connecting the iron to maintain its heat before the next soldering operation. The foregoing precautions apply equally to the germanium diode.

Transistor TR_1 should be soldered into position first. After soldering, trim back the emitter and collector lead-out wires only, leaving the base wire projecting from the joint. Next, fit and solder TR_2 and, after soldering, leave its collector lead untrimmed. Details of the use to which these two untrimmed lead-out wires will be put are included in the testing instructjons. It should be noted that both TR_1 and TR_2 are surface barrier type transistors.

Transistor TR_3, the a.f. type, should now be soldered into position and all lead-out wires trimmed. Follow this by connecting into circuit the germanium diode and cutting its wire ends to length.

Ferrite Aerial Assembly

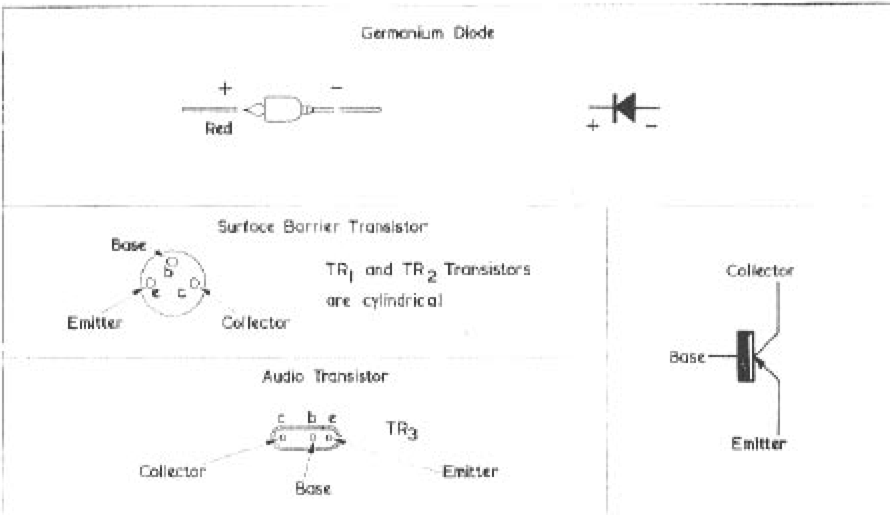
Having completed all the component soldering, the wires connecting to the ferrite rod aerial assembly (L_1), the tuning condenser and the batteries, etc., can be cut to length and soldered into their appropriate positions. As shown in Fig. 3, these wires should be long enough to enable the printed circuit board to be swung away from the case.



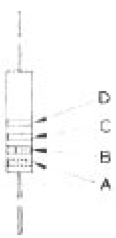
The completed "Super-3" transistor receiver. Compare with diagram on opposite page

Testing and Completion

Solder the battery leads to two 1.5V cells



Resistor Identification



Ref	Value Ohms	Colour Coding A	B	C	D
R_1	2,200	Red	Red	Red	
R_2	4,700	Yellow	Violet	Red	
R_3	680	Blue	Grey	Brown	
R_4	1,000	Brown	Black	Red	
R_5	4,700	Yellow	Violet	Red	
R_6	10,000	Brown	Black	Orange	
R_7	2,200	Red	Red	Red	

FIG 4

M977

(see Components List) connected in series, carefully observing the polarity of connection (the brass cap being positive). The cells may now be tucked into the case using cotton wool for packing. Insert the printed board assembly into the case by feeding the switch spindle and bush through the aperture on the front of the case. Ensure that the printed circuit components do not foul the sides of the receiver case. Secure into position with the switch nut and washer and tighten firmly. The switch knob should now be fitted to the spindle. Note here that with the switch in position 1 (fully anti-clockwise) the receiver is switched off, in position 2 Medium wave operation is selected and in position 3 Long wave operation is selected.

Over each of the projecting wires of TR_1 and TR_2 slide a length of p.v.c. sleeving, this being slightly longer than the transistor wire so that none of the wire is exposed.

Switch to the Long wave position (fully clockwise) and turn the tuning knob about two turns clockwise. Slowly adjust the position of L_1 along the length of the ferrite rod until the B.B.C. Light programme of 200 kc/s (1,500 metres) is heard. Tune for further volume with the screw core of L_2.

Switch to Medium wave and adjust the tuning control until a station is heard. The two transistor wire extensions, now completely sleeved, should be bent in such a manner as to lie parallel with each other—the effective capacity between them being utilised for regeneration purposes. Next bring these two wires closer together, thereby increasing the effective capacitance between them. As the wires approach each other volume will increase, a point being reached where actual oscillations commence. The presence of oscillations indicates that the wires are too close to each other. When the correct position of the wires has been found, they may be fixed into position with p.v.c. tape or a suitable adhesive. As a final check for correct regeneration the tuning knob

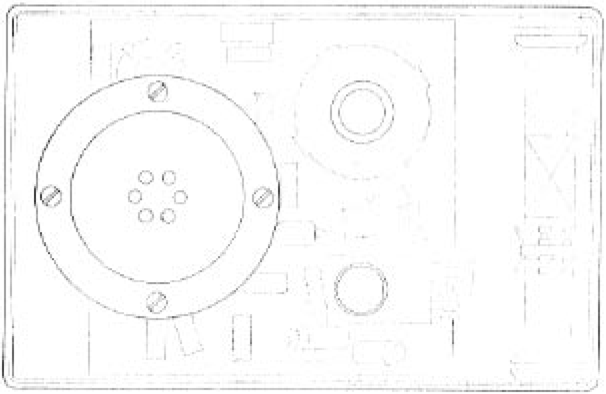


FIG 5

View looking at front of Case with all items in position

M978

should be rotated over its full range, and it should be possible to receive all stations without oscillation occurring. Having made this final check, the plastic rear cover of the receiver can be snapped into position whereupon the receiver is ready for use.

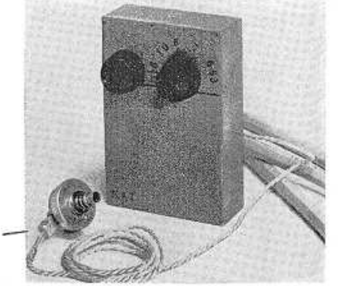
Operation

The following remarks, with respect to operating the "Super-3", may be found useful.

The ferrite rod aerial will exhibit highly directional properties, maximum reception being obtained when the rod is in a horizontal position and at right angles to the direction from which the transmitted signal emanates. When the rod is pointed directly at a transmitter, reception is at a minimum. The angle over which minimum reception occurs is particularly sharp, and this property may be put to good account in eliminating interference from unwanted stations.

4-transistor set is a true cigarette-pack sized radio. Printed circuit speeds construction.

FLIP-TOP RADIO



By NICHOLAS A. TAX

THIS four-transistor receiver uses a regenerative detector and three audio amplifiers to drive an earphone. It fits into a box from a pack of cigarettes. Sensitivity is high and no external antenna or ground is needed. A printed-circuit board is available to simplify construction. The transistors are reasonably priced and keep the total cost down.

The circuit is comparatively simple. The AO-1 works well as a regenerative detector. Other transistors were tried, but the AO-1 gave the best results. You may note that its collector load resistor (R2) seems high (100,000 ohms), but lower values reduce volume and selectivity.

Chassis assembly

A printed-circuit board makes this unit easy to build. If you don't care to use one, you will need some stiff cardboard approximately 1/16 inch thick to make the chassis. From this cut two pieces ⅞ x 3-1/32, then two pieces ⅞ x 1-29/32 inches. Cement these together to form a rectangle. Place the two short pieces on the inside so that the outer dimensions of the rectangle are 3-1/32 x 2-1/32 inches. This will form the chassis of the radio (around which we wind our antenna and tickler coils). Next cut a piece of cardboard 1-29/32 x 1⅛ inches (A in Fig. 2). Cement this piece inside the chassis 1/16 inch from the outer edge and at one end (Fig. 2). Then cut a piece of cardboard in the shape of a T (see drawing for dimensions) and cut the holes for the transistor sockets. Sockets are not needed with the printed circuit; the leads are simply soldered to the printed wiring (if desired, sockets can be used). Cement this piece inside the rectangle.

Place some Duco or similar cement in a small container and thin it down to a paintlike consistency with lacquer thinner or nail-polish remover. Then use a small paint brush to give the entire chassis two coats of this mixture (let the first coat dry about 30 minutes). This moistureproofs and stiffens the cardboard.

After the chassis is thoroughly dry, lock the sockets in the holes with the small clips furnished. Next cut the three holes needed for C2 on piece A. Mount C2, using two small screws supplied. Make a single hole on the other side of A in line with the capacitor-shaft hole. Mount the potentiometer with its lock washer and nut. There is enough space above the pot for the two electrolytic capacitors (C4 and C5). The capacitor and potentiometer shafts may have to be shortened so the knobs can be installed.

Battery holders

Get a scrap of 1/16-inch Bakelite or other insulating material. Cut two pieces 1-3/16 inches long and 13/16 inch wide. You now need a scrap piece of 25-gauge stainless steel, copper or brass (shim stock will do). If you use the latter, tin it with solder to prevent corrosion. Make eight L-shape clips (see drawing for dimensions). Place four of them on a piece of lumber and give each one a sharp blow with an ⅛-inch center punch to make a round dent in the metal (to hold the positive end of the battery firmly). Then, rivet the clips to the Bakelite. Small rivets were not readily available, so I used screen wire tacks.

Arrange four clips on each piece, spaced so the batteries will fit in firmly. The heads of the rivets were ground down somewhat so that the underside of the holder will be fairly smooth. Cut the rivets so that about 1/32 inch is left to flatten out. I used a very small ball peen hammer to do this. Stainless steel is relatively hard to drill, so use a center punch to make the hole, and smooth off the underside with a file. Then ream out the hole with a 1/16-inch drill bit.

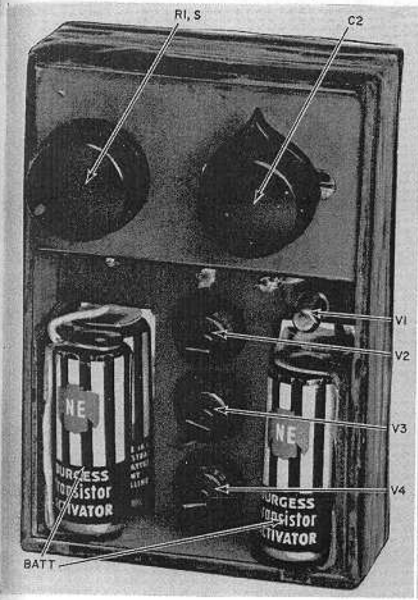
Make sure that the width across the batteries in each holder is less than ⅞ inch (the width of the chassis) so that they will slide into the cigarette box easily. Use *acid*-core solder to tin a small spot on the outer side of each battery clip. Rosin-core solder will not stick to stainless steel. *Wipe or wash these spots off well because acid and radio parts just do not go together.* Now you can solder the wires to the clips with rosin-core solder. The next step is to cement the two battery holders to the inside of the chassis, one on each side. I cemented a piece of paper on each holder to indicate battery polarity for proper battery installation.

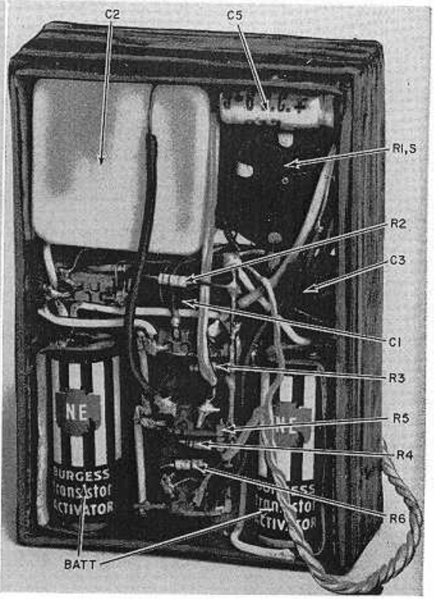
Wind the antenna

The antenna and tickler coils are wound around the ⅞-inch surface of the chassis with No. 30 enameled magnet wire. Make three small holes about 1/32 inch from the edge of the chassis by pushing a needle through the cardboard. Anchor the end of the wire through the holes, the free end extending inside the chassis. Leave about 3 inches to connect to the antenna terminal of the tuning capacitor. This will be the start of the winding.

Measure off 39 feet 9½ inches of wire beforehand and wind the 46-turn antenna coil, making sure that the windings are as close together as possible. Run the finish of the winding through the chassis (as before) and connect it to the ground terminal of the tuning capacitor. The tickler winding is 9 feet 7½ inches (11 turns). Wind it in the same direction and use the same size wire. Space the tickler coil ⅛ inch from the antenna winding, the start lead (TS in Fig. 1) going to the center terminal and the finish lead (TF) going to the left-hand terminal of the potentiometer (shaft facing you and terminals down).

Once again RADIO-ELECTRONICS is pleased to be able to offer its readers a printed-circuit board for an interesting construction project. The price is $1.25 each, postpaid. They are available from Detroit Electronic Corp., 13000 Capital Avenue, Oak Park, Mich.





Inside the case, looking at the transistor side of the chassis.

Parts layout under the chassis.

R1—pot, 10,000 ohms, with spst switch (Lafayette VC-28 or Philmore PC-53 or equivalent)
R2, R6—100,000 ohms, 1/10 watt, 10%
R3, R5—3,300 ohms, 1/10 watt, 10%
R4—120,000 ohms, 1/10 watt, 10%
C1, C3—.02 uf, 50 volts, ceramic
C2—10—365 μμf, variable (Lafayette MS-274 or equivalent) (For printed-circuit unit: Calrad CR-220, Lafayette MS-445 or equivalent)
C4, C5—3 μf, 6 volts, miniature electrolytic
BATT—6 volts, four 1.5-volt NE cells (For printed-circuit unit; 7-volts, Mallory TR-175 or equivalent)
L1—see text
L2—see text
V1—AO-1 (Philco)
V2, V3, V4—2N107
Earphone, 1,500 ohms
Transistor sockets (4)
Wire, No. 30 enameled, ¼-lb roll
Miscellaneous hardware

When the coils are finished, give them a thin coat of hot paraffin to keep out moisture and secure them nicely.

BENCH TESTED

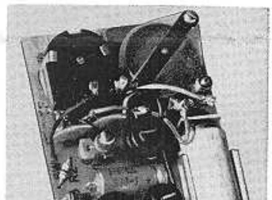
The TAX radio was tested about 20 miles from New York City. Nine stations were received with ample earphone volume and good quality, and more could no doubt have been received with careful tuning. The loudest station, about 7 miles away, came in with sufficient volume to permit two persons to listen, with the earphone in a small dish on the table between them.

It is important to have the correct amount of wire in the tickler winding. If the set does not oscillate (hissing or rushing noise) at the low end of the dial, add a few more turns of wire.

I noted a slight variation among some of the AO-1 transistors. One required about four turns more in the tickler winding so the set would oscillate at all points on the dial. If this happens to you, add these turns even if it is necessary to alter the spacing between the coils (⅛ to 3/32 inch). If the set will not oscillate at all, you have probably reversed the leads to the potentiometer.

If your set motorboats when completed, add a stabilizing resistor from the positive end of the battery to V3's base. Start with about 2,700 ohms and work your way down.

Now wire the set, following the schematic (Fig. 1), or use the special RADIO-ELECTRONICS printed-circuit



The printed-circuit board with all components mounted. Only the antenna still has to be connected.

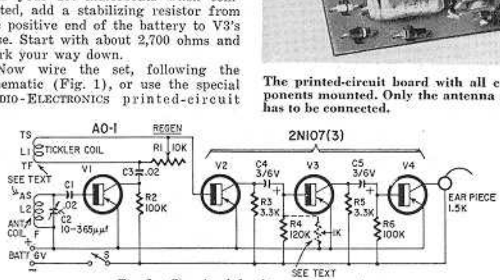


Fig. 1—Circuit of the 4-transistor receiver.

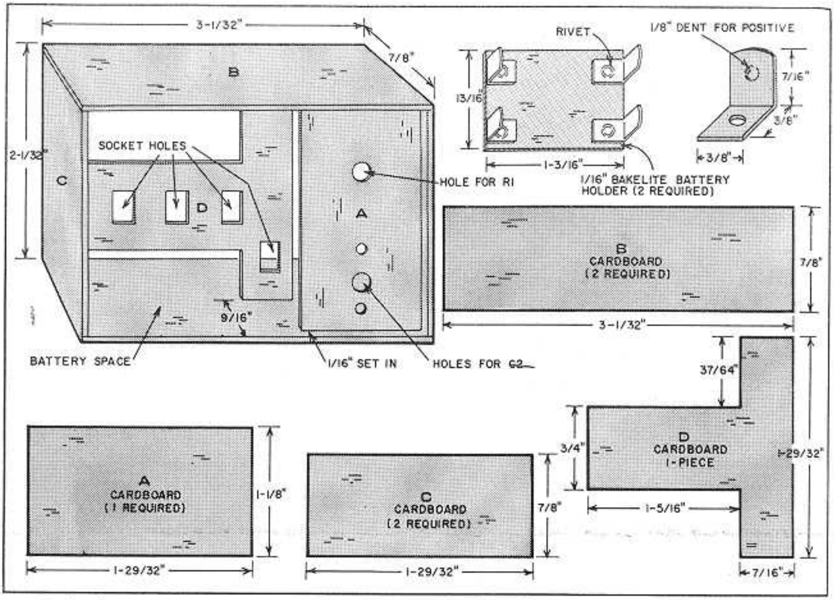


Fig. 2—Chassis assembly for the flip-top radio. If you use the printed-circuit board, only parts C and B are needed.

board. I used a piece of tinned copper wire as a negative bus. Solder it to one side of the switch and run it along the transistor sockets. I used 1/10-watt resistors; there would not have been space for ½-watt units.

The case

Select a cigarette flip-top box in good condition. Take a razor blade and carefully cut off the top where it hinges. Now make two slots in the top and two in the higher part of the box, so the chassis can be slid into the box and the top can be placed back on. Cut the slots wide enough to allow the tuning capacitor and potentiometer slots, and the case looks neat.

Now treat the cardboard box as you did the chassis (two coats of the thinned mixture, inside and out). When thoroughly dry, give the case two coats of shafts to fit. The knobs will hide the your favorite-color enamel. Let the case dry for a few days before inserting the chassis. The box lips should be steel-wooled or sanded lightly to allow the top to slip on and off more easily (the freshly painted surface has a tendency to be a little tight). The chassis can be removed easily by grasping the two knobs and pulling upward.

To give the set a little added touch, calibrate the dial. The tuning-capacitor knob has a pointer on it. After some experience, you will know where the various stations in your locale come in and the dial can be calibrated. I have marked my set 16, 10, 8, 7, 6 and 53. These numbers can be put on by using a toy printing or rubber-stamp set. Hold each number with tweezers and press it against a piece of glass that has a light coat of wet paint. Then press the piece of type to the case.

My set is very selective and will tune the entire broadcast band. Late at night, I have received stations 400 miles away and three stations some 1,500 miles distant. It is well established that regenerative receivers are distance getters. But, as with all regenerative sets, careful adjustments of both controls is absolutely essential. If the regeneration control is turned up too high, the set oscillates and reception is spoiled. On my set, the local stations can be heard with the earphone 6 feet away. Battery drain is low, so batteries last a long time. END

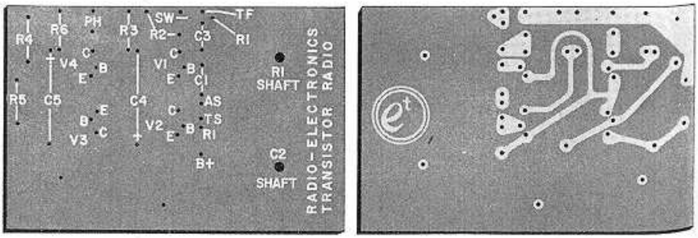


Fig. 3 — The printed-circuit board; left—component side; right—wiring side.

A REAL MINIATURE

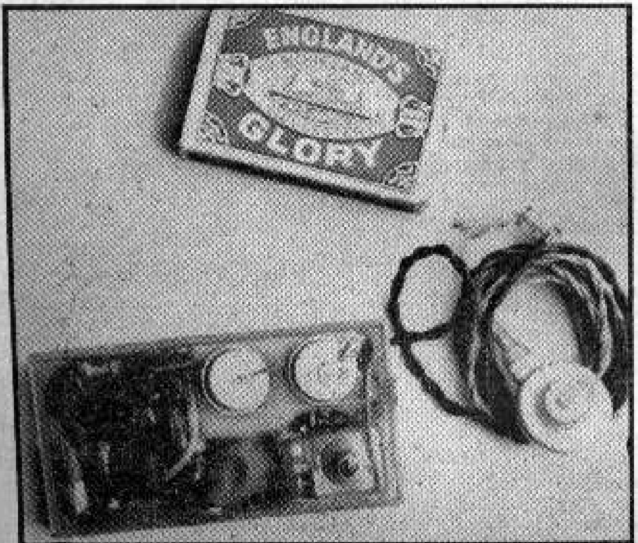
BY J. M. E. SMITH

(This article describes a pre-tuned transistor receiver in which extreme compactness has been achieved by the use of simple circuitry and by further reduction in size of "miniature" standard components.—Editor.)

SEVERAL ARTICLES HAVE APPEARED IN recent years describing the construction of so-called "pocket receivers" using transistors, and although their bulk has been considerably reduced compared with traditional portables, full use has not been made of the diminutive size of transistors. The sets described have not been small enough to warrant a permanent niche in one's pocket, and therefore it was decided to build a receiver in as small a space as was reasonably possible.

The result was a three-transistor one station pre-selected set built into a smaller space, including batteries and earphone, than that occupied by a packet of ten cigarettes. The small size of the receiver may be judged from the accompanying photograph.

The circuit uses standard components throughout, and R–C coupling was decided upon in order to save space. It is built into a small plastic box, size 3 x 1½ x ⅝in, as sold by most large stores for containing needles, pins, etc. Slight modification is required to



This photograph shows the compactness and extremely small size of the 3-transistor receiver built by the author and described herewith.

Circuit of the miniature transistor receiver.

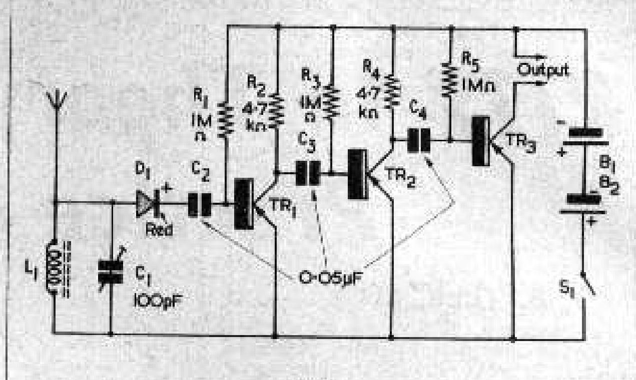


FIG.1.

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enable the coupling condensers to fit into the space allocated. This is achieved by holding each 0.05μF condenser in turn over a candle flame until the wax becomes soft, when it can be peeled off, thus leaving the condenser itself exposed. Wrapping with a layer of p.v.c. insulating tape will then prevent damage.

The coil is the top section of a medium wave Osmor miniature aerial coil, the section being cut off with a small saw just below the winding. Two 1.5 volt Mallory RM625 batteries provide the power, and these may be either soldered into circuit or connected, as in this case, by means of pressure contact with the battery leads. A small piece of foam rubber underneath the batteries provides the pressure and also retains them in position. The box lid slides off for battery renewal.

Components List (Fig. 1)

L_1	Osmor M.W. coil, type QA8, modified
D_1	OA71 Mullard crystal diode
TR_1, TR_2, TR_3	PNP junction transistors, "Red-Spot"
C_1	100pF pre-set trimmer
C_2, C_3, C_4	0.05μF 150WV Hunts
R_1, R_3, R_5	1MΩ $\frac{1}{8}$ Watt
R_2, R_4	4.7kΩ $\frac{1}{8}$ Watt
B_1, B_2	Mallory RM625
S_1	On-off, miniature, slide-action switch. Bulgin S591 or equivalent

Personal earphone

External transformer (optional) Ardente D239

continued on page 856

Fig. 2. Connecting the optional external transformer into the earphone leads
Fig. 3. Underside view of component layout. The on-off switch is bolted to the front panel, away from the reader

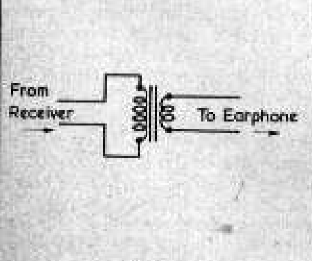

FIG.2

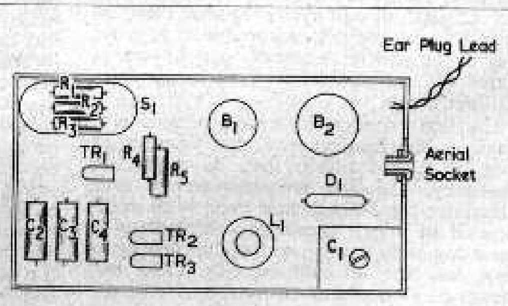

FIG.3

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A Real Miniature

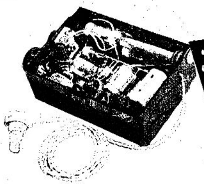
continued from page 853

An aerial socket is fixed to the end of the set next to the hole ($\frac{1}{16}$in) drilled for the earphone lead. Excellent results are obtained with about 9in of heavy gauge copper wire plugged into the socket as an aerial. In poor districts, however, it may be necessary to use a slightly longer aerial.

Improved performance may be obtained by inserting an external inter-transistor transformer in the earphone lead as shown in Fig. 2. When the transformer is employed sufficient aerial pick-up will be achieved in some districts by merely touching the aerial socket with a finger.

A hole drilled into the sliding lid of the box above the trimmer condenser enables a screwdriver to be inserted to tune in the local station. In strong signal strength areas, overloading of the earphone may be offset by slightly detuning the receiver.

This little set has been used with considerable success both at home and on the Continent.



The MAJOR THREE Personal Transistor Receiver

Designed by D. J. French, GRAD.I.E.E.
of Henry's Radio Ltd.

THE POCKET PORTABLE TRANSISTOR RECEIVER about to be described here is in logical sequence to the two earlier designs which were described in previous issues of this magazine. ("The Minor-One" and "The Major-Two"—see page 204, October 1958 issue.—*Ed.*) These were one- and two-transistor receivers respectively, which proved very popular with the home constructor fraternity. In the present design, three transistors—all Ediswan types—have been included, the circuit being that of a five-stage reflex receiver.

The "Major-Three" is fully tunable over the Medium wave range, and portability is ensured by the use of a Ferrite rod aerial together with the usual battery h.t. supply. Some three to six months of life may be expected from the battery specified—subject, of course, to the amount of usage. The whole receiver weighs only some 4 ounces and the "pocketability" may be judged by the overall size of 4⅜in x 3in x 1¼in. It is contained in an attractive black and white moulded plastic case. The protruding controls are on/off switch and volume control combined, and tuning knob.

Circuit

This is shown in Fig. 1, from which it will be seen that it is a three-transistor five-stage reflex design. The transistor TR_1 functions primarily as an r.f. amplifier, the resultant r.f. signal being fed, via C_7, to the crystal diode. The signal is rectified here and then fed back, via the volume control and C_4, into the ferrite secondary winding and from thence into the base of the same transistor. The audio signal applied to the base of TR_1 is now amplified by the transistor and fed, from the collector and via the r.f. choke and C_3, into the base of TR_2. The amplified signal obtained from this second stage is now passed, from the collector and via the inter-stage transformer, to the base of TR_3. From here, the audio output is taken via the collector to the deaf-aid insert. All three transistors operate in the earthed emitter mode.

Constructing the "Major-Three"

Constructors should note particularly the colour coding of both the ferrite rod aerial windings and the inter-stage transformer and ensure that these are correct—as given in the circuit diagram—when wiring these components into position. The correct polarity of both the electrolytic condensers and the battery should also be noted. As received, both the cabinet and the chassis are ready drilled and riveted.

With the exception of the volume control and the tuning condenser, the chassis should be wired up outside of the cabinet, the whole being assembled together when the chassis is wired, except for the two aforementioned components.

(1) Solder the bare wire to those solder tags forming the positive bar. Deal similarly with those tags forming the negative bar.

(2) Solder into position TR_1 holder (centre pin to one end of double solder tag).

(3) Connect C_2 (red to positive bar) and R_2 (black/brown/red) into circuit.

(4) Ensuring that the leads of RFC_1 are approximately 1in in length, solder this component into circuit, together with R_4 (yellow/mauve/red) and C_5 (0.1µF).

(5) Solder into position C_7 (47pF), and RFC_2.

(6) Connect the plain end of the diode to one end of C_7. Leave the red or dot end unconnected at this stage.

(7) Solder into position both R_5 (grey/yellow/blue) and R_6 (brown/black/orange).

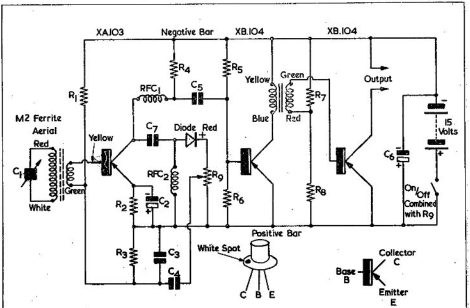


FIG.1.
Circuit of the 'Major-Three' Transistor Receiver M681

Components List

Resistors

- R_1 100kΩ
- R_2 1kΩ
- R_3 10kΩ
- R_4 4.7kΩ
- R_5 680kΩ
- R_6 10kΩ
- R_7 100kΩ
- R_8 4.7kΩ
- R_9 10kΩ potentiometer w/switch

Condensers

- C_1 500pF trimmer
- C_2 25μF electrolytic
- C_3 0.005μF
- C_4 0.1μF
- C_5 0.1μF
- C_6 100μF 18V wkg, electrolytic
- C_7 47pF

Transistors

- TR_1 Ediswan XA103
- TR_2, TR_3 Ediswan XB104

Miscellaneous

- RFC_1, RFC_2 Henry's Radio Ltd.
- Ferrite Aerial, Type M2. Henry's Radio Ltd.
- Transformer type D240. Henry's Radio Ltd.
- 15V battery—Ever-Ready type B121
- Crystal diode
- Transistor holders
- Drilled cabinet and chassis. Henry's Radio Ltd.
- Deaf-Aid Insert. Henry's Radio Ltd.

To the junction of these two components, connect the other end of C_5 (0.1μF).

(8) Secure R_1 (brown/black/yellow) in position (one end only), and follow this by soldering R_3 (brown/black/orange) into circuit.

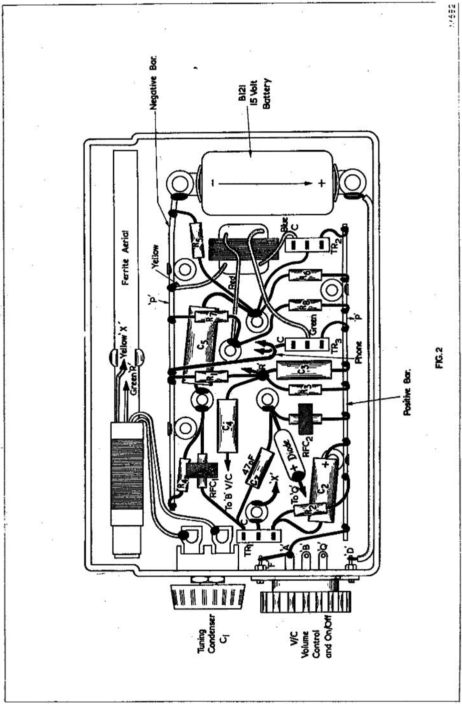
(9) On top of R_3 mount C_3 (0.005μF) and solder. Connect one end of C_4 (0.1μF) to the junction of R_3, C_3, leaving the remaining wire for the time being.

(10) Connect into circuit and join R_7 (brown/black/yellow) and R_8 (yellow/mauve/red).

(11) Solder into position the holder of TR_3 (third transistor).

(12) Secure into position the type D240 transformer and the holder of TR_2. Observe here the lead colour code of the transformer.

(13) Solder the deaf-aid insert leads but



Negative Bar.
B121
15 Volt
Battery
Ferrite Aerial
Yellow
'p'
Yellow 'X'
Green 'R'
Red
Blue
C
TR_2
R_5
R_6
R_8
Green
'p'
TR_3
Phone
C_5
R_7
R_1
'R'
C_3
R_3
Positive Bar.
C_4
RFC_2
+ Diode
47pF
C_7
'X'
To 'Q'
C_2
R_2
R_4
RFC_1
To 'B' V/C
TR_1
'A'
'B'
'Q'
'D'
'F'
Tuning
Condenser
C_1
V/C
Volume
Control
and On/Off

FIG.2

leave the actual earpiece unconnected in order to prevent heat damage.

(14) Place the ferrite rod aerial assembly into the mounting clip and connect the secondary winding leads into position as shown on the circuit diagram. Leave these leads somewhat on the long side.

(15) Bolt the volume control and the tuning condenser to the side of the cabinet. Connect the remaining two leads of the ferrite rod primary winding to the tuning condenser.

(16) Connect C_6 (100μF) between points "PP" on negative and positive bars. (Black end to positive bar.)

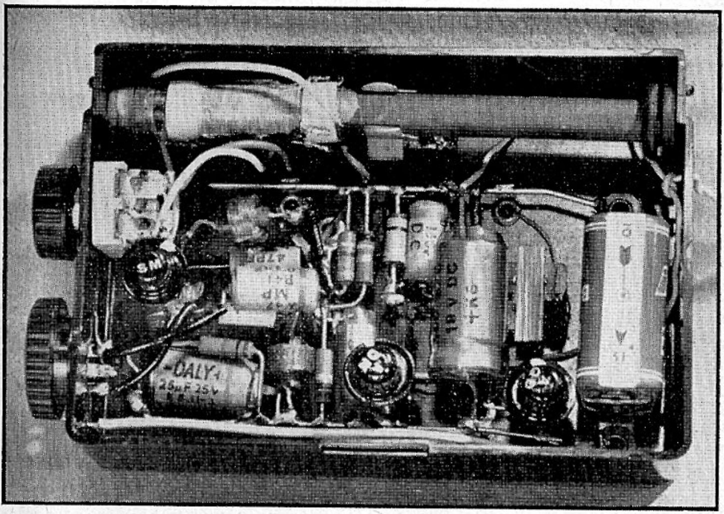
(17) Solder the red or dot end of the crystal diode to "Q" tag of the volume control.

sistors are placed the correct way round, i.e. white dot at "C" on each holder.

(21) Thoroughly check the wiring before inserting the battery into position. Look especially for component wires touching each other where they should not be in contact at all. Ascertain that no "dry" joints have been made. Carefully check with the circuit diagram that the receiver has been correctly wired and with the illustration that the components occupy roughly the same positions as those shown.

Getting the Best Results

Once the receiver has been completed and is in working order, one small adjustment is capable of greatly increasing both the selectivity and sensitivity of the circuit. This



Inside view of the "Major-Three". Compare with Fig. 2

(18) Solder the remaining end of C_4 to tag "B" of the volume control and connect tags "A" and "F" of the volume control to the positive bar.

(19) Connect a lead from the positive battery connection to tag "D" of the volume control.

(20) Cut the transistor leads to about half an inch in length and plug these into the transistor holders thus: TR_1, XA103; TR_2 and TR_3, XB104. Ensure that these tran-

is achieved by the careful positioning of the choke RFC_1 in relation to the aerial winding on the ferrite rod assembly. This positioning of RFC_1 for optimum performance should be carried out with the tuning condenser set to the wavelength of strongest station receivable according to the location of the constructor. Should RFC_1 be positioned too near the aerial winding, a "bubbling" will be heard in the deaf-aid insert, in which case the r.f. choke will have to be spaced a greater distance from the winding.

Small enough to slip into your coat pocket, the Red Hot has excellent sensitivity and selectivity and plenty of power.

The RED HOT

A simple economical portable that packs a BIG wallop

By FORREST H. FRANTZ, SR.

Here's that economical, power-packed pocket portable you've been looking for. Measuring only 1¼ x 3¼ x 4 in., this set has loudspeaker power and is extremely sensitive and selective. What's more, no pick-up lead of any kind dangles from the set and its design is simplicity itself.

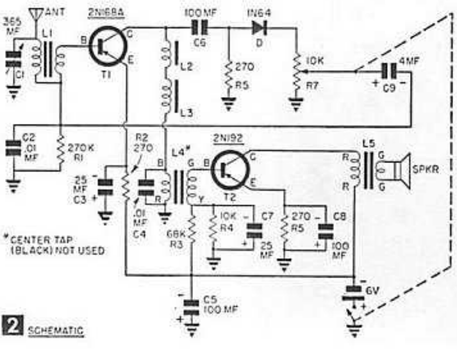
If you're wondering how a two-transistor set can pack the kind of wallop the Red Hot does, here are the reasons. In the first place, it uses entertainment grade transistors. Though better in quality than experimenter grade transistors, entertainment grade transistors cost only a little more. The GE 2N168A transistor, for example, has a much higher cut-off frequency than the experimenter types of the AF and RF varieties, an important consideration when the transistor is to be used as an RF amplifier. And the GE 2N192 transistor, used in the output stage, has a higher beta (current gain or amplifying capacity) than the experimenter grades.

With good transistors as basic ingredients, the design determines how well a piece of transistorized electronic gear will perform. To get plenty of gain in the Red Hot, T1 (see Fig. 2) is used to amplify the signal twice. With this "reflex" technique, T1 amplifies the received signal while it is still in the radio frequency form, and then again when it is in the audio frequency form after detection by diode D. The audio output of T1 is introduced to the base of transistor T2 through the audio driver transformer L4. The better impedance match between T1 and T2 given by L4 provides considerably more gain than you can expect from resistance-capacitance coupling.

Another feature contributing to the gain is that there's positive feedback in the RF stage. It's not apparent from the circuit, and it's not enough feedback to make the set oscillate, but there is feedback, resulting from the relative placement of the components in the case. This feedback feature and the high Q of the antenna coil (L1) make the set quite selective in spite of the fact that it has only one tuned circuit.

Cost of the Red Hot is about $15 (and the four penlite cells used last a long, long time). You can construct the set in six to 20 hours, depending upon your experience. An expert might even do it in less than six hours. To make the construction go smoothly and quickly, obtain all of the parts in advance (see the Materials List), have the required tools handy, and go over the instructions a time or two before you actually begin work.

Construction. You'll need 1) an ice pick; 2) a hand drill; 3) a ⅛ in. dia. drill bit; 4) a hand taper reamer; 5) a measuring scale or tape; 6) a hack saw; 7) needle nose pliers; 8) diagonal (cutting) pliers; 9) small screwdriver



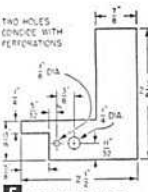
2 SCHEMATIC

MATERIALS LIST—THE RED HOT

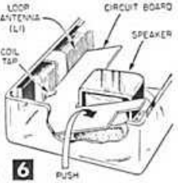
R2, R5	270 ohms } ½ watt, carbon resistors, 10% tolerance
R4	10K ohms } ½ watt, carbon resistors, 10% tolerance
R6	33K ohms } ½ watt, carbon resistors, 10% tolerance
R3	68K ohms } ½ watt, carbon resistors, 10% tolerance
R1	270K ohms } ½ watt, carbon resistors, 10% tolerance
R7	10K miniature volume control with switch (Lafayette VC-28)
C1	365 mmfd tuning capacitor (Lafayette MS-215)
C6	100 mmfd miniature ceramic capacitor (Centralab DM-101)
C2, C4	.01 mfd 75v miniature ceramic capacitor (Lafayette C-612)
C9	4 mfd 6v miniature electrolytic capacitor (Lafayette CF-101)
C3, C7	25 mfd 6v miniature electrolytic capacitor (Lafayette P6-25)
C5, C8	100 mfd, 6v miniature electrolytic capacitor (Lafayette CF-106)
D	diode (GE 1N64)
T1	RF NPN transistor (GE 2N168A)
T2	audio PNP transistor (GE 2N192)
L1	flat ferrite antenna loop (Miller 2004)
L4	driver transformer 10K to 2K (Lafayette TR-96)
L5	output transformer 2K to 10 ohms (Lafayette TR-93)
SPKR	2½" loudspeaker (Lafayette SK-66)
1	battery holder (Lafayette MS-170)
4	batteries (#7 penlite cells)
1	miniature knob (Lafayette MS-185)
1	small pointer knob (Smith 2220)
1	plastic case 1¼ x 3¼ x 4" (Lafayette MS-298)
1	perforated Bakelite wiring board (Lafayette MS-304)
L2	25' 7/41 litz wire* jumble-wound on ¾" length, ¼" diameter ferrite core
L3	15' 7/41 litz wire* jumble-wound on ½" length, ¼" diameter ferrite core

(Apply a coat of Duco Cement to hold windings of L2 and L3 in place.)

*A 7½" long core (MS-331) and 100' of litz wire (Belden 8817), more than enough for these coils, may be obtained from Lafayette Radio, 165-08 Liberty Avenue, Jamaica 33, N. Y., source for all of the components in this radio.



5 CIRCUIT BOARD LAYOUT



6 SLIP CIRCUIT BOARD UNDER TAP ON L1 AND PUSH ON OTHER SIDE OF BOARD TO SLIP IN PLACE

you've removed the turns, leave about 3 in. lead lengths on each end, providing connections at the lead ends by stripping off about ½ in. of the cotton insulation. Rub the lead ends gently with very fine sandpaper to partially remove the enamel insulation from the individual strands, being careful not to break any of the strands. Then, using a hot iron and rosin core solder, heat up the lead ends and apply solder while rubbing the iron back and forth along the ends. Continue until you've burned off the enamel and the coil ends look shiny and well tinned. Replace the coil on the Masonite mounting strip and fasten in place with the original tape.

Next, make L2 and L3. Both of these coils are wound on short lengths of ferrite core. Dimensions, type of wire and winding data are given in the Materials List. Cut the lengths of ferrite core from the 7½-in. length by notching the core material with a hacksaw or file and then breaking it off. Or you can try to saw it off all the way.

Mounting Coil Components. Fasten the loudspeaker in the case with 4-36 x ¼-in. machine screws and nuts. Terminals should be along the hinge side of the case (see Fig. 4). Then mount the volume control (R7), the tuning capacitor (C1), output transformer (L5), antenna coil (L1), and the battery holder. Place two thicknesses of electrical tape along the edge of C1 that will be behind the edge of the loudspeaker and be sure to slip a lockwasher on the bushing of C1 before you mount it. Otherwise it may short-circuit through the loudspeaker frame.

When you fasten the battery holder to the back of the case, stick the screws through from the battery holder side and fasten the nuts on the outside of the case. If the nuts are fastened against the battery holder, they may puncture the insulating paper cover on the batteries and short circuit them through the holder's frame. The connecting lugs on the holder should be bent down to allow clearance to close the case.

Mount L5 with the 10-ohm winding connections toward the loudspeaker terminals. Don't uncoil these leads; connect them to the terminals of the loudspeaker before you fasten the transformer in place.

Finally, wire these components in the case. Note that the connection between the switch and volume control lugs is also soldered to the volume control frame and that the center lug on the tuning capacitor is soldered to the volume control frame, too.

Wiring the Circuit Board. Cut and drill the perforated circuit board according to the layout of Figure 5. Use a hacksaw to do the cutting, smoothing the edges with a file. Drill the holes with a ⅛-in. drill, and use a taper reamer to enlarge to the ¼-in. hole. Try the board in the case for fit. It should fit between the upper edge of the case and the speaker, and the antenna coil and the speaker with the antenna coil tap above the circuit board. Insert the board as shown in Fig. 6 to check the fit. If it doesn't fit, file the edges of the board as required. The fit should be tight. When you're sure you have a good fit, remove board and mount components.

When you mount the driver transformer (L4) be sure to place the mounting flange of the transformer on the underside of the circuit board or you'll find it impossible to close the lid on the receiver after assembly. The other transformer mounting flange is bent down to allow the circuit board to fit in the case.

Connections are made by pushing lead pigtails through the perforations in the board. The long lead on the bottom of the board that runs around most of the board is the common return and it is formed from the extra length of lead pigtails (blade about 1/16 in. wide); 10) medium size screwdriver (blade about 3/16 in. wide); 11) small soldering iron; 12) tin snips.

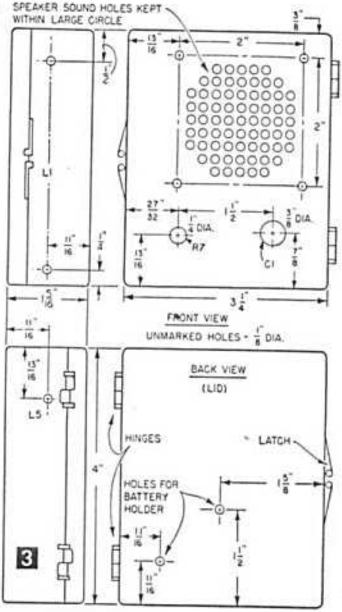
Mounting holes are required in the plastic case for 1) the antenna coil, L1; 2) the output transformer, L5; 3) the tuning capacitor, C1; 4) the volume control, R9; 5) the battery holder; 6) the loudspeaker (Spkr.). Sound holes are also required for the loudspeaker. Figure 3 shows the positions and the dimensions of these holes in the plastic case.

Mark off the hole positions on the case, then heat the ice pick and use it to make holes in the case on the marked centers. Don't get the ice pick red hot or it will melt the plastic too fast and make the work difficult. Make the holes just big enough so that the hand taper reamer can be made to bite in without difficulty. When all pilot holes have been made with the hot ice pick, allow the melted plastic around the holes to harden. To assure yourself that the holes are properly located, place the components over the appropriate holes. If necessary, use the hot ice pick to relocate centers. After you're sure of the hole center locations, enlarge all the holes to size with the taper reamer with the exception of the loudspeaker sound holes. These are closely spaced and you might get into difficulty trying to ream them out smooth, so leave them rough.

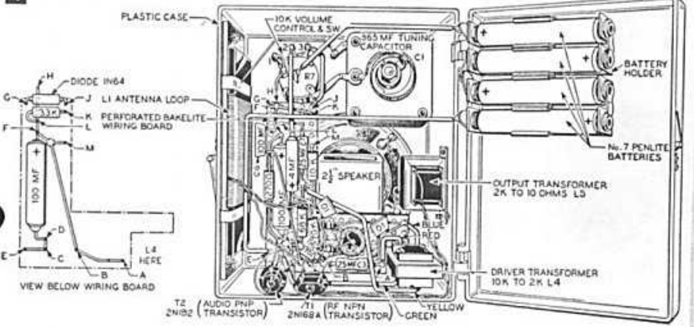
When you've completed this work, wash the case with soap and cold water to remove dirt and finger prints. Rinse in clear cold water and dry.

If you want to paint the interior of the case, do it now. Spraying will be more effective than brushing since the paint may run—particularly around the speaker sound hole openings—if you brush paint.

Now, cut the volume control (R7) shaft to a length of 1/4 in. and the shaft of the tuning capacitor (C1) to a length of 5/8 in. Remove five turns from the tuning coil (the end of L1 with many turns), and one turn from the transistor input coil (the end of L1 with few turns). Remove the coil from the Masonite mounting base to do this. (Simply take off the tape which is wrapped around each end of the coil). When



4 PICTORIAL



that remain after the parts are mounted on the board. The short straight lead on the bottom of the circuit board to which the negative end of C5 is connected is the battery negative bus. All parts except the transistors and C6 and C9 are mounted tight against the circuit board. A ⅛ in. space is left between the transistor bottoms and the circuit board to prevent straining the leads and to keep heat transfer to the transistors during the soldering process within reason.

Mount L2 by applying a small amount of Duco cement to the core and inserting it in the ¼-in. hole on the circuit board. Apply a very small amount of Duco cement to L3 and fasten it perpendicular to L2. Don't use too much Duco for this because you'll have to loosen L3 later. Be sure that L2 and the other components do not extend more than ⅝ in. above the top of the circuit board. If they do, you may have trouble closing the lid of the case after assembly. None of the components, with the exception of the output transformer (L5), should protrude beyond the edges of the circuit board because the circuit board will be held in place by the tight fit between it, the loudspeaker, the edge of the case, and the antenna coil.

Final Assembly. There are eight connections which will have to be made from the circuit board to components in the case. They are, in order of connection: 1) collector of T2 to primary of L5; 2) negative bus to primary of L5; 3) base of T1 to end of short winding on L1; 4) junction of C2, R1 and C9 to tap on L1; 5) common return to switch; 6) plus terminal of C9 to center terminal of R7; 7) K terminal of D to upper terminal of R7; 8) negative line to negative terminal of battery.

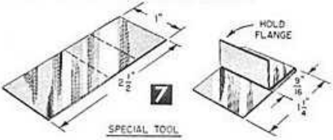
The first three connections must be made before the circuit board is mounted in the case. After they're made, place the edge of the circuit board against L1 but below the coil tap as shown in Fig. 6, and push the board into place in the case. Then, make the other five connections.

Now close the lid, and move parts and leads as required to allow easy closing. You may find that the back of the loudspeaker interferes with complete closure of the lid. If it does, trace the outline of the speaker magnet frame on the lid of the case and make a tool from a piece of sheet metal (which can be cut out of a tin can) as shown in Fig. 7. Grip the hold flange of this tool with a pair of needle nose pliers, heat the tool slightly, and apply it to the inside of the case lid along the magnet frame tracing using a small amount of pressure. This will dent the lid slightly to allow it to close over the speaker magnet frame without interference. It's wise to do this several times if necessary, starting with low temperatures. Otherwise, you may get the tool too hot and damage the case.

Now you're ready to insert the batteries. Do this cautiously with the switch in *Off* position and be sure to position the plus and minus terminals properly. Do not let the clips on the holder cut through the insulating paper cover on the batteries.

If you have a milliameter, connect it across the switch terminals (plus meter terminal to battery side of switch) with the meter on a range of 100 *ma* or more. The meter deflection should be less than 10 *ma*. If it's more than 10 *ma*, start looking for trouble, perhaps an error in wiring, an incorrect resistor, reversal of capacitor polarity, short circuits, or similar mistakes. (Occasionally, you may run into trouble due to bad components; this occurs so rarely if all new components are used, however, that this possibility

CUT STRIP OF SHEET METAL AND BEND AS SHOWN



should be dismissed till the circuit has been checked several times). If the meter reads less than 10 *ma*, switch to the range nearest 10 *ma* (but not less than 10 *ma* on your meter). You should get a reading of 6 *ma* or less. On my set the reading was 4 *ma*, but tolerance variations in transistors and other components might allow variations in current from about 3 to 6 *ma*. You can expect long battery life with such a small current demand.

Next, turn the set on and try it out. If it squeals at the high frequency end of the dial, move C6 away from L1 a small amount at a time till the squeal is eliminated. Some feedback between C6 and L1 is desirable for maximum sensitivity, but if there's too much feedback, squealing may occur. The feedback is increased by moving C6 closer to L1, decreased by moving C6 away from L1.

The orientation of L3 also affects feedback. The contribution is most noticeable at the low frequency end of the dial. The axis of L3 should be parallel to L1. To find the correct orientation for this coil, tune in a station on the low frequency end of the dial and note the volume level. Then break the Duco cement bond between L2 and L3 and reverse the positions of the ends of L3. Retune the set to the station for maximum volume. If the station comes in louder, fasten L3 in this position with Duco. If the volume decreases, however, return the coil ends to their original positions and re-cement.

Although this little set is one of the hottest performers I've seen with such a simple circuit configuration, a little additional experimenting with the orientation and positions of L2 and L3, can make it even more sensitive and selective. Since no external pick-up lead is used, this set is highly directional. The antenna coil must be horizontal; rotate the set in a horizontal plane for best pick-up.

A Pocket Trans

THIS little receiver is a self-contained two-transistor set having three stages of amplification. It is housed in a plastic container measuring 4in. × 3in. × 1¼in. The circuit employed ensures good sensitivity and selectivity, and yet without the annoying whistle of a regenerative circuit. The size and cost of the set will suit most home constructors' pockets and it

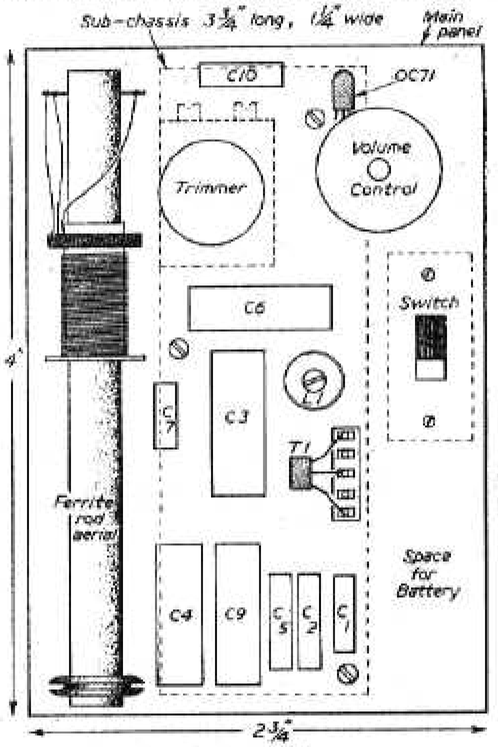


Fig. 2.—General layout.

should be noted that there are no knobs protruding from the set, merely leads to the earpiece and the optional aerials.

The Circuit

The circuit employed is a "reflex" circuit having a stage of R.F. amplification prior to the crystal detector. Signals picked up by the Ferrite rod aerial are fed to the base of the transistor T1. The amplified R.F. is then coupled to the detector

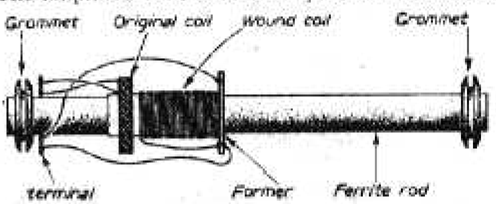
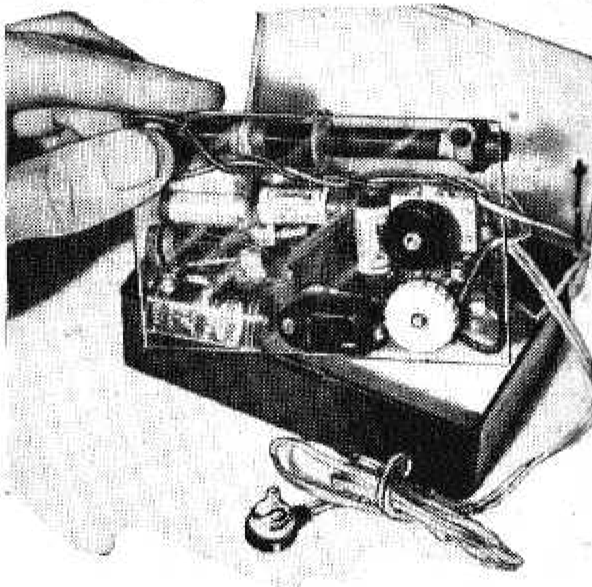


Fig. 3.—Details of the aerial.



D1 through C1. The detected audio is then returned to the base of T1, to be amplified once more, through C3. The audio output is developed across R4, and C6 feeds the audio signal to T2 for final amplification. The output is loud enough for most purposes, although further

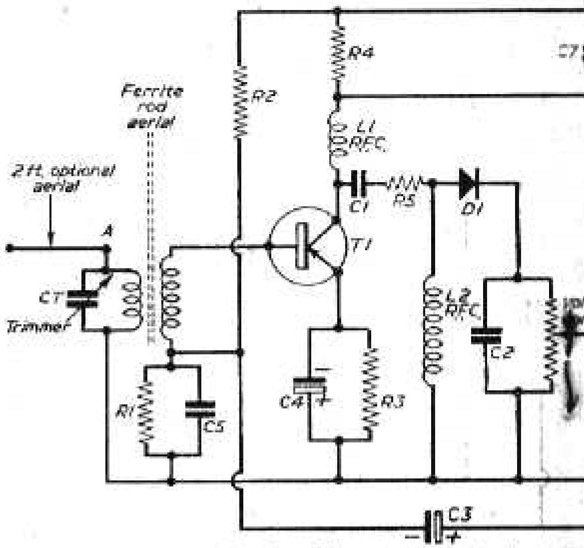


Fig. 1.—Theoretical circuit of the rec

nough for most purposes, although various ... mounted on the main panel, the rear

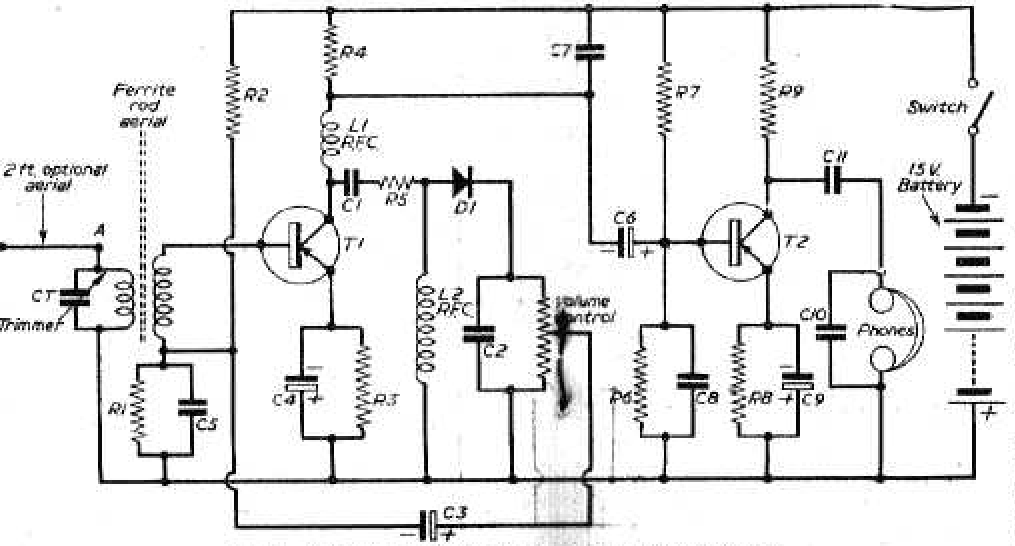


Fig. 1.—Theoretical circuit of the receiver described above.

...istor Receiver

A TWO-TRANSISTOR SET UTILISING A REFLEX ARRANGEMENT

By W. K. Hsu

amplification may be added. R9 is the load for T2 and high-impedance phones or earpiece should be used. L1 prevents R.F. signals from appearing across R4, and L2 allows no A.F. to reach D1. Both L1 and L2 are essential for the operation of this receiver. R1, R2 supplies base current for T1, and R6, R7 supplies that for T2. These offer the advantage that only a single battery is required. R3 and R8 are the usual stabilising emitter resistance and C4, C9 bypass any A.C. developed across them. C7, C8, C10 may, in certain cases, be omitted.

Construction

The whole assembly can be built on a detachable panel and sub-chassis assembly, and all wiring may be completed prior to fitting in the containing box. Only the volume control, a surplus hearing aid type, trimmer tuning condenser and the rod aerial and switch are mounted on the main panel; the rest of the components are distributed on the sub-chassis as indicated. An additional close winding of 45 turns of 32 gauge enamel copper wire is added on the same former. The ends of the new coil are secured on the edge of the former with punched holes and soldered on the same terminals as shown.

Both the panel and chassis are of 1/16in. thick transparent Perspex material. In Fig. 2 only the knobs are above, the rod and sub-chassis are under the panel.

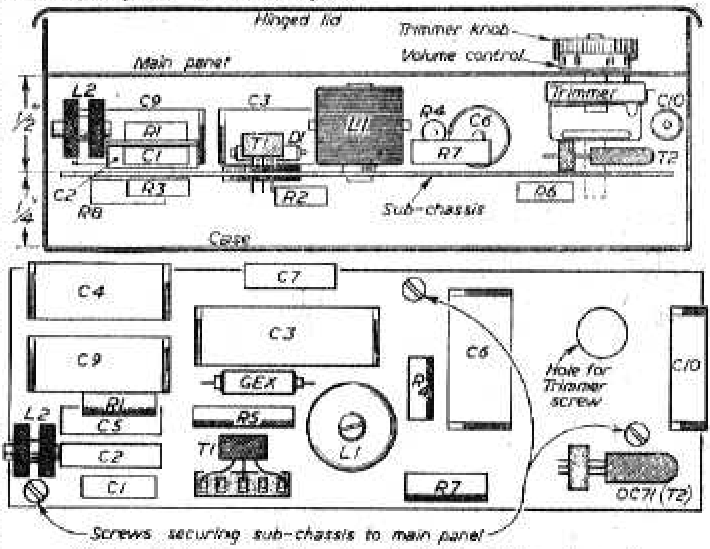
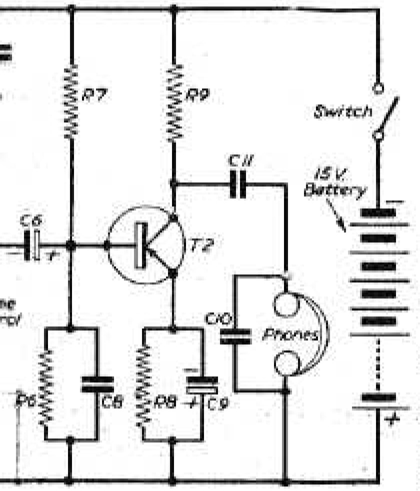


Fig. 4.—Side view of the set, and details of the sub-panel.

The components shown are all secured on the sub-chassis by passing their leads through drilled small holes of ⅛in. diameter. R3, R6, R8 and R2 are positioned on the other side of the sub-chassis. Most wiring can be done on the chassis before bolting on to the main panel. The R.F. chokes L1, L2 and Ferrite frame should be positioned so that each is at right-angles to the other. A most suitable substitute for L1 is the potted coil of a disused 465 kc/s miniature I.F. transformer. The coil and its terminals should be carefully removed from the transformer. The



...ver described above.

LIST OF COMPONENTS

C1, C7—0.001 μF.
C10, C2, C5, C8—0.005 μF.
C11, C3, C6—12 μF (Plessey CE257 12 v. D.C. electrolytic).
C4, C9—50 μF 6 v. D.C. electrolytic.
R1—10 K. R2—68 K.
R3—1 K. R4—5 K.
R5—82 Ω. R6—5.6 K.
R7—250 K. R8—180 Ω.
R9—4.7 K.
All resistors are ¼-watt rating.

L1—0.5 Mh ("two π") Radio Clearance Ltd.,
L2—4.5 Mh or Lasky's Radio.
CT—Trimmer, volume-control 10 K case. (From Henry's Radio)
Ferrite rod aerial Teletron F.R.M. (From Henry's Radio)
T1—R.F. transistor (red/yellow spots) or others. (From Henry's Radio)
T2—OC71 or A.F. transistor (red spot) (From Henry's Radio)
D1—GEX34. (From Henry's Radio)
Transistor sockets, switch, Henry Radio type. (From Henry's Radio)
All resistors and capacitors are obtainable from Radio Clearance Ltd.

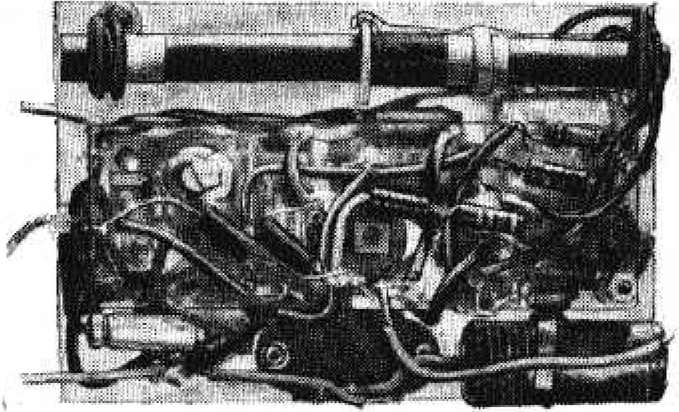
pot offers a good means of screening and the centre hole for convenient mounting.

The battery used should be placed on the other side of the sub-chassis, near the switch. An Ever Ready type B144 hearing aid battery is used.

Theoretical Circuit

The switch is mounted near the volume control and alongside it the battery.

At initial testing a short throw-out aerial of a yard in length should be connected to the point on the theoretical diagram marked "A." If the coil on the aerial rod is set to the centre of the rod the Home Service of the BBC will be found on the "tight" end of the trimmer, and Light programme at the "slack" end.



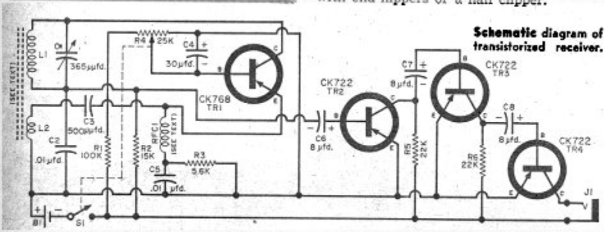
A view of the receiver without the case.

HOW IT WORKS

The first transistor *(TR1)* is an r.f. type used as a grounded-base regenerative reflex detector. Antenna coil *L1* picks up a radio signal and induces an identical signal in the tickler coil *(L2)*. The latter feeds this signal to the emitter of *TR1*. The signal is amplified and passes through *L1*, which is in the collector (output) circuit. As a result, a large signal is induced in *L2* and the cycle repeats itself. This is what causes regeneration.

That part of the r.f. signal induced in *L2* is detected by the emitter and base junction of *TR1*. The audio voltage developed across *R3* and *C5* is reapplied to the emitter and base, amplified, and coupled to the CK722 transistor *TR2*.

TR2, *TR3* and *TR4* form a simple three-stage audio amplifier. It differs from many other transistor amplifiers in that the bases have no bias resistors. The collector leakage current and the minute current leaking through the coupling capacitors is all the bias current that is needed for the small signals that are handled.



Schematic diagram of transistorized receiver.

the danger of accidental shorts between the closely spaced conductors.

Etching and Drilling. After the resist has dried, put the boards in the etching solution. They should be ready if you use the cold etching method.*

Next, drill the holes for mounting the components. All are made with a 1/16" drill, except the mounting holes for the tuning capacitor (*C1*). Two of these holes are 1/8" in diameter and countersunk from the non-etched side of the board. The hole for the shaft of the same capacitor is 1/4" in diameter and countersunk from the etched side of the board. Although the flea clips are intended to be mounted in 3/32" holes, it is better if only the smaller bottom part is fitted into the 1/16" holes.

Follow the lists of connections (two numbers or letters indicate that a component should be connected between these two points, and a single letter designates a terminal such as one of the transistor electrodes or a battery terminal), and insert all the components in their respective positions but do *not* solder them in as you go along. They are all mounted on the non-etched side of the board with the exception of *C1*, *R1*, and the battery holder.

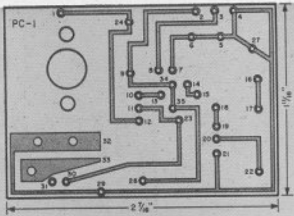
Soldering. If all parts fit well, solder them in place with hot, well-tinned, small-tip soldering iron or gun. Use a special printed-circuit solder such as Print-Kote because its low melting point reduces the danger of overheating the etched board and components.

When soldering the parts in place, always hold the leads close to the parts with long-nose pliers to dissipate excessive heat. Make sure that you *don't* have the transistors in place when soldering the flea clips to the conductors. After the parts are soldered in place, clip off the excess lead with end nippers or a nail clipper.

* For detailed information on making printed circuits, see "'Printed Wiring' Techniques for the Experimenter," Part 1 in the August 1956 issue of POP'tronics, and Part 2 in the September 1956 issue. Also see "Simplified Etched Circuits" in the June 1957 issue.

PARTS LIST

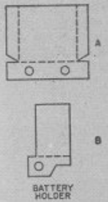
B1—1.3-volt mercury cell (Mallory RM-630)
C1—365-μfd., single-gang, midget variable capacitor (Argonne Poly-Vari-Con)
C2, C5—0.01-μfd. subminiature capacitor (Aerovox P832)
C3—0.0005-μfd. subminiature capacitor (Centralab DM-501)
C4—30-μfd., 6-volt electrolytic capacitor
C6, C7, C8—8-μfd., 6-volt electrolytic capacitor
J1—Miniature jack (Telex 9240)
L1—50 turns of #22 s.c.e. wire on 1/4" x 2 1/8" ferrite core (Lafayette MS-331)—see text
L2—Six turns #22 s.c.e. wire on same core
L3—R.f choke (winding from a discarded miniature i.f. transformer)
PC1, PC2—XXXP printed-circuit copper laminate board (one 2" x 4 1/4" section cut in two parts—1 11/16" x 2 7/16" for PC1 and 1 11/16" x 2 9/16" for PC2)
R1—100,000-ohm resistor, 1/2-watt resistor
R2—15,000-ohm, 1/2-watt resistor
R3—5600-ohm, 1/2-watt resistor
R4—25,000-ohm subminiature volume-regeneration potentiometer (Lafayette VC-45)
R5, R6—22,000-ohm, 1/2-watt resistor
S1—S.p.s.t. switch (on R4)
TR1—CK768 transistor
TR2, TR3, TR4—CK722 transistor
1—6-oz. bottle of etching solution (Lafayette PE3)
1—Roll of resist-tape or ball-point tube (Lafayette PRT-2 or PRTL)
12—"Flea" clips for soldering contacts
Misc. eyelets (0.062" in diameter by 0.093" long); tin, copper or brass for battery holder; plastic cabinet

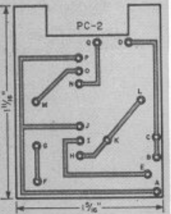


CONNECTIONS FOR PC1

1—Top of antenna coil
2—Bottom of antenna coil
3—Top of tickler coil
4—Bottom of tickler coil
5 and 15—R3
6 and 14—C5
7 and 34—C2
8 and 13—C3
9—Top terminal of C1
10—Emitter of TR1
11—Base of TR1
12—Collector of TR1
13 and 15—L3
16 and 18—R5
17 and 26—Jumper wire
18—2" wire to G of PC2
19—Collector of TR2
20—Base of TR2
21—Emitter of TR2
22—C6 (pos. terminal)
23—C4 (neg. terminal)
24—C1 (bottom terminal)
25 and 31—R1
25 and 35—R2
25—Wire to PC2, Point B
26—S1 (either terminal)
27—C4 (pos. terminal)
28—C6 (neg. terminal)
29—Wire to PC2, Point A
29—Right terminal of R4 (with prongs facing you)
30—R4 (center terminal)
31—Left terminal of R4 (with prongs facing you)
32—Positive terminal of battery holder (Part A)—see text
33—Negative terminal of battery holder (Part B)—see text
33—S1 (remaining terminal)

Printed-circuit boards PC1 (above) and PC2 (below) are assembled after components are mounted (right). The battery holder parts (A and B, below) are cut from sheet metal and bent as described in text; folds should be made on the dotted lines.





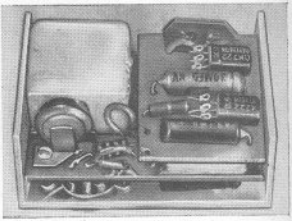
CONNECTIONS FOR PC2

A—Wire from 29 of PC1
B—Wire from 25 of PC1
C and K—R6
D—Wire to one terminal of J1
E—C7 (pos. terminal)
F—C7 (neg. terminal)
G—Wire from 18 of PC1
H—Collector of TR3
I—Base of TR3
J—Emitter of TR3
L—C8 (neg. terminal)
M—C8 (pos. terminal)
N—Collector of TR4
O—Base of TR4
P—Emitter of TR4
Q—Remaining terminal of J1

Antenna coil *L1* is wound on a piece of ferrite core which measures 2⅜" x ¼" in diameter. This coil consists of 50 turns of #22 single cotton enamel wire, and the tickler coil (*L2*) is made from six turns of the same kind of wire. Wind both coils immediately adjacent to each other and in the same direction; otherwise you won't get positive feedback and the detector won't oscillate.

The battery holder consists of two parts: part *A*, the positive terminal, connected at 32; and part *B*, the negative terminal, connected at 33. Trace the pattern of these parts as shown in the diagram (below, left) on brass, tin or copper; then cut them out. Bend them on the dotted line toward you while you hold the parts as shown. Mounting holes for the battery holder are also 1/16" in diameter, and terminals are riveted to the board using small eyelets or miniature screws and bolts.

Housing. Either a home-built or commercial cabinet may be used for the transistor radio. Pieces needed to construct your own cabinet can be cut from a clear polystyrene sheet. The front and back of the case shown measure 1⅞"x2⅝", the top



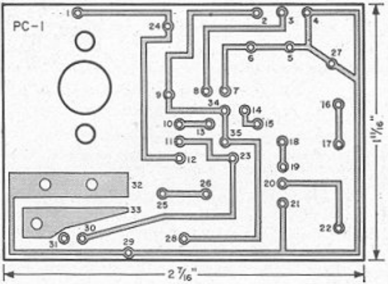
and bottom are 1"x2⅝", and the sides measure 1"x1¾". Glue the pieces together temporarily using household cement, but leave the back off.

Place the completed "Half-Pack" inside the case and mark the spots for the shaft of *C1* and the regeneration control (*R4*). Drill the ¼"-diameter hole for the shaft and another one for the starting hole of *R4*. With a ⅝" chassis punch, score a ⅝"-diameter circle in the plastic. Cut out the circle with a jigsaw and smooth the edges of the hole with a round file. The subminiature control specified in the parts list should fit snugly. Fasten it to the panel with small nuts and bolts through the on-off switch tabs.

The pieces of the box can now be cemented together permanently. Place the radio inside and drill the mounting holes for *R4* and earphone jack *J1*. —30—

Out of Tune

Build a "Half-Pack" (*May,* 1958, page 49): Soldering points 25 and 26 were omitted from printed-circuit board PC1. The correct positions of these points are shown here. If the board has already been etched,



you can add 25 and 26 by drilling two 1/16" holes in the proper positions and installing a short length of wire between them.

In the schematic diagram on page 48, *RFC1* (*L3* in the Parts List) can be any small r.f. choke or section or winding from an r.f. coil. It's not critical.

choice of circuit.

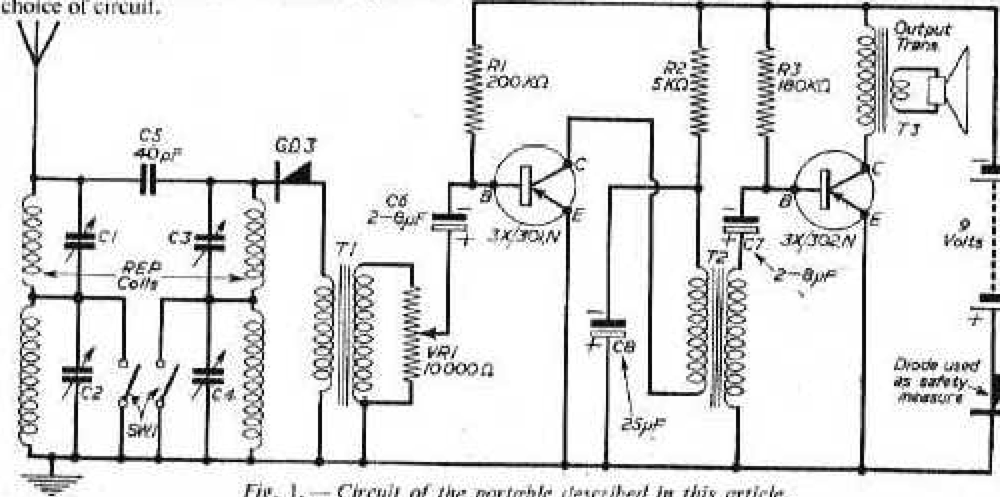


Fig. 1.—Circuit of the portable described in this article.

REPANCO ... STE

INSTRUCTIONS

STAGE THREE (Cont:).

11. Connect the RED eyelet of the FS3 aerial to ...2 of the switch.
12. Fit solder tag at either of points D and join ... tag at R.
13. Bolt the top of the speaker to the angle brackets at A of the top panel, and the bottom of the speaker to the 'U' bracket at D of the rear panel, using 6BA screws & nuts with a 6BA washer under the screw heads.
14. Insert T1 in the T1 holder and T2 in the T2 holder.
15. Fit a pointer to the spindles of C1 & C5 and the switch.
16. Connect the +ve battery connector to the +ve stud of the PP4 battery and the -ve connector to the -ve stud of the battery and switch on. Select station by using C1 (tuning) in conjunction with C5 (reaction) for volume.

COMPONENT LIST

REPANCO COMPONENTS.

Medium Wave Ferrite Slab Aerial type FS3....................7/6d.
Long Wave " " " " FS4....................7/6d.
RF chokes types RF1 & RF2....................6/- pr.
Top & Rear panels with brackets.Group board type 6/T..........5/-.
Interstage transformer,ratio 4.5 to 1,type TT14..............12/6d.
Output transformer type TT5....................8/-.
Set of 3 dial plates....................2/3d.

RESISTORS:-

R1.	220K
R2.	10K
R3.	10K
R4.	47K

CAPACITORS:-

C1	300 pf variable Jackson Bros Dilicon.
C2	0.005 mfd
C3	2 mfd electrolytic.
C4	100 pf.
C5	100 pf variable Jackson Bros Dilicon.
C6.	2 mfd electrolytic.
C7.	100 pf.
C8.	100 mfd electrolytic.

SUNDRIES:-

2	Transistor holders Cinch type 61/001.
2	Transistor holder clips Cinch type 77/765
1	4 pole 3 way switch
1	Elac 7" x 4" eliptical speaker.
½ yd	dial drive cord.
3	Pointer knobs.
1	type PP4 battery.

HARDWARE:-

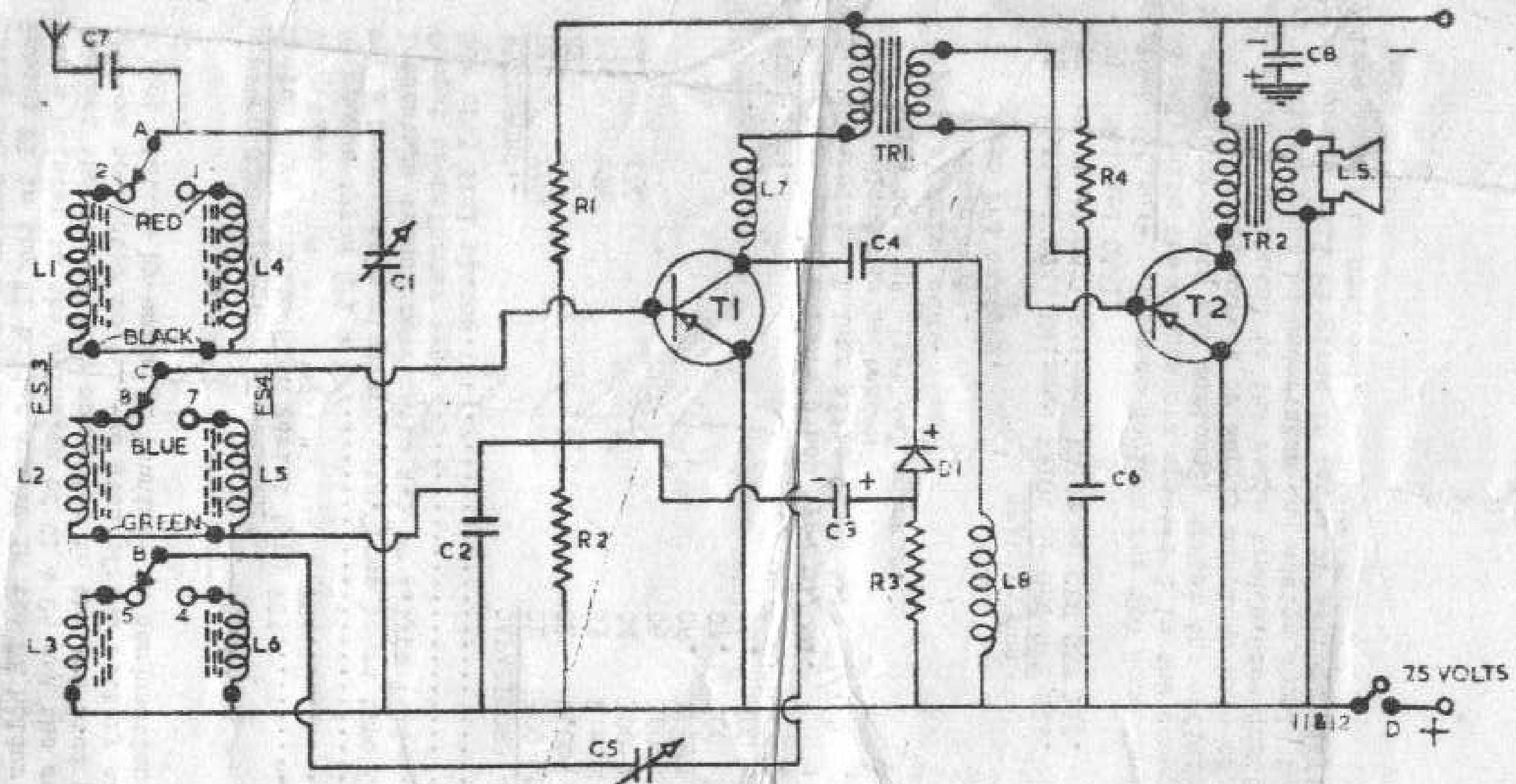
2	4BA x ¼" screws RH.
2	4BA nuts.
3	4BA solder tags.
12	6BA x ¼" Screws RH.
12	6BA nuts.
4	6BA washers.

TRANSISTORS

T1	Mullard OC44, Ediswan XA104 or GEC GET 874.
T2	Mullard OC71, Ediswan XB103 or GEC GET 113.
D1	Mullard OA81.

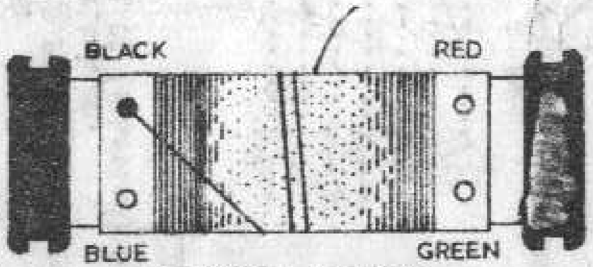
Important Notice:- Repanco designs for the Home Constructor have been tried and tested only with the components specified in the component list. Any substitution with other components may seriously affect the efficiency of the circuit in question.

We do not market or supply complete kits of parts, our components and designs are distributed to the radio trades. Consequrntly repairs and service work to kits cannot be undertaken and advice should be sought from the supplier. Advice however will be given in cases of extreme difficulty. A stamped addressed envelope should be enclosed.



THEORETICAL CIRCUIT

TWINETTE

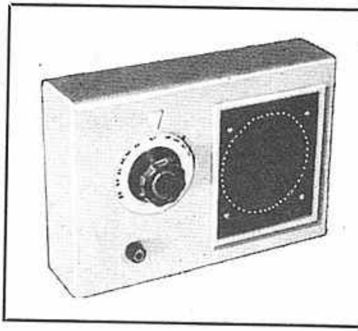


REACTION WINDING

FS3 2.5 turns
FS4 10 "
} WOUND IN SAME DIRECTION AS AERIAL COIL, WITH COTTON COVERED ENAMEL COPPER WIRE. APPROX 30 swg.

REPANCO LTD.
OBRIENS BUILDINGS
203-269 FOLESHILL ROAD
COVENTRY

Transistor Portable with a *Punch*



HOW IT WORKS

Most crystal receivers are lacking in selectivity because the crystal detector loads down the tuned circuit, reducing its *Q*. In the antenna arrangement used here, a long core is employed to intercept a maximum of r.f. energy from broadcast stations, and the coil is tapped down to match the low impedance of the detector. Thus, a high *Q* is maintained, and good selectivity results. The coil is wound with litz wire, which is made up of a number of strands of fine insulated wire twisted together. This type of construction reduces the r.f. resistance of the coil, and helps in maintaining a high *Q*.

Capacitor *C2* bypasses the r.f. from the detected signal, and the audio passes through the base-emitter circuit of transistor *TR1*. Amplification takes place in this stage, and the signal is coupled to the next stage by transformer *T1*. This transformer matches the output impedance of *TR1* to the input impedance of *TR2*, resulting in maximum power transfer.

The desired portion of the audio signal is selected by volume control *R1* and is passed to *TR2* through *C3*. A high value of capacity is required here because of the low impedance of the base-emitter circuit of *TR2*. Further amplification is provided by *TR2*, which is biased by means of resistor *R2*. Transformer *T2* again matches the output of *TR2* to the input of the push-pull output stage *TR3-TR4*. Base bias for Class B operation of the output stage is provided by the voltage divider *R3-R4*. *T3* matches the output of the push-pull stage to the voice coil of the loudspeaker.

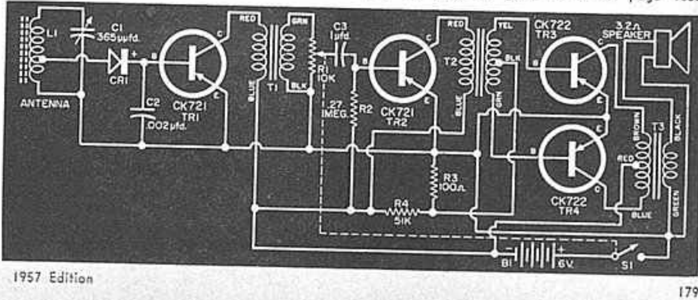
Transistors *TR1* and *TR2* may be replaced by the cheaper CK722's, with somewhat decreased gain. Other transistors could also be substituted, with possibly some change in performance. If such substitutions are made, *R2* should be selected for optimum performance of *TR2*, and *R3-R4* for optimum performance of the output stage *TR3-TR4*.

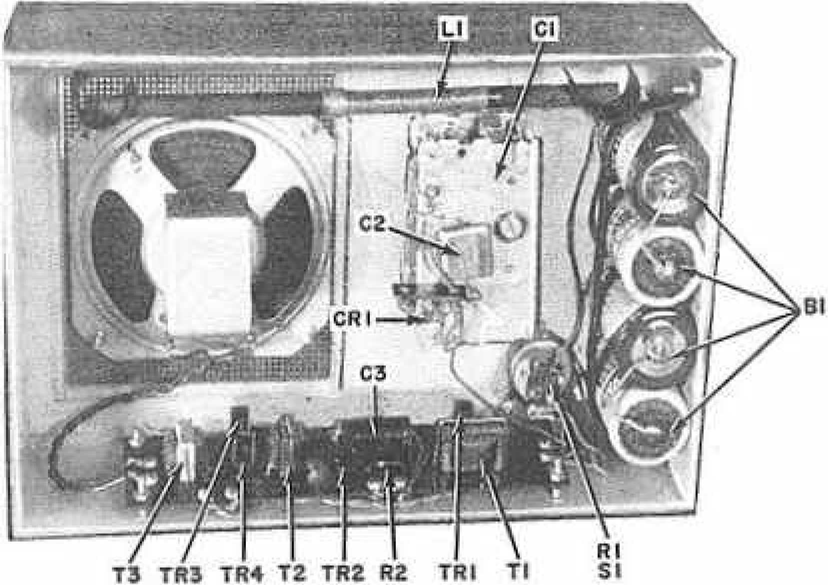
By RUFUS P. TURNER

HERE IS something a little out of the ordinary in a transistorized radio receiver. Although it avoids the complications of a superhet design, it still has good selectivity and does not require an external antenna for quality performance. And it provides loudspeaker operation.

Heart of the receiver is a long, high-*Q*, ferrite-cored coil which serves as an excellent antenna without any external antenna wire. Tuning is accomplished by a 365-μμfd. capacitor in parallel with the whole of the antenna coil, and selectivity is main-

Schematic diagram of the portable radio receiver. The pictorial diagram for the set appears on page 182, the complete parts list is on page 183.

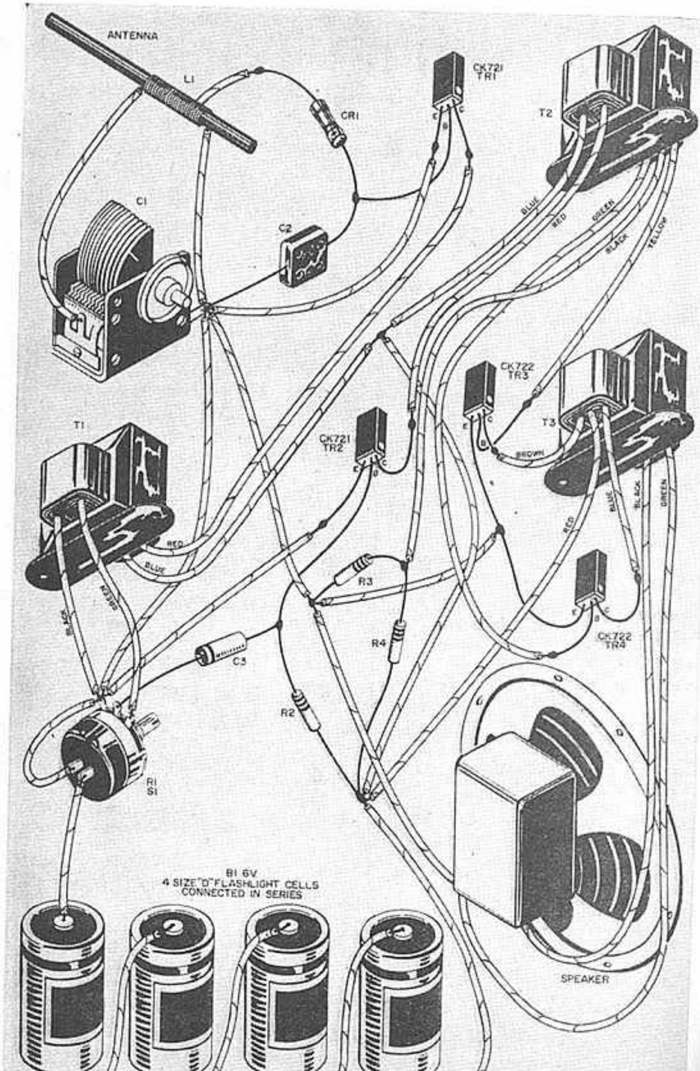




Interior view of complete receiver, showing location of the major components.

tained by connecting the crystal detector to a low-impedance tap on this coil. All of the amplification takes place at audio frequencies, so you don't have to worry about poor transistor performance in the r.f. or i.f. region.

Transformer coupling is used in the audio amplifier to provide maximum gain.


ANTENNA
L1
CR1
CK721
TR1
T2
C1
C2
BLUE
RED
GREEN
BLACK
YELLOW
CK722
TR3
T1
CK721
TR2
T3
BROWN
RED
BLUE
BLACK
GREEN
RED
BLUE
BLACK
GREEN
R3
R4
C3
CK722
TR4
R2
R1
S1
B1 6V
4 SIZE "D" FLASHLIGHT CELLS
CONNECTED IN SERIES
SPEAKER

The push-pull Class B output stage will provide about 110 milliwatts of audio, which is adequate for the average room.

Construction

You can't use a metal cabinet with this receiver, as metal would shield the antenna coil and greatly reduce signal pickup. Use a plastic box about 10½" long, 7" high and 3" deep, or build a wooden box about this size and finish it as desired. (One experimenter built the receiver in a cigar box!) Size is not all critical, except that the length must be at least 10" so that the horizontally mounted antenna will fit in it.

Mount the amplifier section on a strip of plastic 1/16" thick, 7" long and 2" wide. Components are held in place by passing their leads through small holes drilled in the strip, and bending the leads over on the other side. Fasten the transformers in place with a loop of wire passed around the core, and through holes in the strip. Twist the ends of the wire together under the strip for good anchoring. Then, pass the transformer leads through separate small holes in the plastic strip. Make all connections under the strip by soldering appropriate pigtails and leads together.

Check and double-check the transistor connections, because wrong wiring can ruin them. Hold the transistor pigtails tightly between the jaws of long-nose pliers when soldering, to avoid damage due to heat. Observe the color coding on the transformer leads; incorrect connections could cause the amplifier to oscillate.

After assembly, mount the amplifier on the floor of the enclosure.

Now mount the loopstick antenna lengthwise in the top of the case. Use the fiber mounting strips provided for this purpose. Don't use metal brackets of any kind. Install the tuning capacitor *C1* immediately below the antenna, and mount the diode detector and capacitor *C2* on the frame of *C1*. For the tuning dial, fasten a white plastic disc to a skirted Bakelite knob and inscribe it with the broadcast frequencies. Or use a commercial dial.

Cut a hole of the appropriate size for the loudspeaker which you are using, and cover inside with suitable grille cloth. Mount the speaker with 6-32 screws.

You can use your ingenuity in mounting the batteries. The author wired them in series, and then secured them in place with a metal strip fastened to the case at each end with a 6-32 machine screw. Install the volume control (with switch attached) in the approximate location shown in the photo. Wire up the various components according to the schematic and pictorial.

Operation

Calibrate the tuning dial by tuning in various local stations and marking their frequencies on the dial. Or, if you have an amplitude-modulated signal generator available, calibration can be easily carried out by laying the "hot" output lead of the generator across the middle of the antenna. Then set the generator successively to different broadcast-band frequencies, set the receiver tuning dial for peak output at each of these frequencies, and mark the dial accordingly. Adjust the generator output and receiver volume for best audible signal without overloading, as this sharpens receiver response and increases accuracy of the dial calibration.

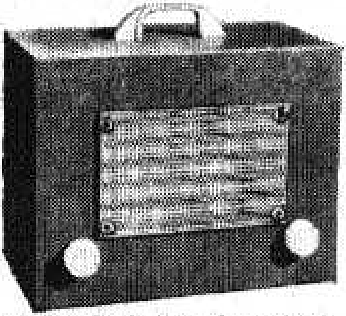
Actual battery drain in this receiver varies with the sound output, since the final stage operates Class B, but drain will be much less than with a tube set. The specified batteries should give very long life—approaching shelf life if the receiver isn't used more than a few hours each day.

Volume of this little set is adequate to make it useful for the home, in a car, or on the beach. The antenna is slightly directional, so try rotating the receiver for best reception. You'll get many hours of enjoyment as a reward for the few evenings it will take you to build the set. —30—

PARTS LIST

B1—6-volt battery (four Size-D flashlight cells connected in series)
C1—365-μμfd. variable capacitor
C2—0.002-μfd. mica capacitor
C3—1.0-μfd., 200-volt, miniature, metalized tubular capacitor (Aerovox P-82Z)
CR1—Germanium diode (Raytheon CK705 or 1N34)
L1—Ferrite-type transistor loop antenna (Miller Type 2000)
R1—10,000-ohm potentiometer
R2—0.27-megohm, ½-watt carbon resistor
R3—100-ohm, ½-watt carbon resistor
R4—51,000-ohm, ½-watt carbon resistor
S1—S.p.s.t. switch installed on potentiometer R1
T1—Transistor driver transformer: primary, 15,000 ohms; secondary, 200 ohms (Argonne AR-107)*
T2—Transistor Class B driver transformer: primary, 10,000 ohms; secondary, 2000 ohms, c.t. (Argonne AR-109)*
T3—Transistor Class B output transformer: primary, 500 ohms, center-tapped; secondary, 3.2 ohms (Argonne AR-119)*
TR1, TR2—CK721 transistors (Raytheon)
TR3, TR4—CK722—transistors (Raytheon)
1—Plastic cabinet, 10½" x 7" x 3" (see text)
1—Plastic strip, 1/16" x 7" x 2"
Misc. machine screws, wire, solder, etc.
**Argonne transistor transformers are obtainable from stock at Lafayette Radio, 100 Sixth Ave., New York 13, N. Y.*

A TRANSISTOR DIODE *Portable*



A USEFUL RECEIVER WITH MANY APPLICATIONS

By R. V. Moore

THE small size of transistors, the low power requirements and the few components required compared with valve circuits lead inevitably to the development of midget receivers. However, apart from the novelty, there can be no point in producing such a receiver unless complete portability is desired, and achieved at reasonable cost. A midget set requires a midget speaker, and transistors are not at their best when working these. Furthermore, to eliminate aerial and earth at least two H.F. stages in a straight circuit are needed for only moderate results with present available types. Otherwise, an even more costly superheterodyne circuit is required. A proprietary set recently launched has 8 transistors!

After many hours of experimenting and testing it seemed to be time to produce more tangible results in the shape of a finished receiver with cabinet. Although designed primarily for the bedside this little receiver will obviously have other applications, and it should be noted that it is designed for use with an aerial and earth. For bedside use the aerial was 50 feet of plastic covered aerial wire fastened to the picture moulding by insulated staples. The earth wire was taken to the cold water inlet in the cylinder cupboard. The locality required long wave tuning for the Light programme. The power supply was to be 9 volts, and the size of the speaker limited to 6in. These considerations, and the desire to keep costs down by using a minimum of transistors, governed the choice of circuit.

The Circuit

The circuit, as shown in Fig. 1, consists of a diode detector stage followed by two stages of L.F. amplification using junction transistors. To obtain maximum volume from such a combination transformer coupling is required. Resistance-capacity coupling gives less volume. Quality may be somewhat better, but it takes a very discriminating ear to notice any difference. With resistance-capacity coupling there may be sufficient volume for the listener from a circuit employing a diode and two junction transistors if an 8 in. speaker is used, or if the listener is situated in a good reception area even with a 6in. speaker. For readers who wish to try this an alternative circuit is given in Fig. 3 (see notes later).

The Detector Stage

This is a simple crystal diode feeder employing two tuned circuits. The coils are R.E.P. dual-wave crystal coils chosen for their modest price (2s. 6d.) and reasonable efficiency. No single dual-wave coil was found to be satisfactory such that a fair compromise between sensitivity and selectivity could be attained. The coils are pretuned by trimmers C1, C2, C3, C4, each 250 pF. Station selection is by a double-pole on/off switch, SW1, giving medium-wave Home service or long-wave Light programme. The value of the coupling condenser, C5, is 40 pF, but any value between 10 and 100 pF may be tried.

Any diode may be tried but perferably a good one such as the GD3 should be used. Results with cheap

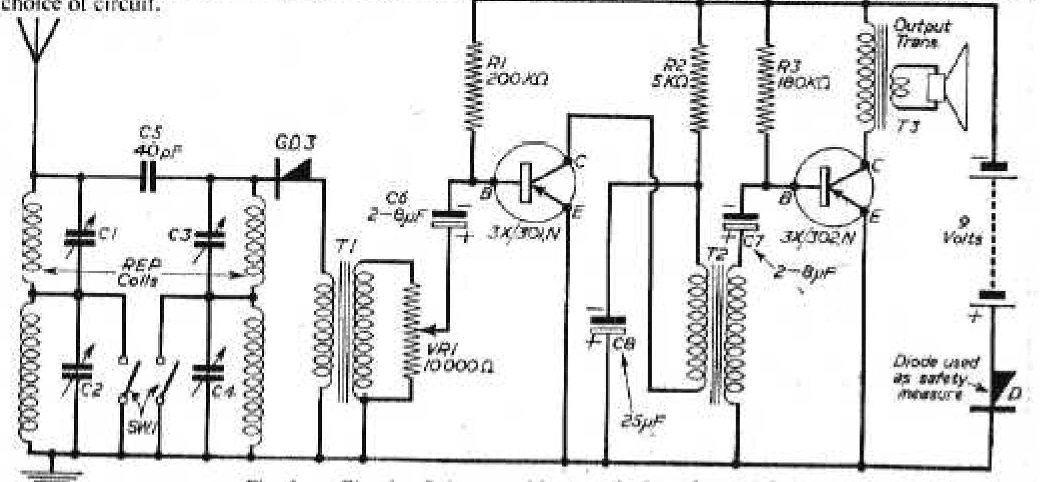


Fig. 1.—Circuit of the portable described in this article.

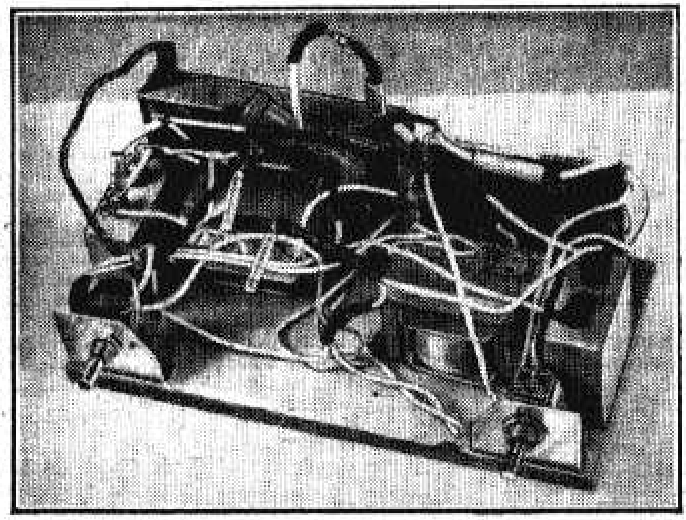
diodes are often disappointing, giving poor quality reception and a marked diminution in volume.

The Amplifier

Brimar junction transistors are used; a 3X/301N in the first stage followed by a 3X/302N.

The output from the crystal feeder is matched into the input of the first transistor by a step-down transformer, ratio 5 to 1. A similar transformer is used to match into the second transistor. Suitable transformers can be purchased from Whiteley Electric Co., Mansfield, or H. Ashworth, Bradford. Much ex-Service equipment contains suitable transformers; ratios 4 and 6 to 1 step-down can be used as the ratio is not critical.

V1, across the secondary of T1, controls volume; it may be any value 5,000 to 10,000 ohms and should have an on/off switch for the battery. When operating the set the volume control should be used judiciously, otherwise distortion may occur due to overloading the transistors.



A view of the components and wiring.

Coupling condensers, C6 and C7, may be any value 2 to 8 μF. Electrolytics should be connected with polarity as shown in Fig. 1. Decoupling condenser C8 may be 25 or 50 μF, 25 or 50 volt test.

A diode is connected in the battery lead as a safety measure. A cheap diode may be used provided it is tested first by connecting it in series with a voltmeter, across a 9 volt battery. Connected with anode of diode to positive of battery, voltage should be about 8½ volts. Reversing diode should result in scarcely any reading. With such a diode inserted in the battery lead the minute reverse current which would pass through the diode if the battery were accidentally reversed would cause no damage to the transistors in the set.

The values of resistances R1, R2, R3 were found experimentally having due regard for the maximum ratings of the transistors as given in the manufacturers' literature. The collector current of Trans. 2 is about 4 mA; allowing for the voltage drop in the output transformer and the diode there will be about 26 milliwatts output to the speaker. This may seem very small in comparison with modern valve outputs, but a surprisingly useful volume and tone can be obtained from a good quality loudspeaker. A good output transformer to match the speaker is also a decided asset. If the constructor can afford the room a larger speaker than 6 in., preferably mounted on a large baffle board, will enhance the quality considerably.

Constructional Details

Home constructed sets do not always find favour with the opposite sex. Few radio enthusiasts are

LIST OF COMPONENTS

- Two R.E.P. crystal coils (coils 1 and 2).
- Four trimmers, each 250 pF (C1, C2, C3, C4).
- One condenser 40 pF (C5).
- Two condensers, each 2 μF (C6 and C7). These may be electrolytics and any value 2 to 8 μF.
- One condenser 25 μF, electrolytic, 25 volt test (C8).
- One switch, double pole on/off (Bulgin or similar), SW1.
- Two transformers, step-down, ratio 5 to 1 (T1 and T2) (Whiteley Electric Co., Mansfield, or H. Ashworth, Bradford).
- One transformer, output, to match speaker (T3).
- One volume control, 10,000 ohms with on/off switch (V1).
- One resistance, 200 K., ¼ watt (R1).
- One resistance, 180 K. ¼ watt (R3).

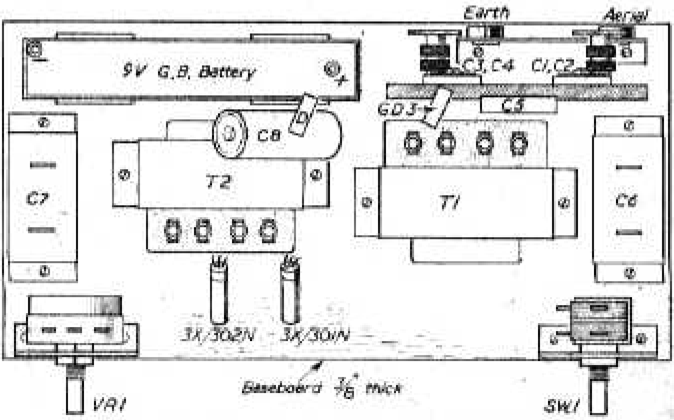


Fig. 2.—Layout of the components.

skilled cabinetmakers. Making a cabinet, staining and polishing to high standards is either beyond most of us or considered too tedious a job to give up many hours of pure radio work. This difficulty is overcome by making the cabinet of plywood and covering with rexine cloth, resulting in a very satisfactory finish.

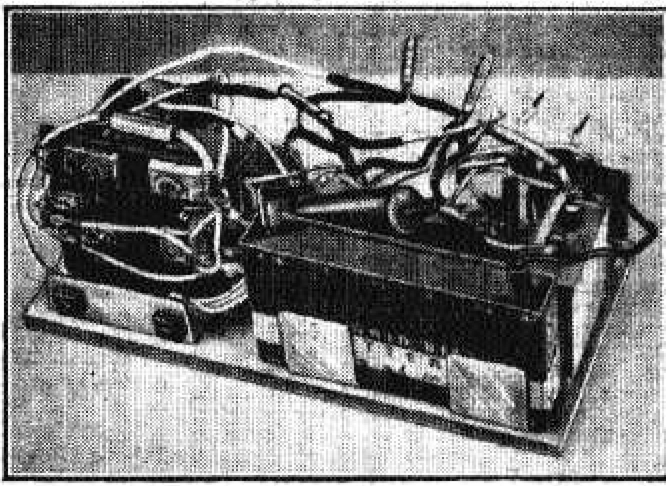
The Cabinet

The dimensions are as follows: Front 10in. × 7¼in., depth 5¾in. (outside). Front and sides are cut out of ⅜in. plywood; one front piece 10in. × 7¼in., and two side pieces 7in. × 4⅞in. Top and bottom are two pieces of ¼in. plywood, each 10in. × 5½in. A hole for the speaker 4⅝in. × 3⅜in., and 1⅞in. from the top edge of the front and centrally placed is cut out before nailing the pieces together. Two holes are required at the top for the carrying handle and two holes in the front panel to take the control spindles. The position of these is best found by mounting the two controls on the baseboard (see later), rubbing chalk on the ends of the spindles and pressing on to the back of the panel.

Covering

A piece of rexine cloth 23in. × 20½in. is required. Rexine cloth can be purchased in many shades and it is not difficult to obtain a suitable pattern to match any desired colour scheme. Alternatively the cabinet may be covered with Formica.

The rexine is placed face downwards on the bench and the cabinet placed on it centrally, face downwards. Pencil marks are made round the front edges and round the speaker hole; the cabinet is then removed and white Bostik applied to the pencilled portion. The cabinet is then placed on top face downwards, the whole turned over and the rexine smoothed and pressed down with a cloth. Cuts are made in the rexine diagonally to the corners; the two side pieces are stuck down and trimmed to the edges, followed by the same procedure with the top and bottom pieces, using the same adhesive. The wrap-over pieces are then trimmed diagonally at the corners of the back and stuck down. From the back small holes are pierced in the centre of the loudspeaker hole and in the centres of the two spindle holes. Cuts are made from the centres to the edges of these holes and the strips of rexine stuck down. A rectangular plastic grill is screwed to the front and decorated with four chromium-plated domes at the corners. Finally, the back is cut out of ¼in. plywood, size 9⅝in. by 6¾in., drilled with several vent holes (three rows ⅛in. diameter) and holes for the trimmers and aerial and earth plugs. This is



Another view of the interior.

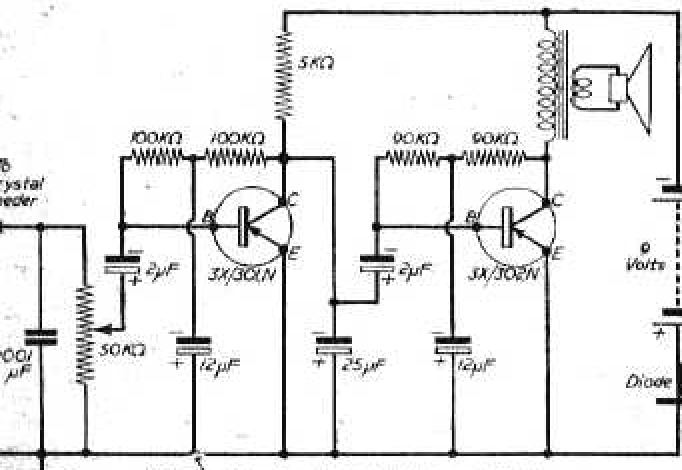


Fig. 3.—An alternative circuit arrangement.

LIST OF COMPONENTS

One resistance, 5 K. ¼ watt (R2).
One 6in. P.M. loudspeaker (W.B. or similar).
One 9-volt G.B. type battery or two 4½ volt flashlamp batteries connected in series.
One diode GD3, Brimar, and one diode (D), GD5 or cheap one passing test.
One transistor, 3X/301N., Brimar.
One transistor, 3X/302N., Brimar.
Connecting wire, solder, plugs, plywood, rexine,
Bostik (white), small nails, aluminium sheet, insulating tape, wood screws (½in. and ¾in.), knobs, handle, plastic grill, chromium domes.

If it is desired to use other makes of junction transistors a 5 mA meter should be inserted in series with the collector leads and the values of R.1, R2, R3 and voltage supply adjusted to conform to manufacturers' ratings.

covered with rexine, the holes cut round with scissors and trimmed with a small round file. The back is screwed to two small triangular corner pieces at the top corners of the back of the cabinet, cut out of ⅜in. plywood and screwed to the baseboard at the bottom corners. The carrying handle holes are pierced and the handle screwed in position. If care is taken before covering to ensure that there are no projecting nails or rough edges the finished cabinet should present a pleasing appearance.

Mounting the Components

The components are mounted on a plywood baseboard, size 9½in. × 4½in., ⅜in. thick. The switch, volume control and two plugs (aerial and earth) are mounted on small brackets made out of scrap pieces of aluminium sheet, and screwed to the baseboard with wood screws. Two strips of aluminium sheet bent twice and screwed down on the board formed clips for the battery. The coils and trimmers are mounted on a piece of paxolin 3in. × 3in., bolted to a bracket and screwed to the baseboard. The position of all these components is shown in Fig. 2.

Wiring

Care should be taken when soldering the transistors; they can be damaged by heat. The leads should not be cut short, and should be held with pliers, tinned and soldered to the connecting leads, using a minimum amount of heat, and allowed to cool before removing the pliers. Then each lead should be covered with insulating tape right up to the body of the transistor. The diode leads should also be held with pliers when soldering. Leads and plugs to the battery should be of a distinctive colour, preferably red for positive and black for negative connections. Brackets and condenser cans are earthed. It is advisable to cover all exposed joints and wires with insulating tape to avoid any possibility of any wires touching and causing a reversal of the battery connections.

Apart from these precautions the wiring is straightforward. To avoid a muffled tone due to small cabinet size the speaker is mounted on four small pieces of plywood ½in. thick.

Testing and Adjusting

Before switching on the wiring should be rechecked, paying particular regard to the base, emitter and collector connections of each transistor, and also the battery connections. A reversal of polarity will quickly destroy the transistors. On this account it is wise to plug in to a low voltage—3 volts—for preliminary testing. The medium-wave trimmers should be adjusted first on a low setting of the volume control, followed by the long-wave trimmers. If everything seems to be in order the voltage should be increased to maximum and the process repeated. Howling indicates a fault in the wiring. If this occurs the set should be switched off and the fault found before proceeding any farther with the testing.

The final result should be satisfactory to the constructor, who should have a receiver providing ample volume for bedside listening and presenting a pleasing appearance.

Alternative Circuit

Fig. 3 shows an alternative resistance capacity coupled circuit. This will be satisfactory only under the following working conditions:

(i) Using a 6in. speaker in a good reception area and indoor aerial.

(ii) Using an 8in. speaker in a moderate reception area and same aerial.

(iii) Using either type of speaker with a good outdoor aerial or in a few districts with a good indoor aerial.

To obtain maximum volume from a resistance capacity coupled circuit it is necessary to eliminate regenerative feedback caused by the biasing resistances connected between base and collector. To do this the resistances are divided equally and the centre bypassed to earth through a condenser value 8 to 20 μF.

This circuit is given solely for the benefit of those readers who are experimentally minded. Anyone in doubt should keep to the transformer coupled circuit (Fig. 1), which will be satisfactory under all but the most adverse conditions.

MARCH 1956

RADIO-ELECTRONICS

TELEVISION · SERVICING · HIGH FIDELITY

HUGO GERNSBACK, Editor

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U. S. and CANADA

Build a Solar-Powered Radio

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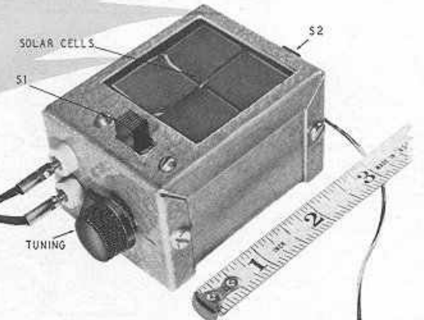
COVER FEATURE

build a SOLAR-powered RADIO

Futuratomic power supply feeds transistorized receiver

By EDWIN BOHR

JUST think of it! As long as the sun shines—even a very cloudy day will do—this radio operates from a solar power supply. When there is no sunlight, an auxiliary mercury cell can be switched into operation.



Self-generating cell is seen at top.

Anyone can build this solar-powered radio. The solar energy converter is a modified self-generating selenium photocell. Previously described solar radios and transmitters have been laboratory-built devices, very expensive and next to impossible for the hobbyist to reproduce. This solar radio, however, uses only standard components and can be built for around $15.

A high-gain transistor (Fig. 1) provides plenty of amplification; a Superex-Grayburne type EFL Loopstick gives souped-up sensitivity and selectivity. Actually the circuit is a crystal set followed by a stage of transistor amplification, but the sensitivity and selectivity are very much better than usually associated with this type of radio.

A fabulously high Q of 350 is the hallmark of the new "energized" loopstick. Detector loading of the tuned circuit can quickly degrade this figure. Nevertheless, by using loose coupling between coil and detector, we retain a single tuned circuit with exceptionally sharp selectivity.

One end of L1 connects directly to the antenna. The opposite end seems to float without any electrical connection to the remainder of the circuit. Coupling does exist though in the form of stray capacitance between L1, the loopstick core and L2.

A padder type variable capacitor with an attached knob is used for station tuning but does not have sufficient range to cover the lower end of the broadcast band. Thus, an extra capacitance is used to permit low-end tuning. (Diagram shows variable unit, but 200-μμf fixed capacitor may be used.) This capacitor parallels the tuned circuit through S1 and effectively splits the broadcast band in two.

L2 is a winding added to the loopstick. Nominally, this coil should be 12 turns wound at one end of L1 as shown in Fig. 2. Increasing the number of turns gives increased sensitivity or loudness, accompanied by some loss in selectivity, and, of course, decreasing the L2 turns gives better selectivity at the expense of signal volume. The size of the wire used to wind L2 is noncritical, but space the turns slightly apart.

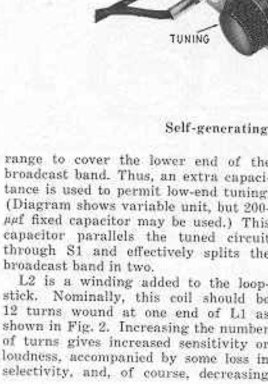


Fig. 1—Schematic of the receiver.

The detector is a germanium diode. Any of the many available types are satisfactory. The surplus silicon "radar" crystals, however, are *not* suitable. Typical crystals that can be used are the Raytheon CK705, Sylvania or Radio Receptor 1N34 and the G-E 1N69.

Crystal-detector receivers operate the diode in the low millivolt region. In this low-level signal range no diode is a really good rectifier. Detection takes place because the diode is a nonlinear resistance element passing more cur-

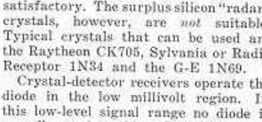
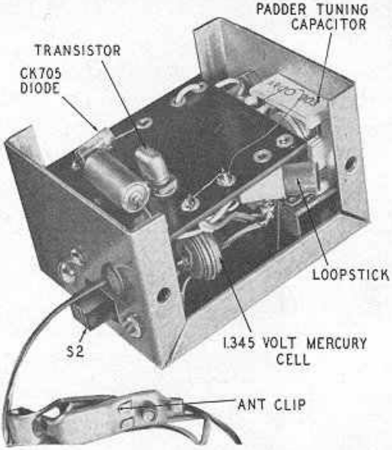


Fig. 2—Windings on the loopstick.



Internal view of solar-powered radio.

rent in one direction than the other. This is termed "square-law detection," the name being derived from the diode characteristics at low signal levels.

Crystal detectors, with no exceptions, operate on this principle. And despite indications to the contrary in some articles, they are not distortion-free. All produce some second-harmonic distortion.

Audio output from the detector is coupled to the transistor by a 0.1-μf capacitor. This can be one of the miniature 200- or 120-volt units commonly found in personal radios. Since the capacitor can discharge back through the nonlinear diode resistance, there is no need for a diode load resistor between the diode and capacitor—they are connected directly together.

The transistor should be a high-gain type, the CK721 for example. Using the CK722 results in a considerable lowering of performance. With a CK721 and 2,000-ohm earphones, the power gain of the transistor stage should be at least 160. A hermetically sealed type of high-gain transistor was used in the original receiver and is visible in the photograph. Except for the metal case, it is almost identical to the CK721.

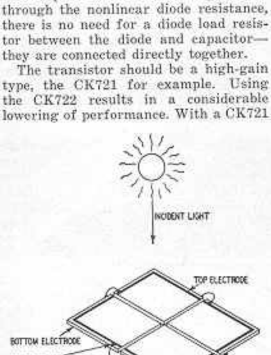


Fig. 3—Details of the solar cell.

Solar power supply

A type B-15 self-generating photocell, manufactured by International Rectifier Corp., forms the basis for the solar power supply. This manufacturer also currently advertises a smaller cell, of the same type, called the "Sun Battery."

The B-15 cell is unmounted. A rectangular silver band around the perimeter of the cell is the negative or front electrode. The solid silver backing is the positive terminal.

For our purpose, the cell must be cut into four equal-area sections. A small hacksaw is suitable for the cutting operation. To avoid overheating the edges, cut slowly. If the cell is clamped in a vise, use cardboard buffers to avoid mutilation of the cell's surface.

Check each of the four photocells by connecting a milliammeter—0-1 ma will do—across its terminals. The four cells should all give approximately the same output. For checking, each cell can be held near a 100-watt light bulb. If any cell gives appreciably lower output, the edge formed by the cut may be partially shorted. This can be corrected by scraping the edge with a screwdriver or knife blade until the cell reads normal.

Pieces of small, flexible, stranded wire connect the cells in series. The wiring arrangement is given in Fig. 3. The wires should be tinned first and then *quickly* soldered to the appropriate silver band or back; otherwise, the silver may melt away from the solder connection. When the cells are soldered together, check them again by connecting a voltmeter across the two output wires. In sunlight, the meter reading should be in excess of 1.5 volts. After the final check, place the cells face down on a square piece of clear plastic and bind them to the plastic with cloth adhesive tape. The modified cell is then ready for installation in the receiver.

Construction and operation

The original receiver was mounted in a small aluminum case. However, I discovered the closed aluminum box reduced the Q of the loopstick. A nonmetallic case is recommended.

To attach a tuning knob to the padder, take a piece of ¼-inch shaft and drill a hole in its center very slightly smaller than the padder shaft. Then heat the ¼-inch shaft until the hole enlarges enough to be pushed onto the padder. When the shaft cools, it will be solidly mounted to the tuning capacitor.

The remaining mechanical details are simple and the parts may be placed wherever most convenient. An easy way to mount the mercury cells is simply to solder the metal extension tab (negative terminal) to the S2 terminal. To avoid damage, soldering to any part of the mercury cell must be done quickly and the cell should be checked afterward with a voltmeter.

For an operational check, clip the antenna lead to something metallic. A screen door, clothesline or short length of wire, say 15 feet long, should do. By tuning the receiver, stations should be heard with the power switch in the mercury cell position. Hold the receiver facing through an open window and flip the switch to the solar cell position. The station should come in just as loud as with the RM cell. Direct sunlight can have an intensity of 10,000 foot-candles; yet the radio operates satisfactorily with only 100 foot-candles.

Parts for solar-powered radio

1—200-μμf mica capacitor; 1—0.1-μf 200-volt capacitor; 1—65-340-μμf padder (Arco 303 or equivalent); 1—CK721 transistor (see text); 1—CK705 diode; 1—self-generating photocell (International Rectifier Corp. B-15); 1—Superex-Grayburne type EFL loopstick; 1—mercury cell (Mallory RM-625-RT or equivalent); 1—s.p.s.t. slide switch; 2—phone tip jacks; 1—5-pin hearing-aid tube socket; 1—piece of clear plastic; 1—nonmetallic case; 1—piece of ¼-inch shaft; 1—knob; 1—antenna wire and clip.

Most people are amazed by the volume and selectivity obtainable from such a simple circuit. Strong stations are loud enough to be heard with the phones pushed back from the ears. Selectivity is good enough to separate three stations located at 1550, 1450 and 1230 kc and it "takes some going" to do this with only one tuned circuit. Full credit for this achievement goes jointly to the super loopstick and the high-gain transistor. END

"Little Giant" Transistor Radio

By L. M. Dezettel

SMALL IN SIZE but giant in performance, this little radio makes an ideal project for beginners, students and experimenters. Beginners will appreciate its simplicity which practically eliminates the possibility of wiring errors, while experimenters will welcome the opportunity to work with transistors which have only recently come into general use.

For so small a set, this "Little Giant" offers surprising selectivity. Even stations which are very close together can be separated without difficulty, and strong stations will come in with sufficient power to drive the built-in loudspeaker to room-volume levels. A headphone jack is provided for reception of the more distant stations.

The little radio is completely divorced from the power line and, therefore, presents no shock hazard. All of the necessary operating power is supplied by a single long-lasting 4½-volt battery.

Construction: The simplicity of this little set is illustrated by the schematic diagram in Fig. 1. In order to prevent crowding of parts and to simplify construction, the model was built into a commercially available aluminum case which is actually much larger than necessary. Since the placement of parts is not at all critical, the receiver could be built into a much smaller housing.

Assembly and wiring of the receiver can easily be accomplished by following the illustrations in Figs. 2 through 5. The spacing and diameters of the case mounting holes are shown in Fig. 2. Unless otherwise marked, all hole diameters are made to clear No. 6 screws. Before drilling the case, all of the necessary parts should be purchased. If it is necessary to substitute some of the components listed in the parts list with units by other manufacturers, some of the hole spacings may need to be changed to accommodate the parts on hand.

The speaker opening can be cut out with a circle cutter or an ordinary coping saw and file. The latter tools can also be used for the rectangular switch cutout and for the ½-in. holes. A tapered reamer, if available, will simplify the job of making the ½-in. holes by enlarging No. 6 holes to the required sizes.

After drilling the case, the large parts can be fastened in place as shown in Fig. 4. The hardboard block which mounts the transistors should be prewired before being fastened in place by means of the two lower speaker-mounting screws and nuts. To prevent damaging the transistors while soldering, the leads should be left long and, during the soldering operation, each lead should be held firmly with a pair of long-nosed pliers. The pliers will conduct some of the heat away from the transistor.

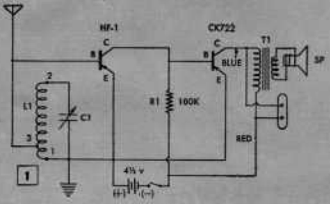
The variable capacitor is fastened to the front of the case with two 6-32 x ¼-in. machine screws which fit into corresponding holes in the capacitor frame. If these screws are too long, so that they interfere with the rotation of the capacitor plates, one or more small washers can be inserted between the capacitor frame and the case to eliminate this difficulty.

The battery is fastened to the case cover with a homemade bracket, as shown in Fig. 3. The positive (+) battery terminal is grounded to a solder lug.

Final assembly and wiring are shown in Fig. 5. The r.f. coil is soldered securely to the grounded lug of the antenna terminal strip. It is important that the coil be mounted by its No. 1 lug which can be identified from the detailed coil drawing.

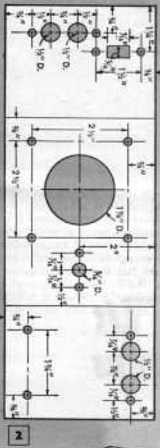
Operation: A good outdoor aerial and ground are essential for proper operation of this simple receiver. While excellent results have been obtained with an outdoor TV antenna (by disconnecting the lead from the TV set, twisting the two wires together, and connecting this to the "antenna" terminal of the radio), reception will be even better with a good radio aerial. A cold-water tap or a rod driven into the earth will serve as a ground.

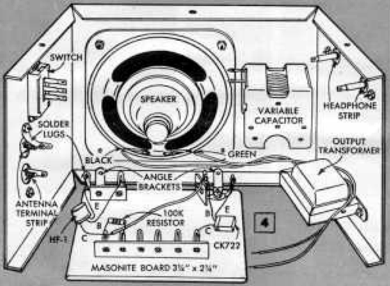
Broadcast-band aerials are available in kit form from most radio-parts distributors. These kits, some of which cost less than one dollar, are complete with all parts and installation instructions. ★ ★ ★

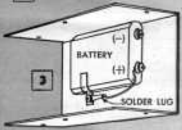


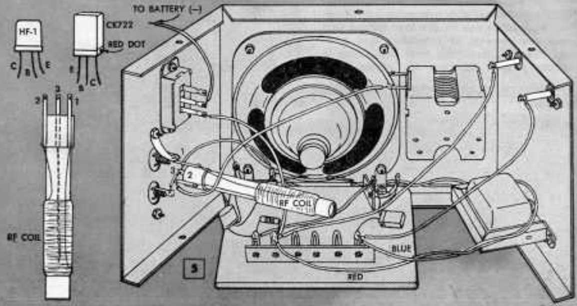
LIST OF MATERIAL

1—High-frequency transistor, Marvelco HF-1
1—Audio-frequency transistor, Raytheon CK722
1—3-in. loudspeaker, Jensen 3J6 (SP)
1—Resistor, 100,000 ohm, ½ watt (R1)
1—4½-volt battery, Burgess 5360
1—Slide switch, S.P.D.T.
1—Output transformer (T1), 8000 ohm to 3.2 ohm, Stancor A3329 or equiv.
1—Single gang, midget variable capacitor (C1), 365 or 375 mmfd. Allied 61H009 or equiv.
1—Transistor r.f. coil, Allied RK-121101 (L1)
1—Aluminum case, 3 x 5 x 4 in. ICA 29340
1—Knob with setscrew, for ¼-in. shaft
1—Antenna-ground term. strip
1—Headphone jack strip
3—1-terminal tie-points
1—6-terminal tie-point
2—Angle brackets
4—Solder lugs









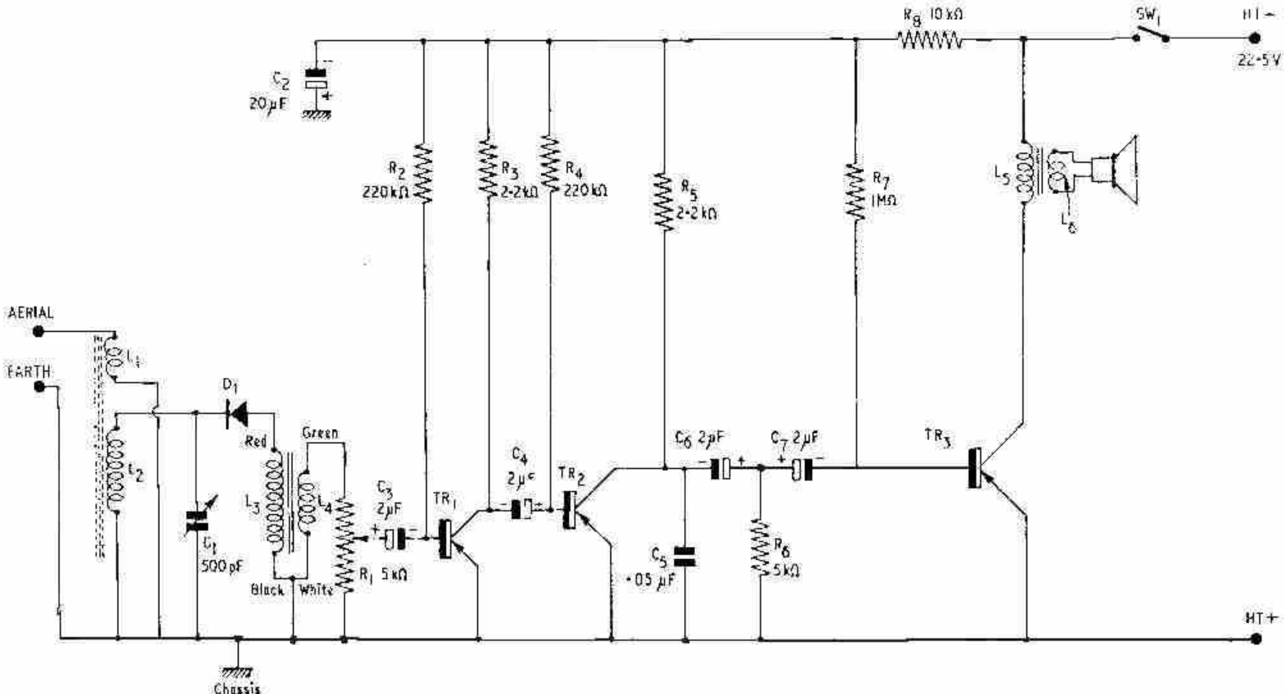
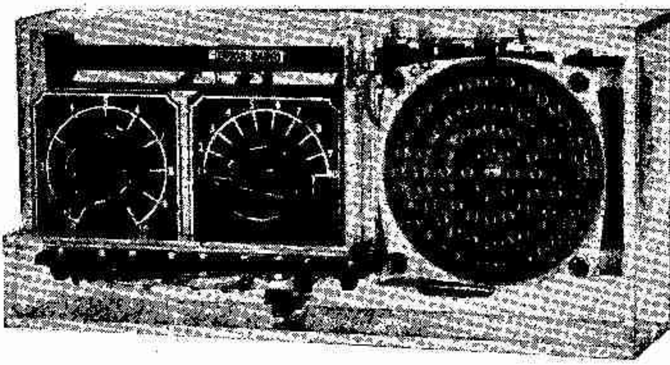


FIG. 1.

Fig. 1. The complete circuit of the Transistorette

The "TRANSISTORETTE"



PART 1. *by* **G. A. FRENCH**

Introducing the miniature transistor receiver which created so much interest when it was exhibited at the last National Radio Show at Earl's Court

As soon as transistors became available on the British market, *The Radio Constructor* commenced experiments in order to produce a practicable transistor receiver which could be built at home by the amateur. A considerable amount of development work was undertaken, and, as a result, we now introduce the little receiver which is to be described in this and the following articles.

This receiver, the Transistorette, is intended to provide good loudspeaker strength reception on the medium-wave band with the aid of a short aerial and an earth connection. Headphones are not required. It is hoped, at a future date, to dispense with the aerial and earth connection and make the receiver fully portable; and further experimental work to this end has already been set in progress. In the meantime, it is pointed out that the present version, requiring the aerial and earth system, is capable of giving excellent results in its existing form, and that it represents the nearest approach to a really "personal" transistor receiver yet to be described in the British constructional press. It is also emphasised that, apart from one or two resistors and similar small components, the receiver now under discussion will be capable of lending itself to the future modification for portable working without the necessity of any changes to the main chassis assembly at all. What extra circuitry is required will be accommodated by a small "add-on" chassis assembly. In consequence, constructors who built the present receiver will not have to make major changes when modification details are later published.

The Circuit

The circuit of the Transistorette is given in Fig. 1. As may be seen, the receiver consists of a three-transistor a.f. amplifier following a simple detector and input tuned circuit. It would be advisable to commence the theoretical consideration of this circuit by starting at the output stage and working backwards.

The output stage consists of a Brimar transistor type TJ3 (TR_3 in Fig. 1) operated as an earthed emitter a.f. amplifier. This choice of operation is due to the fact that the earthed emitter circuit enables maximum gain to be obtained from the transistor. It is probable that slightly increased power output would be obtainable if the output transistor stage were employed in an earthed base circuit, but critical listening tests did not detect any significant difference between the two different modes of operation. So far as practical circuitry is concerned, the earthed emitter arrangement has the additional advantage of enabling a very simple biasing arrangement to be employed without the need for separate biasing supplies. Since it was intended that the completed receiver be made to function from a single battery, this point, whilst not of itself being sufficient to justify the choice, had nevertheless to be taken into full account.

The h.t. current flowing through the emitter-collector circuit of the output transistor is approximately 2.25mA. Assuming negligible resistance in the speaker transformer primary, such a current indicates a dissipation in this transistor of some 51mW (the h.t. voltage is 22.5). The maximum total dissipation figures quoted by Standard Telephones and Cables for the transistor used here is 200mW at 20°C., and 100mW at 50°C. Thus, the output transistor is operated well within its maximum dissipation figure.

Due to the component values employed in the output stage, a very good match into the loudspeaker transformer primary is achieved. With negligible distortion it is probable that at least 30mW of audio are fed to the speaker. If distortion is allowed to occur (due to overload) a higher power output is available. The distortion given by overload is not of an unpleasant nature, fortunately, and can be tolerated without discomfort. Overloading would normally occur only during heavy peaks in, say, a musical programme or in a programme in which speech and music are interspersed. The loudspeaker specified for the Transistorette is very sensitive for its size, and the output of this little set compares most favourably in practice with that of a conventional "personal" portable employing valves.

The bias for the output transistor is obtained via the 1MΩ resistor R_7. This resistor plays an extremely important part in the output stage since it limits the bias current passed by TR_3 to a safe value. If R_7 should happen to be accidentally reduced in value, the output transistor bias current would increase, thereby possibly increasing the collector current beyond its safe maximum. Before proceeding further, it must be pointed out that the value of R_7 can be accidentally decreased by mounting it on a "leaky" tag panel, by accidentally bridging it with the hands or fingers, or by carelessly applying the prods of a test meter to it. For these reasons, some care has to be taken when handling the chassis of this receiver when the h.t. battery is connected. The golden rule with this, as indeed with almost all other transistor receivers, is to disconnect the h.t. supply before making internal adjustments to the receiver.

A further precaution to limit the bias current to TR_3 is provided by the input circuit to its base. Fig. 2 (*a*) shows the usual method of coupling one transistor stage to the next when earthed emitter circuits are employed. The circuit of Fig. 2 (*a*), however, suffers from one important disadvantage. This is the fact that, when the h.t. voltage is switched off, the coupling condenser between the two transistors is discharged. As soon as h.t. is switched on, therefore, this condenser commences to charge, causing a momentary charging current to pass through the collector load resistor of the first transistor, and the internal base-emitter path of the second transistor. This momentary charging current results in the sudden application of a high value of bias current to the second transistor, causing a similiarly high collector current. At low operating voltages such surges are normally within the rated maximums of the transistors concerned, but at higher operating voltages, such as are found in the output stage of the Transistorette, they might result in damage. To ignore such surges would be definitely unwise.

In the Transistorette a simple surge limiting circuit is provided by means of the arrangement illustrated in Fig. 2 (*b*). When the h.t supply is switched on in this circuit the initial charging current to C_6 passes through R_5 and R_6. A very small momentary voltage appears at the upper end of R_6 at the instant of switching on, but the resultant charging current through C_7 and the base-emitter path of TR_3 is considerably smaller than that occuring in Fig. 2 (*a*). Because of this, relatively high h.t. voltages may be employed for TR_3 without risk of damage due to surges.

It will be noted that the two electrolytic coupling condensers in Fig. 2 (*b*), C_6 and C_7, are fitted into the circuit such that their positive plates connect to R_6. This method of connection is correct because the upper end of R_6 is at chassis potential, so far as d.c. is concerned, whilst both the collector of TR_2 and the base of TR_3 are at negative potential.

From the point of view of a.f. amplification, the circuit of Fig. 2 (*b*) gives similar results to that of Fig. 2 (*a*). The 5kΩ resistor R_6 causes little diminution in a.f. voltage (the collector load resistor for TR_2, R_5, has a value of 2.2kΩ only) and the two condensers in series replace the single condenser of Fig. 2 (*a*).

TR_1 and TR_2

The circuit of Fig. 2 (*b*) is, of course, that employed in Fig. 1 to provide coupling between TR_2 and TR_3. Not shown in Fig. 2 (*b*), however, is the 0.05μF condenser C_5. The purpose of this condenser is mainly that of tone correction; although it may help, in one or two instances, to reduce any possible r.f. instability which may be caused by the relatively high gain of the a.f. strip at supersonic frequencies.

TR_1 and TR_2 are Brimar transistors type TJ2, and they form a conventional two-stage transistor a.f. amplifier. Both function in earthed emitter circuits. The two transistors are operated at a lower h.t. potential than that supplied to the output transistor, this lower potential being provided through the resistor R_8 decoupled by the condenser C_2. As a result of the lower h.t. voltage, surge precautions as used in the output stage are not required, and the more conventional transistor circuitry can be employed. This state of affairs does not infer, incidentally, that component values can be altered by any large amount from those shown in the parts list. If optimum results are required, component values in the TR_1 and TR_2 stages are still somewhat critical. The h.t. potential applied to TR_1 and TR_2 (i.e. that appearing across the decoupling condenser, C_2) lies between 7 and 9 volts.

The input circuit for TR_1 is very simple, consisting of the deaf-aid type step-down transformer L_3, L_4. The secondary of this transformer, L_4, connects to the 5kΩ volume control R_1, the a.f. tapped off by the slider of this potentiometer being passed to the base of TR_1 via C_3. (The isolating condenser, C_3, is needed because the base of TR_1 requires a small negative bias potential with respect to chassis, and this would otherwise be short-circuited by R_1.)

Signal selection is provided by the tuned circuit L_2, C_1. The r.f. appearing across this circuit is applied to the primary, L_3, of the step-down a.f. transformer via the germanium diode D_1. The self-capacity of L_4 is sufficient to by-pass the r.f. appearing in the rectified output from D_1 and no further r.f. filtering is required. L_2 is wound on a long ferrite core as this enables a tuned coil to be obtained with a high value of Q. The coil assembly is very similar in practice to a "ferrite frame" and it is, in fact, possible to obtain weak signals with this alone. However, performance in this respect can by no means be guaranteed, and it is pointed out again that the main reason for using the ferrite core is given by the high value of Q that it provides.

The coupling winding L_1, which is also wound on the ferrite core, enables an aerial and earth to be connected to the receiver.

Components List for the Transistorette

Resistors

All ¼ or ⅛ watt. (See note below).

R_1	5kΩ volume control with s.p.s.t. switch. Radiohm miniature. (H. L. Smith, Edgware Road).
R_2, R_4	220kΩ, 10%
R_3, R_5	2.2kΩ, 10%
R_6	5kΩ, 20%
R_7	1MΩ, 10%
R_8	10kΩ, 20%

N.B.—Maximum individual resistor dimensions are 7/16in. long by ⅛in. diameter. These may be specified as ¼W or ⅛W by different suppliers.

Condensers

C_1	500pF bakelite dielectric (linear capacity). (Wavemaster)
C_2	20μF 12V Pk. wkg. T.C.C. type CE30B
C_3, C_4, C_6, C_7	2μF 150V Pk. wkg. T.C.C. type CE30B
C_5	0.05μF 200 W.V. T.C.C. Miniature Metalmite (case insulated) or equivalent wax finish

Inductors

L_1, L_2	Ferrite Frame, medium-wave, type QFR1 (Osmor)
L_3, L_4	Hearing-aid a.f. transformer. Type T100 (Multitone)
L_5, L_6	Output transformer, "Transistorette Miniature"—7,000Ω. (H. L. Smith, Edgware Road)

Transistors and Diode

TR_1, TR_2	Junction transistor type TJ2 (3X/301N) or T.S.2—Brimar
TR_3	Junction Transistor type TJ3 (3X/302N) or T.S.3—Brimar
D_1	Germanium Diode type GD3—Brimar

Loudspeaker

2½in. cone diameter, type 2P/O1 (Elac)

Battery

22.5 volt hearing-aid battery. Type B110 or B122 (Ever-Ready).

The Aerial System

Due to the low input impedance offered by L_1, an earth connection is desirable in addition to an aerial. Although the necessity for an earth connection may appear at first sight to be a disadvantage, quite the reverse holds true in practice. The reason for this is that it is in many cases possible to obtain a certain effective pick-up through the earth connection itself, whereupon only a short aerial wire is needed. If, for instance, the earth terminal of the receiver is connected to, say, the mains conduit in a house, adequate sensitivity can often be obtained with the aid of an aerial only five to ten feet long. The same applies to any other effective earths which may be available where the set is to be used. Such earth connections may be given by water pipes, wire fences and so on. To quote examples experienced with the prototype, it was possible to obtain excellent reception of the Light Programme and Home Service in the London area with a "flex" aerial only ten feet long. The various earth connections employed were water pipes, mains conduit and the metalwork of a telephone dial. In another locality similar results were given merely by twisting the earth lead several times around the mains flex to a reading lamp. The coupling in this case was provided by the capacity existing between the two leads. By the use of techniques such as this, there is no reason why the receiver should not be able to give good results when used as a travelling companion in hotel rooms, on picnics or in similar locations. The use of a short aerial, incidentally, assists in reducing any damping of L_2 which may occur.

In localities where interference is very high, the simple tuning arrangements employed in this version of the receiver may not be adequate for clear reception of the local medium wave transmitters. In such instances it may be necessary to fit an external wavetrap in order to improve selectivity. This point is dealt with later in this present series of articles.

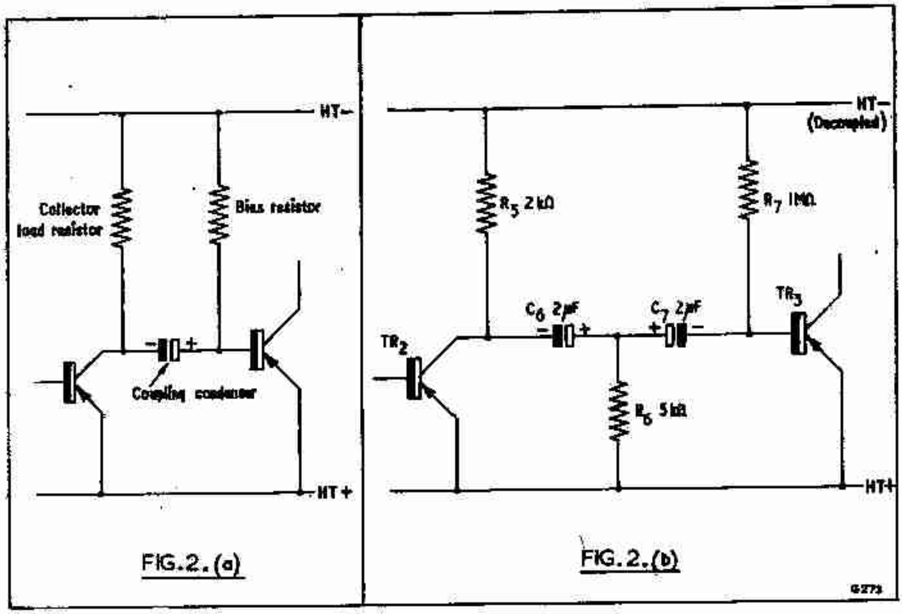


Fig. 2(a). A typical resistance-capacity coupling circuit as fitted between two earthed-emitter transistors. (b). The coupling circuit used to feed the output stage of the Transistorette. This circuit has the advantage of obviating bias current surges at the instant of switching on the h.t. supply

Precautions

As readers will be aware, great care has to be taken when working with circuits which employ transistors. This is due to the fact that, should any mistakes be made in the application of voltage to any transistor, it can be immediately and irrevocably ruined. This point has already been discussed above in some detail with regard to the bias circuit for TR_3. The following reminders may help to show some of the other precautions which should also be taken.

1. Never connect an h.t. battery to transistor equipment with incorrect polarity, or the transistors will almost certainly be damaged. In the Transistorette the chassis is *positive* and h.t. rail *negative*. Connecting the h.t. battery wrong way round will burn out TR_3 and will possibly damage TR_1 and TR_2 as well.

2. Never make any circuit adjustments or even handle the components in the Transistorette circuit whilst the h.t. battery is connected. Accidental surges may easily damage a transistor, and it is very easily possible for one's hands or fingers to bridge critical components with resultant damge.

3. If testmeter readings must be taken when the h.t. supply is connected, care should be taken in the choice of test points. In the construction of the Transistorette no test readings (apart from those given by a milliammeter in series with the h.t. supply) are required at all. Voltage readings at transistor terminals should not be taken unless it is certain that the current flowing through the meter will not cause excess bias current to flow in the transistor. Ohmmeter readings, when the h.t. supply is switched on, may also cause trouble if the internal battery in the meter happens to be connected such that it applies additional bias current to a transistor.

4. If a transistor amplifier breaks into violent a.f. oscillation it is advisable to switch off at once. This is due to the fact that excessive a.c. voltages could cause damage. The fault causing the oscillation should be rectified by normal test procedure with the h.t. switched off or reduced in voltage.

The above precautions may appear at first sight to err on the side of excessive caution, but the writer would be failing in his duty to his readers if he did not draw their attention to them. It will be remembered that transistor replacements are liable to be somewhat expensive.

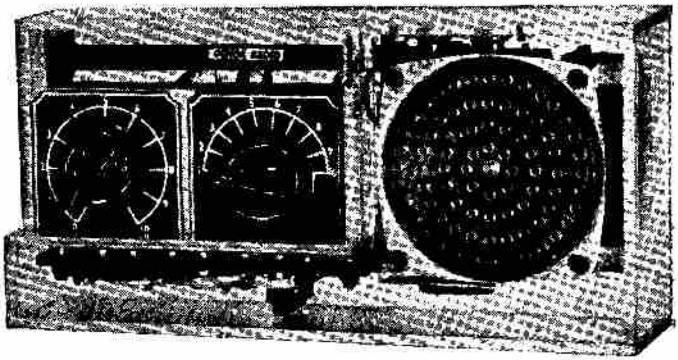
The Transistorette Supply

In the Transistorette a fairly high h.t. potential (22.5 volts) is employed. It is advisable, when the receiver is being tested immediately after construction, to employ a much lower voltage than this to guard against possible component failures and mistakes in wiring, etc. One of the best methods of checking the receiver consists of employing two 9-volt grid bias batteries in series to provide h.t. for testing purposes, these being connected to the set via a moving-coil milliammeter whose f.s.d is 10mA or thereabouts. During tests, the h.t. voltage may then be tapped up in 1.5 volt stages, whilst an eye is kept on the milliammeter for excess current. The Transistorette will function reasonably well during test, incidentally, with an h.t. potential between 6 and 9 volts only.

Next Month

In next month's article, the first constructional details of this modern receiver will be given.

The "TRANSISTORETTE"



PART 2. *by* **G. A. FRENCH**

This article is the second in the series describing this modern miniature transistor receiver, and it discusses the chassis-work which is needed for its construction

LAST MONTH WE INTRODUCED THE TRANSISTORETTE, and we dealt with its circuit from the theoretical point of view. We also discussed the various precautions which should be observed during its construction and testing in order to prevent damage to the transistors. It is pointed out again here that these precautions must be kept in mind continually whilst the receiver is being made and checked. They will be further referred to at the appropriate places in the wiring instructions.

Metal-work

Several items of metal-work are required for the receiver, and these should not present any serious difficulties to the home constructor who has the simple metal-working tools found in the average amateur radio workshop. A steel rule, a small vice, a centre punch, and a hand brace are practically all that is required in addition to the essential screwdriver and pliers. Owing to the small dimensions of the completed receiver a slightly unconventional chassis layout is used, and the dimensions of the individual parts are fairly critical if the whole assembly is to fit together in a "professional" manner. A tolerance of $\pm\frac{1}{32}$in should prove to be more than adequate for all chassis dimensions, and such a tolerance may be obtained quite easily with the simple tools mentioned above. It should be pointed out that no harm will result if the chassis assembly is made up outside these tolerances (provided, of course, that adequate clearance is maintained between adjacent electrical connections), and the newcomer to metal-work need not feel, therefore, that anything that is at all ambitious is required of him.

The first metal part to make up is the main chassis holding the tuning condenser and volume control. The dimensions of this are given in Fig. 3 and Fig. 4. The chassis shown in these diagrams is made from aluminium of between 14 and 18 s.w.g.

Contrary to the normal practice of some amateurs, it may be found advisable in this instance to drill the holes in the main chassis *after* bending. The reason for this is that inaccuracies in bending could cause holes drilled beforehand to appear in slightly incorrect positions. It is also possible that, due to the softness of the metal, the $\frac{1}{4}$in dimension shown in Fig. 4 for the width of the side apron may not be maintained after bending. A touch with a file should normally clear any inaccuracies here.

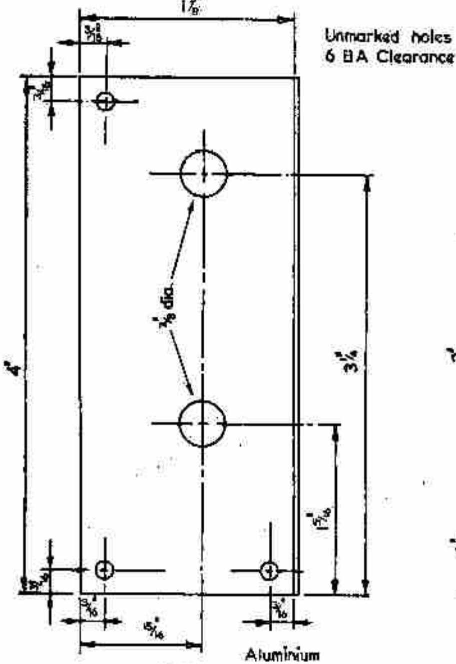


Fig.3.

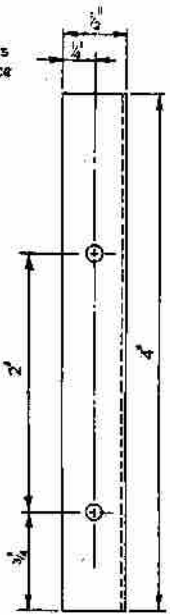


Fig.4.

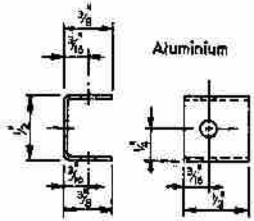


Fig.5.

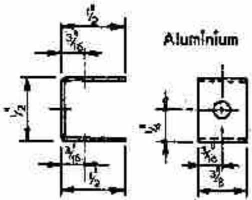


Fig.6.

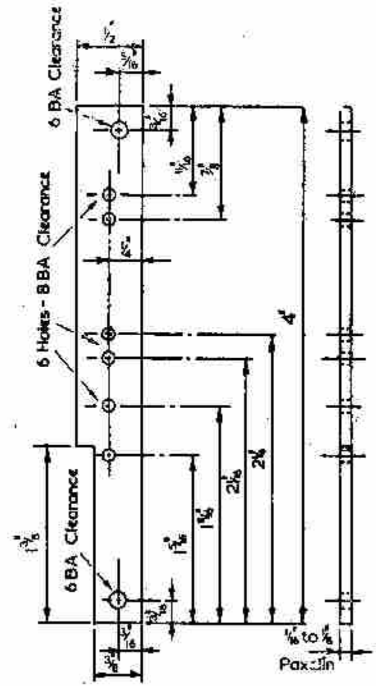


Fig.7.

Fig. 3. Front view of the main chassis of the Transistorette. The material is 14 to 18 s.w.g. aluminium sheet, and all holes are 6-BA clearance (No. 32 drill) unless otherwise stated. Fig. 4. Side view of the main chassis. The two holes are 6-BA clearance. Fig. 5. The "inner" bracket. The material is 14 to 18 s.w.g. aluminium and all three holes are 6-BA clearance. Fig. 6. The "outer" bracket. This uses the same material and has the same diameter holes as the bracket of Fig. 5. Fig. 7. The dimensions of the the condenser-support strip. The 8-BA clearance holes shown may be made with a No. 41 or 42 drill

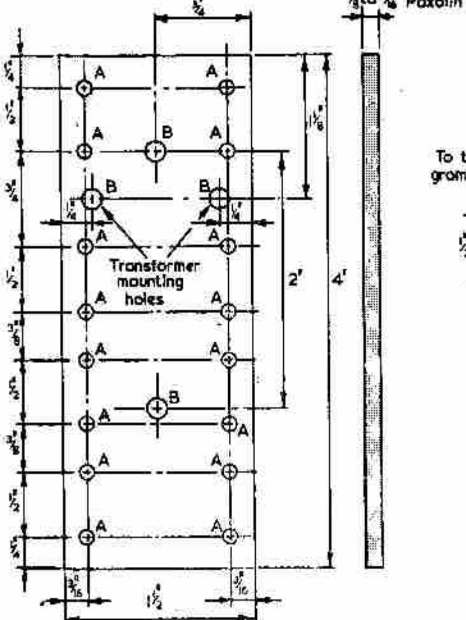


Fig. 8.

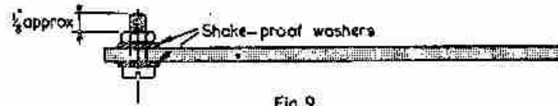


Fig. 9.

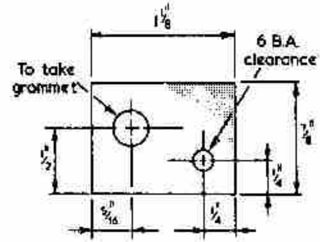


Fig. 10.
(Paxolin)

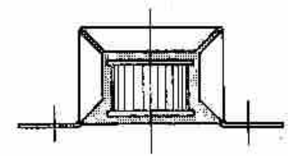


Fig. 12.

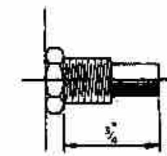


Fig. 13.

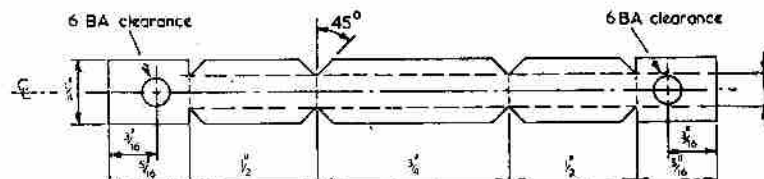


Fig. 11.
(Aluminium)

Fig. 8. The transistor tag-board. This is made from s.r.b.p. of thickness 1/8 to 3/16 inch. Holes marked A are 8-BA clearance; and those marked B are 6-BA clearance. Fig. 9. This diagram illustrates the method of mounting the individual 8-BA nuts and screws to the transistor tag-board. Fig. 10. Dimensions of the brackets used for mounting the ferrite core of the aerial coil. Two of these brackets are required. The material is thin s.r.b.p. Fig. 11. The clamp required for the Multitone hearing-aid transformer. Fig. 12. Showing how the clamp of Fig. 11 is folded to fit around the laminations of the transformer. Fig. 13. The dimension to which the tuning condenser and volume control spindles should be cut before assembly

The next parts to make are the two brackets shown in Figs. 5 and 6. These are called, respectively, the "inner" and "outer" brackets, and they are made of the same material as the main chassis. Although rather small in size, they should not prove too difficult or fiddling to make. Owing, once more, to the softness of the material used, it might be advisable to cut out these brackets a little oversize before bending, after which operation they may then be quickly cleaned up with a file. As was just mentioned, and in common with all the other parts used in the construction of this receiver, a high degree of accuracy is not essential provided that the essential electrical clearances are maintained. Nevertheless, a little care in the construction of the metal work at this stage pays good dividends, since it can result in a very neat looking job when the whole receiver is completed.

The Transistor Tag-board

The transistor tag-board follows, its dimensions being illustrated in Fig. 8. This is a most important part of the assembly because it mounts the various tag-spills together with the three transistors and the miniature deaf-aid a.f. transformer. The tag-board should be marked out with reasonable care before drilling, this precaution obviating any troubles at a later date due to difficulties of component spacing, etc. The tag-board is made from s.r.b.p. also.

As will be seen from Fig. 8 there are two rows of 8-BA clearance holes along either side of the transistor tag-board. These holes are intended to accommodate 8-BA brass nuts and screws; these acting as the actual tag-spills to which the various soldered connections are made. 8-BA screws are employed for this purpose because it would almost certainly be difficult for the constructor

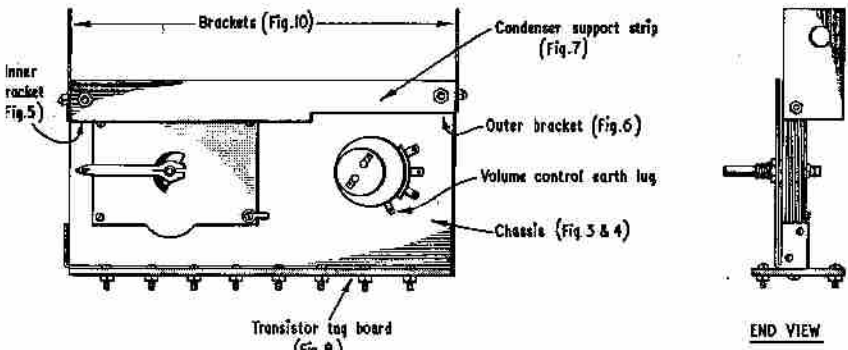


FIG.14.

Fig. 14. *How the main parts of the chassis are assembled*

The condenser support strip comes next, and its dimensions are given in Fig. 7. This strip is a piece of s.r.b.p. which supports some of the electrolytic condensers used in the a.f. amplifier. The term s.r.b.p. stands for "synthetic resin-bonded paper" and is a generic term for most of the well-known range of insulating materials described under trade-names such as "Paxolin," etc. The s.r.b.p. used for the condenser support strip should have a thickness of between $\frac{1}{16}$ and $\frac{1}{8}$ of an inch.

to obtain the small solder tags which would otherwise be required, and which might also need to be eyeletted instead of bolted to the tag-board. If the constructor has access to small two-way solder tags capable of being held under 8-BA nuts, these could be used as soldering spills instead of the screws suggested here. In practice, however, very little advantage would be given by such tags as the screws themselves form quite efficient and practical spills. 8-BA screws are used instead of 6-BA screws because the latter, being larger, retain the heat of the soldering iron for too long a period.

After completion of the tag-board, the 8-BA brass nuts and screws may be fitted. Before this is done, however, the individual nuts and screws should be de-greased in order to facilitate soldering. De-greasing can be carried out by standing the nuts and screws for a time in a small container of petrol, carbon tetrachloride, or similar solvent. (Carbon tetrachloride is available from any chemist in the form of an inexpensive proprietary household cleaning fluid.)

The individual 8-BA nuts and screws are mounted as shown in Fig. 9. It will be seen from this diagram that approximately $\frac{1}{8}$in of each screw should project above its nut. If long screws are used, these can be cut after mounting. Shake-proof washers under both nut and screw-head are desirable, as these will help to prevent the screws working loose after soldering. It will be remembered, of course, that once the soldering iron has been applied to a screw its nut will become soldered to its threads, thereby preventing any subsequent adjustment of tightness.

The next job is the construction of two small brackets of the type shown in Fig. 10. These brackets are made from thin s.r.b.p. of approximately $\frac{1}{32}$in thickness, and they hold the grommets which, in turn, hold the ferrite core of the aerial coil. These brackets have to be made of insulating material instead of metal in order to prevent losses in the ferrite core material. Metal brackets could constitute a single "shorted turn" around the ferrite rod. The grommets, incidentally, are supplied by the manufacturers with the coil.

The Transformer Clamp

All that now remains at this stage is a clamp for the deaf-aid step-down transformer. The dimensions for this clamp, in its flat state, are given in Fig. 11, and the clamp should be made from very thin tinplate, copper strip, or similar material. One of the easiest ways of constructing this clamp consists of cutting it out initially and then bending it carefully around the laminations of the transformer itself. The greatest care should be taken during this operation in order to prevent damage to the transformer, this being somewhat fragile and capable of being damaged by a slip of a tool. The transformer, fitted with its clamp, should have the appearance shown in Fig. 12.

This completes practically all the metalwork with the exception of the mountings for the h.t. battery. This mounting is dealt with in the later article which describes the construction of the cabinet.

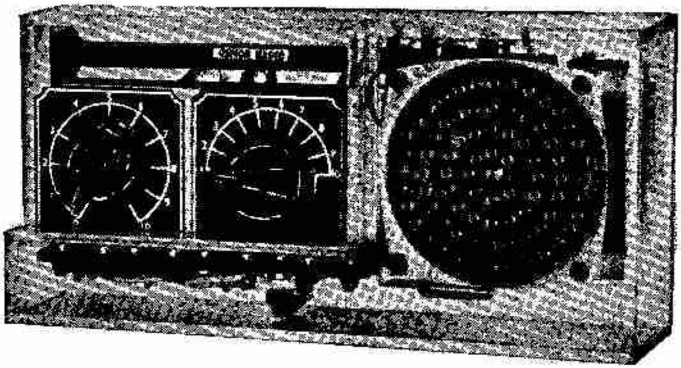
Assembly

The assembly of the various chassis parts may now commence, together with the fitting of the volume control and tuning condenser. Before these two components are mounted, however, their spindles should be cut to the dimension illustrated in Fig. 13. The appearance of the complete assembly is illustrated in Fig. 14.

Next Month

In next month's article we shall carry on to the wiring and testing of this little receiver.

The "TRANSISTORETTE"



PART 3. *by* **G. A. FRENCH**

This article is the third in the series describing this modern transistor receiver, and it deals fully with the wiring and testing of the completed chassis

In last month's article we discussed the various parts which go together to make the chassis of this miniature receiver. We ended by assembling the principal parts and components in readiness for wiring up. We shall now carry on to discuss that process.

Precautions

Before proceeding further, however, it would be very advisable at this stage to reiterate the simple precautions which are necessary when building a miniature receiver employing transistors. Apart from the care which is normally needed when wiring up any miniaturised equipment, especial attention has to be paid in this case to the question of preventing damage to the transistors by overheating. Amongst other things, such overheating can be caused by holding the iron too long against the lead-out wires whilst soldering the transistors into position.

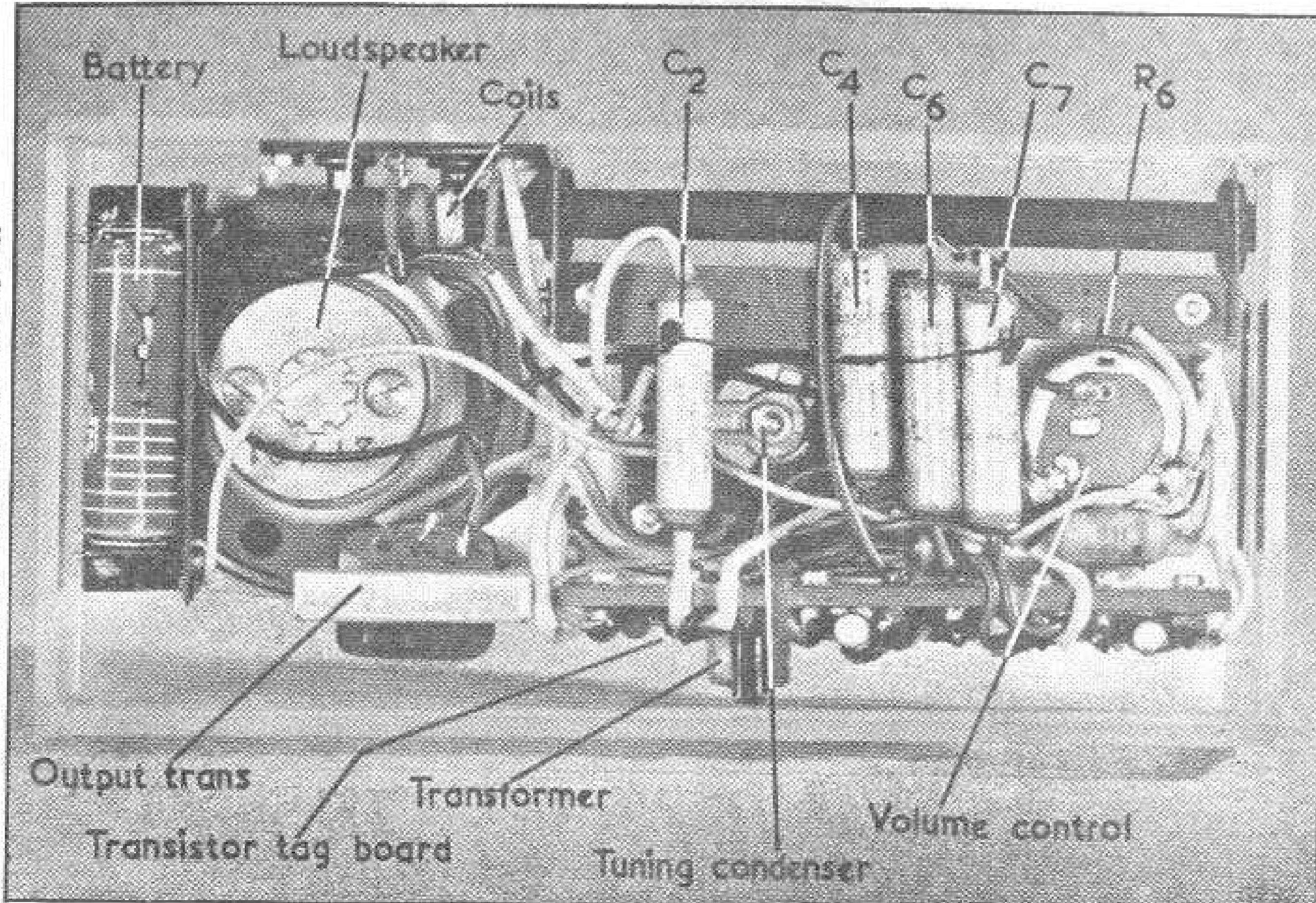
Because of this possible trouble, three precautions are recommended in the present design. Firstly, the transistor lead-out wires are cut some distance away from the body of the transistor, even when this necessitates folding the appropriate lead-out wire back on itself. Secondly, the transistors are the last components to be fitted to the chassis. And, thirdly, they are connected by "laid-on" joints.

These "laid-on" joints are obtained by previously soldering the tag-spills to which the individual transistors are to be connected. The appropriate length of the transistor lead-out wire is next quickly tinned and laid against its tag-spill. A quick application of the soldering iron then causes the solder on the tag-spill to cover the lead-out wire and a quite satisfactory joint results. This joint should be just as good as that given by the more normal method of twisting the appropriate lead around its tag before soldering, and it has the considerable advantage of reducing any possible risk of overheating the transistor. It also enables transistors to be removed from the chassis in a similarly quick manner, should this ever be required.

Wiring

We may now commence with the wiring details proper for this receiver. The first step is illustrated in Fig. 15. To facilitate simplicity of presentation, the resistors and condensers shown in this and succeeding wiring diagrams may not necessarily be drawn exactly to scale.

Fig. 15 shows the view looking at the back of the receiver chassis. The row of 8-BA



View from rear, with main components identified tag-spills shown are those which are closer to the reader's eye. The other row of tag-spills are not employed in this or any succeeding diagram which gives this view. Note that the miniature deaf-aid transformer is also mounted at this stage, its clamp being secured by two short 6-BA nuts and bolts to the "transformer-mounting holes" of the transistor tag-board. (See Fig. 8 of last month's article.) The transformer is mounted such that its green lead leaves the transformer bobbin on the side shown in Fig. 15. As was mentioned last month, the transformer should be handled with reasonable care in order to avoid damage.

Apart from the three tags connecting to the potentiometer section, there are three further tags on the volume control. Two of these, to the left in Fig. 15, are those of the on-off switch, and the third (designated in Fig. 14 of last month's article) is the earth lug integral with the metal case of the volume control. This point is mentioned in order to stress the importance of connecting the switch circuit correctly. The earth lug on the volume control also supplies the earth connection to the metal parts of the chassis.

R_8 and C_3 in Fig. 15 should be positioned such that they lie below the level of the condenser support strip. This is done to allow room for later components to be fitted. As C_3 has a metal case it is advisable to insulate this in order to prevent its touching adjacent metal parts and, in consequence, giving rise to crackles. Adequate insulation may be given by wrapping thin cellulose tape over the metal part of the condenser or by fitting it with a thin insulating sleeve. This type of condenser may be available from some suppliers, incidentally, already fitted with an insulating sleeve. It must, of course, be connected into circuit with correct polarity. Condenser C_5 is mounted close to the back of the transistor tag-board and has to lie only below the level of the bottom edge of this board. In practice it fits in comfortably between the volume control and the tag-board.

The wiring shown in Fig. 15 is self-explanatory and requires little further discussion. Although not shown, all leads should be insulated with sleeving which must cover the appropriate wires right up to their respective soldered connections. Almost any bare lead, with the consequent risk of short-circuits in the miniaturised layout used here, is inviting future trouble or even possible accidental damage to the transistors. All joints marked "X" in this and successive wiring diagrams should not be soldered, as subsequent leads have to be fitted to the solder tags so designated.

The next stage in the wiring is illustrated in Fig. 16. This stage adds C_2, C_4, C_6, C_7 and R_6. C_6 and C_7 are connected together at their positive ends by means of a twisted joint, R_6 being connected also to this twisted joint. The joint is, of course, subsequently soldered. As C_4, C_6 and C_7 lie very close to each other, crackling may be caused by their metal bodies touching each other. This trouble can be obviated by insulating the body of C_6 in the same manner as was described above for C_3. The four electrolytic condensers should be mounted such that they lie horizontally, their ends resting on the condenser-support strip as illustrated in Fig. 16. In such a position they should then be situated just below the level of the transistor tag-board.

Some of the connecting leads from the four electrolytic condensers pass over the edge of the tag-board to connect with the appropriate tag-spills on the front. These leads should lie close to the edge of the tag-board. The negative lead from C_4 will probably not be sufficiently long to reach the tag-spill shown for it in Fig. 16. If this occurs it may be extended, the consequent joint being adequately covered with sleeving.

Some care will be needed in positioning the four electrolytic condensers, this being due to the fact that excessive strain on their wires may cause damage at the lead-out points. It is possible in consequence that the condenser lead-out points will overhang the condenser support strip. This is unimportant so long as they will not foul the Ferrite rod of the aerial coil when it is later fitted. It must also be pointed out at this stage that the lead-out wires at either end of the electrolytic condensers are anchored to metal plug-like terminals. It is important to ensure that, at the transistor tag-board end of the individual condensers, the sleeving used covers both the lead-out wire *and* these anchoring terminals. Otherwise, short circuits to the 8-BA bolt-heads may occur.

After wiring, the condensers are secured to the condenser-support strip by means of thread. A length of this thread should be looped and its two ends passed through the pair of holes in the support strip which is adjacent to the particular condenser or condensers to be secured. The ends are then brought round the underside of the support strip, up around the body of the condenser and tied securely. C_2 and C_4 are fixed individually in this manner, whilst C_6 and C_7 are secured together. The knots in the thread may afterwards be painted with varnish to prevent their working loose.

The three "fly-leads" shown in Fig. 16 can be from two to three feet long and should employ flexible wire. These leads are used for testing the receiver and will be later cut down for connection to the h.t. battery and speaker transformer when the set is installed in its cabinet. It is very advisable to use red and

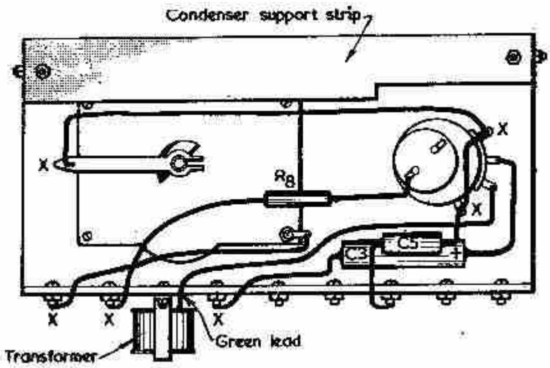


FIG. 15.

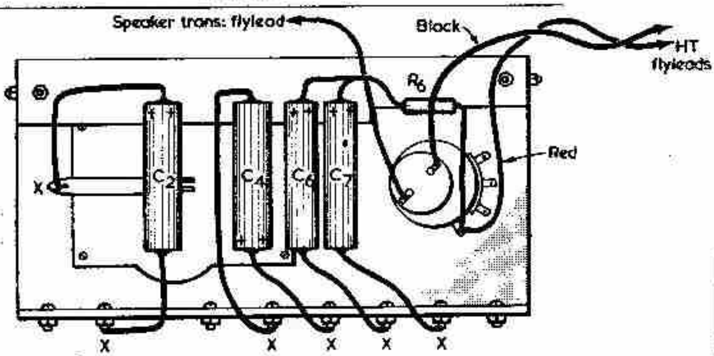


FIG. 16.

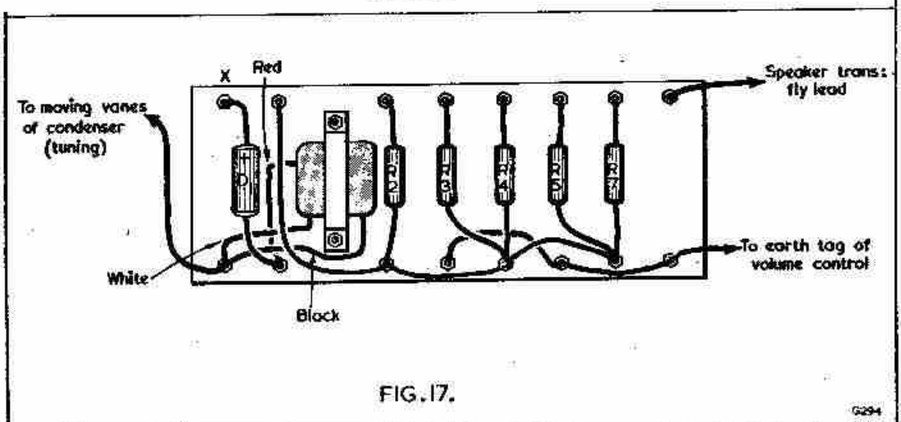


FIG. 17.

G294

Fig. 15. First stage in wiring the receiver. Fig. 16. Fitting the electrolytic coupling condensers and R_6. Fig. 17. The positioning of the components on the transistor tag-board

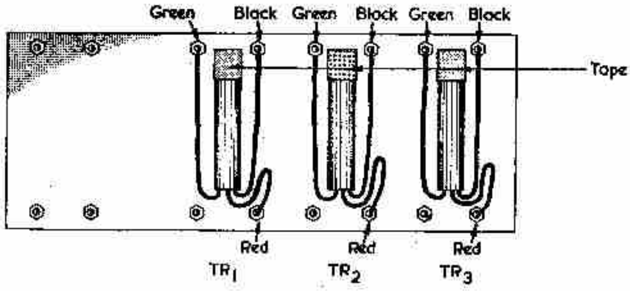


FIG. 18.

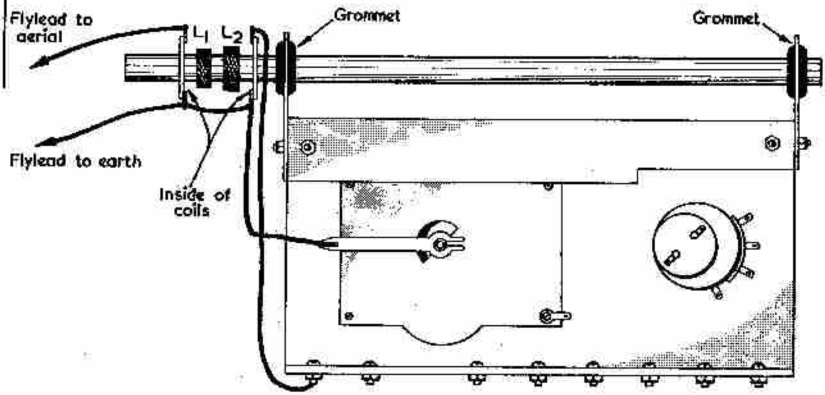


FIG. 19.

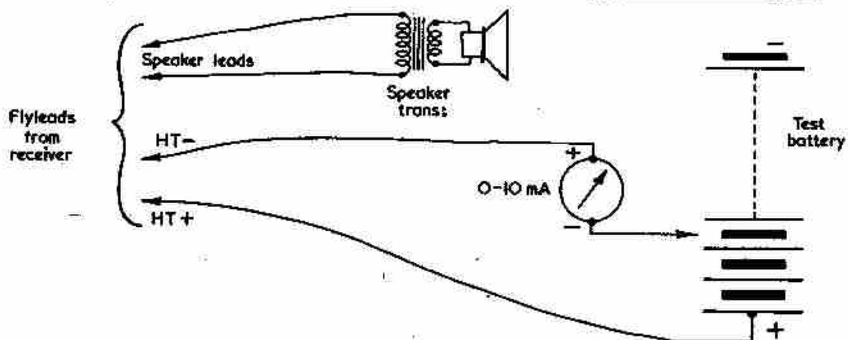


FIG. 20.

Fig. 18. Mounting the transistors themselves Fig. 19. The wiring connected to the aerial coil Fig. 20. The external circuit needed for testing the main chassis

black leads for the h.t. fly-leads (red connects to chassis). The speaker transformer fly-lead should be a different colour, again, from red or black.

The Tag-Board

Fig. 17 shows the transistor tag-board and the components which connect to it, with the exception of the transistors themselves. As will be seen, this diagram is quite self-explanatory and shows the various connections clearly. It should, nevertheless, be emphasised once more that all wires should be insulated with sleeving over their entire length. If the constructor wishes, however, the lead-out wires from the resistors need not, with two exceptions, be so insulated. The two exceptions are the lower leads of R_3 and R_5 which, travelling over a relatively long route, might possibly cause short-circuits if not covered with sleeving. The speaker transformer fly-lead shown in the diagram may be similar in length and colour to that of Fig. 16.

Next comes the fitting of the transistors themselves. As may be seen from Fig. 18, these are supported on their lead-out wires and lie flat against the tag-board between the appropriate tag spills. To prevent short-circuits, the end of the metal body of each transistor should be covered with a thin layer of tape, as shown in Fig. 18. The transistors will mount quite securely in position, although it may be necessary to bend the lead-out wires carefully before soldering each transistor into circuit. Care should be taken to ensure that the colour identification of the transistor lead-out wires corresponds to that shown in the diagram. All transistor leads must be covered with sleeving.

As was described above, the transistor connections are made by the use of "laid-on" joints, and not by twisting around the tag spill before soldering.

All that now remains is to fit the aerial coil and wire it up. The Ferrite core of the aerial coil is mounted as shown in Fig. 19. This core should be handled with great care as the material used is brittle. It should also, incidentally, be kept well away from the magnet pot of the speaker specified during tests as, otherwise, it is liable to be suddenly attracted to it with sufficient violence to become broken. In Fig. 19, reference is made to the inside connections of the two coils on the Ferrite rod. These connections may be identified by examining the coils themselves in order to see which lead appears from the inside of the coil concerned. The soldered connections to the coil tags should be made carefully to avoid damaging the coil wires themselves. Two more fly-leads (aerial and earth) are fitted at this stage. These fly-leads will be later shortened and connected to an aerial-earth socket strip.

Testing

The receiver should now be carefully examined to ensure that all connections have been correctly made, and agree with the circuit of Fig. 1. The set may then be tested.

To do this it is first of all necessary to connect up the loudspeaker and speaker transformer. The speaker specified has a very small diaphragm area, and it should be mounted on a small baffle to realise its full audible output. A temporary and quite effective baffle, or "cabinet," may be made by cutting a 2¼in diameter hole in a cardboard box and mounting the speaker therein.

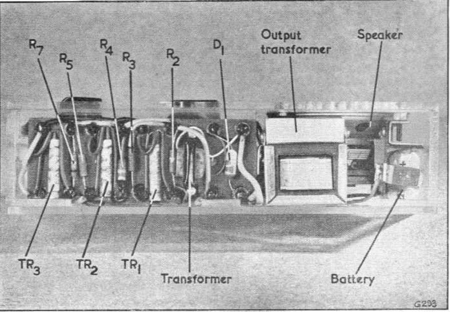
The aerial and earth leads are next connected up. Suitable aerial and earth systems were discussed in the first article in this series.

So far as a battery supply is concerned, it would be very advisable to check the receiver at a low h.t. potential before applying the full voltage. Any errors may then be made apparent, and the low voltage will not cause any damage. As an additional precaution, a milliammeter should be connected in series with the h.t. lead. A 0–10mA meter is specified here, although a meter with a suitable alternative f.s.d. can be employed, if desired. The range of readings to be expected will be between 1 and 6mA. A moving-coil meter is essential for this test, incidentally, as the relatively high resistance of a moving-iron meter may upset the stability of the receiver.

The whole set-up is illustrated in Fig. 20. As may be seen from this diagram, it is intended that the negative lead from the receiver should be tapped into the h.t. battery. The most practicable and satisfactory way of doing this would consist of using two 9 volt grid-bias batteries connected in series as a source of test h.t. voltage. Tappings could then be made in steps of 1.5 volts.

After connecting the speaker and aerial-earth system, the positive h.t. lead from the receiver should be connected to the positive end of the test battery. The set should be switched on, and the negative h.t. lead connected to the negative 3-volt tapping in the test battery. This should cause a slight crackle in the speaker, and the milliammeter should read 0.5mA. The negative lead should then be taken, in 1.5 volt steps and checking current at each step, up to 9 volts, at which potential the milliammeter should indicate approximately 1.4mA. A check should be made, at this point, for current surges at the instant of connecting the h.t. supply. Such surges should be negligible, if existent at all.

An h.t. potential of 9 volts is sufficient to operate the receiver at reduced sensitivity. When the h.t. is connected a gentle "rushing" noise should be audible from the loudspeaker. This is the hiss given by the transistors, and it has a greater amplitude than that given by a



Side view showing Transistor Top Panel

valve amplifier of similar gain. Turning the volume control will have little effect on the strength of the hiss.

The tuning condenser should next be rotated, whereupon it should be possible to pick up the local medium-wave transmitters. The volume control may also be checked for operation at this stage. It will be noted that loud signals will cause slight deflections in the h.t. milliammeter, and it should be possible to increase volume such that these deflections are quite large before noticeable distortion due to overloading sets in.

Assuming that everything is satisfactory, all that now remains is to increase the h.t. potential in further steps of 1.5 volts (still checking h.t. current at each step) until the full potential of 18 volts available from the test battery is given. At this potential the h.t. current should be approximately 2.8mA, the maximum safe current being 3.3mA.

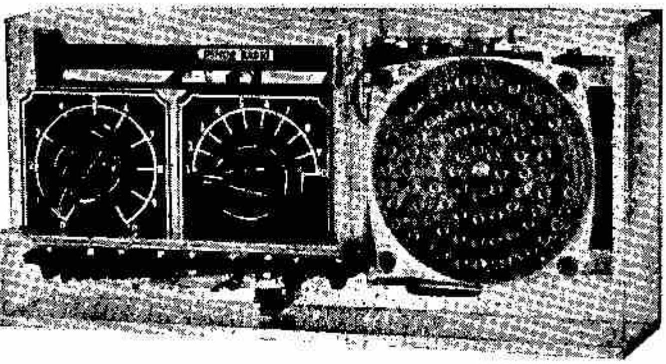
The volume of the signal will, of course, increase as h.t. voltage is increased. The h.t. current readings should be made both under signal and no-signal conditions. At 18 volts, also, the volume control should be checked for smooth operation similarly; that is, under signal and no-signal conditions.

If everything is satisfactory at 18 volts, the 22.5 volt deaf-aid battery may now be connected to the receiver, whereupon the h.t. current should rise to approximately 3.8mA (maximum safe current 4.5mA). It may be mentioned at this point that it would be unwise to attempt to operate the receiver at an h.t. potential higher than 22.5 volts. If at any time during the test a.f. instability occurs, the h.t. voltage should be reduced until the cause has been located and cleared. Such instability can be caused, incidentally, if the output transformer is positioned too close (i.e. within an inch or so) to the deaf-aid transformer on the transistor tag-board. This point should be borne in mind if the chassis is housed in a cabinet of the constructor's own design.

Next Month

Apart from the cabinet, the receiver is now complete. These articles will be concluded next month with a description of the cabinet, and several further points concerning the operation of the set.

The "TRANSISTORETTE"



PART 4. *by* **G. A. FRENCH**

In this article, the fourth in the series describing the Transistorette, G. A. French gives details of the Perspex cabinet in which this transistor receiver was presented in the 1955 Radio Show at Earl's Court. Our contributor also discusses one or two small points concerned with operation.

IN THE LAST THREE ISSUES OF *The Radio Constructor* full details of the chassis of this modern transistor receiver were given. In this concluding article we pass on to the construction of a suitable cabinet.

When the Transistorette was exhibited at the 1955 Radio Show it was housed in a cabinet made of Perspex. As may be imagined, the effect given by this method of presentation was most striking, since the cabinet was very attractive and it also enabled the public to obtain an excellent idea of the internal construction of the receiver. It is possible that many constructors may wish to employ this type of cabinet in their own versions.

Alternatively, it might be found preferable to build the cabinet with an opaque material. In such a case the dimensions given in this article will still apply, so long as provision is made for any differences given by varying thicknesses of material. The Perspex employed for the Exhibition cabinet had a thickness of ⅛-inch, and joints were made with the aid of an adhesive, it being sufficient to have all corners butt-jointed. A similar technique is, of course, quite possible with other materials. A typical choice for such a material would be plywood. An attractive finish could be given also by covering the completed cabinet with rexine, skyver, or a similar type of cloth.

Dimensions

The appearance and general layout of the completed cabinet will already have been learned from the photographs accompanying these articles. As will have been seen, a particularly compact assembly is given by means of sinking the two control knobs. The tops of these knobs then lie slightly above the surface of the remainder of the cabinet.

Apart from their being applicable to materials of ⅛-inch thickness, it should be pointed out also that the dimensions given in this article apply to the receiver when it is used with the Ever Ready B.122 hearing-aid battery. If a B.110 battery, which is slightly larger, is used it will be necessary to extend the dimensions of the top, bottom and two sides by ⅜-inch at the loudspeaker end.

As we mentioned above, butt jointing is used for the corners of the cabinet. The adhesive employed for the prototype was

Durafix, and this enabled a cabinet of more than adequate mechanical strength to be constructed.

The dimensions of the top piece of the cabinet are illustrated in Fig. 22. It will be noted that a centre is shown in this diagram for the loudspeaker cut-out. The cut-out may be obtained either by making a clean hole of 1¼ inch radius on this centre (the hole being later covered on the underside by loudspeaker fabric), or by drilling a series of holes in the material. If the latter device is adopted, a suitable drilling layout is given in Fig. 21.

Fig. 26 (*a*) and (*b*) show the two side pieces. That illustrated in Fig. 26 (*a*) is purely rectangular in form and requires no further discussion. The side piece shown in Fig. 26 (*b*) will butt against the control panel, and it has four holes drilled in it for the aerial-earth panel. This latter should be a standard item available from an advertiser, but the reader is advised to check the dimensions of the particular panel obtained before finally drilling the holes for it. The aerial-earth panel will be mounted behind the cabinet material, the aerial and earth plugs passing through the two ½-inch holes illustrated in Fig. 26 (*b*) before making contact with the appropriate sockets.

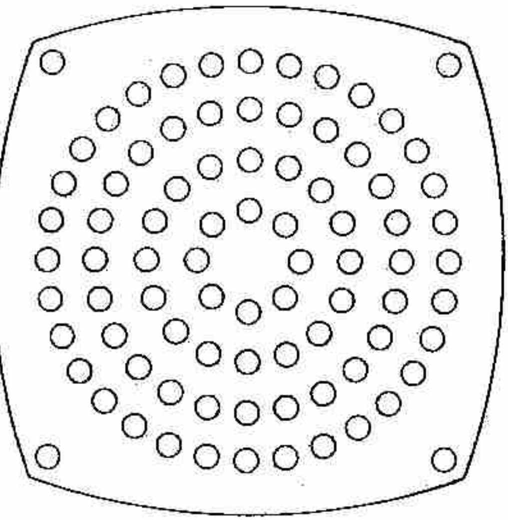


FIG. 21.

SPEAKER CUT OUT DRILLING TEMPLATE AS SUPPLIED

ACTUAL SIZE

G310

The two ends of the cabinet come next. These are illustrated in Fig. 23 (*a*) and (*b*). Fig 24 (*a*) and (*b*) illustrate the two pieces which form the recess for the sunken control panel.

The panel itself is illustrated in Fig. 25. There is little that requires comment here, apart from emphasising the necessity of marking out and drilling the two ⅜-inch diameter holes accurately. The chassis will later be mounted by fitting the bushes of the volume control and tuning condenser through these holes.

The bottom of the cabinet is shown in Fig. 27. This diagram, together with those showing the side end dimensions, does not include any details for fixing the bottom to the remainder of the cabinet. This omission is due to the difficulty of specifying standard parts for such a fixture, in addition to the fact that readers' individual ideas may vary on this point according to their tastes and the workability of the material employed. In the prototype, the cabinet bottom was

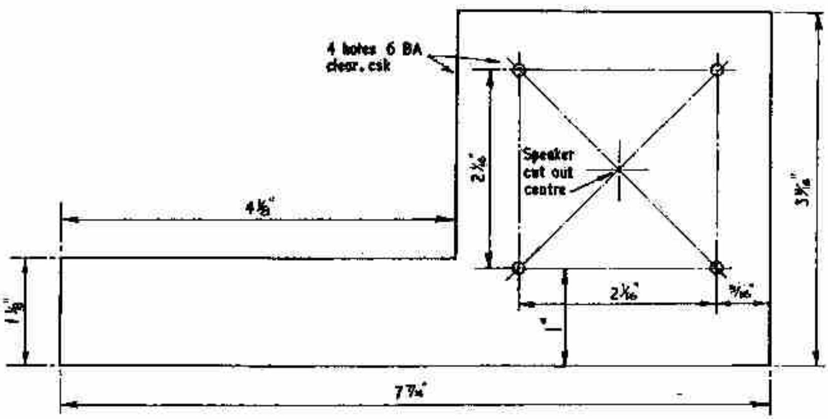


FIG. 22.

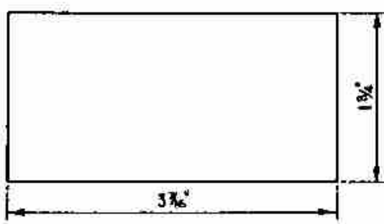


FIG. 23 (a)

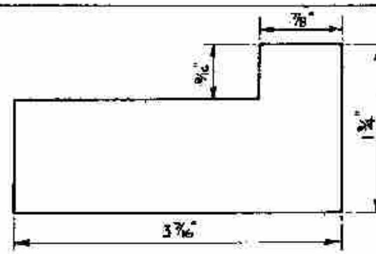


FIG. 23 (b)

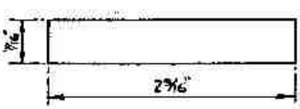


FIG. 24 (a)

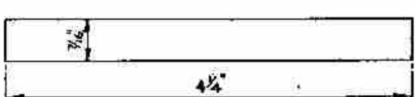


FIG. 24 (b)

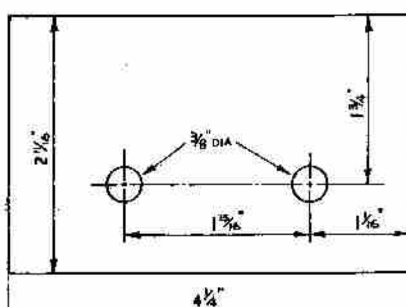


FIG. 25.

Fig. 22. The top section of the Transistorette cabinet. Fig. 23 (a) and (b). The end sections of the cabinet. Fig. 24 (a) and (b). The two pieces which form the sides of the sunken control panel. Fig. 25. The control panel.

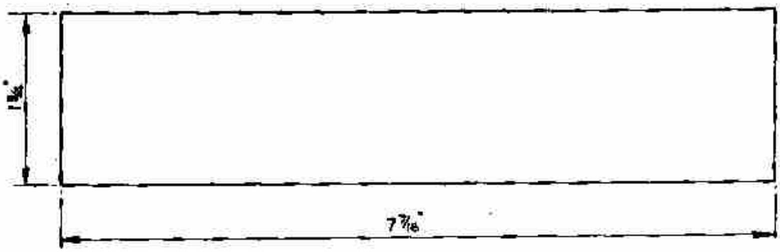


FIG. 26 (a)

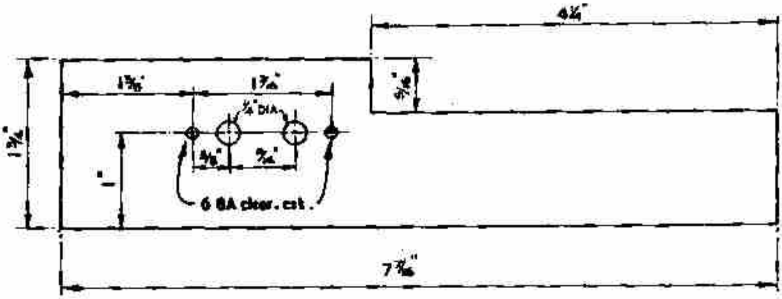


FIG. 26 (b)

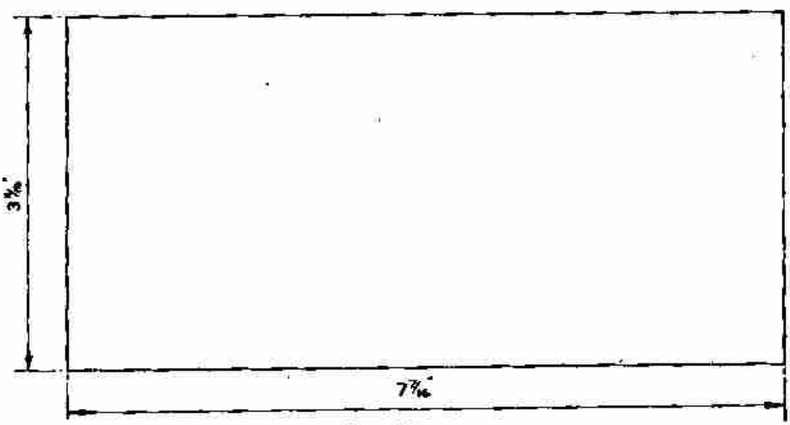


FIG. 27.

Fig. 26 (a) and (b). The side sections. Fig. 27. The dimensions of the cabinet bottom fixed by small rectangular pieces of Perspex stuck to the inside of the bottom, these locating with the inside walls of the cabinet. An alternative arrangement would be provided by the use of small hinges, or similar fixtures.

Fitting the Chassis

Before fitting the chassis to the cabinet it is necessary to mount the loudspeaker. It is possible to employ two of its mounting screws to hold a battery housing as well, and a typical example of such a housing is shown in Fig. 28. No fixed dimensions are given in this diagram, since the available tolerances are quite wide and the constructor may wish to take advantage of what materials he may happen to have on hand. Also shown in Fig. 28 is the loudspeaker itself; and this should be fitted so that its tags lie below those of the aerial-earth panel.

The output transformer can be mounted by bolting it to the side panel—that shown in Fig. 26 (*a*) of the cabinet. In the photographs, this component is shown mounted to a small bracket integral with the chassis. It is felt that the construction of this bracket is more complicated than the simple overall design of the receiver warrants, and that the alternative method of mounting suggested here is preferable. The transformer will occupy the same position as that shown in the photographs, although its axis will now be turned through 90 degrees.

All that remains is to fit the chassis in the cabinet. As was mentioned above, this is done by passing the bushes of the volume control and tuning condenser through the ⅜-inch holes of the control panel. To ensure a snug fit, it is advisable to remove the locking nuts and washers from the bushes before passing the latter through the holes. They may then be fitted and tightened down again on the outside of the panel. It is recommended that the appropriate Panel-Sign transfers be fitted to this panel, as these give an extremely neat finish to the whole assembly. For best results, the transfers should be affixed to the front panel and allowed to dry firmly before finally tightening the bush nuts.

Warning

As it is possible that the h.t. battery may be replaced by non-technical persons, it is important to ensure that the battery compartment is adequately marked with the polarity of the appropriate terminals. A dab of red paint could be used on the positive contact spring. An effective warning notice is given in Fig. 29. This notice can be cut out and stuck in a prominent place in the cabinet.

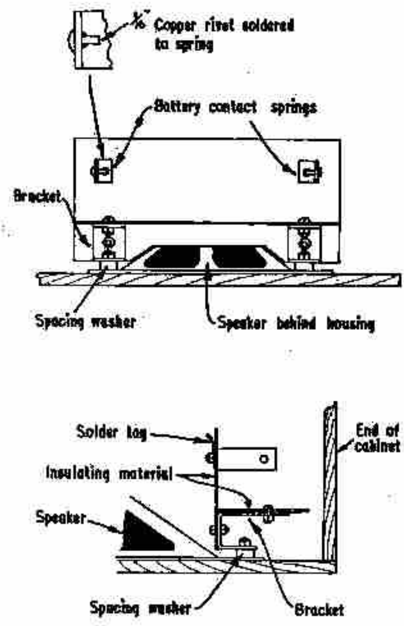


FIG. 28.

Fig. 28. A suggested housing for the h.t. battery

Selectivity

Due to the simple tuning circuit employed, it is possible that sufficient selectivity may not be available in one or two parts of the British Isles where medium-wave interference levels are very high. Although this fact was not considered detrimental to per-

WARNING

CONNECT BATTERY CORRECT WAY ROUND OR TRANSISTORS WILL BE RUINED

Fig. 29. Warning Label. This label may be cut out and fixed in a prominent place in the cabinet

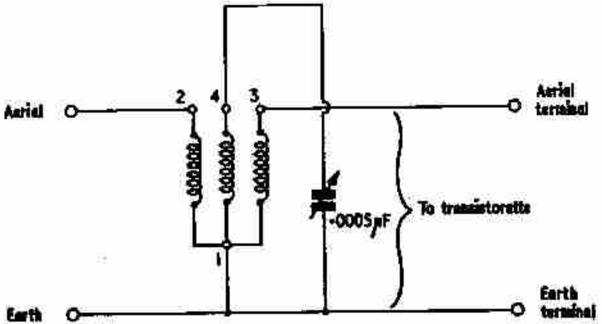


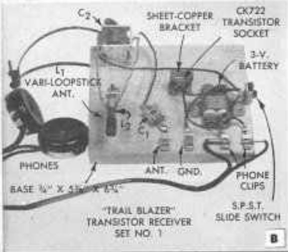
FIG. 30.

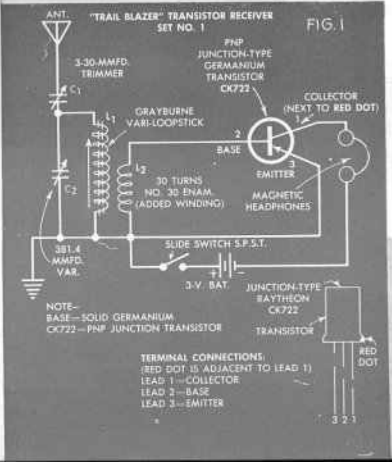
Fig. 30. The circuit of a medium wave trap. This should be required only in areas of heavy medium-wave interference

formance during the tests of the prototype, it was decided that a simple wave trap circuit would prove beneficial to those who experienced difficulty in this respect.

A suitable circuit is shown in Fig. 30. This employs a triple-wound coil, in which the aerial energy is passed to a tuned coil and, thence, to the tertiary winding. This tertiary winding then connects to the receiver. A suitable coil for this application is the Teletron type HAX, and the numbers shown in the diagram apply to the tags of this coil. The tuning condenser shown in Fig. 30 may be a bakelite dielectric model similar to that used in the receiver itself; in which case the external wave trap can be built into a very compact little unit indeed. As was just stated, such a wave trap will only be required for districts which suffer from heavy medium-wave interference.

HOW TO BUILD EXPERIMENTAL





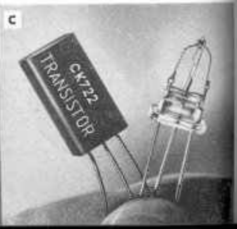
TRANSISTORS were developed by the engineers of the Bell Telephone Laboratories in a series of experiments with germanium that began in 1948. The original contact types were used to replace tubes in certain telephone and radar applications, but they were highly variable in their characteristics and of uncertain reliability.

Under the direction of Dr. William Shockley and J. A. Morton, an improved unit known as the junction type was developed, and this new unbelievably small, low-voltage amplifying device was announced in 1951, and described in *Popular Mechanics Magazine.*

The transistor is the first practical solid device that, like the vacuum tube, could amplify an electric signal. The new Raytheon CK722, photo C, junction or "sandwich" type used in these experimental receivers has recently been made available to students and experimenters. Transistors are still in limited supply and quite expensive, this CK722 junction type being one of the least costly.

These experimental transistor receivers are for the dyed-in-the-wool experimenter. Please remember, that transistors are still in the experimental stage although they replace tubes in some special, commercial applications.

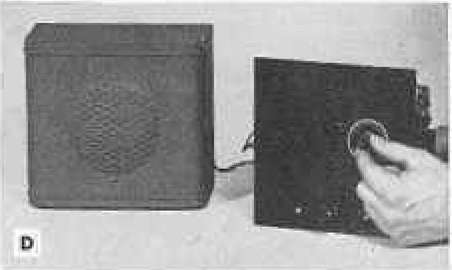
Set No. 1, photos A and B, Fig. 1, is a very simple transistor receiver for headphones only. It will receive local broadcast stations with comfortable volume. It uses a vari-loopstick antenna coil, with an added winding wound right at the end of the raised cardboard cylinder. Once the wiring is completed, check the set over very carefully. Mark the transistor socket to properly position the transistor in relation to the red dot. If the transistor is inserted in reverse it will be ruined. Check and recheck leads 1, 2 and 3



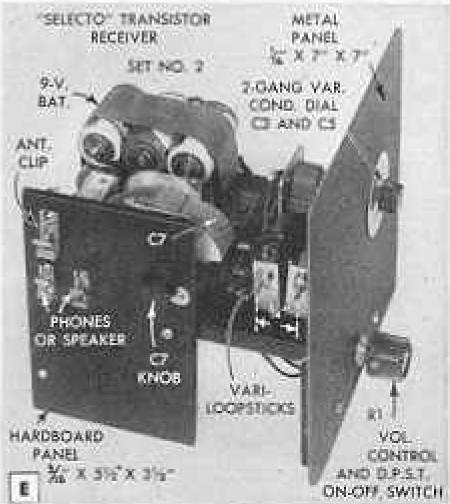
TRANSISTOR RECEIVERS • • •

before throwing the switch. The outdoor antenna should be at least 75 ft. long. The antenna trimmer condenser C1, is adjusted for best volume, and all tuning is done with the main variable condenser.

Set No. 2 is definitely not for beginners, and even greater care should be taken not to accidentally reverse any of the transistors in their sockets. These CK722 junction-type transistors cost $7.60 each, and a wrong circuit connection, or a reversal would be an expensive accident. All specifications are given in Fig. 2. A long outdoor antenna, and a good ground should be used. Set condenser C7 at half capacity, and turn the set on. Rotate the 2-gang variable condenser to a station on the low end of the band and adjust the slugs in the vari-loopsticks for maximum signal. Antenna coupling is critical; load up right to point of distortion. Next tune to a station on the high end and adjust the trimmers (Tr.) for maximum signal on that end. Transistors are essentially voltage amplifying devices, and not capable of a great amount of power; but they have amazingly low battery drain and real gain on low voltage. The volume of the detector-amplifier 3-unit set cannot be compared to even a 2-tube receiver, but it is sufficient for a small room. Study diagram Fig. 2, and photos D, E, F, G and H carefully. The loudspeaker should have a very large baffle.



D



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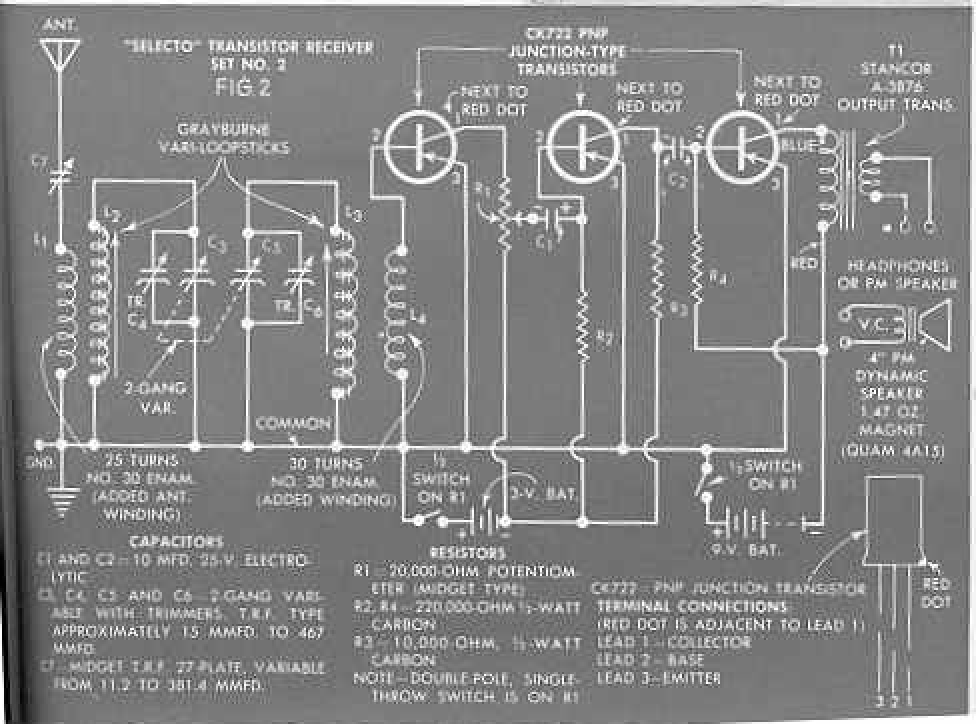
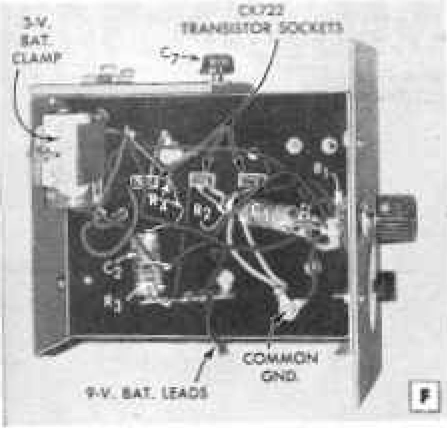
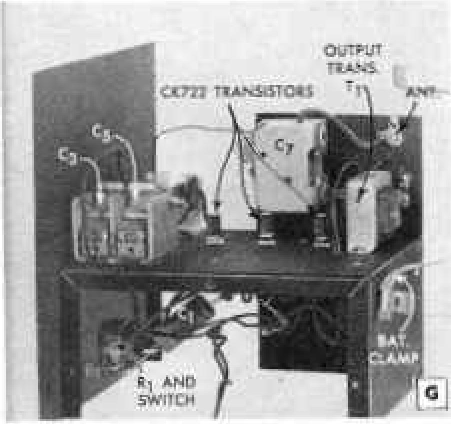
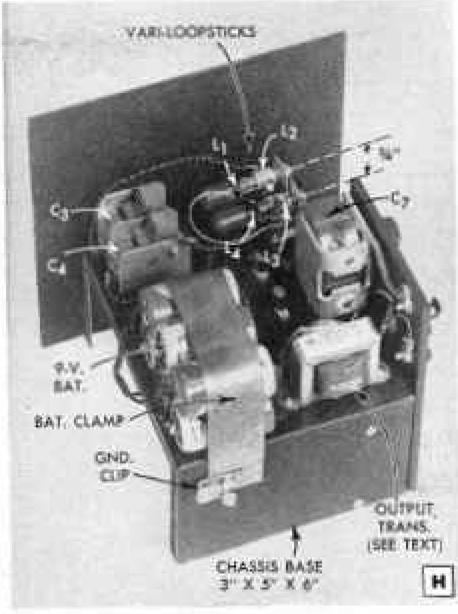








Omit output transformer if headphones are used, and connect as in Fig. 1.

Transistor theory represents a radical departure from vacuum-tube theory. Space does not permit a complete theoretical explanation, but sketch Fig. 3 illustrates the basic idea of the point-contact type. The arrangement shows a small block of semiconductor material (germanium) placed in electrical contact with a conducting metal base which is then grounded, as shown at 2. On top of the block, spaced a few thousandths of an inch apart, are the two cat whiskers 1 and 3. Collector cat whisker No. 1 is negative with respect to the germanium block by virtue of the high-voltage battery (about 10 volts). A milliammeter is shown in series with this connection. Observing the sketch, it appears that the electrons flow from the collector cat whisker (1) to the base (2) within the semiconductor material under the influence of this applied battery voltage. The electron flow produces a meter reading. High gains are possible because of the very high ratios of output circuit to input circuit impedance. Emitter cat whisker (3) is at opposite polarity to collector (1) as it connects to the positive side of the low-voltage battery. When switch (SW) is closed, a meter placed in this circuit would indicate a current in the No. 2 to No. 3 circuit. Since the diode (cat whisker) on the No. 3 side is connected in the forward (low resistance) direction, a very small potential at low-voltage battery will cause current to flow. A study of the current flow cannot be explained on the basis of electron flow alone. A new concept of "hole conduction" must be adopted to understand transistor action. When the switch is closed, the positive plus signs indicate positively charged "holes" that migrate from emitter No. 3 to collector No. 1.

The internal construction of the new PNP junction type is illustrated in Fig. 4. It differs from the point-contact type in that the rectifying barrier layers are formed by boundaries, or junctions, between different types of germanium semiconductor material. ★ ★ ★

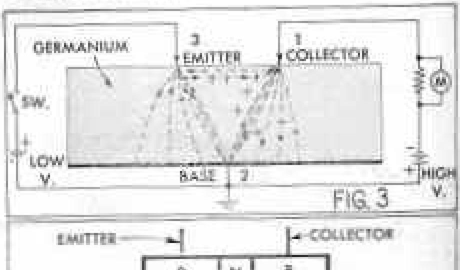
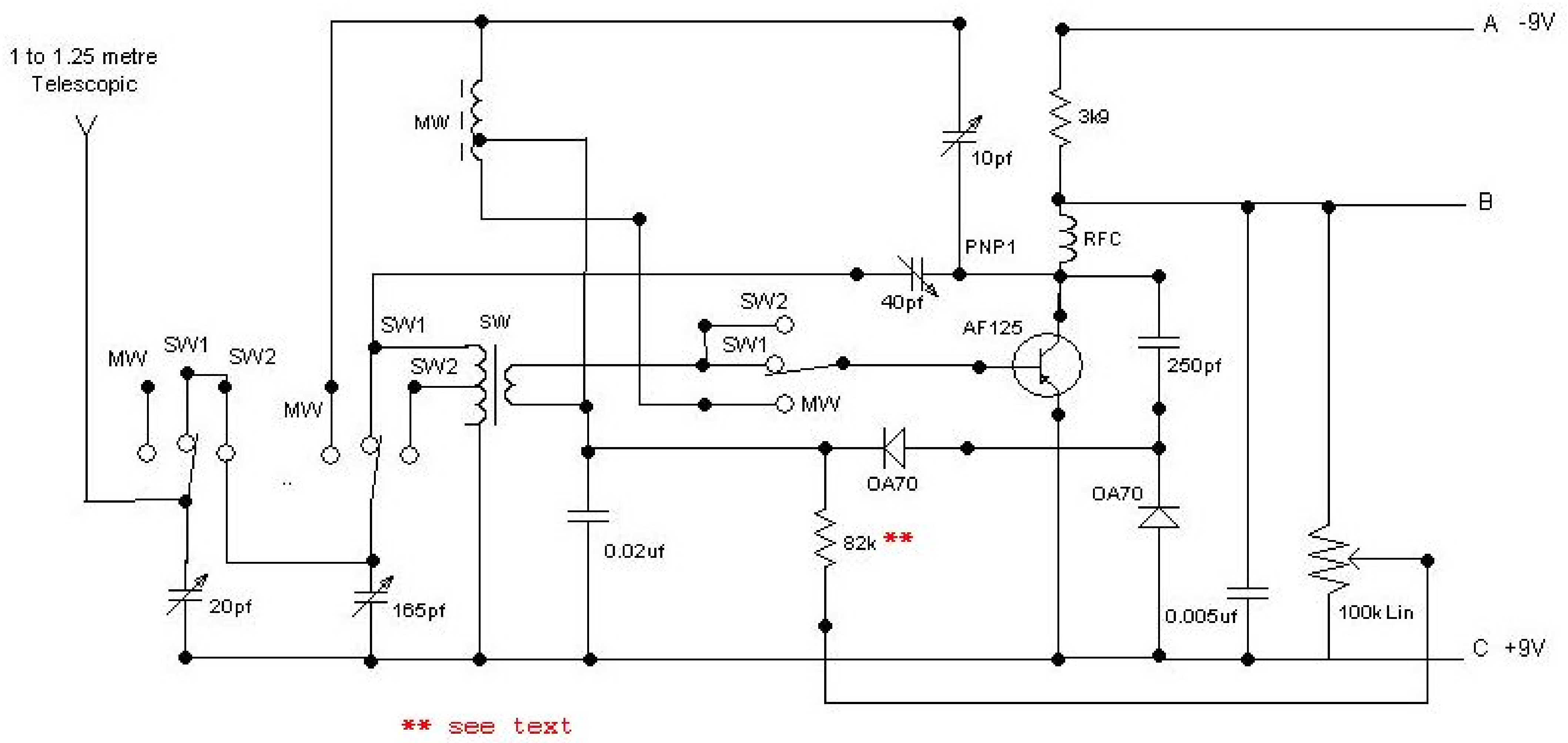


FIG. 3

FIG. 4


1 to 1.25 metre
Telescopic
MW
SW1
SW2
MW
SW1
SW2
SW
MW
20pf
165pf
0.02uf
SW2
SW1
MW
10pf
40pf
PNP1
AF125
3k9
RFC
250pf
OA70
OA70
82k **
0.005uf
100k Lin
A -9V
B
C +9V
** see text

VINTAGE 2008 REFLEX RECEIVER

Readers of The Radio Constructor magazine during the 60's & 70's will no doubt remember some of my circuits. I recently found another of my circuits from that era that had never been published hence the apparent contradiction in the title.
This circuit to be described is for a 5-transistor MW & SW receiver that may be built in stages for ease of construction.
Short Wave coverage is adjustable to suit the constructor's requirements, many stations will be found using the telescopic aerial but for DX reception an external aerial is recommended.

The Circuit

TR1 amplifies first at RF then AF in the normal reflex circuit. A panel mounted 100K linear pot acts as a sensitivity control & a separate 20pf variable capacitor provides bandspread to ease tuning on the SW band. The audio amplifier may be built as a 2 transistor headphone or a 4 transistor push pull output stage to drive a loudspeaker.

Components

Inductors

The SW coil is wound on a ¼" Aladdin former with core using Litz or 32 SWG enamelled copper wire. The 1 ¾ turn coupling is wound first followed alongside by the 20 turn winding with a tap at 8 turns. Coverage will be approximately 5.7 to 18 MHz. the dust allows for some variation.
Details for increasing the SW coverage are given at the end of this article.

The MW coil is wound on a 5" X ½" ferrite rod using 30 SWG enamelled copper wire.
73 turns with a tap at 8 turns are wound on a paper or card sleeve, not too tight as the former must be able too slide along the rod for adjustment, this being finally fixed in place with a drop of wax when in the optimum position.

The RFC consists of 900 turns of 36 SWG silk covered copper wire wound in three pies of 300 turns on a 1 Megohm 2 Watt resistor or similar 7mm diameter former. The number of turns is not critical & need not be exact. Clean & tin both ends of the winding then solder these to the resistor lead-outs.
Alternatively a 2.5 mH commercial choke may be used if available.

The original AF transformers were similar to the type used at that time in commercial superhets, these were somewhat larger than the common 200mw LT700/LT44 & capable of driving a large speaker at good volume but are no longer available unless the constructor has a well-stocked junk box.
Alternatively the output stage of the Experimental Reflex published in March 1970 may be used with the smaller transformers.

At the time of writing this article (Christmas 2007) both the LT700 & LT44 are still available at modest cost from Maplin, Sycom or N.R.Bardwell.

Semiconductors

For Tr1 use an AF 125 or AF115 with the screen disconnected.
For Tr2 use an AF 126 or AF116, the receiver will be more sensitive if this screen is also left disconnected.
For Tr3 use an AC151.
For Tr4 & Tr5 use a matched pair of AC117's
Both Diodes may be OA70 or equivalents.

Misc.

Electrolytic capacitors may be 10 Volt working
Resistors may be 1/4W 10%
The On/Off switch may be part of the Volume Control

Setting Up

Important (Fit a new battery first)

RF Stage

Separate trimmers for each band are adjusted for optimum performance of the 100K sensitivity control. With the trimmers correctly adjusted it should be possible to keep the receiver just below the oscillation point over the whole band using the sensitivity control.
In extreme cases or if different transistors or diodes are used then the 82K resistor in series with this control may require adjustment.
If regeneration is fierce or uncontrollable even with the trimmer at minimum capacitance then the resistor value needs increased. If the opposite occurs & regeneration cannot be obtained with the trimmer set at maximum capacitance then the value needs reduced.

AF Stage

Set the 10K pre-set to insert ***maximum*** resistance, tune in a clear signal then slowly reduce the resistance until any crossover distortion just clears. Do this slowly & carefully, as reducing the value past this point will result in the output transistors passing excessive current.

Options

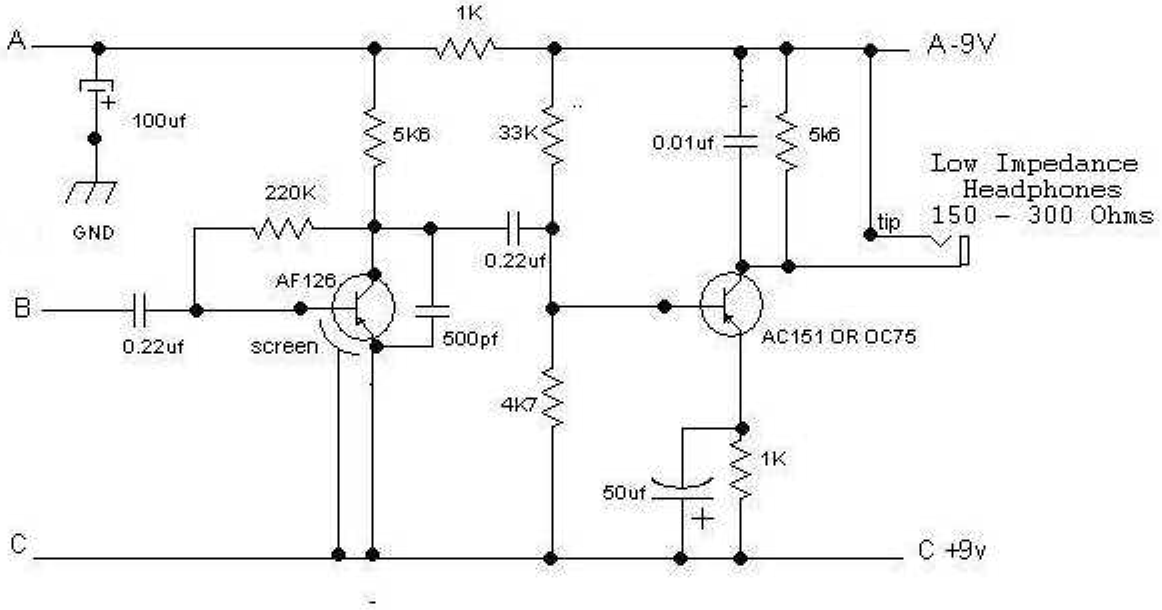
4 Transistor Circuit

A 4 transistor version may be built by eliminating TR2 & its associated components then using the AF amplifier stages of the Experimental Reflex published in March 1970

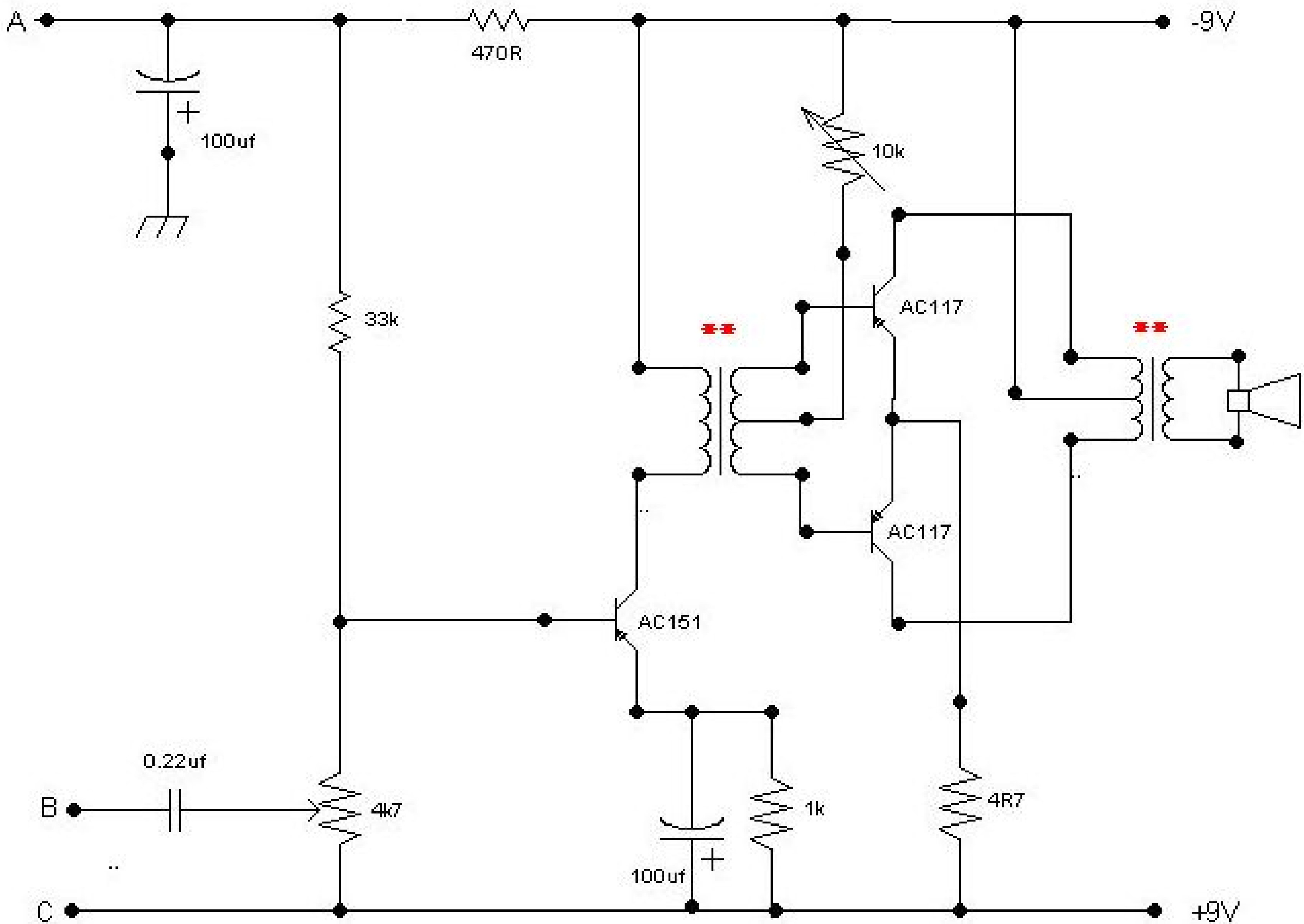
Increasing SW Coverage

Coverage may be increased by adding 5 more turns to the SW coil & using a 3 pole 4 way switch to connect the extra winding, see diagram.

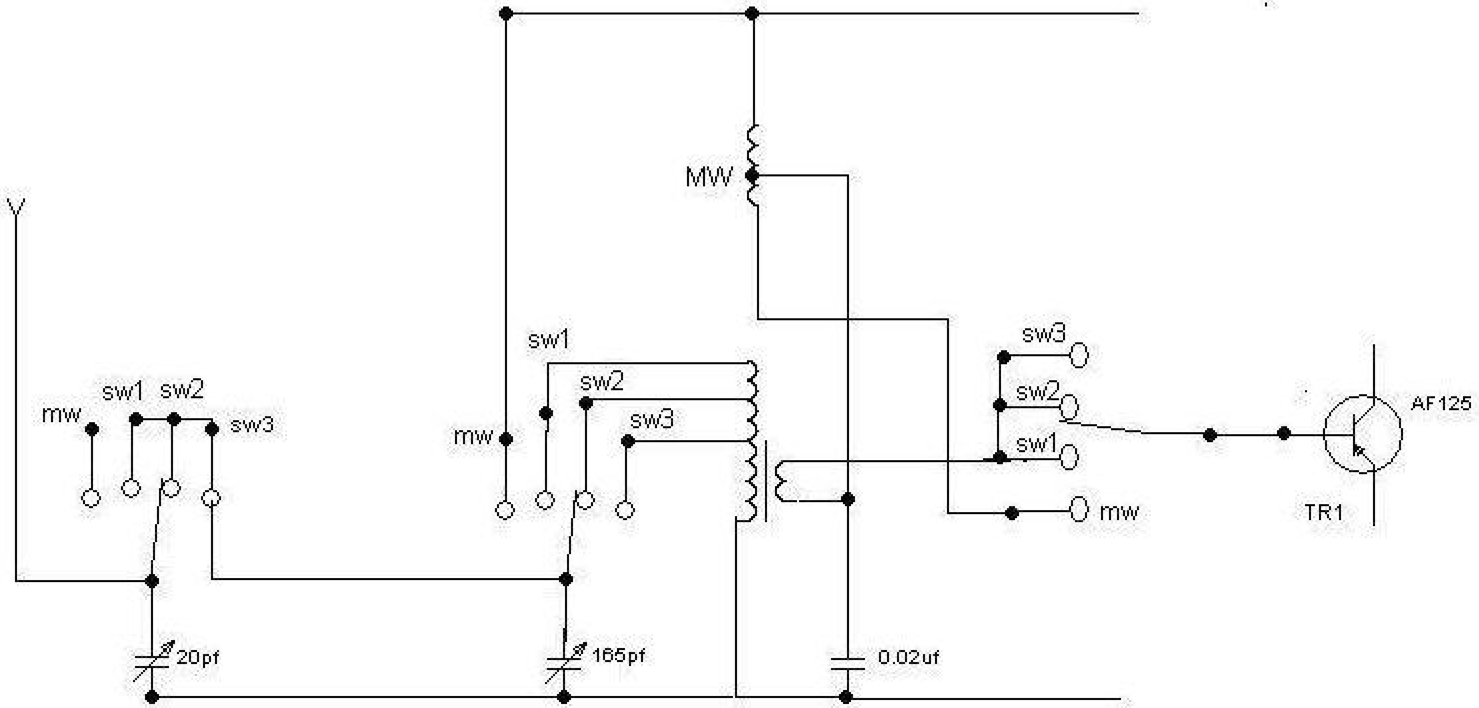
Arman's Homepage
http://vintageradios.homestead.com/arman.html



A
1K
A -9V
100uf
GND
5K6
33K
0.01uf
5k6
Low Impedance
Headphones
150 - 300 Ohms
220K
tip
0.22uf
AF126
B
0.22uf
screen
500pf
AC151 OR OC75
4K7
1K
50uf
C
C +9v



** see text for transformer types



WIRING DIAGRAM FOR 25 TURN SW COIL WITH 2 TAPS & 3 POLE 4 WAY SWITCH


BANDSPREAD
SELECT
OFF
MIN.
SPEAKER
VOL
WAVEBAND
SENSITIVITY
VERNIER