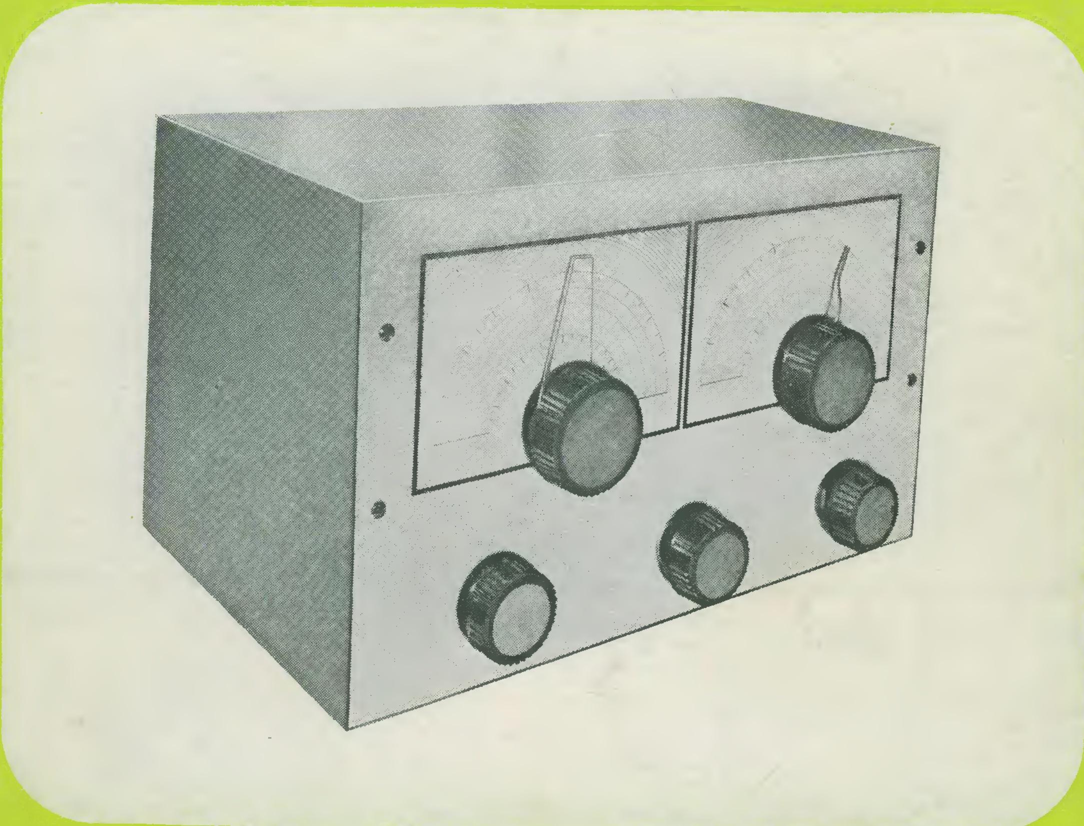
THE
# RADIO CONSTRUCTOR

Vol. 23 No. 6 JANUARY 1970 THREE SHILLINGS



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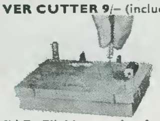

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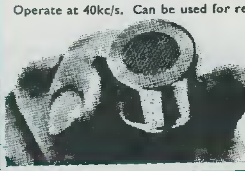

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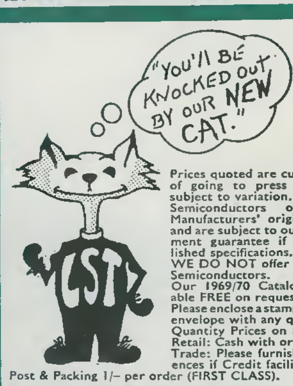


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| U4 | 40 Germanium Transistors like OC81, AC128 | 10/- |
| U5 | 60 200mA Sub-min. Sil. Diodes | 10/- |
| U6 | 40 Silicon Planar Transistors NPN sim. BSY95A, 2N706 | 10/- |
| U7 | 16 Silicon Rectifiers Top-Hat 750mA up to 1,000V | 10/- |
| U8 | 50 Sil. Planar Diodes 250mA OA/200/202 | 10/- |
| U9 | 20 Mixed Volts 1 watt Zener Diodes | 10/- |
| U11 | 30 PNP Silicon Planar Transistors TO-5 sim. 2N1132 | 10/- |
| U13 | 30 PNP-NPN Sil. Transistors OC200 & 2S104 | 10/- |
| U14 | 150 Mixed Silicon and Germanium Diodes | 10/- |
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Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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| 1 Amp (TO-5) PIV | Each | 3 Amp (TO-66) PIV | Each | 7 Amp (TO-48) PIV | Each |
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| 800 | 12/6 | 800 | 14/- | 800 | 18/- |

| 16 Amp (TO-48) PIV | Each | 30 Amp PIV | Eakh |
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| 100 | 12/6 | 50 | 23/- |
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| 400 | 18/6 | 200 | 32/- |
| 600 | 25/- | 400 | 35/- |
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| 300 | 2/3 | 4/6 | 6/6 | 22/- |
| 400 | 2/6 | 5/6 | 7/6 | 25/- |
| 500 | 3/- | 6/- | 8/6 | 30/- |
| 600 | 3/3 | 6/9 | 9/- | 37/- |
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| 1000 | 5/- | 9/3 | 12/6 | 50/- |
| 1200 | 6/6 | 11/6 | 15/- | |

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| 400 | 20/- | 25/- | 35/- |

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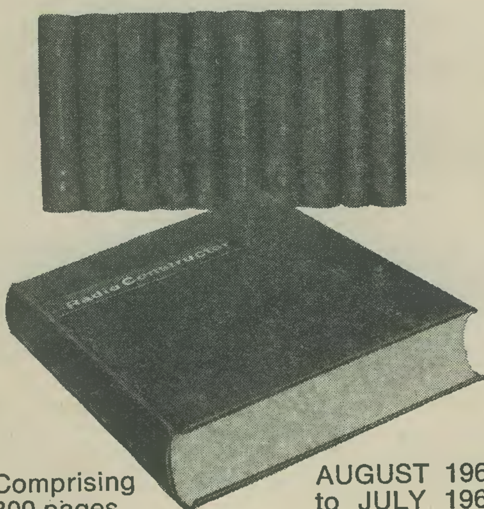


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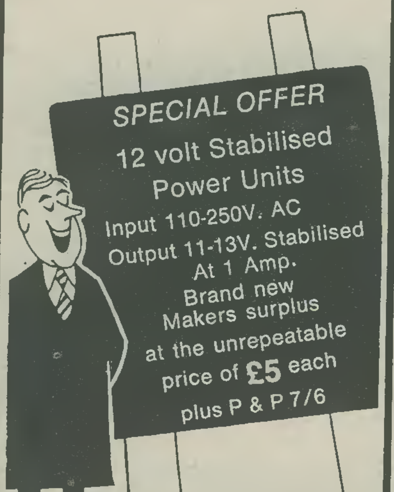


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*Queries.* We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing and accompanied by a stamped addressed envelope for reply.

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**FEBRUARY ISSUE WILL BE PUBLISHED ON FEBRUARY 1st**

# TORCH BATTERY POWER PACK

by

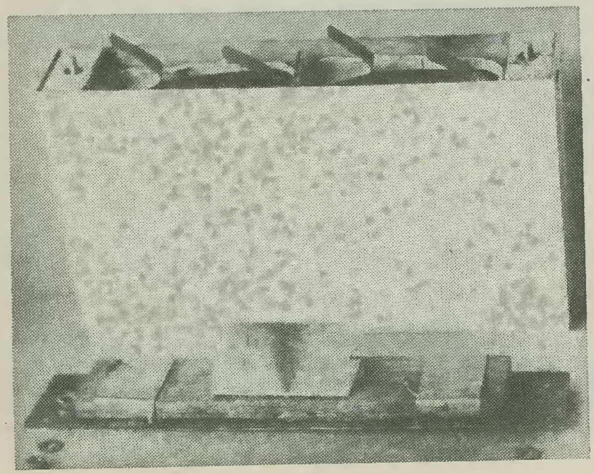
R. L. GRAPER

**Quite a few constructors, including in particular the younger enthusiasts, prefer to power transistor receivers and similar equipment with torch batteries rather than with the standard batteries that are specifically intended for transistor work. Apart from the possibility of initial cost saving, this approach certainly makes it possible for the batteries to serve a double function during their useful life. The article published here describes a simple home-built battery case with external connectors which can accommodate two 1289 torch batteries**

THE BATTERY UNIT DESCRIBED CONSISTS OF A SIMPLE home-constructed case in which two 1289 torch batteries are fitted. These are automatically connected in series when the case lid is fitted, with the result that a 9 volt supply becomes available for transistor radios and similar equipment. One advantage with the unit is that it is not necessary to solder any connections to the battery terminal strips, and the batteries can at any time be employed for other uses, if desired.

## ASSEMBLY

The completed assembly is illustrated in Fig. 1. This diagram shows one side panel partly cut away to reveal construction and the positions of the batteries. Above these appears the contact cover and lid. This is shown partly assembled, illustrating the contact strips at the ends for positive and negative connections, and the central springy contact for connecting the batteries in series. The end strips are wrapped around the plywood and then glued. The top panel is glued to the plywood panel, and has clearance holes for the plug and socket connections. The latter are taken from an old PP9 battery or similar, the insulated panel on which they are mounted being cut, as required, to fit the present assembly.



*The unit with its lid removed*

The various parts forming the unit are shown in Fig. 2. Six lengths of ½in. square planed stripwood are cut and glued to form two U-shaped sections. These are then glued together, in their turn, to give a single cradle 1in. wide. On to this are glued the two side and two end panels, these being cut from Formica laminate 1/32in. thick. Due allowance has been given in the sizes of these panels so that the edges can be bevelled at 45° and a knife edge fitting secured. There is no Formica panel at the bottom of the case. The bottom consists of the four bottom panel edges and the bottom surfaces of the wood, these all being cleaned up flush.

The top cover is formed from a rectangle of 3/16in. plywood, size 4 15/16in. by 1in. This is carefully sanded down to fit into the top opening of the box. A recess is cut out for the battery connector panels. After soldering appropriate lengths of wire to them, these are glued in position as also are the two end contacts. Note that a groove is needed for the wire to the negative connector, and that the wires must be soldered to the end contact strips. A V-shaped piece of brass foil, as illustrated in Fig. 1, is also glued at the centre of the plywood. This contact connects together the inner terminal strips of the batteries,

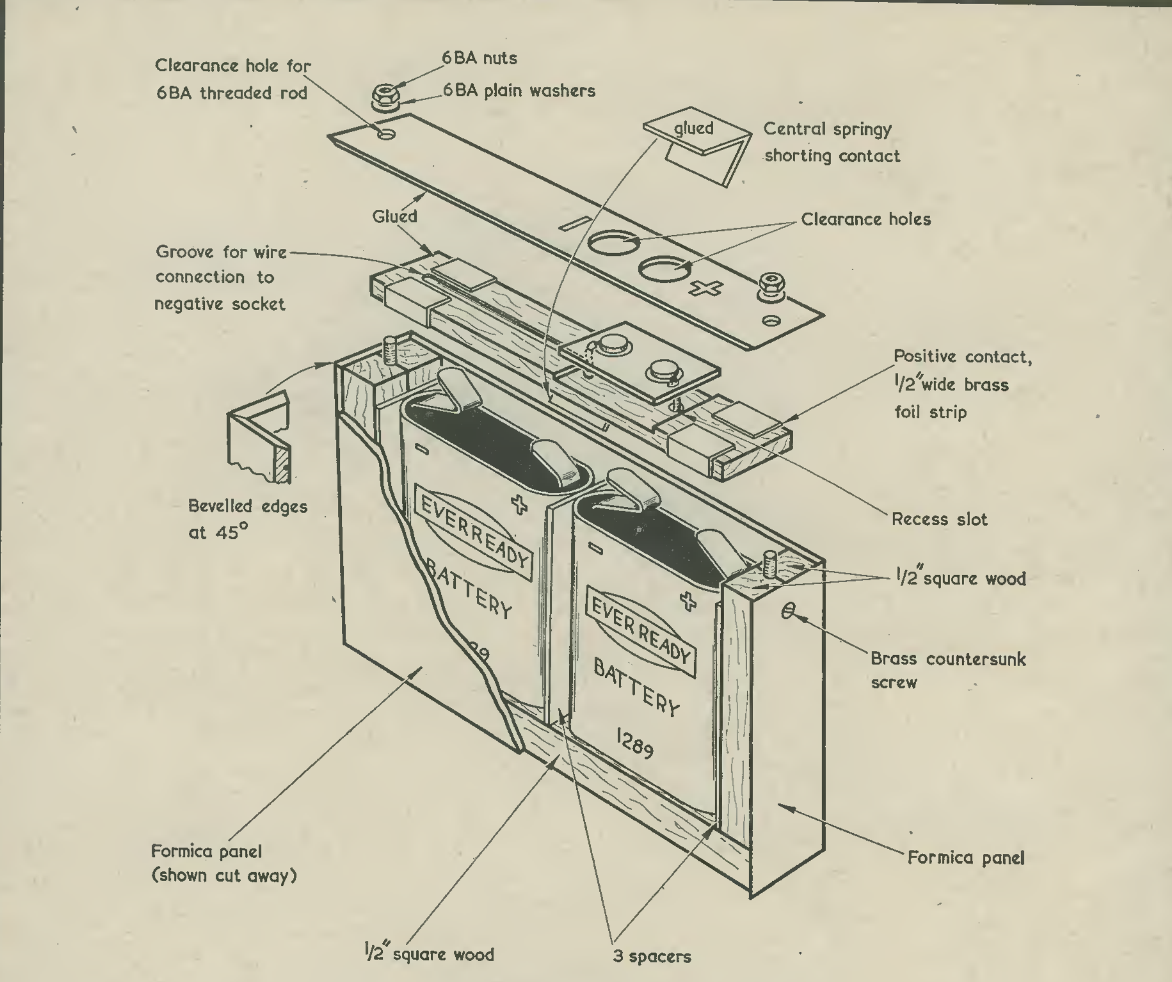
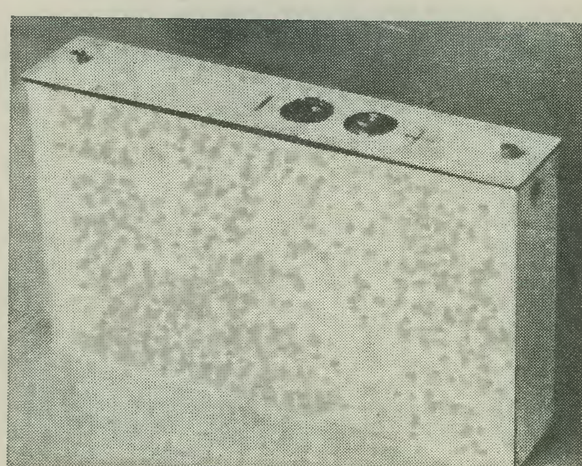



*Fig. 1. Illustrating the final assembly of the unit*

causing them to be in series. No external connection is made to this centre contact. Finally, the top surface of the contact panel is treated with Evo-Stik, as also is the Formica top panel above, and the two brought into contact to form the complete lid. The output connectors are then marked "+" and "−" to show their polarity. This should, of course, correspond to their polarity when fitted to a standard battery.

Two $\frac{3}{4}$in. lengths of 6BA brass studding act as fixtures for the lid. These lengths are sunk into suitably drilled holes in the wooden cradle as shown. They project by about $\frac{1}{8}$in. and are securely fixed at this height by short countersunk brass wood-screws which engage them through the end panels. See Fig. 1. The three spacers illustrated can be of cardboard or plastic laminate, and are pushed in after the batteries have been lowered into the case. They prevent excessive movement of the batteries.

The top strips of the batteries should be bent as shown in Fig. 1 and should be nearly level with the top of the box. Very good contact will then be obtained when the cover is fitted and the 6BA nuts



*When the lid is secured in place a 9 volt output is available at the two top connectors*

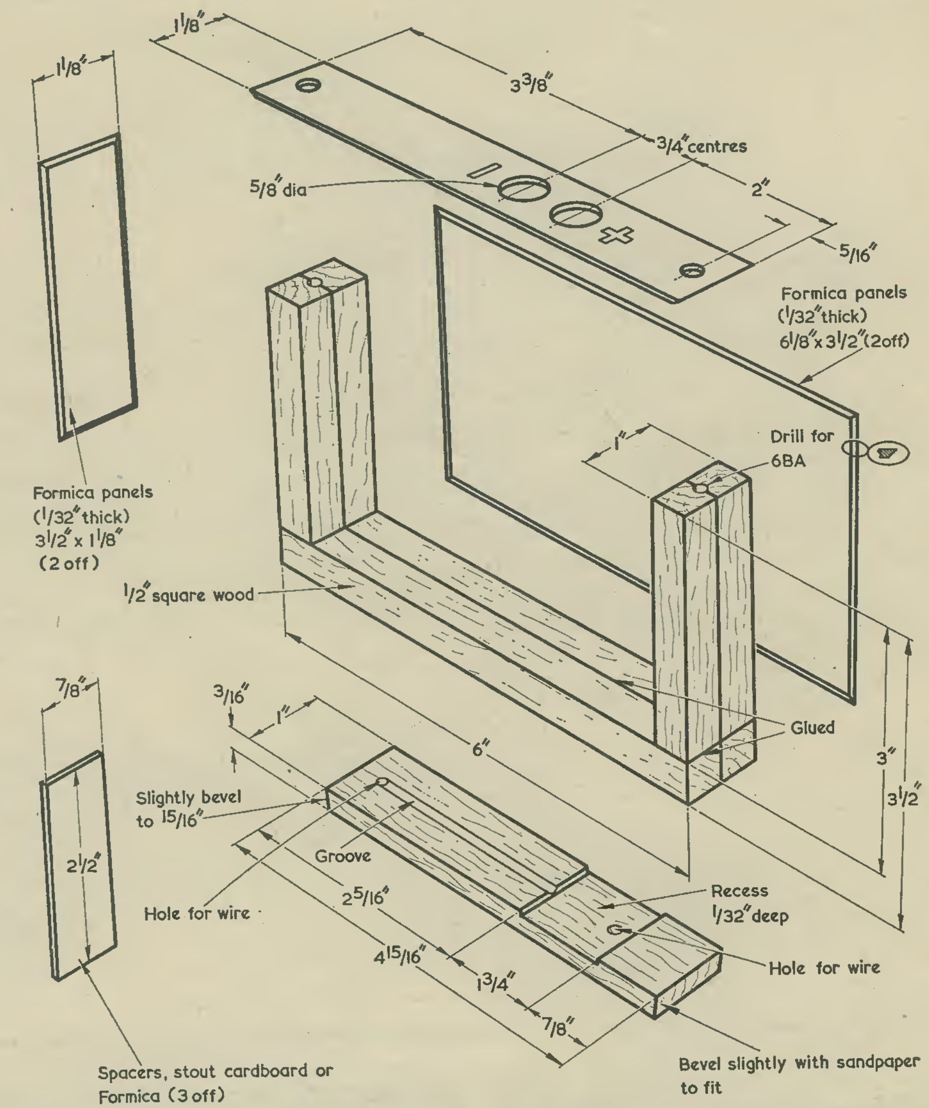



*Fig. 2. The component parts of the unit have the dimensions given here*

screwed down. The form of construction described gives a very robust unit, and replacement of the two batteries takes but a few moments.

Although this unit was intended for a 9 volt output, there is no reason why a larger model could not be made for higher voltages.

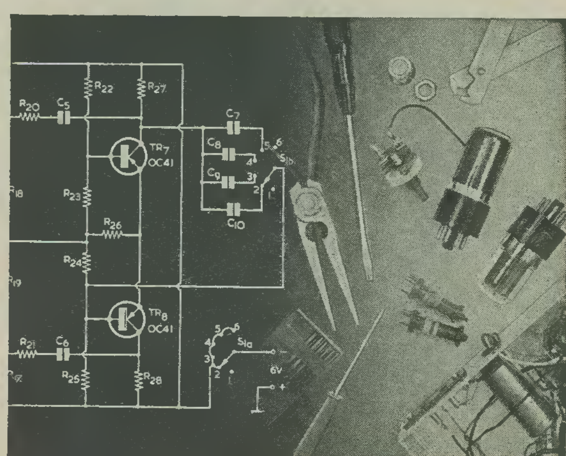
## SGS PUBLICATIONS

**Currently available from SGS (United Kingdom) Ltd. are two manuals giving full details of SGS semiconductor devices. These are entitled respectively 'Professional Discrete Devices' and 'Consumer Devices' and are both printed on an 11¾ by 8¼in. format. Both manuals contain a 'Planar Selector' guide which enables specific devices to be chosen from clearly laid-out tables, the guides being followed by very comprehensive information on all the devices listed. The latter sections constitute the major parts of the manuals. Both manuals are fully up to date as of August 1969.**

**Items in 'Professional Discrete Devices' include transistors for a.f., r.f. and high voltage applications, multiple transistors, phototransistors, reference diodes, high speed diodes and thyristors. The contents of 'Consumer Devices' include general purpose transistors, u.h.f./v.h.f. transistors, high voltage and video output transistors, and integrated circuits.**

**Readers of *The Radio Constructor* may obtain either or both of these publications from SGS (United Kingdom) Ltd., Planar House, Walton Street, Aylesbury, Bucks, at the price of 21s. each.**

# Experimental Record Player Amplifier




by G. A. FRENCH

EVERY NOW AND AGAIN THE writer includes, in the *Suggested Circuit* series, a design which has to be categorised as being "strictly experimental". The circuit to be discussed this month falls into this class because both the transistors it employs are operated under conditions which are well removed from those in which they would normally function. For this reason, the circuit is not recommended for the beginner who wishes merely to follow a tailor-made design which requires no setting up and which employs conventional circuitry. On the other hand, the circuit will be of interest to the more experienced experimenter who likes trying out unconventional applications. The fact that the transistors in the circuit are operated under unusual conditions involves the risk that not all transistors of the types quoted may offer the same results. Such a risk should not be particularly high in the present case but its existence has to be mentioned and accepted.

## THE CIRCUIT

The unit to be described is an experimental record player amplifier intended to be coupled to a low-cost crystal pick-up, and its circuit appears in Fig. 1. The r.m.s. output available is of the order of 100mW. However, when coupled to a reasonably sized speaker of the order of 6in. or more, the audible signal is more than adequate for a small room. The quality of reproduction is not in the high fidelity class, but it is certainly comparable with that offered by a conventional transistor amplifier having a low power Class B output stage. The main advantage of the circuit is its exceptional simplicity. The circuit complications inherent in a more conventional amplifier employing a Class B output stage are completely absent.

The input signal from the crystal pick-up is applied to the volume control, R1, and is then fed, via R2 and C1, to the base of TR1. The collector of TR1 couples direct to the base of TR2, which functions as an emitter follower feeding into the output transformer primary. The latter is one half of the primary of a standard "Eagle" LT~~44~~ 700 output transformer, the secondary of this component coupling to a 3Ω speaker.

Base bias for TR1 is provided by R4 and R3, and it will be noted that these components have much higher values than are usually encountered in circuits of this nature. It was found empirically, nevertheless, that these values enabled the amplifier to function as intended, even though the result is that TR1 is operating at a very low collector current. The rather wide voltage swing from the crystal pick-up is changed to a corresponding current swing at the base of TR1 due to the presence of R2 plus, at settings other than full volume, whatever track resistance happens to appear above the slider of R1. Some non-linearity in TR1 is inevitable but, as was found experimentally by the writer, any resultant distortion in the output of the amplifier appears to be well within acceptable limits for a low-cost design such as this.

Capacitor C1 is a d.c. blocking capacitor and it is essential that it be a good quality paper or plastic

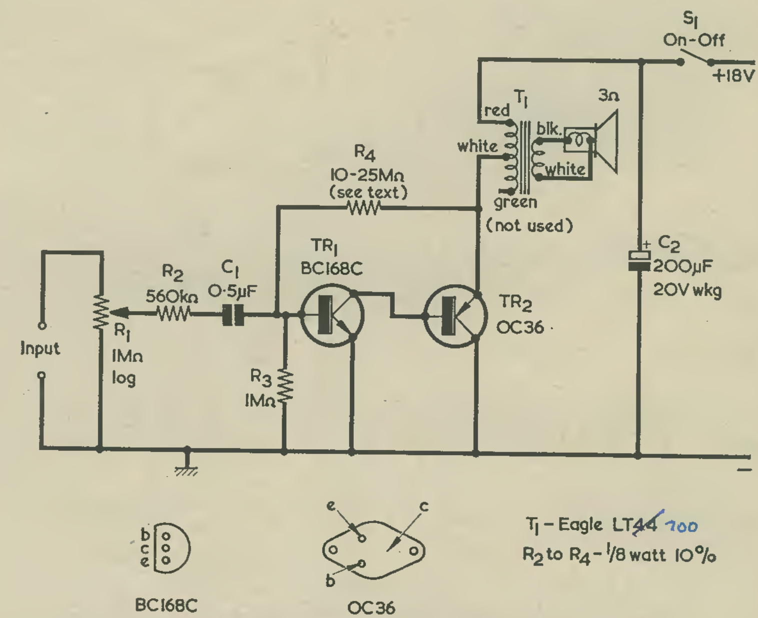



*Fig. 1. Circuit of the experimental record player amplifier*

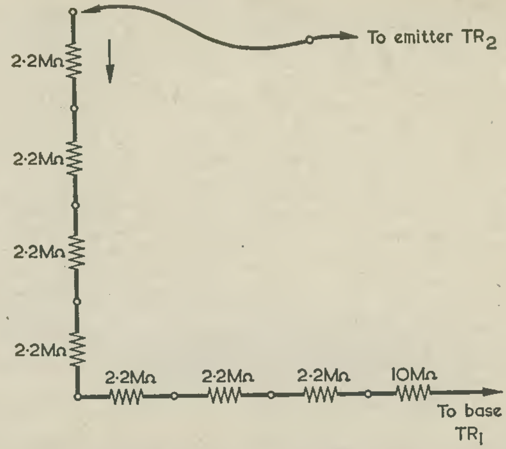



*Fig. 2. A suggested method of finding the value required in R4. The flying lead may be terminated in a crocodile clip*

foil component. If an electrolytic capacitor is used in the C1 position the amplifier will not function.

The output stage draws a standing current of 20mA, which means that TR2 dissipates 360mW all the time that the amplifier is switched on. The circuit offers no protection against thermal runaway in TR2 (due to the small resistance of T1 primary, the level of d.c. feedback via R4 is negligibly low) and the solution to this problem consists, quite simply, of choosing a much larger transistor for TR2 than the signal conditions warrant. In the prototype, TR2 was operated continually for several hours without any heat sink at all and, whilst growing perceptibly warm, still passed exactly the same emitter current at the end of this period as it did at the beginning. It would be wise, nevertheless, to mount TR2 on a small heat sink in order to provide extra thermal stabilisation. Since the collector of TR2 is at chassis potential, the heat sink can be provided by bolting this transistor direct to a small metal plate or chassis on which are mounted all the other components. During early experiments the author used a small TO-5 transistor in the TR2 position and this gave definite evidence of thermal instability. It is necessary, therefore, to employ the large transistor specified.

The transistor used in the TR1 position is a BC168C (available from Amatronix Ltd.). It is essential that TR1 be a silicon transistor with a collector voltage rating in excess of 18 volts.

## SETTING UP

The circuit is set up by finding the value in R4 which causes a standing current of about 20mA to be drawn from the 18 volt supply. A word of warning is necessary here. The OC36 in the TR2 position is capable of passing very high currents if the value of R4 is accidentally made too low, and so the setting up of R4 must be carried out very carefully. The method employed by the author consisted of wiring up a single 10MΩ resistor in series with a string of 2.2MΩ resistors, as shown in Fig. 2. The resistance was then reduced, from its maximum, in 2.2MΩ steps until the desired 20mA was drawn from the supply. In the writer's case it was found that about 17MΩ (10MΩ in series with four 2.2MΩ resistors) produced the desired current, whereupon the circuit was finally wired up with a 10MΩ and 6.8MΩ resistor connected in series.

## THE SUPPLY

As has already been stated, the current drawn from the 18 volt supply is 20mA. This current is not so high as to preclude the use of batteries to power the amplifier, even though the efficiency is not as good as is given by an amplifier with a Class B output. If a mains supply unit is employed there is no need to pay attention to voltage regulation so far as signal handling performance is concerned since the output transistor operates in Class A. Apart from small deviations during overload, the current drawn remains steady at 20mA. The supply voltage should not be allowed to rise above 20 volts, however, as this is the maximum collector voltage rating of TR1. Should the unit be powered by a poorly regulated mains supply it would be advisable to connect an 18 volt zener diode across the supply lines. The function of this diode would be merely that of ensuring that excessive voltage is not accidentally applied to TR1, and it need not draw any zener current when the amplifier and power supply are operating under normal conditions. ■

# QSX

by

## FRANK A. BALDWIN

(All Times GMT)

● **TOPIC**

Short wave listeners, like any group of human beings, tend to be a highly individualistic lot – some eventually obtain an amateur transmitting licence whilst others are quite happy to remain s.w.l.'s and to thoroughly master the craft. Others drift in and out of the hobby over a period of some years. There are those, of course, who remain in the hobby for some time, become quite well known in the world of short wave listening and then, for reasons best known to themselves, vanish completely from the scene, never to return to the fold. The writer can recall s.w.l.'s of the past whose names became a byword in the hobby, even prior to the last war. Others have been on the short wave listening scene for many years and these old timers tend, as a group, to be conversant with all aspects of the hobby, constructing their own equipment – either from published or their own designs – testing and evaluating the results, and operating over both the Broadcast and Amateur bands. On the Amateur bands, both phone (a.m. and s.s.b.) and c.w. stations are logged, the ability to read c.w. being necessary to become an all-rounder.

It is probably true, however, that the majority of short wave listeners tend to specialise in one aspect of the hobby or another. In the main, most listeners operate over the Amateur bands, using a.m. or s.s.b. phone transmissions as their prime targets. Unable to read c.w. they are confined to the phone portions of these bands, thus restricting their sphere of activity and interest and, in the writer's opinion, only gaining a small part of the interest which the short waves offer. If a continued and lasting interest is to be taken in the hobby, such a listener is advised to learn the dots and dashes. The ability to read c.w. widens the horizons of the operator who has previously only used the phone sections of the bands, it following that an increased report/reply ratio is the result, especially when morse transmissions are reported upon. Licence holders who operate on c.w. tend to receive far fewer s.w.l. reports than do their phone counterparts.

Amateur band listeners tend to crowd on to the 14 MHz band, this being the most favoured range of frequencies for the reason that they produce the most varied and choicest Dx signals throughout the year than any of the other bands. Comparatively few listeners are primarily interested, or even operate to any extent, over the lower frequency Amateur bands. It is a truism that Dx is relative, among other considerations, to the band in use – and many choice catches may be made on the lower frequencies. Moreover, these transmissions are reported upon by very few s.w.l.'s, and this implies that a comprehensive report to such a station would stand a very good chance of obtaining a reply.

To be an all-rounder s.w.l., operation over the Broadcast bands should also be included in the spread of interest. Broadcast band operation makes a complete change and a break from the Amateur bands. Many Dx stations are there for those who care to search for them and their reception often represents a major feat of short wave listening.

● **AMATEUR BANDS**

Top band has shown some promise of improvement on last year with signals being heard from across the Atlantic since early October. The dates of Trans-Atlantic Tests still to be held are – 11th January and 1st, 15th of February from 0500 to 0730.

**1.8MHz**

**CW:** DL2PB, DL9KRA, EI9BJ, EI9J, GM3BGW, GM3HLQ, GM3YOR, GW3RHC, GW3VPL, GW3XJC, GW3XST, HBØNL, OK1ATX, OK1JR, OK2BLH, OK3CJE, OL2AIO, OL2AKS, OL5ALY, OL5AMT, OL6ALT, OL9AY.

Trans-Atlantic Dx signals logged to time of writing are:– K1BPW (0525, 1804kHz); W1EXI (0545, 1803kHz); W1BB/1 (0515, 1804kHz) and VP9GW (0530, 1802kHz).

**3.5MHz**

**CW:** K3JH, VE1AJK, VE1AVN, WA1FSU, WA2CPQ.
**SSB:** CN8HD, KV4FZ, VE3DJE, VO1AC, XE1KB.

**7MHz**

**CW:** HP5CFW, HP6ASD, K4DJN, K5AZX, VE3DHC.

**14MHz**

**CW:** CR6AL, CR6KB, CX1JM, HC2HM, HP1BR, KP4DDY, PZ1AV, VP8JV, VQ8CC, ZE1DL, ZM3ABC, ZS1JJ, ZS5SG, ZS6GG, 9J2XZ.
**SSB:** CP6HQ, CR4BP, EL6UN, ET3USA, HC1RF, HC2OA, KP4AC, KZ5NG, PZ1CR, TR8MC, VK2SG, VK7KX, VP2LA, VP2VI, VP7DL, VP7NF, VP8KO, VP9BO, ZM3FT, ZP5GJ, 6Y5RA, 9K2BF.

For those interested, 9K2BF gave his QTH as P.O. Box 1083 Kuwait.

● **BROADCAST BANDS**

Several readers have written stating they are Broadcast band beginners and have not, up to the time of writing, heard an Indonesian station, although they have logged some of the signals from the Indian sub-continent. The Indonesian stations on the l.f. bands are all comparatively low-powered and conditions must be good before any hope can be held out of successful reception and recognition.

As a tip, the most consistent Indonesian signal here is that of YDK6 Djambi on **4927kHz** – listen around **1530** to station close down at **1600.** The receiver must be selective, this channel often being surrounded with CW and teletype QRM. The station closing ceremony – for want of a better term – commences at about **1550** with an Eastern type chanting song rendered by a young woman and this is followed by identification in Indonesian and a most haunting melody rendered on a Hawaiian guitar.

Other Far Eastern stations logged were:–

**4725kHz 1612** Rangoon, Burma, with drama programme in vernacular.

**4740kHz 1620** Radio Maldives, with American religious programme.

**4790kHz 1610** Penang, Malaysia, radiating recorded 'pop' music.

**4877kHz 1545** Saigon, S. Vietnam, with drama programme in vernacular.

**4907kHz 1434** Radio Cambodia, with a drama complete with many gong and cymbal clashes – most impressive!

Still on the lower frequencies, Dx'er Alan Thompson tells me that Radio Botswana is heard on **4845kHz** with BBC news at **1800** and station identification in English at **1809.** He also mentions that Brazzaville (ex-4795kHz) is – or was at the time of writing – on **4801.5kHz.**

**17770kHz 0532** Karachi, Pakistan, with sports commentary in English.

**21535kHz 0800** Tokio, Japan, with identification and news in English.

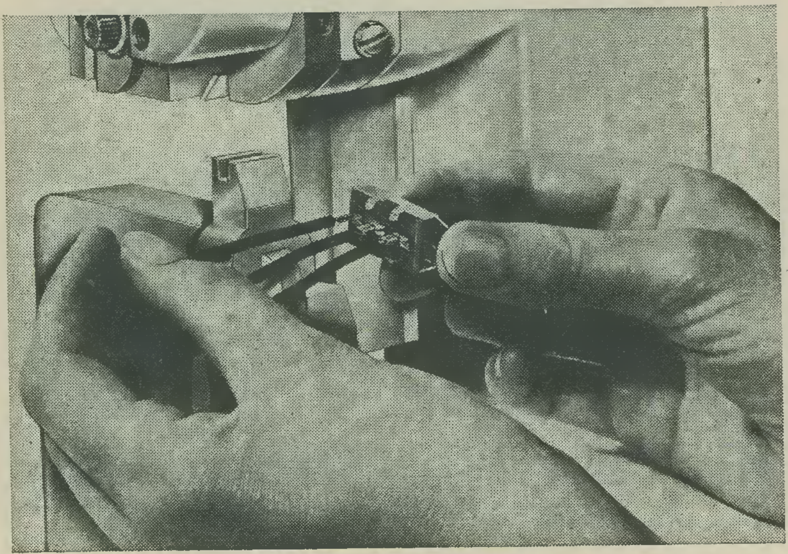
**21545kHz 0800** RSA, South Africa, station identification and music.

Whilst dealing with the higher frequencies, Alan Thompson also brought to my notice the following – **11855kHz** Saudi Arabia in English, good signal between jamming of Tirana (Peking relay) on same channel, try around **1900-1930** when channel is clear. **15540kHz** Tanzania with English programme at **1700-1830. 15723kHz** at **1730** Omdurman in English/Arabic.

■

# NEWS . . . AND .

## PRESSAC 'AUTOSPLICE' CONNECTION SYSTEM



'Autosplice' connections being applied to slider switch.

**'Autosplice' makes its own connectors directly from one coil of correctly grain-oriented conductor ribbon. The press feeds the correct length, cuts it, forms a connector and compresses it securely around the conductors it is joining, in less than a fifth of a second.**

**Various conductor diameters and tag sizes are accommodated by changing dies and adjusting the connector ribbon feed.**

**Using just one width of ribbon and as few as one pair of dies, 'Autosplice' stockholding is reduced to a minimum. There is no longer a need to maintain stocks of thousands of tiny preformed connectors or expensive soldering equipment.**

## INTRODUCTION TO COLOUR TELEVISION

The advent of colour TV on all major channels has stimulated interest in the technical aspects of colour television.

We would draw the attention of new readers to our Data Book – *Understanding Television* by J. R. Davies, which contains an 80 page comprehensive introduction to colour TV. The book covers TV as a whole and has more than 500 pages and over 300 diagrams, costs 37/6, postage 3/6, and is of equal value to those who only have a basic knowledge of radio principles and to established radio engineers.

## 1969-70 FARADAY LECTURE TOUR

*The forty-first in the series of Faraday Lectures arranged by the Institution of Electrical Engineers is to be given by J. H. H. Merriman on the subject of 'People, Communications and Engineering'. Mr. Merriman is the senior director (development) with the British Post Office and also member for technology on the board of the Post Office Corporation.*

*The deputy lecturer is C. H. May who is staff engineer in the P.O. Telecommunications Development Department.*

*Starting in Rugby, Staffordshire on the 18th November, the Faraday Lecture is to be given in thirten towns in the British Isles, finishing in Belfast on the 17th April 1970.*

*The Faraday Lecture series is intended to spotlight various aspects of modern electrical and electronic science and technology in straightforward language for the general public. Special presentations for students are being arranged at all the towns on the tour. Members of the public are admitted by ticket, free of charge, to these lectures.*

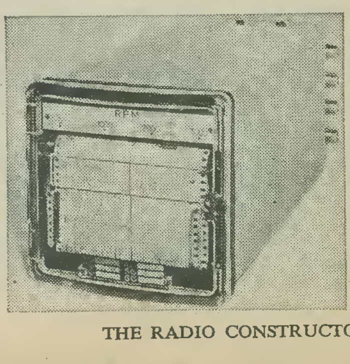
*The lectures will be given at the following centres: Albert Hall, Nottingham, 13.1.70; Victoria Hall, Hanley, Stoke on Trent, 15.1.70; Philharmonic Hall, Liverpool, 29.1.70; City Hall, Sheffield, 10.2.70; Sophia Gardens, Cardiff, 17.2.70; Central Hall, Westminster, London, 19/20.2.70; City Hall, Newcastle, 17.3.70; Usher Hall, Edinburgh, 19.3.70; Royal Dublin Society Hall, Dublin, 15.4.70; William Whitla Hall, Belfast, 17.4.70.*

*Details and tickets may be obtained from The Institution of Electrical Engineers, London, W.C.2.*

## JAQUET RECORDER TYPE 400

**The KSQ 400 series has recently been added to the Radiatron range of Jaquet recorders. Compared with the existing KSQ 300 series the new recorders have been reduced in size by nearly 50% and in cost by approximately 30%. In frontal presentation and accuracy the new recorders are identical to the earlier type. The price and size reductions have been achieved by using the latest electronic techniques and simplifying the circuitry of the instruments. This results in slightly reduced sensitivity and increased response speed, but does not impair accuracy or any other aspects of performance compared to the earlier KSQ 300 series.**

**Brief specifications: 1-6 channels; plug-in range cards; input impedance not less than 20kΩ; sensitivity 0.15% of measuring range; accuracy 0.5% FSD; prices from £212.**



# COMMENT

## ELECTRONICS AID TRAINING TIME CUT

A new method of basic training for teleprinter operators and telegraphists has recently been introduced by the Royal Air Force at R.A.F. Cosford, main training centre for operators of all R.A.F. communications equipment.

Using the Videomatic Tutor pioneered by Sight and Sound Ltd. initial touch-typing speeds of 15-20 words per minute is achieved in less than half the time necessary with conventional methods. Estimates are that the consequent two-week reduction in the present 11-week course will trim more than 20% of the training bill.

A system which has also found favour with the public, the Videomatic Tutor is a machine which incorporates a panel, representing the typewriter keyboard, placed on a wall facing the class. Connected to the panel is an electronic unit consisting of a computer-programmed magnetic tape deck which simultaneously relays instructions through loudspeakers and signals to illuminate the appropriate keys represented on the wall panel. By this means each student is shown the position of his fingers on the blank keys of the typewriter in front of him. Visual indication of the next movement is given on the wall panel fractions of a second before the verbal instruction.

The R.A.F. has found that a pupil's concentration and receptivity are improved to the extent that the entire keyboard is memorised within four hours and finger movements are made without conscious effort.

With the reduction in training time now possible, R.A.F. Cosford will be able to handle more than 200 students a year, in courses of 20 at a time. Fully fledged operators fan out all over the world to maintain the R.A.F.'s vital communications links.



## EXPANSION AT LIND-AIR AUDIO CENTRE


*The newly extended Lind-Air Audio Centre at 18/19 Tottenham Court Road. The Centre, which includes two hi-fi demonstration studios and a colour television showroom, now covers 6,000 square feet.*

## CONNECTING CABLES — NEW COLOUR CODING

**The change in the colour coding for the insulating material covering each core of the 3 cores in a.c. mains connecting cable, the possibility of which we were among the first to announce more than a year ago, comes into effect on 1st July, 1970.**

**Existing electrical apparatus already purchased will not be affected but it will be an offence, after 1st July 1970, for a dealer in electrical goods to sell appliances where the cable does not conform to the new colour code.**

**Although we feel that our present code is more logical and superior to the new, obviously an international standard is highly desirable. The confusion arising between various colour codings by different countries has led to accidents, some fatal, both here and abroad: large quantities of electrical equipment are both exported and imported. Some idea of the existing dangers can readily be envisaged when it is realised, for example, that West Germany uses red for earth, and a number of countries use black for the live wire. Also it appears that colour blind people will be less likely to confuse the earth and live wires, under the new regulations.**

**The coding will be:–**

**Earth – Green and Yellow striped core**

**Live – Brown core**

**Neutral – Blue core**

# TRANSISTORISED CRYSTAL MARKER

by

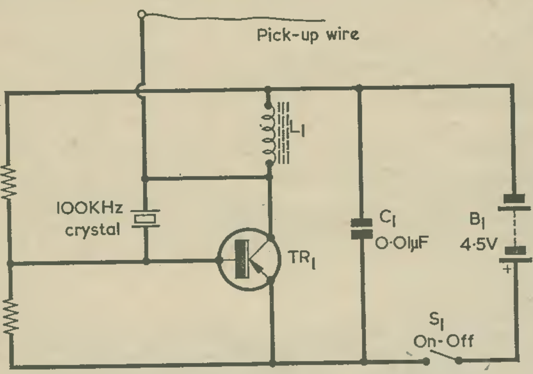
S. G. WOOD, G5UJ

**This simple and inexpensive circuit can produce detectable 100kHz harmonics up to 28MHz**

A 100kHz CRYSTAL OSCILLATOR CAN BE A USEFUL adjunct to any "ham-shack" and it need not be expensive or difficult to build. Apart from the cost of the crystal – and these have been on the market for as little as 7s. 6d. – the total expenditure can be very low.

Good results have been achieved with the circuit shown in the accompanying diagram, using general-purpose germanium transistors such as the Mullard OC70 or OC71. Even the old Red-spot types have been found to function satisfactorily.

The oscillator is of the Pierce type and sufficient r.f. output for most purposes is available when the circuit is powered by a 4.5 volt battery. Resistors R1 and R2 can be $\frac{1}{4}$ or $\frac{1}{8}$ watt 10% components. Switch S1 may be a normal toggle or slide type; alternatively a push-button can be employed, this being pressed to switch on the oscillator when required. Choke L1 can be a small 2.5mH component such as the Repanco CH1. However, the writer employed a home-wound choke, this consisting of 45 turns of 30 s.w.g. enamelled wire pile-wound on a short length (about 1in.) of ferrite rod. The choke inductance is not critical.




*Circuit of the 100kHz marker oscillator. Suitable components for L1 and TR1 are discussed in the text*

The various uses to which this little unit may be put need hardly be enumerated here. It is possible – with care – to pick out the harmonics on a sensitive receiver at 100kHz intervals up to as high as 28MHz. Should any difficulty be experienced due to receiver screening, etc., a short length of "pick-up" wire may be introduced into the collector circuit of the transistor, as shown in the diagram. This can then be positioned near the receiver aerial lead or aerial terminal to increase coupling. ■

# SPACE DX

Have you ever had secret dreams of receiving signals from another civilisation in our galaxy from way across the other side of the Milky Way? If you have then you are normal; if you haven't then you must be unimaginative!

Has a listening watch ever been made for such signals? Yes, the first and only attempt to receive intelligent signals from another planet was made in 1960 and termed the Ozma Project – during which a listening session of 150 hours was made using directional aerials beamed to our nearest solar type stars, Tau Ceti and Epsilon Eridani, at a distance from Earth of some 11 light years, and around which planetary systems may be orbiting. The project was dismally unsuccessful.

## WHICH FREQUENCY?

From experience gained in the field of radio astronomy, the choice of wavelength would lie between 3 to 30cms at which the effects of cosmic noise and atmospheric absorption on a signal would be at a minimum. It has been suggested that the best frequency would be 1,420 MHz – this being the emitting frequency of neutral hydrogen clouds around the spiral arms of our galaxy – the reasoning being based on the assumption that other galactic civilisations may also be conducting surveys of hydrogen distribution.

## SUCCESS OR FAILURE?

At the present time, success is miserably zero. We need more sensitive equipment and improved techniques, much time and investigation before the odds against success are anything like evens. Careful listening will have to be maintained out into space. to distances of hundreds of light years. One powerful radio astronomy transmitter, the 1,000ft. dish in Arecibo, Puerto Rico, is claimed to be able to transmit radio pulses of sufficient power to be detected at a distance of 1,400 light years from Earth.

## WHO WILL LISTEN?

How many intelligent civilisations are there in our galaxy of sufficiently advanced technology able to receive our signals? Well, astronomers have calculated that the number of single solar-like stars that have accompanying planetary systems formed during the 10 billion years of the existence of our galaxy, is something like 50 billion. With these sun-like stars, the forming of accompanying plants is a common event. Of the planet total however only a relatively few will be able to support intelligent life with the required conditions – atmosphere, temperature, water, etc. With the remainder, not all will see the emergence of life, and, where it does emerge, not all species will be technically competent to take part in space communications – and some that are may not be interested in making contact with others.

One authority has calculated that there *ought* to be something *like four million civilisations capable of communicating* with each other.* Of course, all these civilisations will not attain a culture peak at the same period. Nevertheless, there should be sufficient overlap of civilised periods to make interstellar communication possible.

With a total of four million communications minded galactic civilisations, we may yet – at some future date – be holding regular Dx schedules with another far across the vast distances of space!

*L. Berman, K6BW, writing in CQ, November, 1969.

# 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.

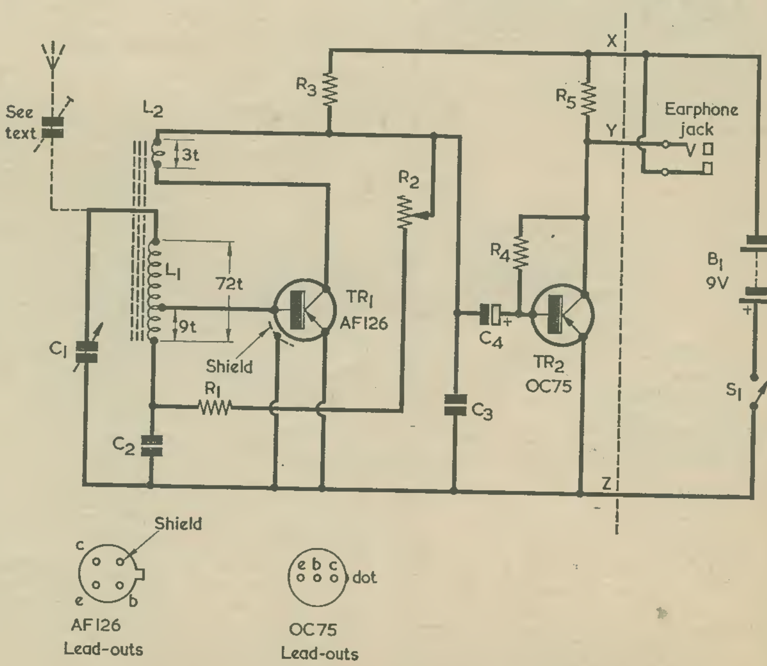



*Fig. 1. The 2-transistor version of the regenerative receiver*

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 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.

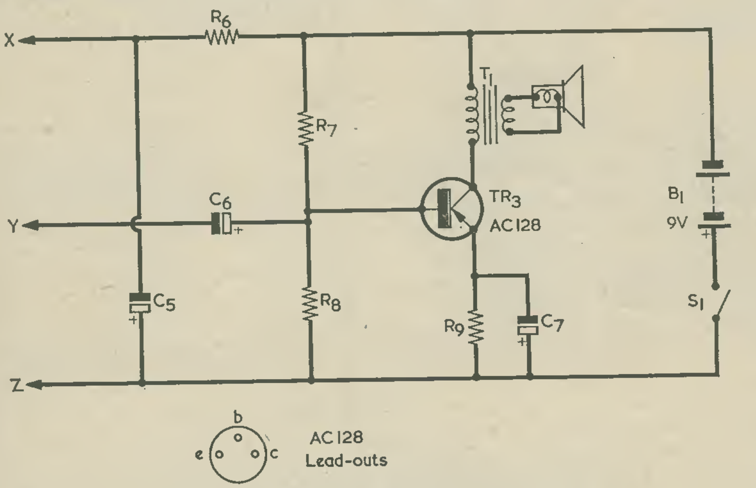



*Fig. 2. This extra stage is added to provide the 3-transistor version*

## COMPONENTS

*Resistors*
(All fixed values ½ 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

## 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 ⅛in. 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. ■

## ELECTRICAL FAULT-FINDING "DOWN UNDER"

Two methods of tracing an intermittent fault, using Electrolube Freezer, have been described by a correspondent to *Electronics Australia*, a leading Australian Technical Journal. In one, groups of components were heated and individually cooled in turn, whereas the reverse procedure was employed in the second case. The first involved a close circuit TV system. After about an hour's operation, the picture on the monitor began to expand and contract at approximately a 1 sec pulse rate. The simple act of opening the side of the control-unit case was sufficient to cure the fault because of the loss of heat. An infra-red lamp was therefore used to raise the temperature of the equipment while the side was open.

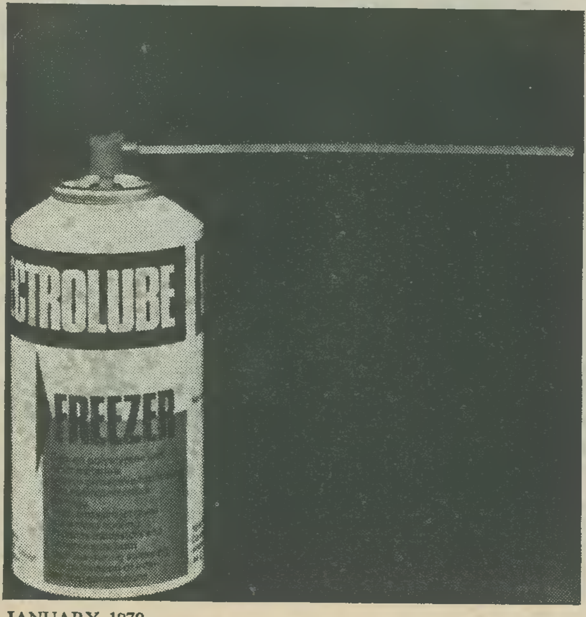
The lamp was arranged to provide local heating of various sections of the equipment in turn. By this means it was established that the section including the master oscillator and the first divided chain contained the fault.

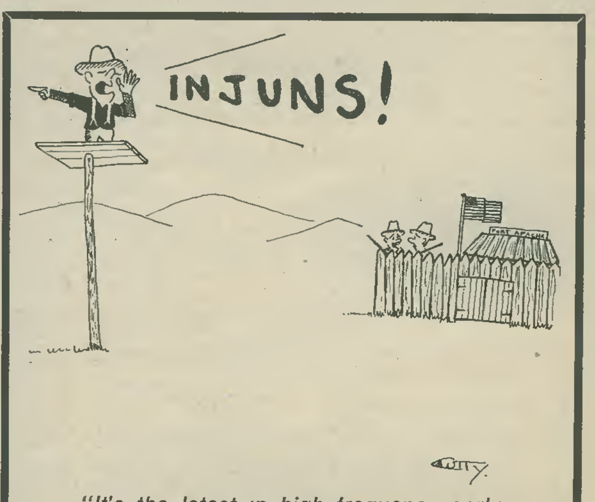
Leaving the heat lamp on so that the fault remained in evidence, the correspondent then applied Electrolube freezer to each component in turn. The fault disappeared when a mica capacitor in the master oscillator was cooled by the spray. Fitment of a new capacitor provided a remedy.

The second case concerned a tape recorder which would not record or play until it had been switched on for about 10-15 minutes.

"It occurred to me", wrote the correspondent, "that I might be able to identify the faulty component by heating each component after mass cooling and note which one restored the performance most rapidly".

A group of components was cooled with the aerosol and the writer placed his finger on each in turn to apply heat. A faulty transistor was discovered in this way to the correspondent's surprise as he did not suspect that a transistor could be temperature-conscious. A colleague, however, suggested that the transistor contained a broken bonding wire or faulty junction to either the chip or pigtail, with only a microscopic gap. ■




"It's the latest in high frequency early warning systems."

# VERSATILE A.C. MILLIVOLTMETER

by

G. W. SHORT

**Intended for the more experienced constructor, this article describes a versatile and inexpensive millivoltmeter design which incorporates many attractive features. These include low battery consumption and the ability to operate with any moving-coil meter having an f.s.d. within the limits 500μA to 5mA. Measuring ranges depend on the existing scale marking on the meter and may be, typically, 5mV to 500V. The frequency response within 5% error extends from 20Hz to 30kHz**

Most millivoltmeters are designed around meters of a specific sensitivity, usually 100μA instruments. The transistor a.c. millivoltmeter described here is different. It has been deliberately designed to accept a wide range of indicating meters so that the constructor, by following some simple rules, can adapt it to accommodate whatever meter he happens to have, the only requirements being that it should be a d.c. instrument with a linear scale and a sensitivity of 500μA to 5mA approx. The amplifier part of the instrument may be used as a general-purpose audio amplifier with an output of up to 2.5V r.m.s. The amplifier will deliver over 30mW to a 70Ω speaker.

### SPECIFICATION

Input impedance: greater than 1MΩ.

Measuring ranges: 5mV – 500V approx., full-scale.

Standby consumption: 9V, 2.5mA approx.

Overload capacity: 240V, 50Hz on most sensitive range.

Frequency response: 20–30,000Hz, ± 5%.

Indicating meter: 500μA to 5mA, any linear scale.

Amplifier section usable for other purposes.

### BATTERY DRAIN

The usual type of transistor millivoltmeter (see Fig. 1) incorporates a Class A amplifier. This drives a rectifier meter, which is placed in a negative feedback path to improve the linearity.

The drawback with this type of circuit is that if a relatively insensitive meter has to be used the battery drain becomes too large. Suppose a 5mA meter is to be used. If the input signal is a sine wave then, to drive the pointer to full scale deflection, the input current to the meter must be 5mA r.m.s., or 7mA peak. The peak current is what matters, because it fixes the minimum current which the second transistor must pass. In the present case, this must be over 7mA d.c. or the peaks of the sine wave will be clipped and the millivoltmeter will be inaccurate. Unfortunately most millivoltmeters will also be called upon to handle speech and music voltages. These have rather peaky waveforms, and to handle them without clipping calls for a much higher standing current, perhaps four times the meter full-scale current. By the time the drain of the earlier stages has been added the consumption will be about five times the meter f.s.d. current, or some 25mA for a 5mA meter, which imposes a severe drain on the battery.

### SELF-RECTIFYING OUTPUT STAGE

The battery drain can be reduced by using a Class B output stage with a low standby current. A Class B amplifier can deliver large peak currents on demand, which is just what is needed for dealing with peaky waveforms. A possible method of using it would be to substitute the Class B output stage for the second stage of Fig. 1, driving the meter from the Class B pair in much the same general way. This, however, is needlessly complicated. An alternative arrangement, shown in Fig. 2, saves the rectifier by making use of the fact that the lower output transistor of the complementary Class B pair conducts only on alternate half cycles, and therefore acts as a half-wave rectifier to drive the meter.

The only problem that now arises is that the meter registers the standby current of the transistor even when there is no input signal. The remedy is to bias the transistor exactly to cut-off. In practice, however, it is better to adjust the bias until the meter registers a tiny current and then move the pointer back into position by means of the zero adjuster screw.

This last approach gets rid of the problem of the standing current, but it creates a new one. An amplifier biased in this way suffers from crossover distortion. Such distortion is not important in itself in a measuring instrument, but it does spoil the linearity. The answer is to apply heavy negative feedback. Some negative feedback is introduced automatically by the d.c. bias resistance RB, which of course allows a.c. to pass from output to input as well, but the feedback given here is not enough. An additional a.c.-only negative feedback resistance, RF, is therefore added.

**DESIGN STRATEGY**

Constructors familiar with the Fig. 2 type of circuit will realise that it is not going to be much use when very high sensitivity is required, because the gain is not very high. More amplifying stages are needed. At this point, however, it pays to forget about the exact circuit configuration and think about the essentials of the feedback arrangement.

These are shown in Fig. 3, and as many textbooks will point out, the performance of such an amplifier

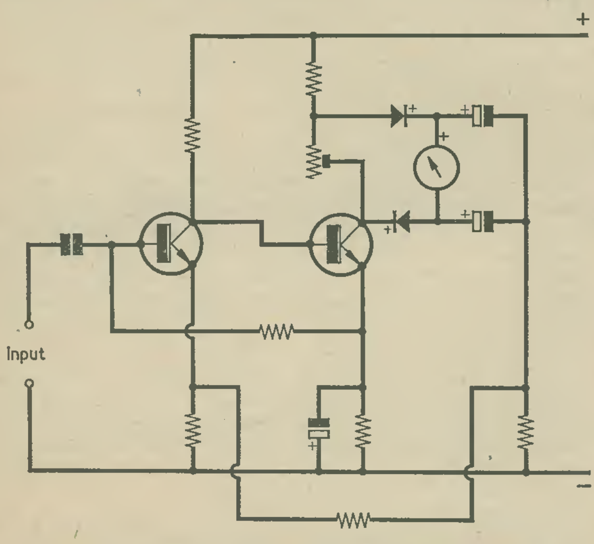



*Fig. 1. Typical transistor a.c. millivoltmeter circuit. To avoid clipping the peaks of the signal waveform, the collector current of the second transistor must be several times the meter full-scale current*

is governed very largely by the three resistances shown, regardless of what is inside the "box", provided that the gain inside the box is very high. For practical purposes, the following statements can be taken as true:

| | | |
|---|---|---|
| Input impedance of whole circuit | = | RS |
| Voltage gain, Vout/Vin | = | RF/RS |
| Current gain, Iout/Iin | = | RF/RL |

These equations tell us that, provided we leave the feedback resistance RF alone, we can adjust the current gain (by changing RL) without affecting the voltage gain. Alternatively, we can adjust the voltage gain (by changing RS) without affecting the current gain. This is just what is needed for adapting the circuit to a wide range of meter sensitivities and scale markings.

### RANGE SETTING

Different voltage ranges could be selected by switching in different values of RS. In this respect, RS acts in exactly the same way as a "multiplier" in any ordinary voltmeter circuit. The idea is attractive if only a few relatively high voltage ranges are required. With a reasonable amount of amplification, the overall sensitivity can be 1MΩ per volt, which is a lot higher than the sensitivity of even the most sensitive non-electronic multi-range meters. But it is still not high enough. For a range of 3mV f.s.d., for example, RS would only be 3KΩ, which is much too small.

For this reason, the complete millivoltmeter described here uses a high input impedance buffer stage in front of RS, and carries out its range selection by means of a potential divider in front of the buffer stage.

### BUFFER AMPLIFIER

A mosfet makes an ideal buffer from the point of view of high input impedance. Fig. 4 shows a suitable circuit, incorporating an R.C.A. mosfet type 40468A, which is the successor to the well-known 40468. (The 40468A is available from Amatronix, Ltd., as indeed are all the other semiconductors employed in the instrument).

The mosfet is connected as a "source follower" with a "gain" of less than 1, and having good stability, virtually infinite input resistance, and a fairly low output resistance. The low output resistance enables fairly small values for RS to be used if need be. The input potential divider shown has six 10 to 1 steps and covers input ranges such as 5mV to 500V. All the resistances except R7 are common standard values, and R7 can be made up from two 22Ω resistors in parallel without much loss of accuracy.

Series resistance R1 and the diodes D1 and D2 perform the very important job of protecting the gate of the mosfet against high voltages. No damage results from a sustained overload of 240V on the most sensitive setting of the range switch. Note that R1 must be able to dissipate 1W under these conditions.

### COMPLETE CIRCUIT

Those extra amplifying stages inside the "box" of Fig. 3 appear in full in the complete circuit of Fig.

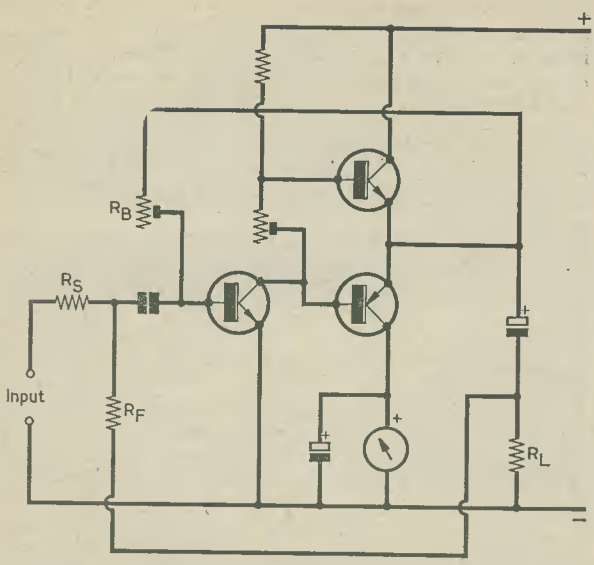



*Fig. 2. A linear class B amplifier draws only a small idling current. It can also be made to do its own rectifying: a meter connected as shown receives d.c. equal to half the mean a.c. output current*

5. The whole of the main amplifier is direct-coupled in the simplest possible way, advantage being taken of the ability of silicon transistors to operate with collector to emitter voltages which are the same as their base to emitter voltages. Using a fairly close tolerance transistor (type BC168C) in the first stage, the d.c. conditions for all stages can be set by means of one preset resistor, R15. This is adjusted so that the standing voltage at the emitters of TR5 and TR6 is 4.7V above the negative supply rail. Setting the bias of the output pair is carried out by R18, which trims the voltage across the stabilising diodes D2 and D3. These diodes can be almost any type of silicon junction diodes.

For calibration purposes, the a.c. gain has to be made adjustable, and this is allowed for by putting a potentiometer, R20, in the negative feedback circuit.

An extra transistor, TR7, is placed across the meter. Its job is to protect the movement from switch-on surges and overloads. TR7 conducts when the voltage across the meter coil exceeds about 500mV. This is quite a lot more than the normal drop at full-scale deflection for most meters, and if desired the drop across the movement can be artificially increased to, say, 400mV at f.s.d. by inserting a series resistor of appropriate value at the point marked with a cross. The author used a BC168 for TR7, but any other silicon p.n.p. type will be satisfactory provided it has a low bottoming voltage and is capable of taking about 100mA peak collector current.

## ADAPTING TO THE METER

With a sine wave input the amplifier can deliver a little over 2.5V r.m.s., but to allow for peakier waveforms it is advisable to design for full-scale deflection at an output of only 1V r.m.s. This output must drive a current through the load resistor R21 which is equal to twice the meter current. The first step in adapting the circuit to a given meter is to select a value for R21 which gives the required current, working from the equation:

$$R21 = \text{(Output voltage)}/\text{(Twice meter current)} = 500/Im$$

(where Im is the meter full-scale current in milliamps and R21 is in ohms). Thus a 1mA meter calls for a value in R21 of 500Ω. A 470Ω resistor may in practice be used.

The meter current having been dealt with, we next have to select ranges which correspond to the existing meter scale markings. This is quite simple. The most sensitive range should be between 3 and 30mV, and we choose a figure that fits the scale markings. If, for example, the meter is marked 0–500, the lowest range can be 0–5mV. Having done this, we then use a value for R10 with as many kilohms as the lowest range has millivolts: e.g. 5kΩ for 0–5mV. Once again, it is quite in order to use a resistor of standard value slightly below the calculated value; e.g. 4.7kΩ instead of 5kΩ.

The design is now complete as far as adapting the circuit to the meter is concerned. There is still, however, a further important point to consider, and we shall next turn to this.

## VOLTAGE LIMITATION

In the writer's opinion, it is always better to be safe than sorry where high voltages are concerned. In the present case, the wattage rating of R2 imposes an upper limit on the input voltage of 700V r.m.s. However, it is quite possible that an even lower limit will be imposed by the voltage ratings of certain components. If, for instance, a co-axial input cable is employed, how much voltage can safely be applied between its inner and outer conductors? Again, how much voltage will the input socket stand? Or the insulation between adjacent tags on the wafer switch? Or between the wafer and the spindle?

These are likely to be unknown quantities, and when dealing with unknown quantities it is always safest to be pessimistic about them. In consequence, it is recommended that the upper limit to the millivoltmeter ranges should not exceed 500V. On this basis the ideal meter scaling is 0–5 (or 0–50, or 0–500) because this gives six ranges starting from 5mV (which covers the signals likely to be obtained from audio sources such as pickups) and ending at

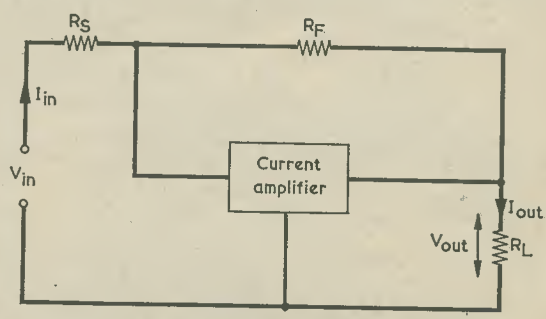



*Fig. 3. General picture of a current amplifier with negative feedback, showing only the important resistances which define the gain and input impedance*

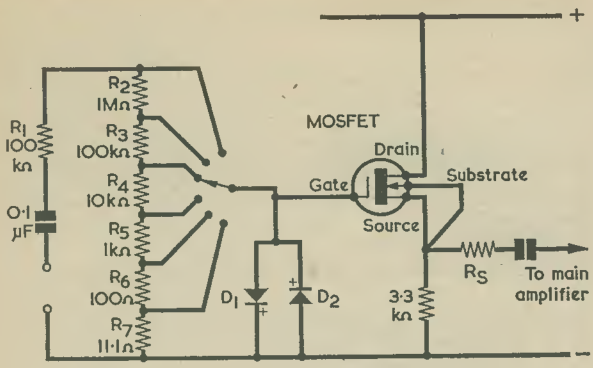



*Fig. 4. High input impedance buffer using a mosfet. The diodes protect the gate from excessive voltages*

500V (which covers the mains and most transformer secondary voltages found in the power packs of valve equipment). An instrument scaled 0–3, etc., which would allow 3mV to 300V to be covered, is also very useful. A rating for R2 of ¼ watt is sufficient in this case, while allowing a fair margin of safety.

If some other meter scaling is used it is best to incorporate only five ranges and to make some special provision for high voltages. The best arrangement here is undoubtedly to make a special high-voltage probe. A probe with a tubular insulated body of thick plastic or s.r.b.p. can easily take a few thousand volts. The limiting factor is flashover or "tracking" between connecting points, and the remedy is to spread the voltage out as much as possible. A probe containing 10MΩ series resistance gives a voltage multiplication of 10 with this instrument. No ordinary 10MΩ resistor will stand 1,000V or so across its ends, so instead of one 10MΩ resistor use, say, ten 1MΩ resistors in series, these being spaced out in line down the barrel of the probe. High voltages of the order we are considering can be very dangerous and the probe must, of course, be designed so that there is no possible risk of shock to the user.

When such a probe is used, it is still quite in order to have a six-*position* range switch. The wiring of the sixth step could be modified as shown in Fig. 6(a) so that the sixth position is now a "meter off" position. (But remember that though the meter is off the power supply is not, and an on-off switch is still needed.)

Alternatively, it is possible to dispense with the probe and modify the resistor values of the last two steps in such a way that the sixth position gives a range multiplication factor, not of 10, but of 2 (Fig. 6(b)) or of 3 (Fig. 6(c)). By using this trick, a meter scaled 0–10 can be given a highest range of 0–200V or 0–300V instead of 0–1,000V. The only disadvantage is that some mental arithmetic is needed when reading the meter on this range. When using the arrangements shown in Figs. 6(b) and (c) the new resistor values are used instead of R6, R7, and R8. The rather complicated network of Fig. 6(c) is employed merely to enable the right range to be obtained using standard resistors.

If a five-position range switch is used, one resistor of 111Ω can replace R6, R7, and R8. In practice it may be easier to use two 220Ω resistors in parallel, though the value 110Ω is also standard and obtainable from some suppliers. It belongs, however, to the "E24 Renard Series" in which successive resist-

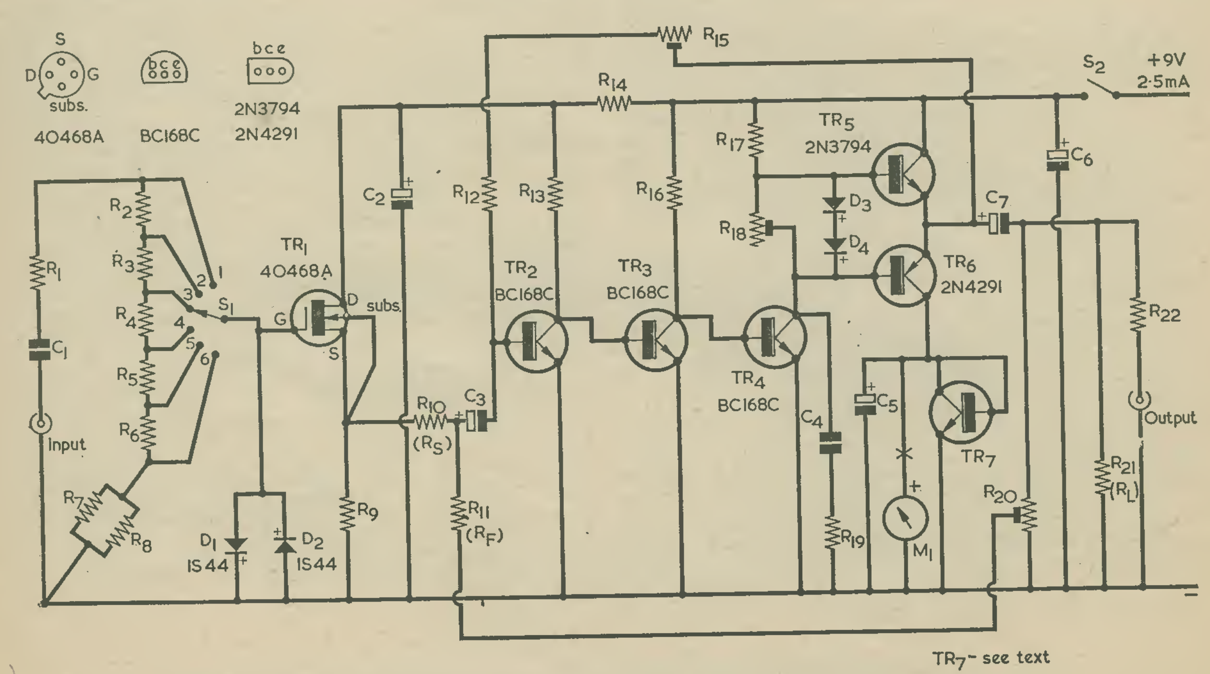



*Fig. 5. Complete millivoltmeter circuit. R10 and R21 are selected to suit the meter, as described in the text*

## COMPONENTS

*Resistors*
(All fixed resistors high stability, and ¼ watt unless otherwise stated. R2 to R8 inclusive 5% or better. All other fixed resistors 10% or better. See text for details on potentiometers).

| | |
|---|---|
| R1 | 100kΩ 1 watt |
| R2 | 1MΩ ½ watt |
| R3 | 100kΩ |
| R4 | 10kΩ |
| R5 | 1kΩ |
| R6 | 100Ω (see text) |
| R7 | 22Ω (see text) |
| R8 | 22Ω (see text) |
| R9 | 3.3kΩ |
| R10 | See text |
| R11 | 1MΩ |
| R12 | 1.5MΩ |
| R13 | 10kΩ |
| R14 | 4.7kΩ |
| R15 | 5MΩ potentiometer, preset |
| R16 | 15kΩ |
| R17 | 4.7kΩ |
| R18 | 15kΩ potentiometer, preset |
| R19 | 330Ω |
| R20 | 5kΩ potentiometer, preset |
| R21 | See text |
| R22 | 10Ω |

*Capacitors*

| | |
|---|---|
| C1 | 0.1μF, 250V wkg. |
| C2 | 125μF electrolytic, 10V wkg. |
| C3 | 2.5μF electrolytic, 64V wkg. |
| C4 | 330pF |
| C5 | 320μF electrolytic, 2.5V wkg. |
| C6 | 125μF electrolytic, 10V wkg. |
| C7 | 250μF electrolytic, 6V wkg. |

*Semiconductors*

| | |
|---|---|
| TR1 | 40468A |
| TR2 | BC168C |
| TR3 | BC168C |
| TR4 | BC168C |
| TR5 | 2N3794 |
| TR6 | 2N4291 |
| TR7 | See text |
| D1 | IS44 |
| D2 | IS44 |
| D3 | IS44, or any silicon junction diode |
| D4 | IS44, or any silicon junction diode |

*Meter*

| | |
|---|---|
| M1 | moving-coil meter, see text |

*Switches*

| | |
|---|---|
| S1 | 1-pole 6-way wafer |
| S2 | s.p.s.t., toggle or wafer |

*Miscellaneous*
Coaxial sockets, terminals (as required)
9V battery

ances increase by 10% increments, whereas 220Ω (and all other resistances in the diagrams) belongs to the more popular E12 Series, with successive increments of 20%.

### SUPPLY VOLTAGE

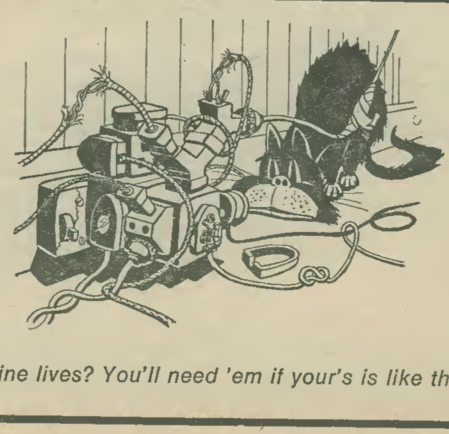
The millivoltmeter is not unduly affected by variations in supply voltage, and no voltage regulation is provided. The prototype, when adjusted for f.s.d. with a sine wave input and a 9V supply, showed an error of less than 3% when the supply was 6V, and less than 10% with 4.5V. The error at 4.5V was due to peak clipping and not to falling-off of gain. The error is, of course, smaller at less than f.s.d. By the same token, the error is larger if the meter is used to measure peaky waveforms. In general, the battery should be replaced when its voltage has dropped to 6V.

### CONSTRUCTION

The instrument still has to be made, of course, and this is not a task to be undertaken in a slap-happy way, using odd bits and pieces from the junk box. A prime consideration is to make sure, well before beginning, that there is going to be plenty of room for everything inside the cabinet and on the front panel. Last-minute alterations and the cramming of components into odd corners are likely to spoil the performance by introducing stray capacitances and couplings which, even if they do not cause instability, may still play havoc with the accuracy. The following points should be given due attention.

*Screening.* It is essential to house the millivoltmeter in a metal box. In addition, the input connections and range switch should be put in a separate screened compartment. This may seem over-elaborate for an audio instrument, but experience with the prototype showed it to be essential. Without screening, the meter registered a reading on all settings of the range switch when a 50kHz input at 15V was applied, even when TR1 was taken out of circuit! This explained a rather striking rise in the frequency response above about 20kHz. Screening the input connections eliminated the effect.

*Input wiring.* The range resistors should be small and wired directly between the tags on the range switch. This keeps down the stray capacitance. Careful attention to the placement of the "earth" connection of the input circuit is essential. The important thing is to return the bottom end of the range attenuator (R7 and R8) to the earthy side of the input socket with a short, thick wire. If, as is



*"Nine lives? You'll need 'em if your's is like this!"*

desirable, a coaxial input socket is used, then the "earth" connection can be made to a solder tag clamped to the metal front panel by one of the bolts that fix the socket. Failing this, make a connection to the panel close to the socket. If an actual earth connection is used, it should go to the same point. All the negative wiring should be carried out with thick wire, to reduce couplings between output and input via the wiring.

*Buffer stage.* The mosfet should be connected last, after all the other components, and especially after diodes D1 and D2 are connected into circuit. When soldering, remember to earth both the bit of the iron and the circuit. When handling the 40468A, always pick it up by the case, never by the leads. Since the gate presents a very high impedance, it should be kept away from the input socket. It is quite a good idea to mount the buffer on a little circuit board or tagstrip supported behind the range switch. The bolts which hold the switch wafer can often be used to support the buffer circuit, and the whole lot can then be put inside the screening compartment for the input circuit.

*Main amplifier.* Use a logical layout, with the input at one end and the output at the other, and positioned so that the input lies near the buffer stage

resistor tolerance which can be accepted is 5%, and 1% is worth having if the meter scale is reasonably long. All resistors in the millivoltmeter should be high-stability. The tolerance of R1 is not important, but it should be rated at 1W.

The weakest link in the calibration circuit is R20. Ideally, it should be wire-wound, but economy will usually dictate a carbon preset component. Use a good make such as Egen type 467, and check the calibration from time to time. (The Egen type 467 potentiometer and suitable potentiometers for R15 and R18 are available from Amatronix, Ltd.)

If an audio generator with a monitored output is available, check the frequency response. Taking the reading at 1kHz as a reference, the error should not exceed 5% between 20Hz and 30kHz, with the possible exception of the second most sensitive range, where the h.f. response may tail off at a lower frequency because of the effect of stray capacitance across the potential divider output.

It will be appreciated that the bandwidth of the amplifier between 3dB points is much larger than the "useful measuring bandwidth" of the instrument. An error of 3dB amounts to some 30%, which is far too great in a measuring instrument. A wider bandwidth can, however, be used when making comparative measurements at a fixed frequency outside the normal measuring band. Indications up to about 3MHz are obtained.

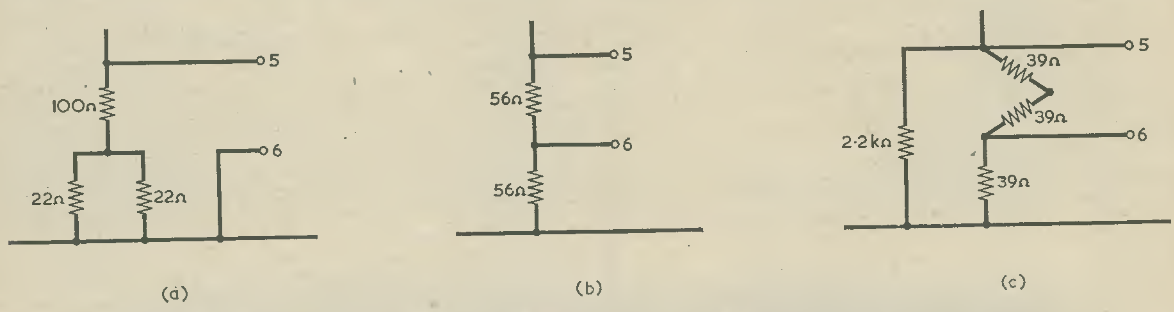



*Fig. 6. Modified "highest range" connections to S1. The circuit of (a) is used when only five ranges are needed but the switch has six positions, whilst (b) gives a sixth range which is twice the fifth range. The configuration in (c) gives a sixth range which is three times the fifth range*

whereupon the connection between these two is kept short. Any of the usual constructional techniques, including pin-board, will do.

*Terminals.* Co-axial connectors are best, and are probably essential if hum pickup is to be avoided, but it is a good idea to provide wander-plug sockets as well. Keep the output terminals away from the input.

## CALIBRATION

Calibration can only be done with the aid of a known input voltage, which usually means monitoring the input with another meter of known accuracy. The applied frequency should not be too high, and should be well inside the range of accurate measurement for the other meter. (Many multimeters are only accurate up to 2kHz). In general, 50Hz will be a good bet. If possible, choose a voltage such that the extra meter reads near full scale but the millivoltmeter reads about half scale. Adjust R20 so that both instruments read the same. Only one adjustment is needed; the other ranges will be right if the range resistances are correct. The worst range

If linearity is unimportant, the sensitivity can be greatly increased by short-circuiting the output terminals. If this is done, the meter will register a reading with no input; the reading being due to noise in the amplifier. (If the wiring layout is poor, short-circuiting the output may cause the circuit to break into oscillation, in which case the meter reads full scale.)

The lower limit of the frequency response can be pushed below 20Hz if desired, by increasing the value of C3. Note, however, that C3, if electrolytic, must have low leakage. This is because its leakage current, if appreciable compared with the base current of TR2 (which is less than 1$\mu$A), will upset the biasing of the whole amplifier. The easiest way of ensuring low leakage is to use a capacitor with a much higher voltage rating than the actual voltage across it in the circuit, which is above 1V. This is why a 64V working capacitor is specified in the parts list. (2.5$\mu$F, 64V is one of the values in the Mullard miniature range). ■

# Design for a Class A Battery Amplifier

by

SIR DOUGLAS HALL, K.C.M.G., M.A.(Oxon)

**Incorporating a field effect transistor, this comprehensive design may be either constructed in the form of an a.f. amplifier, or as an a.f. amplifier combined with a single transistor medium wave tuning head. In the latter instance, some of the components perform dual functions at a.f. and r.f.**

IT DOES NOT SEEM THAT EITHER commercial firms or designers of equipment for home constructors cater very frequently for the listener who wants to be able to hear records, or local broadcast stations, using a battery amplifier which will give really good quality at ordinary room levels of volume. Most home listening is done at an average output level of less than 50mW, and for this purpose, a total of 150mW undistorted output allows for the peaks to be reproduced without distortion.

The output of the amplifier to be described is about 150mW, and this is at a very high level of quality which deserves to be fed into a good speaker. The amplifier draws 18mA from an 18 volt battery, and provided fairly large cells are used—the U2 size is recommended—it will prove economical to use, giving very many hours service from a set of 12 of these cells.

## BASIC CIRCUIT

The circuit is shown, in its simplest form, in Fig. 1. The output from a crystal pick-up, or a similar high impedance source of signal, is applied to a high resistance volume control, and thence to the gate of a field effect transistor. The drain of the f.e.t. is directly coupled to the base of a medium power silicon p.n.p. transistor, the drain current of the f.e.t. being the base current of this output transistor. At the time of writing there is still a dearth of silicon p.n.p. transistors which will maintain their amplification factor when more than about 1 or 2mA pass through them, but the inexpensive 2N3702 will maintain an hFE of from 60 to 300 in the conditions applying in this circuit. Typical specimens may be expected to show a gain of about 120 times. The maximum dissipation of the 2N3702 is 300mW at 25°C and with about 16 volts available from emitter to collector (about 2 volts are lost across the relevant part of the 250Ω preset potentiometer) a maximum current of 18mA is permissible. The output transformer chosen has a ratio of 9.2:1 and will therefore cause a reflected load of about 250Ω to appear across its primary when connected to a 3Ω speaker. With a typical 2N3702 this will produce a load of 250 x 120 = 30kΩ at the base, and this is the drain load for the f.e.t. which will ensure good amplification from that device.

Source bias for the f.e.t. appears across the lower half of the 250Ω pre-set potentiometer. This potentiometer should be a standard 1 watt component, and not a miniature. There is 2-stage negative feedback of d.c., and the circuit is consequently very stable. The large electrolytic capacitor prevents negative feedback of the signal, though a small amount of negative feedback results from the top half of the potentiometer being in the source lead without a bypass capacitor. This feedback is not large as the resistance involved is small in comparison with the drain load.

A capacitor appears across the input to the amplifier, this being found necessary to avoid excessive treble and consequent distortion. Constructors may experiment with different values. The 0.001$\mu$F value shown in Fig. 1 proved to be the best compromise for various pick-up cartridges tried with the prototype.

## MODIFICATIONS

The circuit in Fig. 1 will function as an efficient amplifier as it stands with almost all specimens of the 40468. It is set up by first setting the slider of the potentiometer close to the end connected to the source and then, with a meter in one of the battery leads, adjusting the potentiometer until a reading of 18mA is given.

However, there are various modifications which are worth while, and some of these are shown in Fig. 2.

It will be noted that an a.f. choke now appears between the drain of the f.e.t. and the positive supply line. This component was omitted in Fig. 1 because the great majority of 40468's pass negligible leakage current. But the f.e.t. type 40468 has now been superseded by the 40468A which, while offering certain improvements, is no longer restricted for leakage current, and the latter can, in rare examples, be as high as 100$\mu$A. Let us consider the case where a high leakage f.e.t. is

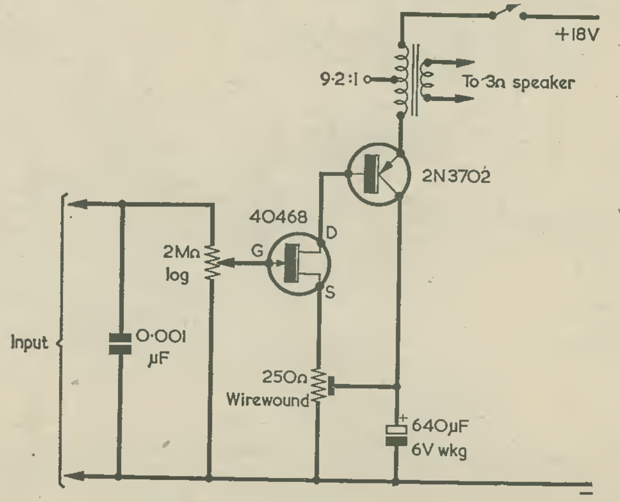



*Fig. 1. Basic amplifier circuit, illustrating the combination of f.e.t. and output transistor*

used in combination with a 2N3702 *offering* a current amplification of 300. If this output transistor passes 18mA, a base current of 18mA divided by 300, i.e. 60$\mu$A, will be required. But such a current is lower than the f.e.t. leakage current alone, so the circuit will not function.

At first sight it might appear that a resistor of about 1kΩ between the drain of the f.e.t. and the positive supply line would put matters right, as the f.e.t. would then pass a total of about 700$\mu$A whilst the output transistor was passing a base current of 60$\mu$A. The leakage current of the f.e.t. then becomes a small proportion of the total current passing through it. However, the 1kΩ resistor would reduce the drain load of the f.e.t. and amplification would fall drastically. A better scheme is to use the primary of an Eagle LT44 interstage transformer instead of the resistor. The primary of this transformer offers a d.c. resistance of about 1kΩ, and presents the a.f. signal with a high inductive load, whereupon all is well. The transformer primary inductance is damped by the output impedance of the f.e.t. and the input impedance of the 2N3702, and no noticeable deterioration of quality accompanies its inclusion in the circuit. The green lead and outer red lead are used here, the central red lead and the black and white leads being left disconnected. (Make sure that the LT44 *is* an Eagle component. This will be sold in a box and its clamp will have stamped into it "20kΩ 1.0kΩ". There are inferior imitations which have "LT44" applied by what appears to be a rubber stamp. These imitations are not suitable for the present requirement, as both the d.c. resistance and the inductance of the winding will be found to be far too low.)

In both Figs. 1 and 2, the substrate of the f.e.t. is left unconnected.

Turning to other points in the circuit of Fig. 2, the non-earthy input lead is now taken to a 330kΩ resistor which is isolated from the volume control by a 0.01$\mu$F capacitor. The capacitor should be rated at 250 volts working. Also, two silicon diodes (*not* germanium) are connected back to back between the slider and the earthy end of the volume control. The 0.01$\mu$F capacitor protects the gate of the f.e.t. from any direct voltage which might accidentally find its way there, and the diodes limit alternating voltage on the gate to about 0.5 volt so that accidental applications of, say, mains hum, are rendered harmless. Whatever other refinements are added it is particularly recommended that the diodes be included in the circuit, or the f.e.t. may die a mysterious death one day. It is also very wise, incidentally, to use a transistor holder for the f.e.t. Although an iron can be used for wiring it up with all due precautions, it is only too easy for a lethal dose of a.c. to be applied to the gate. It is better to make all the connections to a transistor holder first, and then insert the f.e.t. afterwards.

A tone control has been added in Fig. 2, this consisting of a 500pF

## COMPONENTS

*Resistors*
(All fixed values ¼ watt 10%)

| | |
|---|---|
| R1 | 3.3MΩ |
| R2 | 330kΩ |
| R3 | 39kΩ |
| VR1 | 2.5kΩ or 5kΩ, preset potentiometer, miniature |
| VR2 | 2MΩ potentiometer, log, with switch S3 |
| VR3 | 250Ω, preset potentiometer, wirewound, 1 watt |

*Capacitors*

| | |
|---|---|
| C1 | 4$\mu$F electrolytic, 6V wkg. |
| C2 | 640$\mu$F electrolytic, 6V wkg. |
| C3 | 0.01$\mu$F |
| C4 | 0.001$\mu$F |
| C5 | 0.01$\mu$F, 250V wkg. |
| C6 | 50pF |
| C7 | 0.02$\mu$F |
| C8 | 1,000$\mu$F electrolytic, 25V wkg. |
| VC1 | 500pF variable air-spaced or solid dielectric (see text) |
| VC2 | 500pF variable solid dielectric |

*Inductors*
L1, 2 (see text)

| | |
|---|---|
| T1 | Output transformer type T/T7 (Radiospares) |
| T2 | Interstage transformer type LT44, primary connected only (Eagle) |

*Semiconductors*

| | |
|---|---|
| TR1 | BC168C |
| TR2 | 40468 or 40468A |
| TR3 | 2N3702 or TIS61 |
| D1 | OA81 |
| D2,3 | silicon diodes (e.g. IS44) |

*Switches*

| | |
|---|---|
| S1 | 2-pole 2-way rotary |
| S2 | 2-pole 3-way rotary (or 3-pole 3-way (see text) |
| S3 | s.p.s.t., combined with VR2 |

*Sockets, etc.*
PS1, 2 phono sockets
1 transistor holder (for TR2)
3 battery holders for 4 U2 cells each

*Battery*
12 U2 cells

*Speaker*
3Ω speaker

*Miscellaneous*
8in. x ⅜in. ferrite rod
Control knobs, as required
Cabinet, etc.

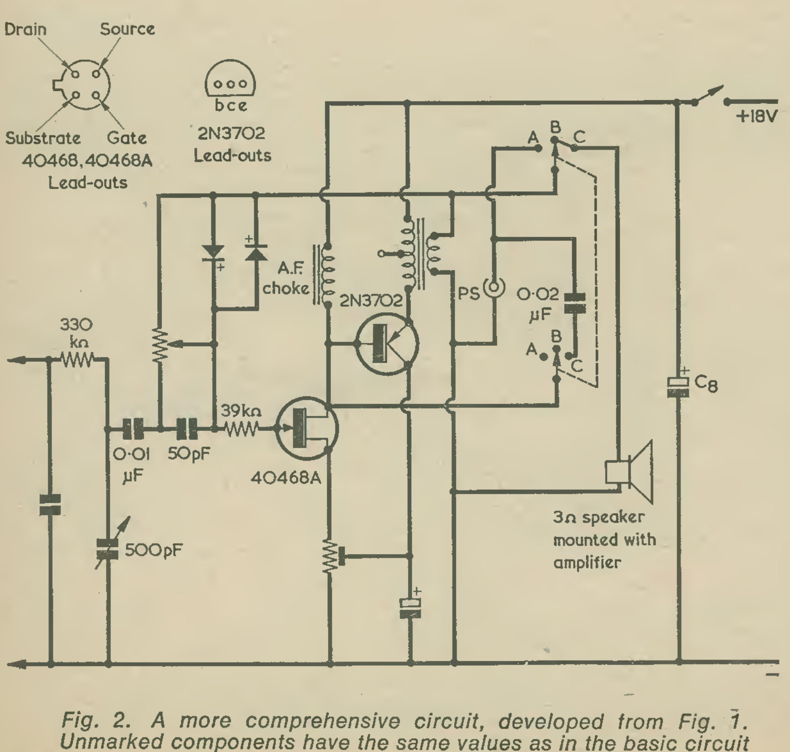



Fig. 2. A more comprehensive circuit, developed from Fig. 1. Unmarked components have the same values as in the basic circuit

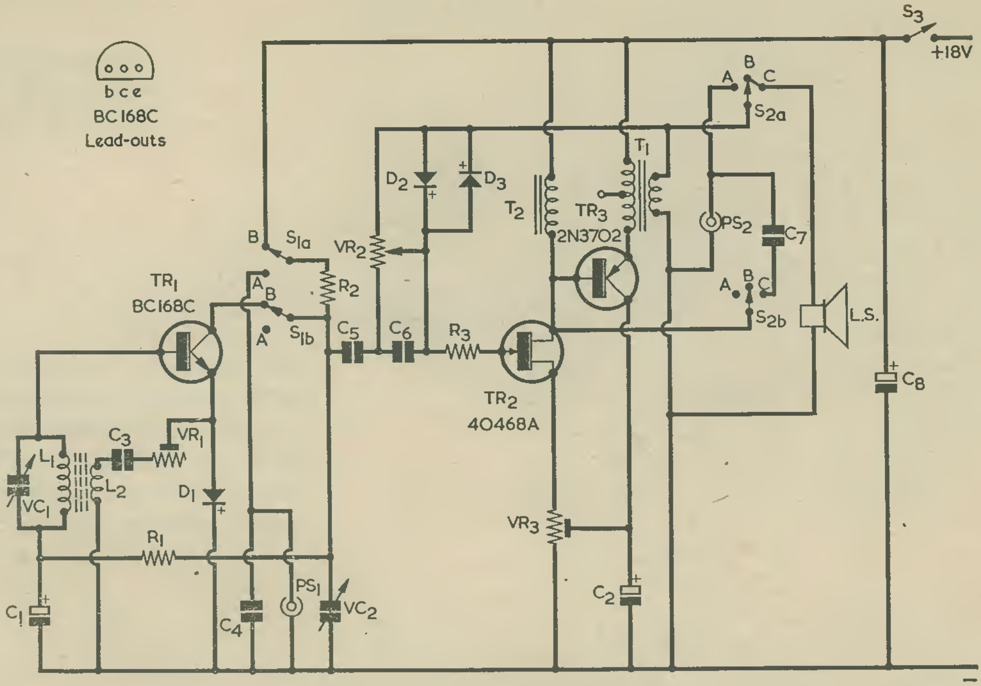



*Fig. 3. Adding a medium wave tuning head. All components in this diagram are specified in the Components List*

variable capacitor. Enmeshing the vanes of this component causes a very smooth loss of the highest audio frequencies. The range of control available is improved at intermediate settings of the volume control by the presence of the 50pF capacitor across the non-earthy half of the volume control circuit, this giving a degree of treble lift when the variable capacitor is set to minimum. Finally, the 39kΩ resistor prevents any possibility of spurious oscillation by the f.e.t.

So much for modifications at the input end. At the output end a 2-pole 3-way switch is employed to make provision for an internal or external speaker, and to take the output direct from the f.e.t. when it is wished to use the amplifier to record on to tape. As shown in Fig. 2, the switch is at position B, and an internal speaker, built together with the amplifier, is in use. If the switch is turned to position A the output is taken to a phono socket, into which a lead from an external speaker may be plugged. If the switch is turned to C, the output is taken to this same socket direct from the f.e.t. and a tape recorder may be used. The internal speaker remains connected and may be used as a monitor though volume will be reduced owing to the additional load across the f.e.t. So far as the switch itself is concerned, it will probably be found easier to obtain a 3-pole 3-way component rather than a 2-pole 3-way switch. In this case the unwanted pole is ignored.

It will be seen that the earthy end of the volume control is now taken to the negative supply line via the secondary of the output transformer. This provides a useful additional degree of negative feedback which considerably improves quality. At first sight the amount of feedback might appear excessive, but it should be remembered that the output transistor functions as an emitter follower, which means that although it is an efficient power amplifier it gives no voltage gain. So the additional feedback introduced is, in effect, over the f.e.t. stage alone. It may be necessary to try both ways of connecting the leads on the secondary of the output transformer. If connected wrong way round, positive feedback will be given with consequent oscillation.

## TUNING HEAD

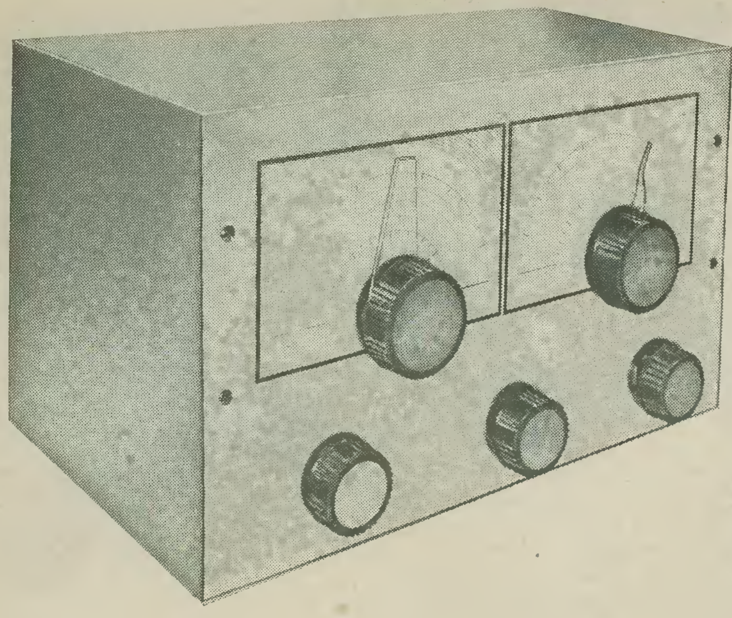
Fig. 3 shows how, if desired, a simple medium wave tuning head may be added. As the amplifier has a high input impedance it is useful for the output of the tuner to be similarly at high impedance. The author's single transistor "Spontaflex" design is very suitable here, offering in this case an output impedance of about 330kΩ.*

All the components to the right of the new switch, S1 in Fig. 3, have already appeared in Fig. 2, and the wiring of this part remains unchanged, although some of the components now have a radio frequency function to perform in addition to their duties at audio frequencies.

The radio signal appears across L1 which is wound on a length of ferrite rod, and is tuned by VC1. The whole of this tuned circuit forms the base input of TR1 which, at radio frequencies, is a common collector amplifier with a high input impedance. The r.f. output, much amplified as to current, appears across diode D1 in the emitter circuit. The diode next functions as an audio frequency load and TR1 amplifies again, this time as a common base audio amplifier. A combination of comparatively high direct voltage from the battery and a type of transistor which maintains good amplification when passing only 50μA means that a very high output

*The author's "Spontaflex" circuit was originally introduced in the June 1964 issue. The latest and most up-to-date version was described in "Modifying the 'Spontaflex' Circuit for Silicon Transistors", published in the May 1969 issue. —Editor.

*(Continued on page 359)*



# HIGH-SEL
# T.R.F. R

b

F. G. RAYER, A

**Our contributor recently turned his a receiver and decided to re-examine design and construction of a simple t taken to ensure that efficient regener the receiver is described in this article of the tests he carried out on his desig between its performance a**

FEW CIRCUITS CAN PROVIDE SUCH GOOD RESULTS with so little complication as an efficiently operated t.r.f. receiver. The writer recently returned to the use of a small t.r.f. circuit for compact equipment required for /A operation. The performance obtained, together with subsequent tests, show that the t.r.f. receiver is in fact an excellent project when the complicated circuitry of a superhet is to be avoided.

This article will describe the t.r.f. receiver used. First, however, the writer would like to give details of the tests he carried out, if only to demonstrate to those who automatically advocate the superhet that the t.r.f. receiver can offer a comparable short wave performance. And, of course, the t.r.f. receiver is much easier to construct and bring up to full working order.

## REGENERATION

Before making comparisons between t.r.f. and superhet receivers, it must be noted that the results obtainable from a t.r.f. set depend almost entirely on regeneration. F. E. Terman, in discussing regenerative detectors, points out that "Although regeneration represents an inexpensive means of increasing the radio-frequency amplification, it increases the selectivity excessively . . . . "*

Nobody tuning a crowded amateur or other short wave band these days is likely to feel that selectivity can be excessive, and it is worth recalling that the adjunct to some expensive communication receivers is a Q-Multiplier, this being a circuit which takes advantage of regeneration to increase selectivity.

*F. E. Terman, "Radio Engineers' Handbook" (First Edition, page 574), Mc-Graw Hill.

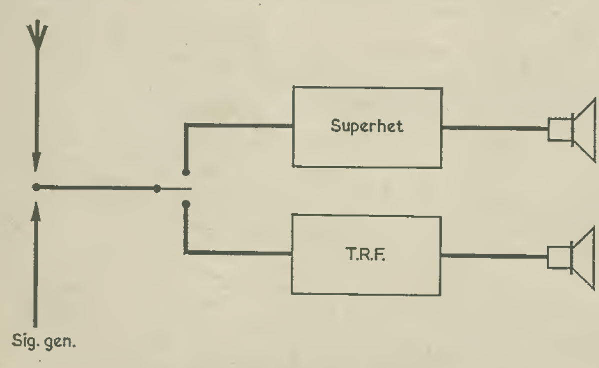



*Fig. 1. The method employed for comparison of t.r.f. and superhet receiver performance*

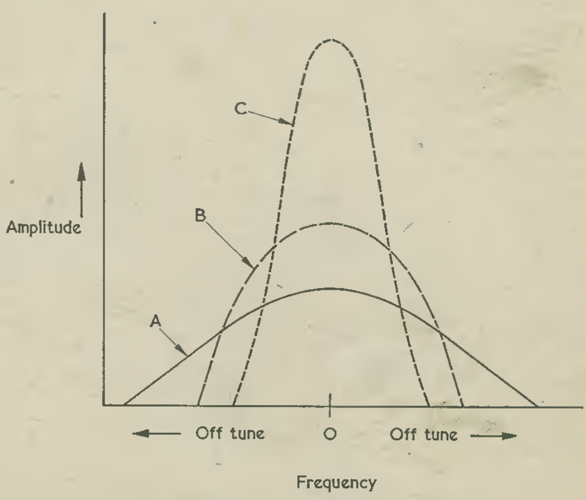



*Fig. 2. Illustrating the sharpening of selectivity which results from the use of regeneration*

# LECTIVITY
# ECEIVER

by

A.I.E.R.E., G3OGR

**attention from the superhet short wave**
**ts t.r.f. counterpart. The result was the**
**t.r.f. circuit in which particular care was**
**ration was obtained. The construction of**
**le, and the author begins by giving details**
**sign, these tests giving direct comparison**
**and that of a superhet receiver**

Cover Feature

One way of comparing t.r.f. and superhet receiver performance is shown in Fig. 1. Each receiver has a speaker, with muting switch if wanted. Input is first applied from the signal generator. The method is to tune in the signal generator output accurately with both receivers, then check for individual off-tune response by retuning the *generator*. The superhet a.g.c. is switched out or temporarily disabled for this test.

Fig. 2 indicates the effects of regeneration with the t.r.f. receiver. With no regeneration, tuned circuit selectivity is broad, as in curve A. Introducing regeneration increases selectivity, and the response is sharpened, as in curve B. With critical regeneration, a high and very sharp curve is obtained, as shown by C.

In tests made in conditions favourable to the t.r.f. receiver (that is, with weak and relatively weak signals over the frequency range 15 to 3MHz) curve C was on the average indistinguishable from that obtained with a superhet having two i.f. transformers incorporating four 465kHz tuned circuits. The superhet also had one r.f. stage but this contributed virtually nothing to adjacent channel selectivity, being provided to reduce second channel interference. This interference arises with a superhet from signals spaced by twice the intermediate frequency from wanted signals, and can be a troublesome effect. It is of course wholly absent with a t.r.f. receiver.

At frequencies higher than 15MHz or so good results were still obtainable with the t.r.f. set, but more care in setting up was required. At lower frequencies, very strong signals may be present, as from medium wave stations, and these tend to swamp a t.r.f. receiver. Strong local signals on any frequency tend to swamp weaker adjacent signals, but this effect can be reduced by suitable means.

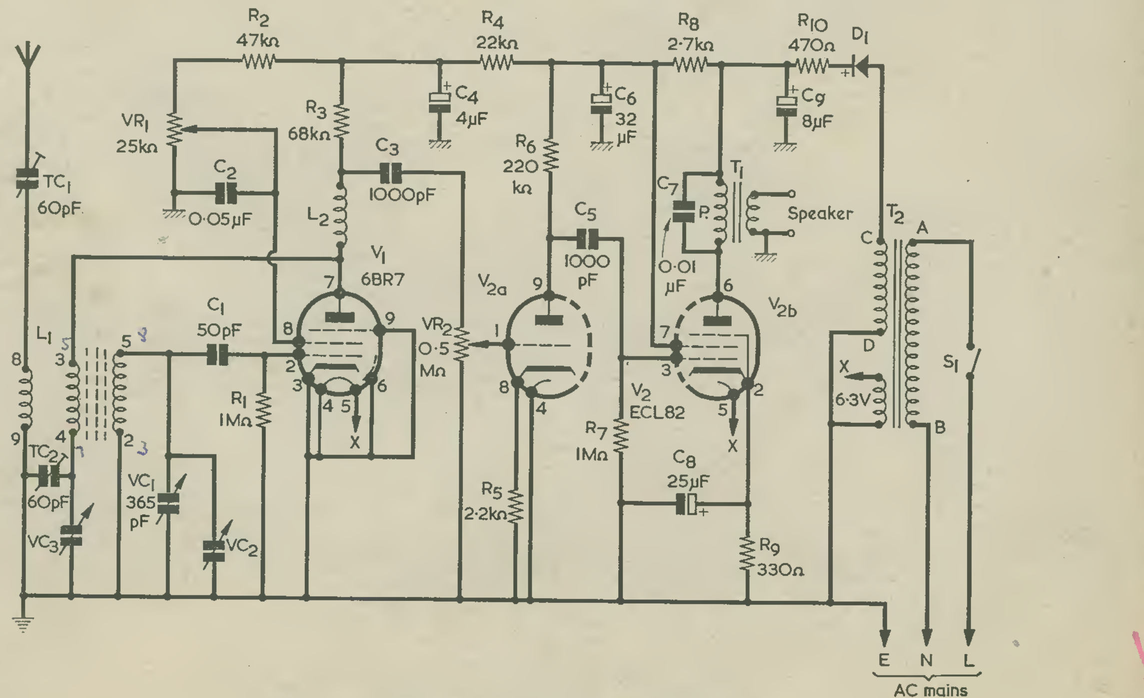



*Fig. 3. Complete circuit of the t.r.f. receiver*

**TABLE I**

Frequency Ranges
(Coils employed are Denco Miniature Dual-Purpose, Green.)

| Range | Coverage |
|---|---|
| 1 | 150-500kHz |
| 2 | 500-1,600kHz |
| 3 | 1.5-5MHz |
| 4 | 5-18MHz |
| 5 | 15-36MHz |

## SENSITIVITY

Sensitivity was checked using a laboratory type signal generator as input, as shown in Fig. 1, the t.r.f. receiver being that to be described here. This receiver employs Denco plug-in coils, the ranges covered being listed in Table I. To compare the results given for differing L/C ratios in the tuning circuit, tests were carried out at 16MHz, which is both at the low frequency end of Range 5 and at the high frequency end of Range 4. Table II gives the results, and it will be seen that readings were also taken at a frequency near the highest tunable, 30MHz, and at 9MHz. The input figures quoted in Table II are for the weakest signal capable of being copied with the t.r.f. receiver, using its loudspeaker, in conditions of insignificant background noise. They vary somewhat, depending on absolute optimum adjustment of regeneration. If there is local ambient background noise, headphones would give better results.

Practical results with an aerial appear to confirm the tests. Stronger distant signals, such as 28MHz U.S. amateurs, and those on 21 and 14MHz, could be received in great number with a modest aerial when propagation was suitable. The best Dx was Australia. In fact, with the arrangement of Fig. 1, it was quite difficult to find a signal with the superhet which could not also be brought in with the t.r.f. set. The signals lost with the t.r.f. receiver were very weak transmissions, and weak or other signals too near a strong transmission. Over the 30 to 1.8MHz range, the t.r.f. set will receive literally hundreds of amateur and other short wave signals.

The t.r.f. receiver employed in the tests will now be described. It should be mentioned that equally good results could have been obtained with any similar type of t.r.f. receiver in which particular attention has been paid to obtaining efficient regeneration.

## CIRCUIT NOTES

A few points should next be mentioned regarding the receiver circuit, which is given in Fig. 3. Commercially made plug-in coils are used for simplicity in band changing and wiring. As may be seen from Table I, five coils cover all short wave bands as well as medium and long waves, should these last two ranges be required. Due partly to slightly different tuning and stray capacitances, and the adjustment of dust cores, some of the ranges listed in the Table differ slightly from the nominal range figures quoted in Denco literature.

VC1 is for coarse tuning, or band-setting. For short wave tuning and critical attention to a narrow band of frequencies, such as in an amateur band, the small variable capacitor VC2 is employed, this giving fine tuning. VC2 should operate smoothly. Its exact value is to some extent a matter of choice, because a valve which gives adequate coverage on lower frequencies is too large for easy band-spreading of higher frequencies. If operated without a slow-motion ball drive a value of about 5 to 10pF is suggested. A value of some 15 to 20pF will be satisfactory if VC2 is fitted with a ball drive or if the main listening interest is in the low frequency bands. A recommended component is the Jackson type C804 variable capacitor.

Trimmer TC1 is practically essential in the circuit, and it reduces aerial loading with all but short aerials. Since one ofthe prime objects in the receiver design is the ability to obtain smooth, easily controlled regeneration, there are three variable components which affect performance in this respect. The first of these is VC3, the reaction control proper. This has a relatively small capacitance and it is paralleled by trimmer TC2. The result is that a wide angle of rotation in VC3 is possible for a relatively small change in overall capacitance, and its adjustment is consequently eased. The third variable component is VR1, which varies the screen-grid potential of V1 and enables this valve to be in the optimum condition for smooth regeneration. With long aerials, adjustment of trimmer TC1 will assist in obtaining best regeneration performance.

The 6BR7 specified for V1 is particularly suitable as a detector, being a high gain type of rigid mechanical design. VR2 is an audio gain control, and the following triode and pentode sections of the ECL82 provide audio amplification. The h.t. supply is obtained from a half-wave rectifier circuit with adequate smoothing, particularly to the early stages.

## MECHANICAL CONSTRUCTION

Construction must be rigid, so a 4-sided chassis is used, with 3in. brackets to give additional support to the panel. The brackets were actually a 4 by 3in. Home Radio "Universal Chassis" side cut from opposite corners at 45 degrees. The chassis is drilled for components as in Fig. 4.

**TABLE II**

T.R.F. Sensitivity

| Frequency | Input Signal Voltage | |
|---|---|---|
| | a.m. | c.w. |
| 30MHz | $4\mu V$ | $2\mu V$ |
| 16MHz (Range 5) | $10\mu V$ | $4\mu V$ |
| 16MHz (Range 4) | $5\mu V$ | $2\mu V$ |
| 9MHz | $8\mu V$ | $3\mu V$ |

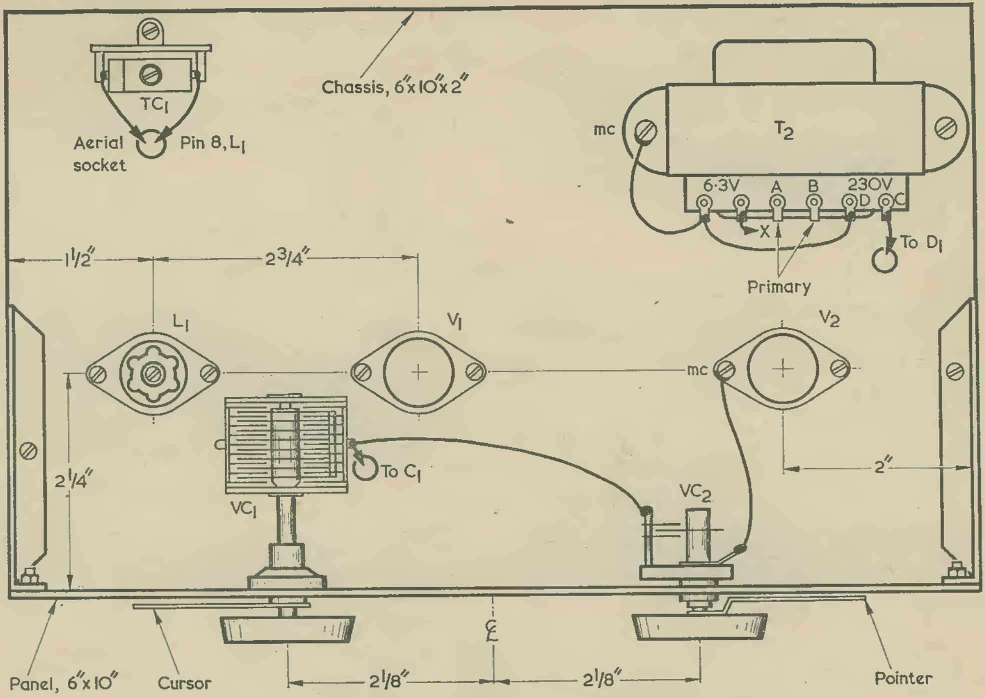



*Fig. 4. Top view of the chassis, giving the more important dimensions*

VC1 is bolted to the chassis, and its spindle must match up with the ball drive. Spacing washers are essential between chassis and this capacitor. A bolt secures the ball drive lug to the panel. If a drive is to be used with VC2, set this capacitor back sufficiently, and mount it on a strong bracket.

Fig. 5 shows the underside. Holes for VR1, VR2, VC3, the mains lead grommet, and to provide clearance for the speaker and aerial/earth sockets are most readily made with a $\frac{3}{8}$in. chassis punch, before chassis assembly. (The type of chassis listed consists actually of a 6 x 10in. flat plate, with separate 6 x 2in. and 10 x 2in. flanged sides which are bolted on.)

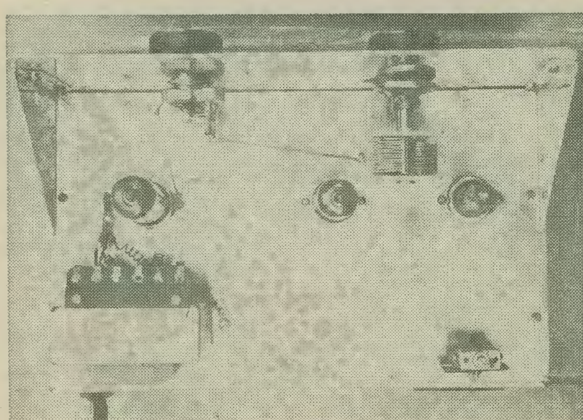
## WIRING NOTES

Heater and a.f. leads run against the chassis. R.F. leads and components are clear of the chassis. The wires from T2 run down through a grommet (See Fig. 4). The rectifier, R4, C4, R10 and several other items and leads are anchored on a 9-way tagstrip, as shown in Fig. 5. A small tagstrip anchors the positive leads C6 and C9. On top, TC1 is soldered to the tags of a similar strip, this being bolted above the Aerial-Earth sockets.

If difficulty is experienced in obtaining a 9-way tagstrip having earthed tags in the positions shown in Fig. 5, a suitable alternative is a 9-way tagstrip with the two end tags earthed, this being available from Henry's Radio, Ltd.

The mains lead is 3-core flex, taken to a 3-pin plug with 3 amp fuse. With the new mains lead coding, use green and yellow striped for earth, this being taken to chassis as in Fig. 5. Blue is neutral, going to "B" on T2 (see Fig. 3). Brown is live, running from the plug fuse to S1, which in turn connects to "A" on T2.

It is important to note that the tag positioning for T2 shown in Fig. 4 is typical only, and that individual transformers may have different tag positions or may have wire lead-outs. The mains transformer should be connected up so that it agrees with the circuit diagram of Fig. 3. Suitable components for both T2 and T1 are available from Home Radio, and the appropriate Catalogue Numbers are given in the Components List.



*Looking down on the top of the chassis*

For chassis wiring, use insulated wire or sleeving where necessary. The connecting wire in the r.f. circuit around the coil and the variable capacitors should be 20 s.w.g. or thicker. All r.f. leads are short and direct. Wiring details should be clear from Figs. 4 and 5. In these diagrams, "MC" indicates earthing tags which are bolted securely to chassis. The tag of VR1 which connects to chassis is that corresponding to the maximum anti-clockwise position of the slider.

## EXTERNAL CONNECTIONS

The receiver should not be operated without a speaker or suitable alternative load connected across the output, as high a.f. voltages may then appear in the primary circuit of T1. For weak signals or personal short wave reception, phones may be connected in parallel with the speaker. If it is intended to occasionally use phones on their own, a 10Ω 1 watt resistor should be permanently connected across the speaker socket terminals to function as a load. This resistor will not cause any significant reduction in speaker output. Low impedance phones will give greatest sensitivity but remember to keep the a.f. gain control at a low setting when searching for signals, because of the high power available from V2(b).

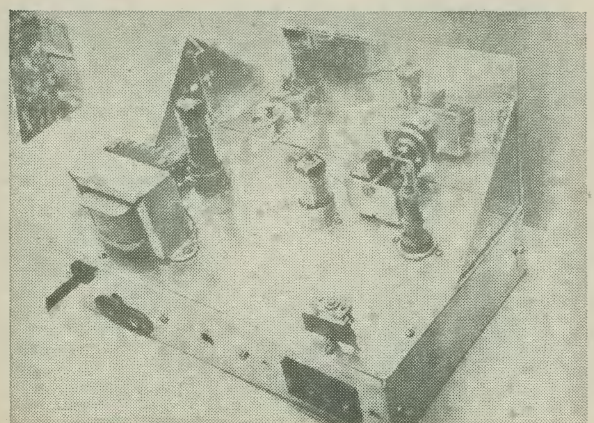
Since the h.t. voltage depends on the mains voltage and several other factors, a voltage check can be made across C9 if wished. The voltage here should be about 180 to 200 volts, and R10 can, if necessary, be changed in value to obtain this figure.

The aerial will probably depend upon what is available—such as an end-connected wire for all bands, or perhaps an aerial made for one band only. Aerial tuners of the usual type may be connected between aerial and receiver.

The receiver will, of course, have an earth connection via the mains socket, but it is desirable to augment this with a more efficient (for r.f.) earth connection run over the shortest route possible. A good earth connection can give a considerable improvement with weak low frequency band signals.

## BAND COVERAGE AND TUNING

As already mentioned, five plug-in coils are available, the actual frequency coverage obtained being listed in Table I.



*Rear upper view. The two panel-strengthening brackets are clearly visible.*

**TABLE III**

Frequency/Dial Readings

Range 1.

| | |
|---|---|
| 150 kHz | 100 |
| 160 | 93 |
| 170 | 78 |
| 180 | 70 |
| 200 | 58 |
| 220 | 49 |
| 240 | 40 |
| 260 | 35 |
| 300 | 27 |
| 350 | 21 |
| 400 | 17 |
| 500 | 10 |

Range 2.

| | |
|---|---|
| 500 kHz | 100 |
| 550 | 83 |
| 600 | 71 |
| 650 | 61 |
| 700 | 53 |
| 750 | 46 |
| 800 | 42 |
| 900 | 33 |
| 1,000 | 27 |
| 1,100 | 22 |
| 1,200 | 20 |
| 1,300 | 17 |
| 1,400 | 14 |
| 1,500 | 12 |
| 1,600 | 9 |

Range 3.

| | |
|---|---|
| 1.5 MHz | 100 |
| 1.6 | 88 |
| 1.7 | 78 |
| 1.8 | 70 |
| 1.9 | 63 |
| 2.0 | 57 |
| 2.5 | 37 |
| 3.0 | 27 |
| 3.5 | 20 |
| 3.8 | 16 |
| 4.0 | 14 |
| 4.5 | 10 |
| 5.0 | 6 |

Range 4.

| | |
|---|---|
| 5.0 MHz | 100 |
| 5.5 | 83 |
| 6.0 | 71 |
| 6.5 | 61 |
| 7.0 | 52 |
| 7.5 | 46 |
| 8.0 | 41 |
| 9.0 | 33 |
| 10 | 27 |
| 11 | 22 |
| 12 | 19 |
| 13 | 16 |
| 14 | 14 |
| 15 | 11 |
| 16 | 9 |
| 17 | 7 |
| 18 | 5 |

Range 5.

| | |
|---|---|
| 15 MHz | 52 |
| 16 | 45 |
| 17 | 41 |
| 18 | 37 |
| 20 | 31 |
| 22 | 26 |
| 24 | 22 |
| 26 | 19 |
| 28 | 17 |
| 30 | 14 |
| 32 | 12 |
| 34 | 10 |
| 36 | 8 |

Coverage at the low frequency end of each range depends considerably on the position of the adjustable cores. The full swing of VC1 is not used for Range 5. Ranges 1 and 2 are the usual long wave and medium wave sectors, while Range 3 is very useful for certain amateur and other transmissions. A very large number of short wave transmissions fall into Range 4. Range 5 is primarily for h.f. bands capable of long distance propagation, but these are much subjected to seasonal and other variations.

As a guide, Table III gives frequencies and dial readings obtained with the prototype with VC2 at half-capacitance. VC1 is fully closed when its cursor

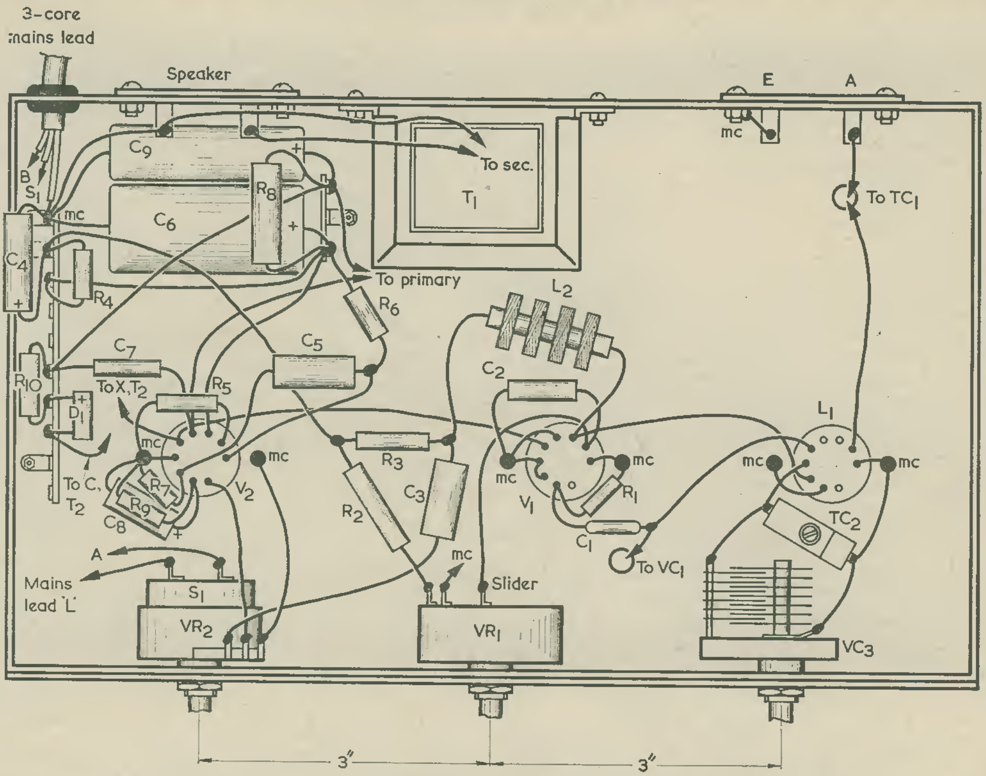



*Fig. 5. Lower view of the chassis. The three valveholders should be mounted with the pin orientation shown here*

is at 100 on the scale. Slight differences at the high frequency end of the ranges may occur, due mainly to varying values chosen for VC2.

Bandspreading with the aid of VC2 does not increase selectivity or the actual separation between stations, but it does help by causing a very narrow band of frequencies to be covered with full 180 degree rotation.

VC1 is used for general tuning, to find a band, or to set the cursor to a previously logged spot. During this time VC2 may be left half-closed (50 on its scale). Signals at nearby higher and lower frequencies can then be tuned in with VC2.

## REGENERATION

Correct regeneration is the point upon which virtually the whole of the receiver selectivity and sensitivity depends. VR1 has a considerable effect on regeneration, due to its changing the screen-grid voltage of V1. Closing VC3 increases regenerative feedback, as does increasing the value of TC2. VC3 and VR1 are never merely turned to the maximum clockwise position, as is possible with an audio or r.f. gain control.

Initially set TC2 and VC3 to about half their maximum capacitance. Rotate VR1 from its minimum (anti-clockwise) position until a heterodyne whistle is heard when VC1 is tuned through a transmission. Opening VC3 slightly should reduce regeneration sufficiently to stop this whistle. The most sensitive condition for a.m. reception is obtained when VC3 is *very slightly* opened from the setting which causes oscillation and the appearance of heterodynes.

If VR1 is advanced too far, VC3 will need to be near minimum capacitance to stop oscillation, and its adjustment will be critical and difficult. Should TC2 insert too much capacitance, oscillation is likely even with VC3 at minimum. But should TC2 insert too little capacitance, the benefit it gives in easing adjustment of VC3 is largely lost. The optimum setting for this trimmer will soon be found after a little experience.

Regeneration is influenced by the position of the coil cores. If these are set up for the range coverages given in Table III they will also be in suitable positions for good regeneration. The cores should be locked, with 6 BA nuts passed over the protruding threaded stems, to retain calibration.

With certain aerials an abrupt loss of regeneration may arise at some frequencies, this being due to resonances in the aerial system. Should this occur, TC1 is adjusted to clear the effect.

There should be no great difficulty in setting up TC2 and VR1 so that VC3 provides an extremely smooth control over regeneration. Once adjusted, TC2 can be left. VR1, on the other hand, will have to be readjusted when making considerable changes in frequency, or after changing coils.

For c.w. reception, it is necessary to maintain V1

## COMPONENTS

*Resistors*
(All fixed values ½ watt 10% unless otherwise stated)

| | |
|---|---|
| R1 | 1MΩ |
| R2 | 47kΩ 1 watt |
| R3 | 68kΩ |
| R4 | 22kΩ |
| R5 | 2.2kΩ |
| R6 | 220kΩ |
| R7 | 1MΩ |
| R8 | 2.7kΩ 1 watt |
| R9 | 330Ω 1 watt |
| R10 | 470Ω 2 watt (see text) |
| VR1 | 25kΩ potentiometer, linear wire-wound, 1 watt (Home Radio Cat. No. VR25) |
| VR2 | 500kΩ potentiometer, log, with switch S1 |

*Capacitors*

| | |
|---|---|
| C1 | 50pF silver-mica |
| C2 | 0.05μF paper or plastic foil, 250V wkg |
| C3 | 0.001μF paper or plastic foil, 350V wkg. |
| C4 | 4μF electrolytic, 350V wkg. |
| C5 | 0.001μF paper or plastic foil, 350V wkg. |
| C6 | 32μF electrolytic, 350V wkg. |
| C7 | 0.01μF paper or plastic foil, 350V wkg. |
| C8 | 25μF electrolytic, 25V wkg. |
| C9 | 8μF electrolytic, 350V wkg. |
| VC1 | 365pF variable, Jackson type 01 (Home Radio Cat. No. VC1A) |
| VC2 | (see text) |
| VC3 | 50pF variable, Jackson type C804 |
| TC1 | 60pF mica trimmer |
| TC2 | 60pF mica trimmer |

*Inductors*

| | |
|---|---|
| L1 | Denco Miniature Dual-Purpose (Valve) coil, Green, ranges as required (see Table I) |
| L2 | 2.6mH r.f. choke, type RFC5 (Denco) |
| T1 | Output transformer, 40:1 (Home Radio Cat. No. TO43) |
| T2 | Mains transformer, secondaries 230V 45mA and 6.3V 1.5A (Home Radio Cat. No. TM26A) |

*Valves*

| | |
|---|---|
| V1 | 6BR7 |
| V2 | ECL82 |

*Rectifier*

| | |
|---|---|
| D1 | 250V (1,000 p.i.v.) silicon rectifier, BY100 or equivalent |

*Switch*

| | |
|---|---|
| S1 | s.p.s.t., part of VR2 |

*Valveholders, Sockets*

| | |
|---|---|
| 2 | B9A valveholders with skirts (for V1 and V2) |
| 1 | B9A valveholder without skirt (for L1) |
| 1 | Socket strip, "Ae/E" (Home Radio Cat. No. Z101A) |
| 1 | Socket strip, "LS" (Home Radio Cat. No. Z101C) |

*Miscellaneous*

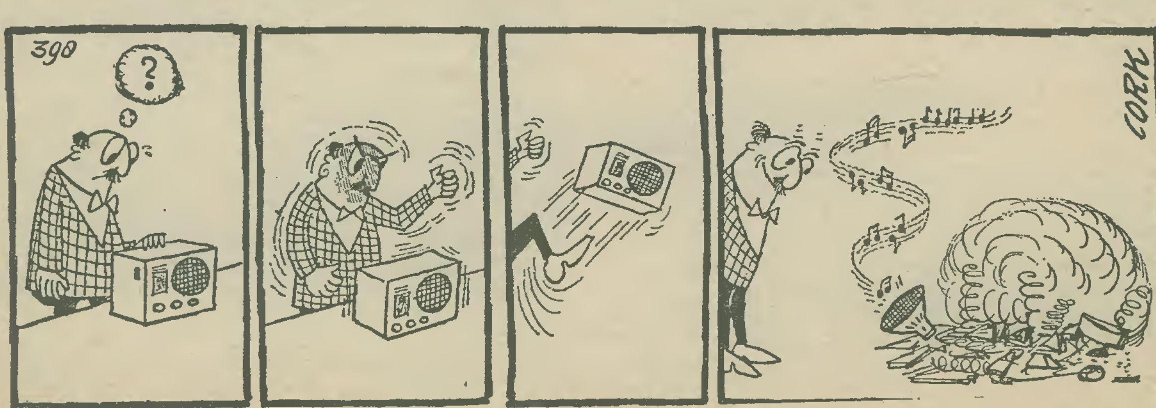
| | |
|---|---|
| 1 | chassis, 6 x 10 x 2in. (Home Radio Cat. No. CU26) |
| 1 | plate (for panel), 6 x 10in. (Home Radio Cat. No. CU180) |
| 2 | brackets, made from single flanged chassis side, 3 x 4in. (Home Radio Cat. No. CU144) |
| 1 | epicyclic ball drive, 6:1, type 4511/F (Jackson Bros.)* |

* If desired, a second ball drive may be employed with VC2 (see text).

---

2 knobs 1 7/16in. dia. (Home Radio Cat. No. KN63)
3 knobs 1 1/8in. dia. (Home Radio Cat. No. KN64)
2 cursors or pointers (home constructed)
2 3-way tagstrips, centre tag earthed
1 9-way tagstrip, 2 tags earthed (see text)
Tuning scales, from Data Panel-Signs, Set No. 5.

in the oscillating condition and slightly off-set the tuning to produce a heterodyne. S.S.B. transmissions can be received above certain signal levels by a similar process, the tuning being adjusted to the missing carrier frequency. ■



## DESIGN FOR A CLASS A BATTERY AMPLIFIER

*(Continued from page 351)*

load can be used with considerable voltage amplification. It will be seen that, with S1 in position B, the 330kΩ and resistor R2, used by the amplifier on its own as part of the tone control arrangements, now becomes the collector load for TR1.

TR1 will not function as a common collector radio frequency amplifier unless its collector is at earth potential for radio frequencies. With VC2 fully open, therefore, only a very small proportion of the signal across the tuned circuit will find itself across the diode, such proportion as does appear being due to to the minimum capacitance of VC2. But as the vanes of VC2 are engaged TR1 then starts to function correctly. L2 is a small coupling coil which allows feedback to occur between the emitter and base circuits, and VR1 is set so that VC2 functions as a reaction control. To set VR1, the vanes of VC1 and VC2 should both be fully enmeshed and VR1 next adjusted so that oscillation just starts, denoted by a hiss, or a whistle if a station is present at the low frequency end of the band. It will then be found that with the vanes of VC1 fully open oscillation will start with the vanes of VC2 about half way in. This setting will remain fairly constant for about the first half of the movement of VC1 but, as the vanes of this capacitor are further enmeshed, it will be found necessary to further increase the value of VC2 to obtain oscillation. This applies when a solid dielectric capacitor is employed for VC1. If an air-spaced component is used, the setting of VC2 will remain rather more constant throughout the tuning range.

L1 and L2 are wound, over a paper sleeve, on a ferrite rod 8in. long with a diameter of $\frac{3}{8}$in. L1 consists of 70 turns of 32 s.w.g. enamelled wire close-wound, whilst L2 has 9 turns of the same gauge wire, close-wound and spaced by about $\frac{1}{4}$in. from L1. The windings are phased as shown in the circuit diagram, the same ends of both connecting to TR1 base and C3 respectively.

It will be seen that bias for the base of TR1 is taken from its collector circuit. This provides a measure of d.c. feedback and is preferable to the use of a separate potentiometer network. (The BC 168C specified for TR1, together with the 40468A f.e.t., is available from Amatronix Ltd.)

It is assumed that the correct connections for the secondary winding of T1 have already been made to ensure that negative, as against positive feedback, takes place in the amplifier part of the circuit. However, even when this has been done it may be found that a different form of instability takes place when switched to radio. The instability may only be noticeable when VC2 is adjusted to the point of oscillation and, if it does occur, it indicates unwanted coupling between T1 and the ferrite rod assembly. It can be cured by reversing the connections to *both* the windings of T1. Both sets of connections have to be changed over because reversal of the connections to one winding only would introduce positive feedback in the amplifier.

C6 has been mentioned with respect to its function as part of the tone control network. On radio there is no variable tone control since VC2 has become a reaction control, but C6 still plays its part by preventing a slight change in tuning or reaction as VR2 is adjusted when its slider is at or near the maximum volume position. If C6 is removed from circuit this effect can be rather annoying and is due to small internal capacitances within VR2 which are easily swamped by C6.

### AUTHOR'S PROTOTYPE

The author's prototype, which has been through all the stages described in this article, and many others which were abandoned for one reason or another, now takes the form of Fig. 3. It is built into a wooden case which houses an 8in. round loudspeaker, and the 12 U2 cells. These are kept in three plastic containers, for four cells each, made by Eagle Products. An external speaker is frequently used. Results from records are extremely good, and the amplifier is fully loaded by an input of the order of 250mV, the exact sensitivity depending on the characteristics of the transistors used. Local stations give splendid results on either internal or external speaker and 20 or 30 other stations can be received at reduced volume after dark.

It has been found that during the hours of daylight a number of stations which are scarcely loud enough for normal listening will produce an amply sufficient signal for recording on tape. At the author's home in South Devon this applies particularly to Radio 3 on 194 metres, which produces a weak but interference-free signal during daylight hours.

Layout may follow the constructor's whim provided that input and output circuits are sensibly separated. It is especially important to keep T1 well away from the ferrite rod assembly, and to arrange for the axis of the coils of T1 to be at right angles to the axis of L1 and L2. ■

# CAN ANYONE HELP?

*Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time.*

*R3673.*—A. Howard, 2 Castle Close, Reffley Estate, Kings Lynn, Norfolk—circuit, manual, modification details or any other information.

*Radio Altimeter APN1.*—R. K. Lloyd, P.O. Box 1164, Lusaka, Zambia—circuit or manual.

*Communications Receiver Type G12.*—B. Lawrence, 32 Bridle Path, Beddington, Croydon, CRO 4SB—circuit diagram, manual, or any other information. Loan or purchase.

# CONSTANT CURRENT GENERATOR FOR OHMMETER CONVERSION

by

J. C. MAYCOCK

**The constant current generator circuit described here enables resistance to be measured directly with the aid of a high impedance voltmeter. If the voltmeter has sufficient sensitivity, very low resistance readings are feasible**

There must be many constructors who have built themselves high input impedance voltmeters and who lack the means to measure resistance. This article describes a simple unit which can be employed with a high resistance voltmeter to enable resistance measurements to be carried out. It requires no modifications to the existing voltmeter. Also, it causes only a low current to be passed through the resistance being measured and is therefore suitable for all but the most delicate of components.

The basis of the technique consists of feeding a known current through the unknown resistor, Rx. The potential developed across Rx is then a measure of its resistance, and can be read off from the scale of a high impedance voltmeter.

The circuit of the constant current generator is shown in Fig. 1 with Rx connected across the output terminals.

## CIRCUIT OPERATION

The unknown resistor Rx forms the collector load of silicon transistor TR2, this operating from a 15 volt supply in what is effectively a grounded base configuration. A large change in collector voltage produces a relatively small change in collector current, and therefore the current through Rx remains constant for a very wide variation in its value.

The collector current of TR2 is controlled by the emitter current. The latter is adjusted to give load

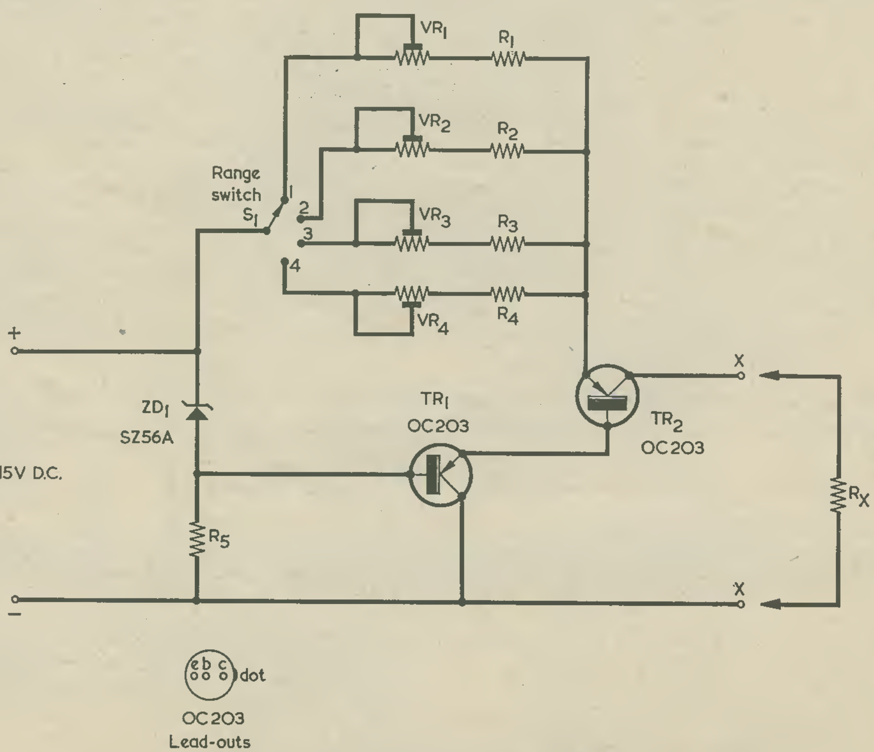



*Fig. 1. Circuit of the constant current generator. Rx is the resistor whose value is to be measured*

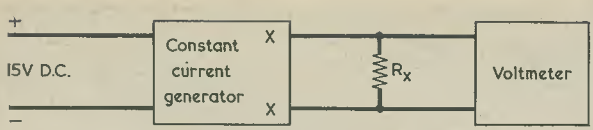



*Fig. 2. Showing correct connections for the two units required*

currents in Rx of 10mA, 1mA, 100$\mu$A and 10$\mu$A by means of range switch S1 and preset controls VR1, VR2, VR3 and VR4 respectively.

To make the emitter-collector current independent of fluctuations in the supply, the base voltage is stabilised by zener diode ZD1. A 5.6 volt zener diode rated at 1 watt was used. Should a stabilised power supply be available, then the zener diode may be replaced by a 560Ω resistor. The maximum current drawn from the 15 volt supply is approximately 20mA.

The potentiometers VR1 to VR4 should all be wirewound and, sufficient to say, of good quality. Colvern 1 watt types were used in the original.

## VOLTMETER

The voltmeter used with this circuit should be either a valve voltmeter or the transistor equivalent. A digital voltmeter is ideally suited and was in fact used with the original circuit.

## RANGE OF THE UNIT

The voltage appearing across the output terminals under open circuit conditions is about 10 volts.

The maximum effective voltage for which the present circuit is intended is about 2 volts, since a fall-off in accuracy exists above this voltage. Range calculations may be based on this. Thus, 2 volts and 10$\mu$A give a maximum measurable resistance on Range 4 of 200kΩ. The accompanying Table gives details of the maximum resistance reading offered, at 2 volts, by each range. Since the resistance values are multiples of voltage readings, the value of any resistance being measured may be quickly judged from the corresponding voltmeter indication. For example, a voltage reading of 1.5 on Range 3 corresponds to a resistance in Rx of 15kΩ. The minimum useful resistance reading for each range depends upon the lowest voltage the voltmeter can reliably measure.

Should a range higher than 200kΩ be required, a further range offering 1$\mu$A could be added, although this has not been tried out in practice by the author. The values of the preset potentiometer and range resistor in the emitter circuit of TR2 would be 1MΩ and 3.3MΩ respectively, and the maximum resistance reading would be 2MΩ. A range switch offering a fifth position would also, of course, be required.

A 12 volt supply may be employed instead of the 15 volt supply, if desired. In this case, the values of the ranging resistors should be changed to multiples of 22, commencing with 220Ω for R1 and ending with 220kΩ for R4. R5 should then be 820Ω and the zener diode a 4.7 volt component (or a 470Ω resistor if a stabilised supply is used).

**TABLE**

| Range | Load Current | Maximum Resistance Reading (for 2 Volts across Rx) |
|---|---|---|
| 1 | 10mA | 200Ω |
| 2 | 1mA | 2kΩ |
| 3 | 100$\mu$A | 20kΩ |
| 4 | 10$\mu$A | 200kΩ |

## COMPONENTS

*Resistors*
(All fixed values ½ watt 5%)

| | |
|---|---|
| R1 | 330Ω high-stability |
| R2 | 3.3kΩ high-stability |
| R3 | 33kΩ high-stability |
| R4 | 330kΩ high-stability |
| R5 | 1kΩ |
| VR1 | 100Ω wirewound potentiometer |
| VR2 | 1kΩ wirewound potentiometer |
| VR3 | 10kΩ wirewound potentiometer |
| VR4 | 100kΩ wirewound potentiometer |

*Semiconductors*

| | |
|---|---|
| TR1 | OC203 |
| TR2 | OC203 |
| ZD1 | SZ56A (Henry's Radio, Ltd.) |

*Switch*

| | |
|---|---|
| S1 | single pole 4-way, rotary |

## CALIBRATION

Calibration is best carried out using standard resistors of known values and adjusting the potentiometers on each range until the voltage indicated is the required multiple or sub-multiple of the resistance.

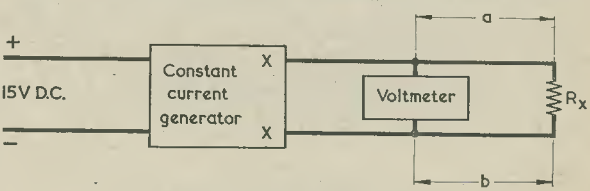



*Fig. 3. Showing errors that may occur through incorrect connection of leads*

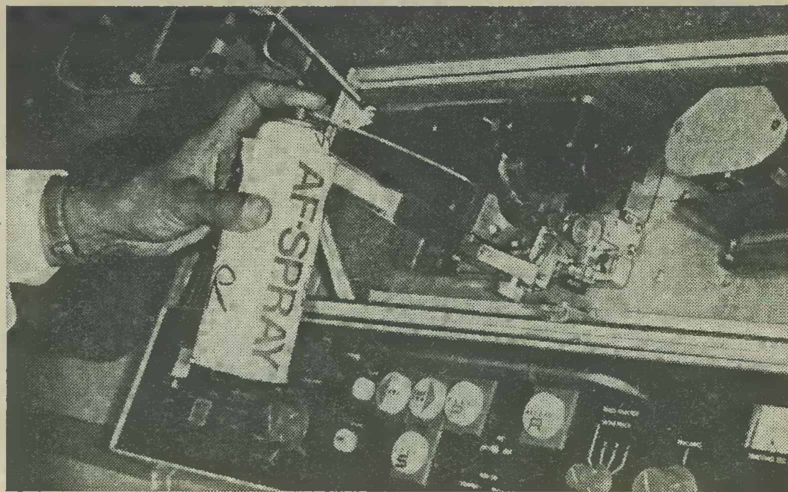
## TRANSISTORS

Any silicon transistors in the series OC200, OC201, OC202 and BZY11 may be used with success in the circuit, though differences in stability may be found. The current stability of the circuit is about 0.05% and thus the accuracy is similar.

## USING THE UNIT

On the low ohms range trouble can be experienced with lead resistance unless the voltage sensing output and current input are both connected directly to resistor Rx, as in Fig. 2. Fig. 3 shows an incorrect method of connection which causes the resistances of the leads "a" and "b" to be added in series with Rx. ■

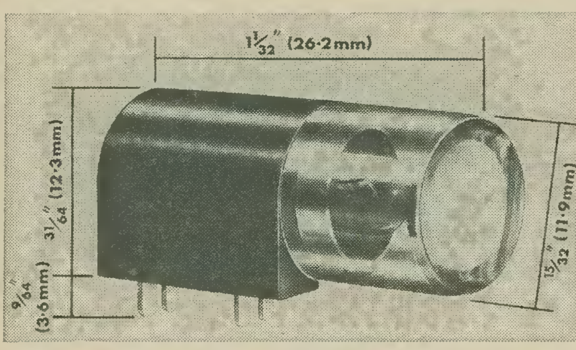
# CURRENT TRENDS




*AF-Spray in use at Thames Television's Teddington Studios for cleaning Ampex videotape record-playback machines*

## ● NEW BULGIN SIGNAL LAMP

The new Signal Lamp illustrated here has been designed specifically for mounting directly into a printed circuit assembly. The body is moulded in high grade black phenolic material and accepts two different lens types – either with a flat or a domed end. Both lenses are available in a choice of five transparent colours, red, amber, green, blue and water clear and five translucent colours, red, orange, green, blue and white, all of which are a push-fit to the body.



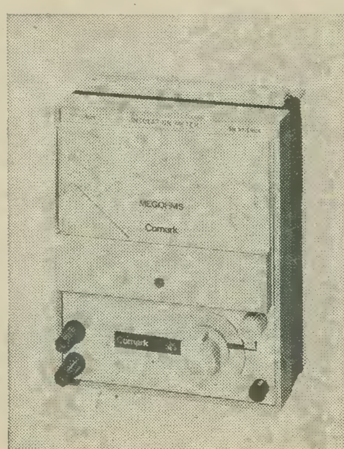

Removal of the lens provides access to the anti-vibration l.e.s. lampholder accepting BS. 98/E.5 tubular lamps 5.5mm diameter by 15mm long. Four mounting pins are employed for stability (2 per lamp contact) which are silver plated for ease of soldering and are on 0.1 x 0.3in. centres, therefore fitting in any required position on proprietary printed circuit boards of 0.1in. standard matrix, as well as specially designed boards. Their length, 9/64in., caters for most common thicknesses of board. Working rating is 30V at 0.5A maximum.

## ● NEW COMARK INSULATION METER

The new Comark Insulation Meter Type 1905 has been allocated JS No. 6625-99-111-2740 for general Service use. The instrument provides six test voltages from 25V to 1,000V and will measure leakage resistance between 0.1 Megohm and 10,000 Megohm to ±5%.

The 1905 is battery powered and easily portable; test voltages are generated by a transistor converter and the output is electronically stabilised to limit the maximum current to 10 microamps. The test voltage falls proportionally and the risk of destructive breakdown is virtually eliminated; semiconductor diodes and rectifiers may be checked with safety for leakage current.

The instrument has a push-button On/Off switch for instant one hand operation, eliminating unnecessary battery drain. The dry cells have a very long shelf life and provide a compact power source capable of giving more than 25,000 average operations. The 4.7in. scale, 10 microamp meter movement has taut band suspension.




## ● AF-SPRAY AIDS TV

With ITV broadcasting in colour, Thames Television viewers will obtain video-tape-recorded programmes of high quality, the degree of which is considerably assisted by AF-Spray aerosols.

At Thames Teddington studios there are two Ampex VR 1200 and three VR 2000 models having electronic editing facilities. The machines are used to record programmes on 2-inch tape for future broadcasting.

A fresh tape is placed on each machine several times a day, and this is preceded by the application of AF-Spray to remove dirt and oxide. The cleanser is applied to all components over which it passes, tension arms, idler, erase head, video heads, vacuum tape guides, control track head, audio and cue track heads, capstan and pinch roller, time counter idler and final tension arm.

The aerosols 5in. nylon extension tube is particularly useful for cleaning the control track head, which, owing to its inaccessible position, is very hard to clean by conventional means. AF-Spray aerosols also greatly simplify the cleaning of the three slots of the vacuum guide shoe which was normally an extremely time-consuming operation.

Before AF-Spray was adopted, cleansing solvent for application by rags was bought in bulk and decanted into smaller containers. Thames Television report that the large evaporation and spillage losses occurring with this method have now been totally eliminated. ■

# UNDERSTANDING RADIO

## METER SHUNTS

$f = \frac{1}{2\pi\sqrt{LC}}$

**by W. G. Morley**

IN LAST MONTH'S ISSUE WE EXAMINED THE MECHanism of the pointer measuring instrument which is used far more frequently than any other type in electronic work, this being the moving-coil meter. We concluded by introducing the concept of the shunt, this being a resistor whose function is to cause the meter to indicate a higher current than that which it indicates on its own.

We shall now deal with the subject of shunts in greater detail.

### SHUNT RESISTORS

In the introductory example we discussed last month, we had a 0-1mA moving-coil meter which we wished to give a full-scale deflection of 100mA, and we connected a shunt across it as shown in Fig. 1. (In this and succeeding diagrams, the arrows indicate the flow of "conventional" current, i.e. from positive to negative.) As we saw last month, we give the shunt a value which causes 99mA to flow through it when 100mA flows through the combination of shunt and meter. The remaining 1mA must then flow through the meter, with the result that it gives an indication of this value when the actual current flowing through the combination of meter and shunt resistor is 100mA. The same relationship holds true for meter scale indications lower than 1mA. If these are multiplied by 100 they will show the actual current flowing through the combination of meter and shunt.

To find the value of resistance needed in the shunt it is necessary, first of all, to know the resistance of the meter (i.e. the resistance offered at the meter terminals due to its coil and the connections to that coil). Let us say that the resistance of the meter in our example is 100Ω. We may next consider the voltage dropped across the meter when, on its own, it is indicating 1mA. From the equation associated with Ohm's Law, E = IR (where E is e.m.f. in volts, I is current in amps and R is resistance in ohms), this voltage must be $\frac{1}{1,000}$ x 100, or $\frac{1}{10}$ volt, and it is indicated in Fig. 2(a). In Fig. 2(b) we add the shunt and increase the current flow to 100mA whereupon the current flowing through the meter is once more 1mA. Again, $\frac{1}{10}$ volt will be dropped across the meter and it is obvious, by inspection, that $\frac{1}{10}$ volt must also appear across the shunt. The current flowing in the shunt is 99mA so, from $R = \frac{E}{I}$, the shunt resistance must be $\frac{1}{10}$ volt divided by $\frac{99}{1,000}$ amp, which works out as $\frac{100}{99}$ Ω.

This simple example shows us that the shunt resistance required is exactly one ninety-ninth part of the meter resistance. It also demonstrates that there is no necessity to know the voltage dropped across the meter at full-scale deflection, since the same voltage is also dropped across the meter and shunt combined. To find the value of any shunt, all we need to know is how many times greater than the meter f.s.d. value is the current it has to pass when the meter indicates full-scale deflection. Fig. 2(c) shows a 0-1mA meter having a shunt whose function is to cause the meter to read f.s.d. when 10mA flows through the combination of shunt and meter. Obviously, the shunt has to pass 9mA, whereupon it follows that its resistance needs to be one-ninth of the resistance of the meter. If the meter resistance in Fig. 2(c) is 100Ω then the shunt resistance required is $\frac{100}{9}$ Ω. Should the meter resistance be 75Ω, the shunt resistance required is $\frac{75}{9}$ Ω, and so on.

It is desirable to employ a common equation to cover all simple shunt resistance calculations and this may be conveniently based on the "scale multiplying factor" which results from the addition of the shunt.

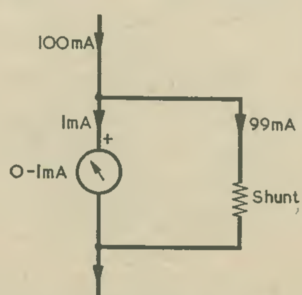



*Fig. 1. Connecting a shunt across a 0—1mA meter to cause it to read 100mA f.s.d.*

In the two examples we have considered the scale multiplying factors have been 100 (1mA to 100mA) and 10 (1mA to 10mA). The actual current flowing through the shunt for f.s.d. is then the current in the meter multiplied by the scale multiplying factor minus one. Thus, a scale multiplying factor of 100 means that the current in the shunt has to be 100 minus 1, or 99, times meter current, this agreeing with what we have already seen.

The general equation for calculating shunt resistance is:

$$Rs = \frac{Rm}{N-1}$$

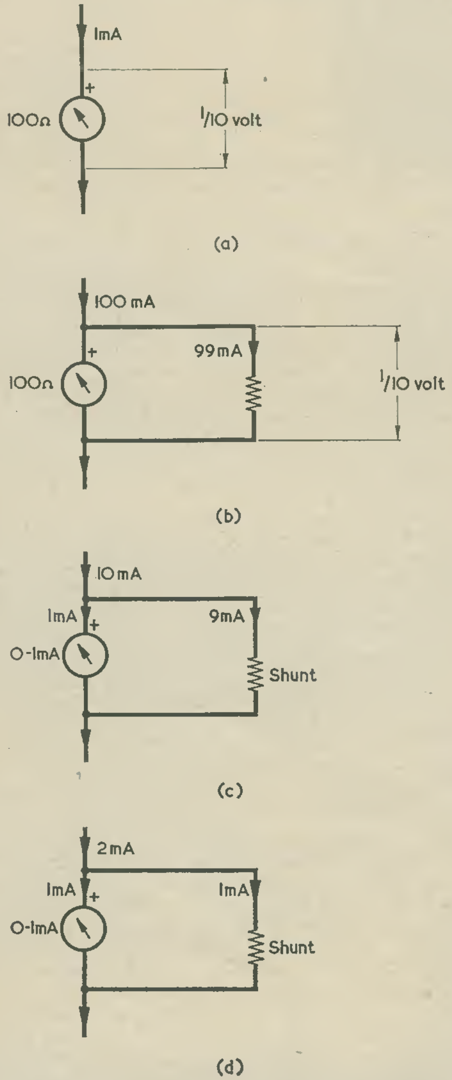



*Fig. 2(a). Indicating the voltage dropped across the meter of Fig. 1 at f.s.d. when the meter has a resistance of 100Ω*

*(b). The same voltage appears across the shunt resistor when the overall current flow is 100mA*

*(c). Adding a shunt to make a 0—1mA meter read 10mA f.s.d.*

*(d). In this instance, the shunt causes the meter to indicate twice its normal f.s.d. value*

where Rs is shunt resistance, Rm is meter resistance and N is scale multiplying factor.

The writer has introduced this equation by way of several intermediate steps because it has been his experience that beginners tend to be confused by the appearance of the "minus one" on the right hand side. It is, of course, necessary to include the "minus one" in order to allow for the current flowing in the meter. To reiterate, the equation tells us that for, say, a scale multiplying factor of 10, the shunt resistance is the meter resistance divided by 10-1, or 9. Note that there is no necessity to include in the equation the actual currents passed by the meter or the shunt as these are automatically catered for by working in terms of the "scale multiplying factor".

An interesting case arises when it is desired to have a scale multiplying factor of 2, as shown in Fig. 2(d). This will occur if we want, say, a 0-1mA meter to read 2mA f.s.d. (as is indicated in the diagram), a 0-50mA meter to read 100mA f.s.d., or any other meter to read twice its scale value. The term N in the general equation for shunt resistance now becomes 2, whereupon we have

$$Rs = \frac{Rm}{2-1}$$

giving us the result that Rs is equal to Rm. This is to be expected since, for a scale multiplying factor of 2, equal currents must flow in the meter and in the shunt.

## MULTIPLE SHUNTS

A very large number of measurements in electronic work are carried out with the aid of an instrument which is usually referred to as a "testmeter" or a "multi-testmeter". This instrument employs a single basic moving-coil meter and, by means of suitable switches and/or sockets, can be set up to give an f.s.d. indication for a wide range of different currents and voltages. Testmeters of this nature also have one or more ranges capable of indicating resistance values.

So far as the current measuring function of a testmeter is concerned, it would appear that a number of different current ranges could be obtained by the simple expedient of connecting different values of shunt resistance across the single basic meter. A system of this nature is in fact used, but the circuit employed has to incorporate features which are designed to protect the basic meter against accidental overload and to reduce the risk of errors in readings on the higher current ranges.

At first sight, it would seem that the switching circuit required is that shown in Fig. 3. In this diagram, the basic meter is coupled all the time to the terminals of the testmeter, and the range selector switch simply brings into use the shunt required for the particular range selected. At one switch position there is no shunt at all. This would correspond to the lowest current range, and the readings indicated would be those given by the basic meter on its own.

In practice, the circuit of Fig. 3 represents extremely poor design approach, and should not be employed in a working testmeter. The reason for this is that it is possible for excessively high currents to pass through the basic meter due to faulty operation of the range switch. To take an example, let us assume that the testmeter is switched to a high current range and that a correspondingly heavy current is being passed through the instrument. Very nearly all of this current should flow through the shunt selected by the switch. If, however, the switch contacts happen to become momentarily open-circuit or should momentarily present a relatively high resistance, virtually all the current will flow through the basic meter itself whereupon the latter can be seriously damaged. The possibility of a momentary open-circuit or high resistance contact is likely to occur in any switch, this being particularly true when the switch is being turned from one range position to the next. A further disadvantage is that the inevitable resistance offered by the switch contacts appears in series with the shunt. Shunts for high current ranges may have resistances considerably lower than 1Ω, and the consequent risk of inaccuracies due to even extremely low values of switch contact resistance becomes very high.

These disadvantages can be overcome in testmeter current range switching circuit design by following the principle that currents greater than the f.s.d. value of the basic meter must always flow directly through the appropriate *shunt*, and that the meter should *then* be connected to that shunt. This principle is followed in the simple circuit shown in Fig. 4(a). Here, there are three current ranges and the current to be measured flows through R1, R2 and R3 in series. The highest current range is selected by position 3 of the switch, whereupon the appropriate shunt is R3. On position 2 of the switch, the shunt is provided by R3 and R2 in series. Position 1 of the switch selects the lowest current range, the shunt being given by R3, R2 and R1 in series. It will be seen that only the meter current flows through the switch contacts, with the result that errors in meter indication due to switch contact resistance become correspondingly reduced. In no instance, also, can open-circuit or high resistance switch contacts allow excessive current to flow accidentally through the meter. Whilst Fig. 4(a) ably demonstrates the correct approach for switching shunt resistors, the circuit has the disadvantage that, due to the relatively high resistances of R1 and, in turn, R2, excessively large voltages will be dropped across the chain of resistors when measuring the larger currents.

An alternative switching circuit is illustrated in Fig. 4(b), in which the two switches shown are ganged. The current to be measured, if higher than the f.s.d. value of the basic meter, passes first through S1 and then flows through the shunt selected. The meter is then coupled by S2 to the same shunt. The circuit meets all the requirements for correct design procedure. The current to be measured must always pass through the shunt, the meter being then connected to that shunt. Only the relatively low meter current flows through S2. The current being measured passes through S1, but the accuracy of the instrument will not be impaired if this switch should exhibit a small contact resistance. Such a contact resistance merely results in a slight increase in the voltage dropped across the terminals of the testmeter as a whole. The circuit has the slight further advantage of enabling the test terminals to be applied direct to the basic meter on the lowest current range (at switch position 1 in the diagram) with no shunt in circuit at all. The only disadvantage of the circuit is that it requires a range switch having two ganged banks of contacts.

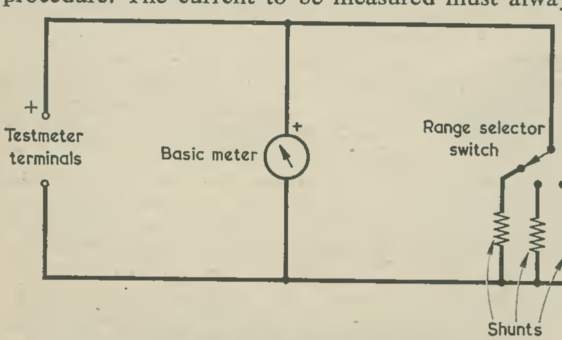
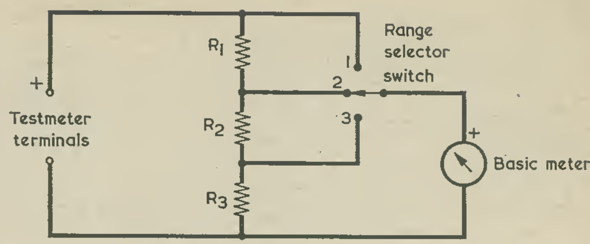
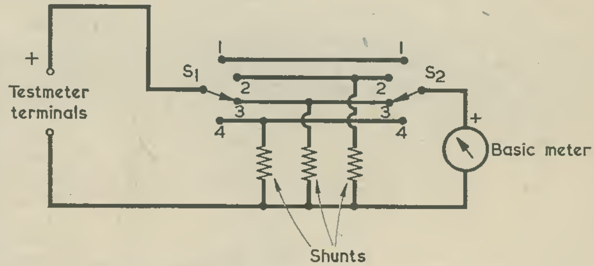



Fig. 3. This method of current range selection in a testmeter may appear attractive at first sight but in practice it represents a poor design approach and its use is not advised




(a)




(b)

*Fig. 4(a). A circuit which, although not practicable for reasons explained in the text, demonstrates the preferred method of switching shunts in a testmeter*

*(b). A range switching circuit which is suitable for use in a testmeter. S1 and S2 are ganged*

## UNIVERSAL SHUNT CIRCUIT

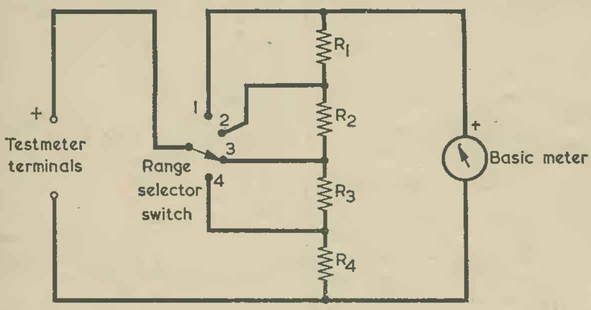
A current range selection circuit which embodies nearly all the advantages of that shown in Fig. 4(b), and which has the added advantage that a single-gang switch with one bank of contacts can be used, is shown in Fig. 5(a). This is known as the *universal shunt* circuit. It is shown with four switch positions in Fig. 5(a), but the principle may be readily adapted for fewer or more positions.*

The lowest current to be measured is given by the switch in position 1, whereupon the basic meter is shunted by R1, R2 and R4 in series. The next higher

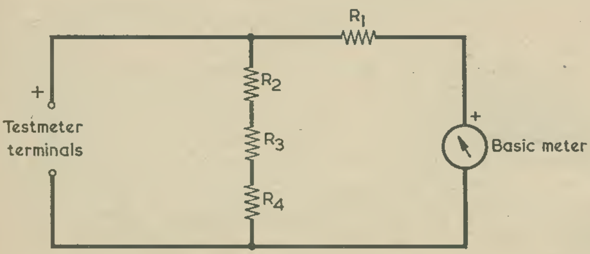
* As is explained later in this article, the basic meter will have an external resistor in series with one of its terminals, whereupon the effective meter resistance presented to the universal shunt circuit is equal to the actual meter resistance plus this external resistance. For the present discussion it can be assumed that the meter resistance is that provided by the meter on its own.

current range is provided by position 2, whereupon the shunt is given by R2, R3 and R4 in series, with R1 appearing in series with the meter. The resulting circuit is shown in Fig. 5(b), and it should be noted that, so far as the shunt is concerned, the effective meter resistance is the actual meter resistance *plus* R1. The values of R2, R3 and R4 are such as to take this fact into account. On the next higher current range, selected by moving the switch to position 3, R3 and R4 provide the shunt whilst the effective meter resistance is the actual meter resistance plus R1 and R2. On the highest current range, given at switch position 4, R4 is the shunt and the effective meter resistance is the actual resistance plus R1, R2 and R3.

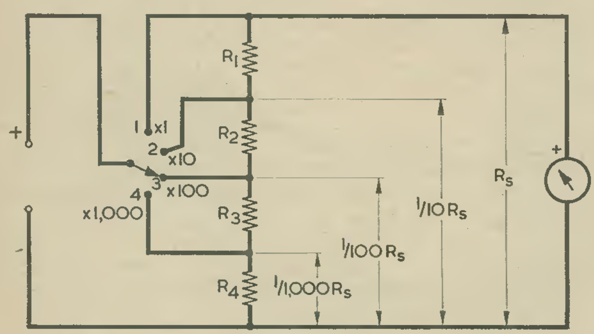
Calculations for resistor values in the universal shunt circuit are complicated by the fact that, in switching to a higher current range, further resistance




(a)




(b)




(c)

*Fig. 5(a). An example of the universal shunt circuit*
*(b). The circuit conditions existing when the range selector switch is in position 2*
*(c). Illustrating the procedure required for finding shunt values*

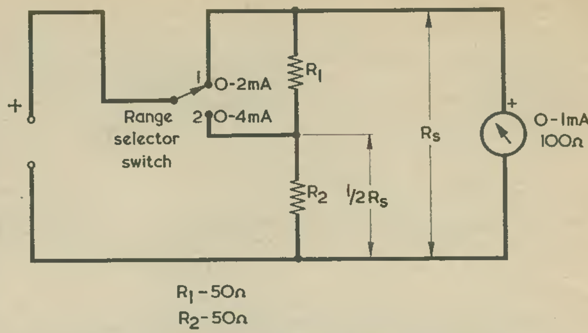



*Fig. 6. A very simple universal shunt circuit*

is automatically added in series with the meter. Thus, the values of resistors in the shunt and series sections for each switch position tend to be interdependent. Fortunately, calculations for universal shunt resistor values may be considerably eased by following the general procedure illustrated in Fig. 5(c), which assumes that each switch position increases the current f.s.d. reading by 10 times. It is first of all necessary to determine the lowest current range to be used and calculate the total value required for R1, R2, R3 and R4 in series. This value is then referred to as Rs. Switch position 2 multiplies the f.s.d. reading by 10. For the circuit to function correctly, the sum of R2, R3 and R4 must be equal to $\frac{1}{10}$ Rs. The process continues to R4, which needs, in this example, to be $\frac{1}{1,000}$ Rs. Since Rs is known the value of R4 may then be determined. The value of R3 then becomes $\frac{1}{100}$ Rs minus the value of R4, the value of R2 becomes $\frac{1}{10}$ Rs minus R3 and R4 in series, and the value of R1 becomes Rs minus R2, R3 and R4 in series. It will be found that calculations along these lines can be applied to any number of resistors employed in a universal shunt chain.

The scale multiplying factor, as the switch moves from one range to the next, need not be 10, and any other factor can be used, as is illustrated in the simple numerical example shown in Fig. 6. This depicts a universal shunt circuit where position 2 of the switch doubles the f.s.d. reading of the meter. For simplicity it is assumed that the meter has an f.s.d. of 1mA and a resistance of 100Ω. It is required that the lowest current range, given on switch position 1, will be 0–2mA. The value of Rs is then equal to meter resistance, i.e. 100Ω. On position 2 the f.s.d. value is doubled whereupon the value of R2 needs to be one-half of Rs. This is 50Ω. Since Rs is 100Ω, R1 must also be 50Ω.

On switch position 1 in Fig. 6, therefore, we have a 1mA meter of 100Ω resistance with a shunt (R1 plus R2) of 100Ω across it. The f.s.d. reading is thus 2mA. On position 2 we have a 50Ω shunt (R2) and an effective meter resistance (the actual meter resistance plus R1) of 150Ω. The result is that three times more current must pass through R2 than through the meter and R1. If 4mA is applied, 3mA will flow through R2 and the remaining 1mA through the meter and R1, whereupon the f.s.d. of the instrument becomes 4mA, as is desired.

The universal shunt circuit is incorporated in vir-

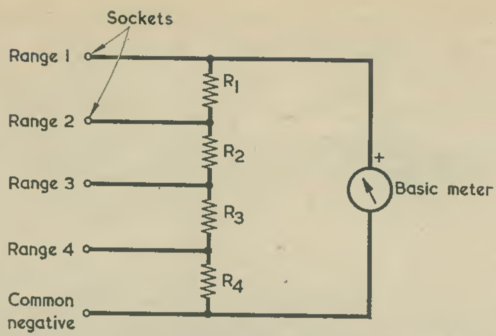



*Fig. 7. The simplicity of the universal shunt circuit makes it possible to dispense with the range selector switch and use sockets instead. This is a version of Fig. 5(a) with sockets*

tually all conventional commercially manufactured testmeters. Its advantages have already been referred to. It has the disadvantage that, since resistance is inserted in series with the meter when higher current ranges are selected, the voltage drop across the instrument as a whole is somewhat greater than in a circuit similar to that of Fig. 4(b). If readers care to work the figures out, they will find that the resistance offered by the circuit of Fig. 6 with the switch in position 2 is 37.5Ω whereas, if a basic meter of the same type had been made to read 4mA f.s.d. by the provision of a single shunt connected directly across its terminals, the resistance offered to the external circuit would be 25Ω. Thus, the universal shunt circuit causes rather greater power to be absorbed from the circuit into which it is connected than does that of Fig. 4(b). A slight disadvantage is that no range is available which connects directly to the meter, thereby preventing the minimum possible f.s.d. reading from being available at the testmeter terminals. In practice,, this disadvantage is not of great consequence, and it is usual to make Rs such that the minimum current range selected by the switch is only some 20 to 35% greater than the actual f.s.d. rating of the basic meter.

The simplicity of the universal shunt circuit makes it possible to dispense with the range selection switch altogether. Instead, a number of sockets may be provided, as illustrated in Fig. 7. The test leads of the instrument are then simply plugged into the sockets corresponding to the particular range required.

## SWAMP RESISTOR

The shunt resistors employed in testmeters are made up with resistive materials (usually one of the resistance wire alloys) having a very low temperature coefficient of resistance. The coil of the moving-coil meter has, on the other hand, to be wound with copper wire, and copper wire has the relatively high temperature coefficient of 0.0039 per degree Centigrade. As a result, the resistance of the meter coil increases with ambient temperature and, possibly, with any heating effect due to the current which passes through it. Changes in coil resistance due to temperature variations can be surprisingly high. For instance, an increase in wire temperature of 13°C results in an increase in winding resistance of 13 x 0.0039, which is equal to 0.05, or 5%. Variations such as this can cause serious inaccuracies in testmeter readings if the basic meter is connected directly to the current shunts.

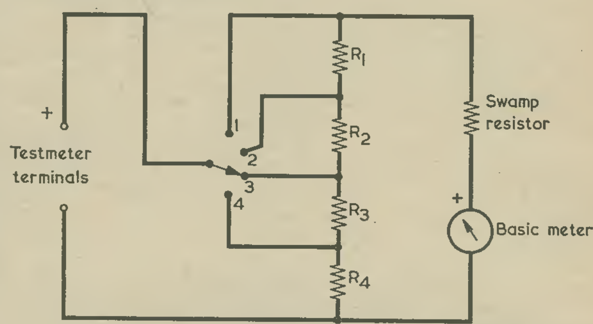



*Fig. 8. To reduce the effect of errors due to variations in meter resistance with changes in coil temperature, a testmeter incorporates a swamp resistor in series with the basic meter. Here, the swamp resistor has been added to the circuit of Fig. 5(a)*

This problem is overcome in a testmeter by inserting a *swamp resistor* in series with the basic meter, as shown in Fig. 8. The swamp resistor has a value which is some 3 to 6 times the resistance of the meter coil and employs resistance wire having a negligibly low temperature coefficient. Changes in the resistance offered by the meter and swamp resistor in series are then reduced to an acceptably low value, and shunt resistance values are calculated on the assumption

## FERRANTI LTD. ENLARGE SEMI-CONDUCTOR ASSEMBLY PLANT

**The Electronics Department of Ferranti Ltd. plans to double the size of its semiconductor assembly plant at Ormsgill, Barrow-in-Furness, Lancs. This expansion, which will double the size of the present 26,000 sq. ft. factory, will provide a production capacity of more than 20 million semiconductor components per annum. The present production capacity at Barrow is nine million components per annum.**

**The first batch of equipment for the new extension will be commissioned in July, and the enlarged plant is scheduled to be fully operational by the Autumn.**

**Ferranti's plans for the new extension will provide a further employment boost for the Barrow area. The present workforce of some 250 workers will be increased to over 700 employees by the end of this year.**

## COMPONENTS

**Where the above appears in this magazine, readers can rest assured that each and every item quoted is currently available from most component suppliers. Where an item is supplied from an individual source, the address is stated.**

**We take great care to ensure that all parts quoted in the various lists are not only obtainable by readers at the time of publication but also for some time ahead. Current catalogues are consulted, letters written and/or telephone calls made to suppliers confirming the present and future stock positions during the pre-publication processing of all articles.**

**From time to time however, and unknown to us, manufacturers change specifications of a particular product or, unfortunately from the constructors point of view, cease producing a particular item – this is a fact of life over which we have no control!**

that the meter resistance is equal to its actual resistance plus the swamp resistance. The swamp resistor is so called because it "swamps out" the variations in the resistance of the meter coil which result from changes in temperature.

Since the only requirement of the swamp resistance is that its value should be at least several times the resistance of the meter coil, it is possible to give it a value which results in the total swamp plus meter resistance becoming a convenient round number of ohms. This can result in the shunt resistor values being expressed in similarly convenient round numbers. A further point follows from the fact that, due to variations in thickness within tolerance of the copper wire employed, it is difficult to produce meter coil windings to a precise value of resistance, this being especially true in the case of sensitive meters having a very large number of turns on their windings. It is possible to take up variations in individual meter coil resistance by pairing up each meter with a swamp resistor whose value allows the total resistance to have the desired round number of ohms. The process of setting up swamp resistance to give the requisite total resistance is carried out at the factory where the testmeter is produced.

A swamp resistor is also required with the circuit of Fig. 4(b), and it may be inserted directly in series with either terminal of the meter. Once again, shunt resistor values are calculated on the assumption that meter resistance is the actual meter resistance plus that of the swamp.

A fact which is not generally realised is that, since a testmeter incorporates a swamp resistor for its current ranges, the voltage drop across the testmeter terminals for any current reading is significantly greater than would be given by a standard moving-coil meter without a shunt which indicates the current directly. The voltage drop in a testmeter is increased further by the fact that the universal shunt circuit is almost always employed. In practice the voltage drop in a good quality commercially manufactured testmeter is not sufficiently high to cause undue disturbance of operating conditions in any normal circuit into which the testmeter is inserted, but the effect can be troublesome on occasion and its presence needs to be borne in mind.

### NEXT MONTH

The writer had intended to introduce the use of the moving-coil meter for the measurement of voltage in this article, but lack of space now prevents this. In consequence, we shall turn to the question of moving-coil voltmeters in next month's issue.

## GUNN EFFECT – A MULLARD PAMPHLET

**Readers may care to know that an article on Gunn effect, devices and their applications, originally published in *Mullard Technical Communications*, is now available as a pamphlet.**

**It contains an explanation of the Gunn effect, describes the construction of the device and gives advice on the design of oscillator cavities for Gunn devices. Factors affecting stability are discussed and information is given on noise, frequency locking and pulsed operation.**

**Requests for the pamphlet should be made on company-headed notepaper to I.E.D./Valves Sales, Mullard Limited, Mullard House, Torrington Place, London, W.C.1.**

## *CURRENT SCENE*

# TOP BAND DX

If you are a sleepy head don't bother to read this column!

If you **can** clamber – somewhat sleepily maybe – out of that warm, snug and comfortable bed at the unearthly hour of 0530 clock time on a Sunday morning, and be ready to enter the shack at 0600BST (0500 GMT) you will be in time for the Top Band Trans-Atlantic Tests!

The Tests held so far were on 30th November, 14th and 28th of December. Tests still to be held are on 11th January, 1st and 15th of February between 0500 and 0730 (0600 to 0830 BST or clock time).

During alternate five minute periods, call "CQ DX Test", the W's and VE's commencing at 0500, unless in QSO, keep to these periods. Eastern W/VE stations operate between 1,800 and 1,820kHz; western W/VE's between 1,975 and 2,000kHz. European stations will use 1,823 to 1,830 kHz or 1,851 to 1,861 kHz.

It is not necessary however to confine trans-Atlantic Dx contacts within the date limits of these tests. Activity "across the pond" has been noted since last October. During the last two weeks of that month, the following Dx stations had been heard busily making contacts on this side of the Atlantic – K1BPW (0525, 1,804kHz); W1BB/1 (0515, 1,803kHz) and W1EXI (0545, 1,803kHz). The Bermudan VP9GW (0530, 1,802kHz) has also been active.

By the time these notes appear in print many more signals will be coming through from across the Atlantic with the season moving to its climax. Last year a veritable spate of Dx was apparent from the W eastern coastal region and reported in our feature **QSX.** This year it is hoped that more stations will join in the tests and attempt to span the Atlantic with a successful QSO.

For short wave listeners the tests are a trial of Dx-capability both of the listener and the station equipment. Reception of a W on Top Band represents quite a feat of Dx – much more so than some of the transmissions logged on the 14Mhz band.

So, if you can make it for opening time – of the tests we hasten to add – why not join in the fun and games?


*QSL card from W1BB/1 received for a period reception report sent last year. Of six such reports sent, each produced a reply in the form of a card, three had accompanying appreciative letters and one a bulletin of Top Band activity and news*

# In your workshop

**This month we find Smithy the Serviceman, aided as always by his able assistant Dick, starting the New Year in a Workshop which contains no equipment for repair whatsoever! But Smithy is not one to waste time, and he takes advantage of the situation to discuss with Dick the latest hints received from readers**

"HAPPY NEW YEAR, SMITHY!"

"And the same," replied Smithy affably, "to you my boy."

Dick glanced warily at the Workshop clock, the hands of which indicated that normal starting time had occurred at least ninety minutes earlier.

"Sorry I'm late," he offered.

"Not to worry, Dick, I've only just got in myself," admitted Smithy. "As I told you before we packed up last night, there was no need for you to come in early today."

The pair looked at the 'For Repair' racks. They were completely bare.

"Thank goodness," commented Dick, "that there are no sets to be fixed. All I want to do today is to take things nice and easy."

He stretched himself luxuriantly then removed his raincoat and hung it up on the hook behind the door.

**READERS' HINTS**

"Did you," asked Smithy, "have a good New Year's Eve celebration last night?"

"I had quite a pleasant little do," replied Dick. "Rather quiet, but otherwise very nice."

"You didn't," queried Smithy slyly, "get another false beard stuck on you, did you?"

Dick winced, then hurried quickly over towards the motley array of utensils ranged alongside the Workshop sink.

"I think," he remarked, hastily changing the subject, "that it would be an excellent idea if I put the kettle on for tea."

"A very sensible suggestion," responded Smithy warmly. "Also, seeing that we've got a nice quiet New Year's Day in front of us, how would it be if we had another session with readers' hints?"

"That would be fine," said Dick eagerly, as he returned to his stool.

"Good," remarked Smithy, opening a drawer in his bench and extracting a sheaf of letters. "Well, I won't waste any more time. We'll have a look at the first one right away."

The Serviceman opened one of the letters and surveyed its contents closely.

"Now here's a jolly good hint," he continued, "and it's just what we need to start the ball rolling. Our correspondent states that he recently had to make up a housing for a small electronic gadget he'd built. When he considered the situation, however, he found that wood was rather too cumbersome for the housing, whilst Perspex didn't quite seem to fit the bill. And so he used copper-clad laminate instead."

"Copper-clad laminate?"

"That's right. In other words, ordinary plain printed circuit board before the circuit pattern is etched on it. This material proved ideal for the purpose, and all that had to be done was to cut the front, sides, top and bottom to size, and secure them together with the copper on the inside to form a small cabinet." (Fig. 1).

"How did he join the bits together?"

Smithy consulted the letter once more.

"He soldered internally at the corners," he replied. "Our correspondent says it's best to spot solder the sections together, rather than to run the solder all along each corner. The case which results is attractive

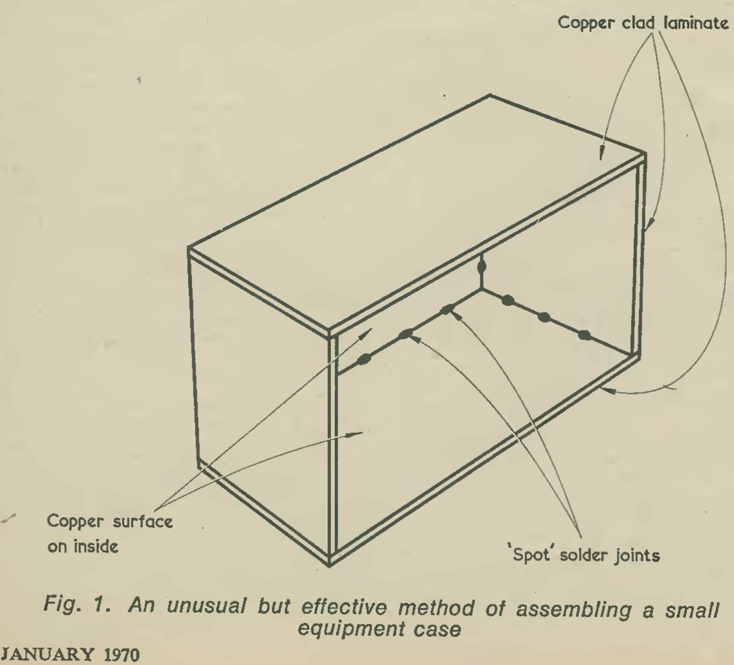



*Fig. 1. An unusual but effective method of assembling a small equipment case*

in appearance. In addition, the copper surface on the inside provides screening. Another advantage is that small components can be mounted to the inside walls by soldering them direct to the copper surface."

"That," remarked Dick, "is what I call a proper copper-bottomed hint!"

"It's certainly a novel idea," chuckled Smithy, as he picked up another letter. "Now, this letter describes quite a simple sort of tip, but it's still one which can save a lot of time and trouble. As you know, the process of soldering components to printed circuit boards and to Veroboard may seem easy in principle, but in practice you can sometimes run into the odd minor difficulty."

"That's true enough," interrupted Dick. "What happens every now and again is that, when you turn the board over to solder the lead-outs to the copper, one or more of the components drops out or moves out of its proper position."

"Exactly," agreed Smithy. "Well, the answer to this problem is to get in a stock of rubber bands of various sizes and just slip one or two of these over the board to keep the more insecure components in place whilst you're soldering them into circuit. Simple, isn't it?"

"I'll say it is," said Dick. "Dash it all, why on earth didn't I think of that myself?"

"The solutions to most problems," pronounced Smithy, "are usually obvious once you've been told what they are. A final point which is made in this letter, incidentally, is that the idea of using rubber bands to hold components in place can be just as useful when you're working with really large boards as it is with small ones."

Smithy picked a further letter from the pile on his bench.

"Here," he announced after a moment's perusal, "is a hint which enables you to fit an extension volume control to a TV set. I'd better add quickly that the scheme doesn't apply to all TV receivers and that, since it involves a direct connection to the chassis of the set, all the circuit points in the extension wiring require insulation which is fully suitable for mains voltages."

"What sort of TV set," asked Dick, "can the volume control be used with?"

"It can be employed," replied Smithy, "with sets in which the slider of the internal volume control couples to the control grid of the a.f. output valve. Bring your stool over here and have a look at the circuit."

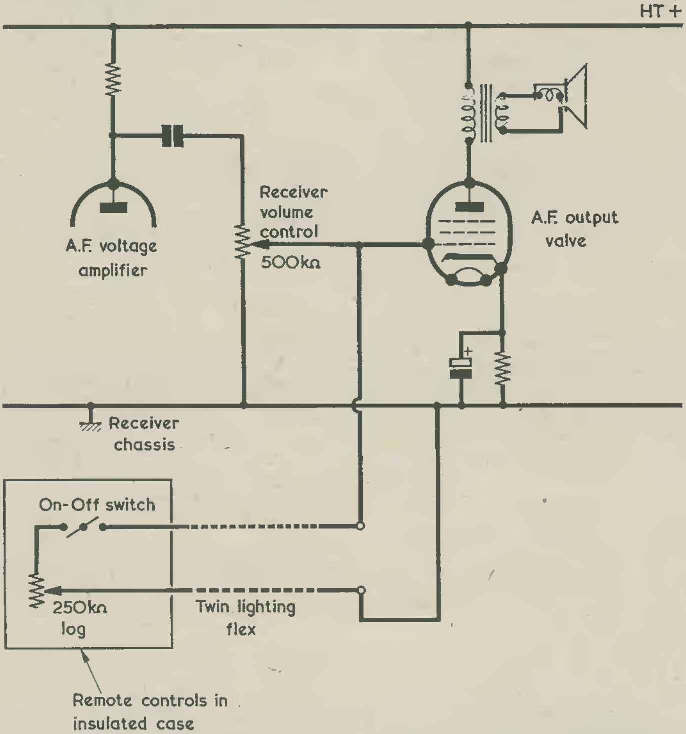



*Fig. 2. A simple extension volume control for use with television receivers whose existing volume control appears in the grid circuit of the a.f. output valve. All insulation in the extension circuit must be adequate for mains voltage*

Dutifully Dick picked up his stool, carried it over to Smithy's bench and settled himself on it comfortably. He then looked at the circuit accompanying the letter Smithy was holding. (Fig. 2).

"As you can see," remarked Smithy, "the idea is not at all complicated. At the extension control point you have an on-off switch in series with a 250kΩ log pot, and these are coupled to the set by twin lighting flex. The volume control in the receiver is set up to provide adequate volume level for quiet speech when the switch at the extension point is open. If the sound programme changes over to loud music the remote switch is then closed, whereupon the extension volume control can be adjusted to allow the music to be reproduced at a comfortable level. In most cases, after the extension volume control has been initially adjusted to the desired level, it will only be necessary to operate the switch. This is just the thing, I might add, to have positioned on the arm of your favourite armchair."

"Won't there be trouble," asked Dick, "due to hum pick-up on the leads to the extension point?"

"There wasn't any trouble on this score in our correspondent's set-up," replied Smithy. "And he simply uses about fourteen feet of ordinary unscreened twin lighting flex. However, you would very definitely get trouble with hum if the extension volume control circuit were introduced any earlier in the receiver a.f. amplifier stages than at the grid of the output valve. Even when the extension circuit appears in the output grid circuit it will still be necessary to connect the TV set to the mains such that its chassis is common with the neutral and not the live side. It would also be preferable to keep the wire to the extension volume control spaced well away from any other mains wiring in the room. Actually the circuit is a wee bit experimental in this respect because, in houses which are wired up with p.v.c. cable, it may be impossible to completely eradicate hum pick-up on the extension lead. Apart from the question of picking up hum, it is extremely important to pay attention to the safety factor. The extension volume control components and wiring are all at mains potential, and the remote potentiometer and switch must be completely enclosed in an insulated case which ensures that none of the connection points can be touched. Also, the wire to the remote control must have insulation suitable for mains voltages. If the remote volume control connects to the receiver by way of a socket fitted to the back of its cabinet the socket must offer insulation suitable for mains voltage. It could, in practice, be a socket intended for mains use, and a suitable type would be one of those small 2-amp 2-way types."

## CORRUGATED STRIP

Smithy turned back to his bench and picked up the next letter. As he removed the contents from its envelope, a length of corrugated strip slipped out and fell to the floor. Dick picked this up and examined it with interest. Fig. 3(a) ).

"Hello," he remarked. "What's this, then?"

"It's original function," said Smithy, "is to provide a means of positioning drawer partitions. But the use to which our correspondent puts it is rather different. He fits it inside equipment housings to enable printed circuit boards or Veroboards to be supported at the ends along the slots between the corrugations."

Smithy pulled his notepad towards him, and sketched out the application. (Fig. 3(b) ).

"Gosh," said Dick, impressed.

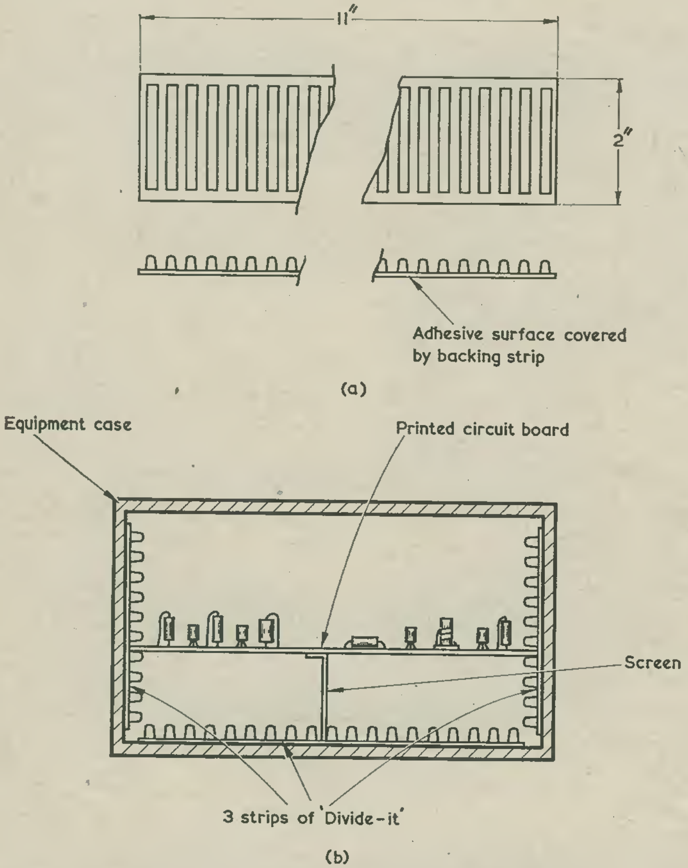



*Fig. 3(a). The appearance of 'Divide-It' strip*
*(b). Employing three strips of 'Divide-It' to position a printed circuit board and a screen in an instrument case*

"It's a strip of special material," replied Smithy, as he studied the letter, "which is known as 'Divide-It', and which you can buy for a few shillings at most Do-It-Yourself stores. One side is flat, and has an adhesive surface which is revealed after pulling off a backing strip. The other side is deeply corrugated and, as you can see if you dig at it with your thumb nail, the corrugations are quite strong physically. The material of which the strip is made offers good insulation along its surface."

"What's the strip intended for?"

"That's a neat idea."

"It is, isn't it?" commented Smithy. "Incidentally, I must say that it's rather surprising to find how many uses there are in electronic work for simple domestic gadgets such as this."

At that instant, the Workshop kettle gave voice to an ear-splitting whistle, and further activity ceased whilst Dick set about the all-important task of preparing the tea. Eventually, he placed Smithy's disgraceful tin mug, brim-full with the precious beverage, alongside the Serviceman.

"Ah," said that gentleman as, after

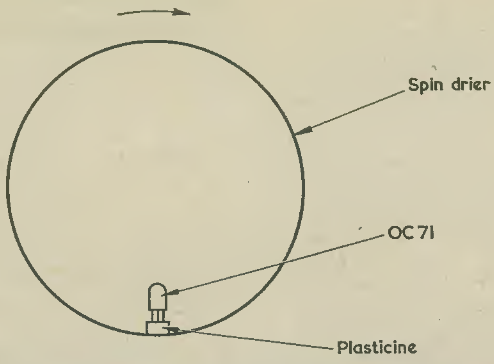



*Fig. 4. A suggested method of displacing the opaque filling in a glass-cased OC71. The transistor can then function as a phototransistor*

judicious blowing over the surface of the mug, he drank deeply of its contents, "that's the stuff to give the troops!"

Smithy noisily smacked his lips in appreciation. Despite the many years he had known the Serviceman, Dick had still retained his sense of wonder at the vast quantities of tea which Smithy was capable of absorbing.

"I've never," he remarked conversationally, "known *anyone* who drinks as much tea as you do."

Smithy quaffed even more mightily at his mug, then placed it back with a clatter on his bench.

"There's nothing like it," he responded cheerfully. "In fact, I rely on a really good intake of tea each day to keep my kidneys fully flushed out!"

Dick shuddered.

"There are times," he complained, "when you're really *horrible*, Smithy. Shall we carry on to the next letter?"

"Half a jiff," responded Smithy, taking a further gargantuan draught from his mug. "Let's get this little lot filled up again first."

Disdainfully, Dick picked up Smithy's empty mug and carried it over to the battered Workshop teapot. He returned with the mug, charged once more with the fluid so vital for the smooth operation of Smithy's renal functions, and placed it carefully on the Serviceman's bench. Smithy snatched it up greedily and again imbibed deeply.

"Ye gods," snorted Dick in disgust. "You're nothing but a tea-junkie, that's all you are. I bet you've got a dirty great hypodermic syringe full of the stuff back home, kept handy for the times when you're *really* in need of a fix."

"Nonsense," replied Smithy indignantly. "And if you must know, it so happens that I acquired my taste for tea during those perilous war years when I was defending this country, so that the future generation – including *you*, mate – could be brought up in a state of peace and tranquility."

"*You* defended this country?" queried Dick incredulously. "From what they tell me, all you ever did was to rise to the rank of acting unpaid lance-corporal in the Pioneer Corps."

Smithy scowled at his assistant.

"We ex-Service types," he remarked loftily, "don't talk about our wartime careers."

"Much."

"Let me tell you," growled Smithy furiously, "that I did my fair turn of service with all the rest. Brothers-in-arms, that's what we were.' '

Dick turned and addressed the empty Workshop.

"We shall next," he announced derisively, "have a vocal rendition of 'Comrades' with an accompaniment on the spoons!"

It was obvious that this last remark on Dick's part was the cause of deep offence to the Serviceman.

"I have no wish," he commented icily, "to pursue this subject any further. I shall, instead, turn to the next letter."

"As you wish," said Dick obligingly.

Smithy gazed suspiciously at his assistant, but that worthy's face carried no expression other than that of interest in the next hint to be discussed.

"Hmm," grunted Smithy, turning back and foraging amongst the letters on his bench. "Well now, let's see what we've got here."

Smithy selected a letter and read it with what was patently a continually increasing interest.

"This one," he chuckled eventually, "is a real dilly! Tell me, Dick, do you remember the old business of using OC71's as phototransistors?"

Clearly, the contents of this last letter had caused Smithy to dismiss from his mind, at least temporarily, the displeasure which had followed Dick's ribald observations on his wartime activities.

"Using OC71's as phototransistors?" repeated Dick. "Why, certainly I do. The early OC71's had glass cases covered with opaque paint to keep the light out. The thing to do was to scrape the paint away, whereupon you had a first-class phototransistor!"

"You've got it," said Smithy. "In fact, I've converted quite a few of those old OC71's in that way myself."

"After the early period, though," cut in Dick, "the design of the OC71 was changed. It still had the opaque paint on the outside of the glass housing but, in addition, the filling inside was made opaque, too."

"That's right," confirmed Smithy. "The result was that, even if you *did* scrape off the paint, you still couldn't use the OC71 as a phototransistor. Eventually, the OC71 changed over to a metal case, but there must still be plenty of glass ones with the opaque filling knocking around."

"All this," remarked Dick, "sounds intriguing. Go on, Smithy."

Smithy returned to the letter.

"What our correspondent has succeeded in doing," he resumed, "has been to shift the opaque filling inside a glass OC71 away from the internal transistor junction by taking advantage of centrifugal force! The scheme consists of pushing the transistor leads into a half-inch cube of Plasticine, and of then fixing the Plasticine to the inside wall of a washing machine spin drier (Fig. 4). He found that, after some two to three minutes spinning around in the drier, the opaque filling of the OC71 was all forced to the bottom

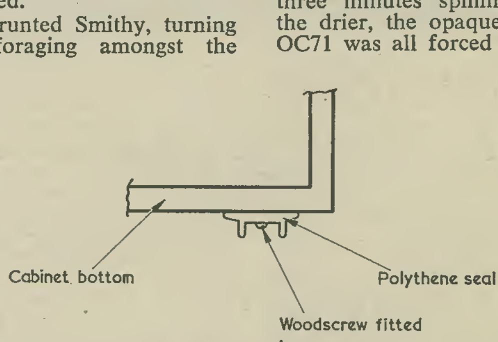



*Fig. 5. Using the polythene seal from a flagon cap as a non-scratch cabinet foot*

of the transistor, leaving the junction free and clear. The OC71 then functioned as a perfectly good phototransistor."

## CABINET FEET

"That idea," grinned Dick, "is very definitely one for the book!"

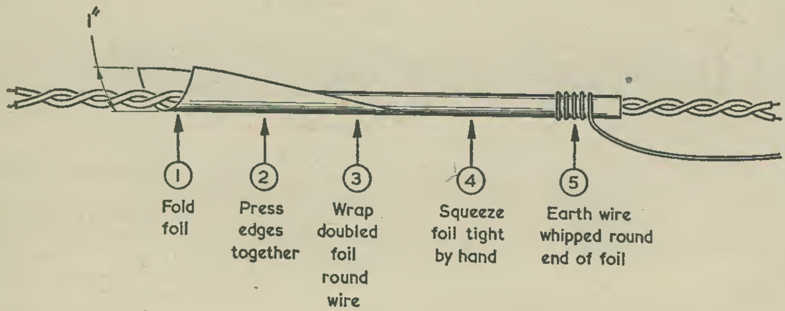
"It certainly represents a jolly crafty approach," replied Smithy, as he took up a further letter.

There was silence as the Serviceman read its contents.

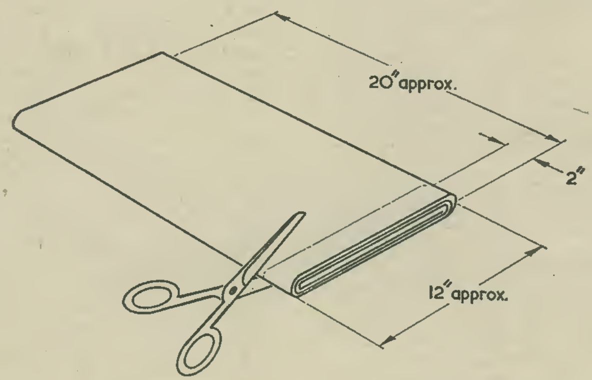
"Here's another simple one," he announced, after a moment. "Our correspondent advises that the polythene seals inside the caps of flagons should not be thrown away, as they make perfect improvised non-scratch feet for small cabinets.

Smithy detached a sheet bearing the diagrams from the remainder of the letter and laid it down on his bench (Figs. 6(a) and (b)).

"The idea behind this hint," he went on, "is to provide temporary screening for a wire or cable if it is suspected of picking up or radiating hum or interference, or of causing instability whilst in the unscreened condition. What you do is to fit a sheath of aluminium foil or aluminium paper around the wire, and it is possible to apply this temporary screening over quite long lengths. Aluminium coated paper is to be preferred because it is tougher, but aluminium kitchen foil is nearly as good and is more readily obtainable since most grocers sell it. It's available in widths of




(a)




(b)

*Fig. 6(a). Successive steps in wrapping a 2 inch strip of aluminium foil or aluminium coated paper around a wire to provide temporary screening*
*(b). How the 2 inch strip is obtained*

There's a sketch in the letter too, and it shows one of these seals being used in this manner."

Smithy showed Dick the sketch (Fig. 5) then proceded to the following letter.

"This is quite a long hint," he remarked. "Also, there are several diagrams which have to be looked at if you're going to understand the general scheme of things."

about 10 or 20 inches, the 20 inch width being better because it works out cheaper."

"How do you apply the foil to the cable?"

"You first of all cut it," replied Smithy, "so that you have a long strip two inches wide. You then lay the two inch strip along the cable to be screened and cut it to the length required, allowing your-



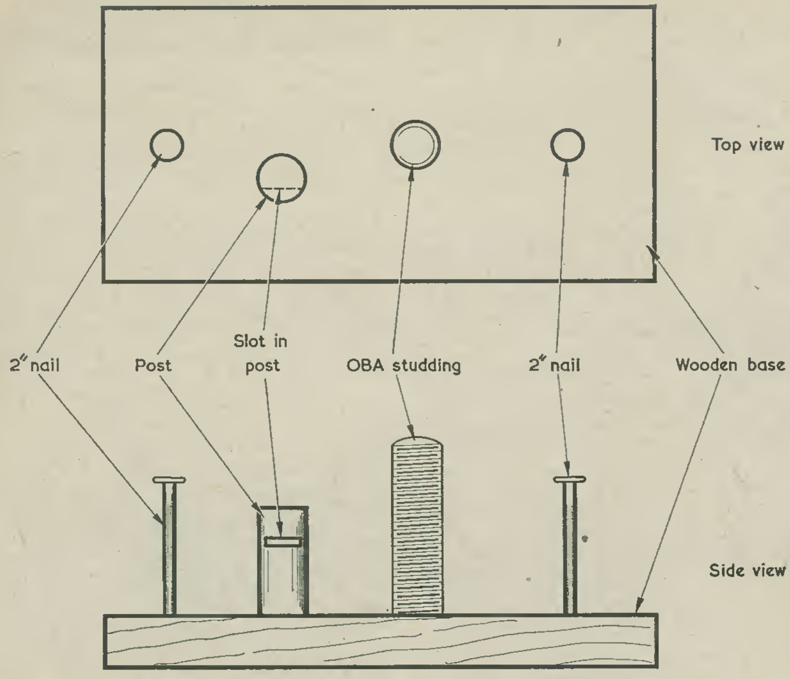



*Fig. 7. The construction of a simple coil winding jig*

self a little extra just to be on the safe side. The strip is then folded in two along its length and the cable is either placed in the fold, or the fold placed over the cable, according to which is more convenient. You then wrap the foil around the cable, holding it in place at one end by wrapping some thin bare tinned copper wire around it for several turns. The other end is similarly held in place with the aid of thin bare copper wire. After a little practice it is possible to make quite a neat job along the whole length of the wire and, despite the temporary nature of the job, the screening which results can be looked upon as being of a semi-permanent nature. Of course, the main intention behind the scheme is the provision of temporary screening in order that causes of pick-up or radiation may be isolated. After this, the temporarily screened wire may then be replaced by proper screened cable as necessary."

"How," asked Dick, "do you cut out the two inch wide strip?"

"You start," replied Smithy, "by unrolling the paper or foil and then folding it up in the same way as they fold lengths of cloth in the draper's. The first fold is made after one foot, and then you simply continue to wrap the succeeding foil or paper around the initial one foot length. The end result is a flat pack measuring roughly 20 inches by slightly in excess of 12 inches. You obtain a two inch strip by cutting across the pack two inches in from the end. Curiously enough, blunt scissors are to be preferred for this operation because very sharp scissors cause the cut edges to stick together, whereupon the two inch strip is liable to tear when it's unfolded."

"That's certainly an original idea," commented Dick. "How much wire can you cover with one roll of the paper or foil?"

"A roll of 20 inch foil," said Smithy, consulting the letter again, "should be sufficient to screen rather more than 100 feet of wire."

"Blimey," said Dick. "A roll of the foil should last for *ages*, then. I'll have to have a dig round our kitchen when nobody's looking and see if I can find any!"

But Smithy was already deeply engrossed in the next letter.

"There are two hints here," he announced, "and they both have to do with coil winding. The first describes a coil winding jig for single-layer coils. Here's the diagram for it."

Smithy showed Dick the sketch in the letter. (Fig. 7).

"As you can see," he continued, "all the bits and pieces are mounted on a block of wood. There are two two-inch nails, a piece of O BA studding, and an upright post which can be made of any convenient material and which has a horizontal slot in its surface. Many coil formers of the type intended to take threaded iron dust cores can be screwed onto O BA studding, and the jig is specifically intended for formers of this nature. You first of all screw the former onto the studding so that the lower starting point of the winding is level with the slot in the post. You then anchor the end of the coil wire by wrapping it several times round the left hand nail, after which you lay it in the slot and pass it round the former. You next wind the coil on the former, making a close-wound or spaced winding as desired. When all the turns have been put on, the wire is taken over to the right hand nail and anchored there by wrapping it round several times. You now have the coil wound on the former in its correct position, and with the wire under slight tension. The final process is to dope the coil. When the dope is dry you have a nice neat coil which is all ready to be connected up."

"That's a jolly useful gadget," said Dick thoughtfully. "It would be just the job for making up 10.7MHz i.f. transformers and things like that, where you use those black Aladdin-type formers with the square bases."

Smithy cast a mildly surprised glance at his assistant.

"That's a very percipient remark," he commented, "because 10.7MHz transformers are one of the main classes of winding which our correspondent uses the jig for."

"What's the other hint in the letter?"

"It's also to do with coil winding," replied Smithy. "And again there are some diagrams to show you. (Figs. 8(a) and (b)). This second idea is designed to assist in the winding of close-wound coils on plain formers. Before winding the coil, a doubled loop of fine string is placed on the former. The wire at the start of the coil is passed through the loop at one end, after which the coil is wound on top of the fine string. The wire at the finish of the coil is then passed through the other loop of the string. The two free ends of the string are next carefully pulled tight, whereupon the wires at both the start and finish of the coil are held securely under the two loops of string. The coil is then doped and the excess lengths of string cut off."

## HEALING THE RIFT

With a gesture of finality, Smithy returned the last letter to the surface of his bench.

"And that," he remarked, "is the end of this present session with readers' hints."

"We certainly had a good selection this time," remarked Dick.

"They were, as always, excellent," agreed Smithy. "I always find that going through these hints represents a very pleasant task."

He picked up his mug and drained it of its contents.

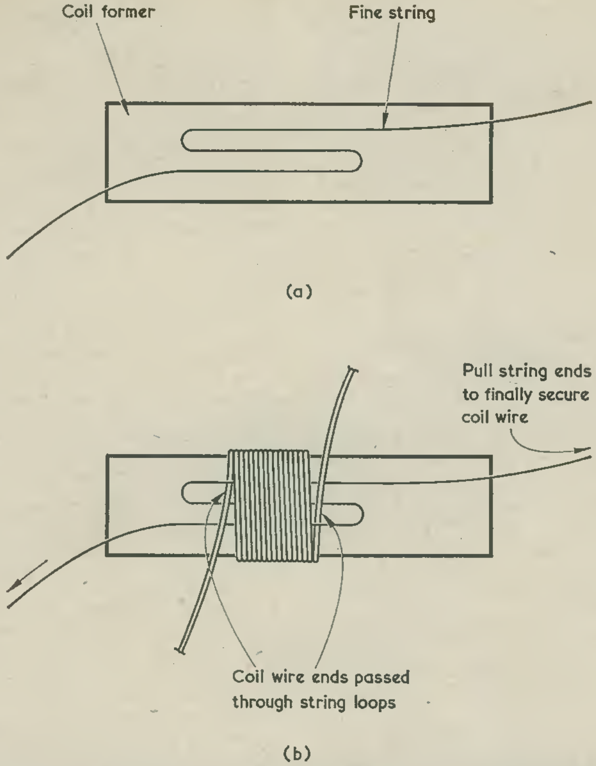



*Fig. 8. How to secure a close-wound coil on a plain former. In (a) a double loop of fine string is laid on the surface of the former. The coil is then wound over the string (b), after which the string ends are pulled tight to secure the coil wires*

"Would you," asked Dick helpfully, "like some more tea?"

Smithy suddenly recalled his previous altercation with his assistant.

"Not," he remarked irritably, "if you're going to make silly comments about my habits and, in particular, about what I did during the war."

"I'm sorry, Smithy," said Dick contritely. "Actually, I was indulging in a little bit of leg-pulling just now. After all, it's only fair that I should do so. *You* take the mickey out of me quite often, you know."

"Do I?" responded Smithy, mollified. "Oh, very well then! I must say that a spot of tea wouldn't be at all a bad idea. All this talking has made me thirsty again."

Whilst Dick busied himself with the preparation of a further mug of tea, Smithy carefully returned the sheaf of letters to the drawer under his bench. Dick came back and placed the third mug of tea for that morning on Smithy's bench.

"An excellent brew," remarked the Serviceman, sipping appreciatively. "I must commend you, Dick, on your ability to make really good tea."

Dick beamed.

"Going back," he commented, "to our earlier conversation, I suppose we younger generation can't really appreciate what did go on during the war."

"Probably not," replied Smithy. "In any case there's one point on which I must definitely correct you. My eventual rank during the war was acting unpaid *corporal*."

"Was it really?" said Dick, assuming the expression of the suitably impressed. "Gosh, that was pretty high up."

"I had to *fight* for that rank," said Smithy darkly.

"I bet you did," said Dick.

"If this," continued Dick happily, "is a sample of what the New Year is going to be like, I reckon that I'm really going to enjoy living in 1970!"

**EDITOR'S NOTE**

The hints published in this episode of 'In Your Workshop' were submitted, in the order in which they appear, by S. Webb, G. M. Watson, A. Luty, J. P. Carlile, D. Playle, D. A. Bishop, T. E. Millsom and J. Rankin. Further hints for this feature are welcomed, and payment is made for all that are published.

# Radio Topics

## By Recorder

JANUARY 1970?

Yes, it's true – the calendar cannot lie – and another New Year is upon us again. This is the period when journalists are expected to take a surreptitious shufti into the future and, conscientious as ever, Old Moore Recorder is now in process of setting the regeneration on his crystal ball so that it is just below the oscillation point.

Let us, therefore, examine what is to happen to us in the electronic world during this year.

**PREDICTIONS FOR 1970**

*January*. There is an encouraging start to the year as a spokesman for the Ministry of Technology states that 1970 will be marked by outstanding new developments in British integrated circuit production. At the same time, the manufacture and introduction of new types of discrete semiconductor components continues to increase unabated and, during the month, 476 new transistor types are released. Defence Ministry sets up monster surplus sale for excess stocks of transistors – notably 10,000,000 of type CV111057. Latest American Moon-shot vehicle returns with further samples of Moon-dust.

*February*. Board of Trade shocks radio retailers by stating that used radio and TV trade-in prices must, in future, be certified as representing true market value by specially appointed B.O.T. Inspectors. Leading semiconductor manufacturer introduces sensational new integrated circuit, claiming that this replaces virtually all the circuitry of a standard monochrome television receiver. An interesting feature of the new integrated circuit is its dual row of connecting terminals, 150 on each side. Post Office Corporation promises further improvements in telephone and postal services, these being directed at attracting increased custom and revenue.

*March*. Mysterious development at Defence Ministry surplus sale – the entire stock of 10,000,000 transistors type CV111057 is purchased for £5,000 by bearded individual in dark glasses and hippy outfit. Ministry of Technology announces that, due to the uncontrollable multiplicity of transistors currently available, it is making available a computer service to other Ministries to enable them to locate specific types of transistor after feeding in details of the characteristics required. The computer can also advise on equivalents and near-equivalents. Unmanned Soviet Moon-shot capsule returns to Earth with samples of the Moon's surface. 724 new transistor types released.

*April*. Working model of TV receiver incorporating new integrated circuit shown to Trade Press. The only components external to the integrated circuit are 60 fixed resistors, 40 capacitors, 22 preset potentiometers, 7 i.f. transformers, the tube, the scanning yoke, the line and field output transformers and a u.h.f. tuner. Cooling of the integrated circuit is achieved by means of a motor-driven blower rated at ¼ h.p. Mysterious bearded individual in dark glasses and hippy outfit registers new company under the name of Transistors (Soho) Ltd. Retailers shocked by 100% Budget increase in S.E.T. for service engineers.

*May*. Under pressure from radio retailers, Board of Trade announces that certification of trade-in prices may also be carried out by retailers' engineering staff – details of qualifications required to be announced later. Ministry of Technology states that, due to a disappointing lack of response on the part of other Ministries, the new computer service for advising on transistor types is to be made available also to *bona fide* companies in the public sector. Defence Ministry invites tenders for supply of new semiconductor devices, notably 10,000,000 of transistor type 2N152765A. American research scientists state that recently recovered Moon-dust contains high percentage of silicon with n-type characteristics. 910 new transistor types released.

*June*. Front page 6-column story in *Pravda* reveals that superior U.S.S.R. unmanned space vehicle has retrieved material from Moon's surface containing large quantities of silicon having p-type characteristics. Post Office Corporation engineers fit rectangular plugs to the slots of public telephone coin boxes to prevent insertion of sixpenny pieces. Transistors (Soho) Ltd. consults Ministry of Technology computer with respect to devices type CV111057 and 2N152765A. Radio retailers shocked by Board of Trade pronouncement that minimum staff qualifications for trade-in value certification are B.Sc., M.Sc., or Ph.D., together with readiness to sign the Officials Secrets Act.

*July*. N.A.S.A. announces preparations for forthcoming American Moon flight to carry out geological investigations. It is proposed to survey for strata faults by passing electric currents between remote points of the Moon's surface. Transistors (Soho) Ltd. set up small working plant in a cellar in Greek St., London, W1. The production equipment consists of one high-speed transistor re-coding machine operated by two middle-aged ladies during the periods when they are not required upstairs. 1,116 new transistor types released.

*August*. Retailers shocked by plans of Post Office Corporation to transfer to them the administration of TV and radio licence issues. Rumours leaking from the U.S.S.R. persistently refer to a potential new Russian unmanned Moon-shot to investigate magnetic phenomena. A senior Soviet physicist is quoted as saying that the low temperature on the dark side of the Moon enables superconducting electro-magnets of exceptional power to be set up without the necessity for complex cooling apparatus. Meanwhile, the high ambient temperature on Earth resulting from an unusually hot Summer necessitates modifications to the TV receiver with the integrated circuit. Engineers increase the blower motor power to ½ h.p.

*September*. Defence Ministry purchases, for £2,500,000, a quantity of 10,000,000 transistors type 2N152765A from Transistors (Soho) Ltd. Post Office Corporation, as first step towards metrication, changes maximum weight for First Class 5d. postal packages from 4oz. to 2 gr. N.A.S.A. announces that next American Moon-shot will take place in early December. 1,251 new transistor types released. After an extensive Trade Press advertising campaign stating that each set "consists of little more than a single integrated circuit", a pilot quantity of 10,000 TV receivers incorporating the new integrated circuit is offered to the retail trade.

*October*. Total pilot quantity of 10,000 TV receivers is purchased, at a price only slightly greater than that of the integrated circuits, by Transistors (Soho) Ltd., after threats on the part of the purchaser to invoke the Trade Description Act concerning the phrase "little more than". Post Office Corporation engineers fit rectangular plugs to public telephone coin box slots to prevent insertion of shilling pieces. Reports filtering out of the U.S.S.R. state that next Russian Moon probe firing is scheduled for mid-December.

*November*. 1,523 new transistor types released. Transistors (Soho) Ltd. dispose of transistor re-coding machine and purchase two screwdrivers, two pairs of pliers and two pairs of side-cutters. Excited French scientists studying American Moondust samples state that the n-type material coalesces into a homogeneous n-type mass when subjected to magnetic and electric fields positioned at right angles to each other.

*December*. Extra police called in to control vast crowds of radio home-constructors in Lisle St., London, W.C.2, where, using temporarily rented premises, Transistors (Soho) Ltd. successfully dispose of 600,000 fixed resistors, 400,000 capacitors, 220,000 preset potentiometers, 70,000 i.f. transformers, and 10,000 each of cathode ray tubes, scanning yokes, line and field output transformers, u.h.f. tuners and ½ h.p. blower motors. Americans set up Moon surface electrical probes along a line of Moon's latitude. Post Office Corporation announces immediate withdrawal of all coin box telephones due to lack of use by public. *Isvestia* announces that the unmanned Russian space capsule is now set up to produce an intense magnetic field along line of Moon's longitude. Radio retailers shocked by new Home Office regulations for mains lead coding, the new colours being red for earth, black for neutral and green for live. Fortuitously, Americans and Russians switch on their apparatus on the Moon's surface simultaneously. Militant Cleansing Department operatives jostle G.L.C. officials whilst demanding bonus pay for clearing 10,000 television chassis, each bare except for one integrated circuit, from a cellar in Greek St., London, W.1. Mass panic occurs throughout the world as Moon suddenly bursts into self-sustained oscillation, emitting electromagnetic radiation over the entire spectrum from 10kHz to the ultraviolet. Under cover of the resultant communications black-out, a mysterious bearded individual wearing dark glasses and a hippy outfit slips off contentedly to the Bahamas.

## THE "SPONTAFLEX" S.A.4

Well, let's hope that the New Year won't be *quite* as bad as that! And my humble apologies to any company whose name even remotely resembles that of the fictitious "Transistors (Soho) Ltd."—all the above is, of course, just a gag.

And now let me turn to a matter which has been raised by Sir Douglas Hall, the popularity of whose receiver designs continues unabated. One of the most ingenious of these is the "Spontaflex" S.A.4 Transistor Portable, which was described in our May, 1968 issue. Although that issue appeared nearly two years ago, readers are still embarking on the construction of the S.A.4 receiver.

A minor difficulty experienced by a few constructors has risen in districts where a very strong signal from Radio 2 on 1,500 metres is received, the effect being that this cannot be sufficiently reduced in volume. The trouble arises from the fact that the long wave coil is too far from the reaction coil for short-circuiting of the latter to cause adequate damping.

The following modification clears this problem, and the components referred to are all shown in Fig. 1 on page 594 of the May 1968 issue. First, remove L3. Then, connect the arm of S1 (a) to the junction of VC1 and C1. Add a 680pF silver mica capacitor between the base of TR1 and the top contact of S1(a) (this is the contact to which the switch is turned in Fig. 1). These alterations will result in a much better control of volume and they still allow the whole of the long wave band to be tuned. If an upper wavelength of a little over 1,500 metres is enough, a 500pF capacitor may be used instead of the 680pF component. There will be some drop in sensitivity owing to the lowering of the inductance/capacitance ratio, but if the Radio 2 signal is strong enough to make the modification worth-while, there will still be plenty in hand. This occurs even in South Devon, where Sir Douglas Hall has checked the operation of the altered circuit.

## BRAND NEW YEAR

And so I have now come to the end of my contribution for this brand new year of ours. Whereupon, there's nothing better I can do, in finishing, than wish readers all the very best of luck together with an exceptionally Prosperous and Happy New Year. ■

## NEW ITT-COMPONENTS PUBLICATION

ITT Components Group Europe has just published the first of a set of components summaries which heralds a new style for presenting a concise run-down on all the ITT component ranges.

The first publication is the *Passive Components Summary* (ref. 6000/301). This 116-page short-form catalogue covers such products as: Quartz Crystals and Filters, Magnetic Materials, Transformers, Capacitors, Resistors (fixed and variable), Infra-red filters, etc. The books are available in English, French and German languages.

Copies are available free on application to ITT Components Group Europe, Publicity Department, Edinburgh Way, Harlow, Essex. Please use company letterhead and state job title.

# LAST LOOK ROUND

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**Ever tried tape recording birds?**

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## ● 349

**On that page in this issue you will have noted another article by our popular contributor Sir Douglas Hall, K.C.M.G., M.A. Always a source of great interest, his circuits are nothing if not ingenious!**

**In the next issue we shall be publishing another of his interesting articles entitled *Developing the "Spontaflex" Short Wave Receiver*—make sure you get your copy!**

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*(Continued on page 381)*

## SMALL ADVERTISEMENTS

*Continued from page 379*

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**TO CLEAR.** Back numbers of *"The National Geographical Magazine"*, to January 1959. 3/6d. each post paid. Box No. G110.

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*(Continued on page 383)*

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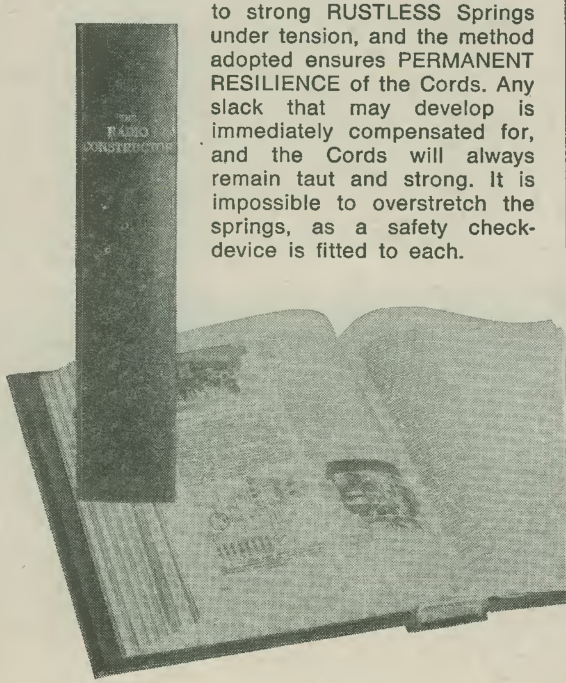

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## SMALL ADVERTISEMENTS

*Continued from page 381*

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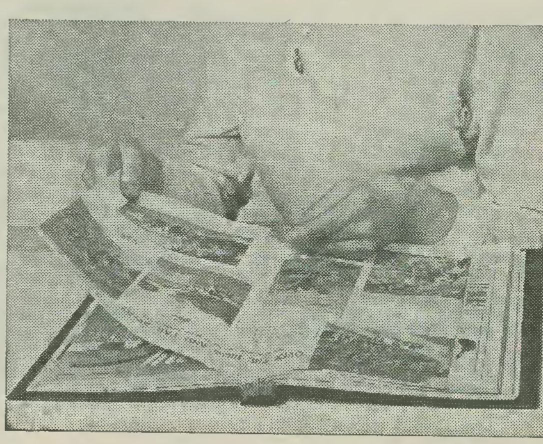

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# RADIO CONSTRUCTORS DATA SHEET 34

## R.M.S., PEAK AND AVERAGE VALUES

The Table lists, to three significant figures, peak values, twice peak values, and average values for sinusoidal alternating voltage or current from 1 to 1,000 r.m.s. units. The column giving twice peak values is included to cover voltage doubling circuits and peak inverse voltage ratings for capacitor input half-wave rectifier circuits; twice peak values are, also, equal to peak-to-peak values.

| R.M.S. | Peak | 2 x Peak | Average | R.M.S. | Peak | 2 x Peak | Average |
|---|---|---|---|---|---|---|---|
| 1 | 1.41 | 2.83 | 0.901 | 150 | 212 | 424 | 135 |
| 2 | 2.83 | 5.66 | 1.80 | 200 | 283 | 566 | 180 |
| 3 | 4.24 | 8.48 | 2.70 | 250 | 354 | 707 | 225 |
| 4 | 5.66 | 11.3 | 3.60 | 300 | 424 | 848 | 270 |
| 5 | 7.07 | 14.1 | 4.51 | 350 | 495 | 990 | 315 |
| 6 | 8.48 | 17.0 | 5.41 | 400 | 566 | 1,130 | 360 |
| 7 | 9.90 | 19.8 | 6.31 | 450 | 636 | 1,270 | 405 |
| 8 | 11.3 | 22.6 | 7.21 | 500 | 707 | 1,410 | 451 |
| 9 | 12.7 | 25.4 | 8.11 | 550 | 778 | 1,560 | 496 |
| 10 | 14.1 | 28.3 | 9.01 | 600 | 848 | 1,700 | 541 |
| 20 | 28.3 | 56.6 | 18.0 | 650 | 919 | 1,840 | 586 |
| 30 | 42.4 | 84.8 | 27.0 | 700 | 990 | 1,980 | 631 |
| 40 | 56.6 | 113 | 36.0 | 750 | 1,060 | 2,120 | 676 |
| 50 | 70.7 | 141 | 45.1 | 800 | 1,130 | 2,260 | 721 |
| 60 | 84.8 | 170 | 54.1 | 850 | 1,200 | 2,400 | 766 |
| 70 | 99.0 | 198 | 63.1 | 900 | 1,270 | 2,540 | 811 |
| 80 | 113 | 226 | 72.1 | 950 | 1,340 | 2,690 | 856 |
| 90 | 127 | 254 | 81.1 | 1,000 | 1,410 | 2,830 | 901 |
| 100 | 141 | 283 | 90.1 | | | | |

# HENRY'S RADIO LTD. ENGLAND'S LEADING COMPONENT AND EQUIPMENT CENTRES

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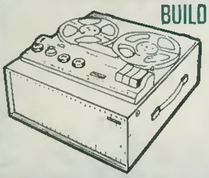

To get the best out of your MAGNAVOX DECK, you need a MARTIN RECORDAKIT. This comprises a special high quality 6 valve amplifier and pre-amplifier which comes to you assembled on it's printed circuit board — in fact everything for making a superb Tape Recorder. You need no experience or technical skill to bring this about.
THE INSTRUCTIONS MANUAL MAKES BUILDING EASY, AND SUCCESS IS ASSURED.
Kit comprises: Deck, Amplifier, Cabinet and speaker, with microphone, 7" 1200 ft. tape, and spare spool.
ASK FOR BROCHURE 6. TODAYS VALUE £60.
**PRICE 39 gns. p.p. 22/6.** NOTHING ELSE TO BUY

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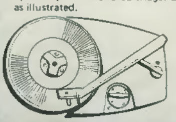

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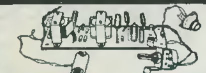
## MULLARD 1 WATT AMPLIFIER



Portable Transistor Unit-Ideal for Intercoms, Baby Alarms, Tele phone, Record Players or Guitar Practice.
9 Volt 5 transistors with volume control, output 3 ohms.
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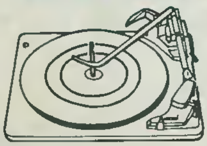
P.P.9 9 volt battery 3/9. Write for leaflet No. 2.

## GARRARD RECORD DECKS



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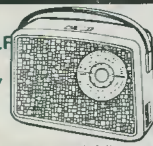

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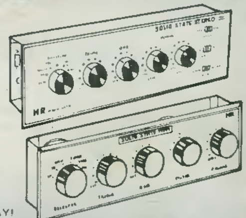

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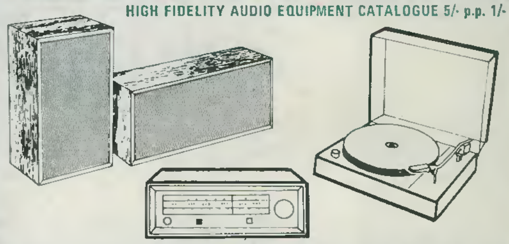

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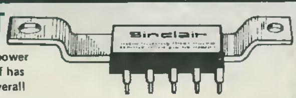
## SINCLAIR EQUIPMENT



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| Q16 Loud Speaker | £8.19.6. |
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| Sinclair I.C.10. | 59/6 |
| G.E. PA230* | 22/6 |
| G.E. PA234* | 20/0 |
| G.E. PA237* | 37/6 |
| G.E. PA246* | 52/6 |
| SL402 Plessey | 45/0 |
| SL403 Plessey | 49/6 |
| S.G.S. UL910 | 10/0 |
| S.G.S. UL900 | 10/0 |
| S.G.S. UL914 | 11/0 |
| Mullard TAA263 | 15/0 |

*Data sheets 3/6 set for these, for others see catalogue.

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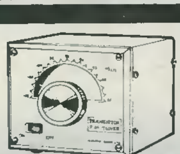

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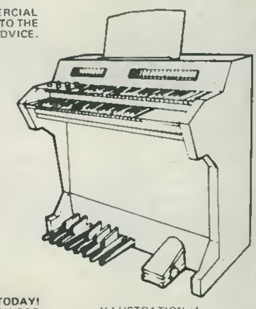

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