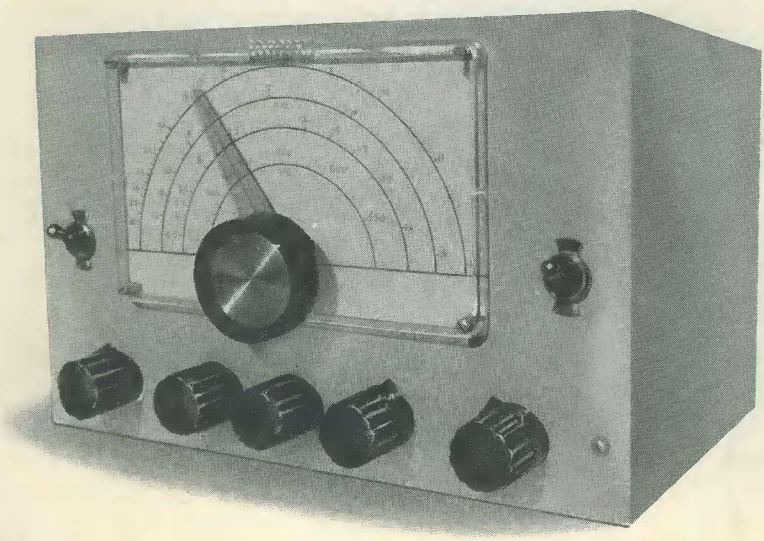
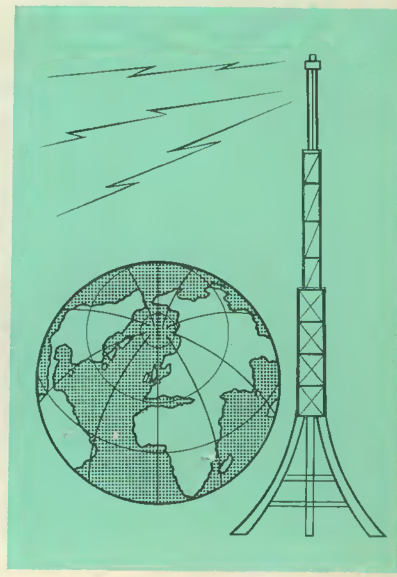
THE

RADIO CONSTRUCTOR

Vol. 22 No. 9 APRIL 1969 THREE SHILLINGS

5-Valve Amateur All-Wave Receiver





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Multi-Channel Mixer Unit

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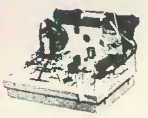

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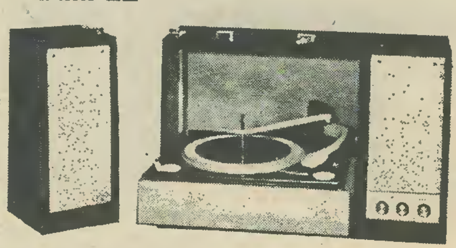

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2S501	2N706A	2S512	2S104	2N697	2N1711	2N726	2S731
BC108	2N3011	2S102	2N2220	2N1507	2N1893	2N2484	2S732

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Incorporating THE RADIO AMATEUR

APRIL 1969

CONTENTS

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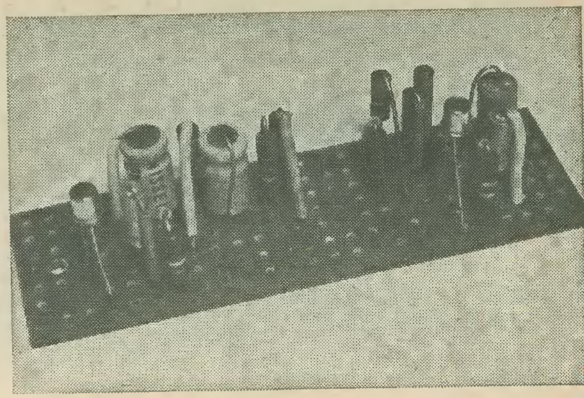
MULTI-CHANNEL MIXER UNIT



by W. KEMP

This inexpensive but very effective mixer unit accepts four a.f. input channels, two at low impedance and two at relatively high impedance. The principles involved are simple to understand, and construction is similarly uncomplicated.

This article describes a simple mixer unit capable of accepting two low impedance a.f. inputs and two relatively high impedance (approximately 65kΩ) a.f. inputs. The unit is, in consequence, capable of working with a.f. inputs from a wide range of sources. The input signals all appear at a single output terminal, their amplitudes depending upon the settings of the individual input controls.

THE CIRCUIT

The circuit of the mixer unit appears in Fig. 1. Channels 1 and 4 are the high impedance inputs, whilst Channels 2 and 3 are the low impedance inputs. The inputs to Channels 1 and 4 are passed, by way of emitter followers TR1 and TR2, to the level controls VR1 and VR4 respectively. The inputs to Channels 2 and 3 are applied directly to the level controls VR2 and VR3. The sliders of all four controls couple to the common resistor, R9, via R5, R6, R7 and R8. These last four resistors are required to provide a reasonable degree of isolation between the inputs. If all the sliders were connected together directly, adjustments in one control would cause considerable variations in the outputs from the others. Adjustments in one control would also cause excessively large alterations in the input impedances of the other channels.

The input impedance at Channels 2 and 3 varies

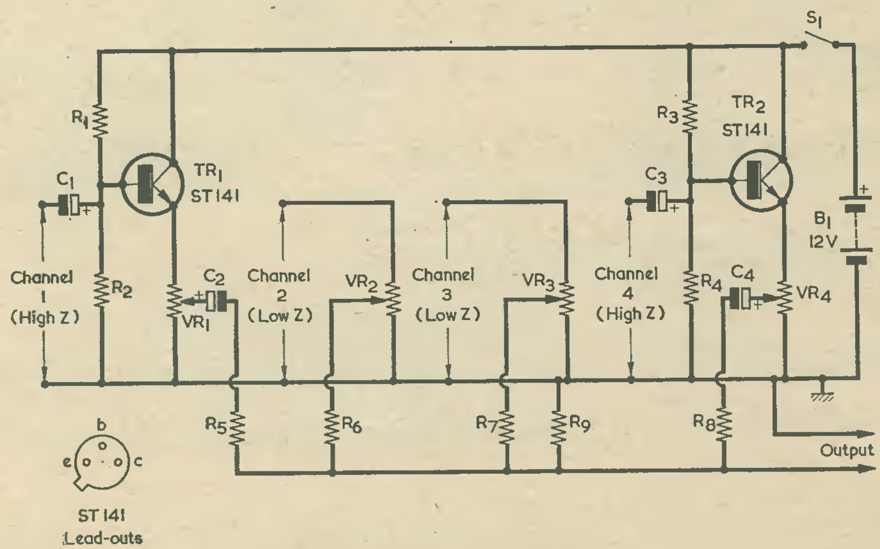


Fig. 1. The circuit of the mixer unit

somewhat according to the setting of the level control. Taking Channel 2 as an example, when the slider of VR2 is at the top of its track the input impedance is the 10kΩ provided by the potentiometer track in parallel with about 6.5kΩ. The latter resistance is given by R6 in series with R9 and the remaining resistive paths to the negative supply line. Thus the impedance, under these conditions, is approximately 4kΩ. As the slider of VR2 is moved downwards the impedance presented at Channel 2 terminals increases until, with VR2 slider at the bottom of its track, it is the 10kΩ offered by the track itself. This variation in impedance should not raise any difficulties with most signal sources liable to be connected to Channel 2. If desired, VR2 may be made lower in value in order that a lower impedance may be presented at Channel 2 input terminals. If the new value for VR2 is, say, 1kΩ or less, the variation in input impedance as its slider is adjusted will be very much lower, and the input impedance could then be considered as being nominally equal to the track resistance for all settings of the slider.

The same comments concerning input impedance apply equally to Channel 3 and VR3.

The impedance presented to the emitter of TR1 varies from 2.8kΩ with VR1 slider at the top of its track to 5kΩ with VR1 slider at the bottom of its track. Assuming a typical gain in TR1 of 100, the impedance at its base is approximately 100 times the impedance at its emitter, this being shunted by the physical resistors R1 and R2. The input impedance is, in consequence, approximately 60kΩ with VR1 slider at the top of its track and approximately 67kΩ with VR1 slider at the bottom of its track. There is less variance here, due to the swamping effect of R1 and R2.

The same impedances are presented at the input terminals of Channel 4. TR1 and TR2 do not, incidentally, offer any voltage gain in this circuit. They are used as emitter followers and very nearly the same a.f. voltage as is applied to their bases appears at their emitters. Their function is to enable a relatively high input impedance to be available at Channels 1 and 4.

The output of the mixer is built up across R9 and has an impedance slightly less than the 1.2kΩ specified for this component. As such, the output is well suited for application via a screened lead of considerable length, if necessary, to the subsequent amplifier. The braiding of the screened lead should connect to the negative supply line of the mixer unit and the centre conductor to the non-earthy output terminal. Speaking in terms of voltage there is a loss of some 15dB (i.e. about one-sixth of any input voltage appears at the output with the appropriate level control at its maximum setting) in all channels. This is due to the isolating resistors R5 to R8.

The mixer can operate with a wide range of input signal voltages, up to a miximum (due to the presence

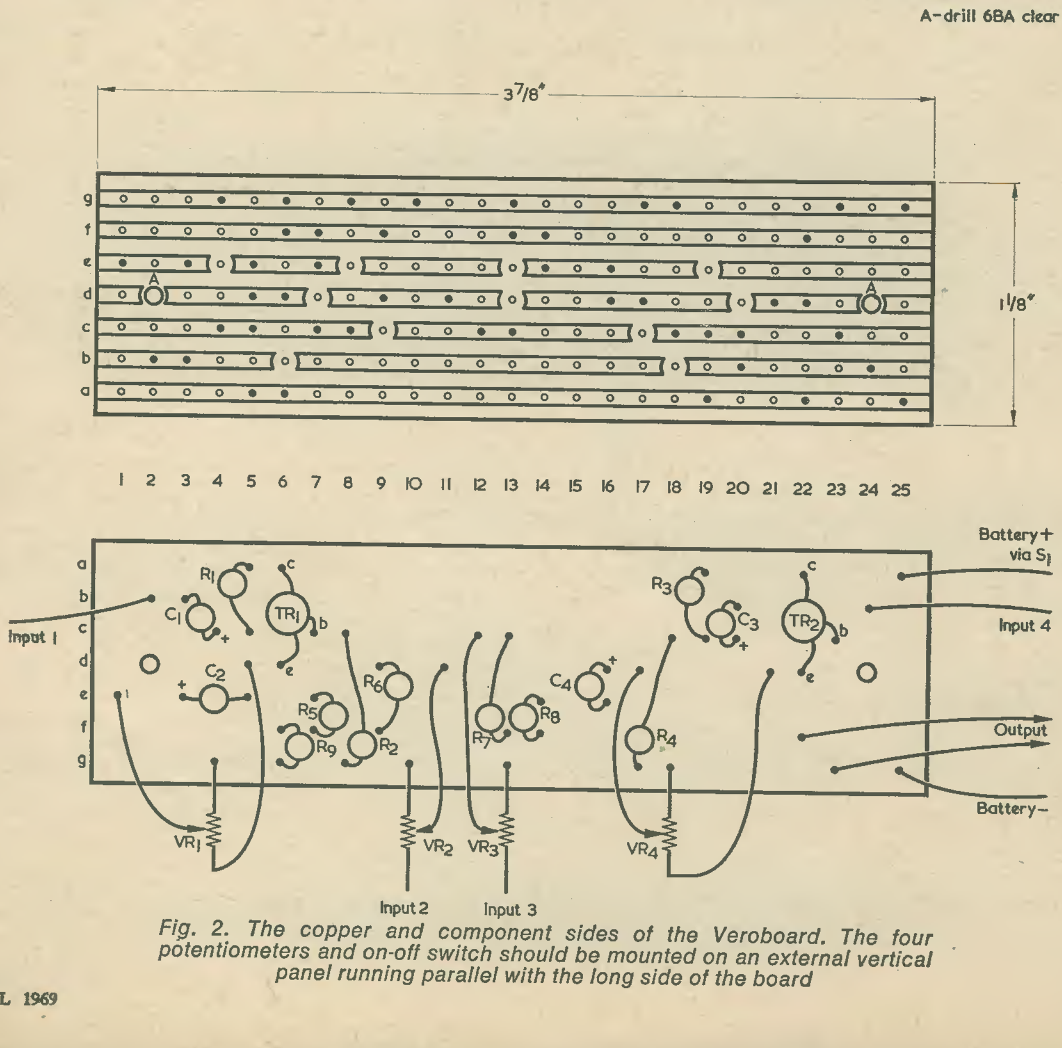
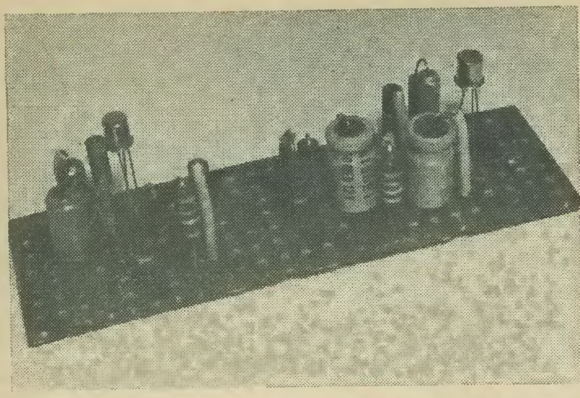


Fig. 2. The copper and component sides of the Veroboard. The four potentiometers and on-off switch should be mounted on an external vertical panel running parallel with the long side of the board



The neat appearance of the completed board. The photograph shows an extra electrolytic capacitor (connected in series with the output) which was deleted in the final design

of TR_1 and TR_2 of 3 volts r.m.s. For convenience of operation, all input signals should be at around the same amplitude.

CONSTRUCTION

Constructional details of the mixer unit are shown in Fig. 2. Start construction by cutting the Veroboard panel to size, as shown, then break the copper strips with the aid of a small drill or the special tool which is available. Also, drill the two small mounting holes, to clear 6BA screws, as indicated.

Next, assemble the components on the Veroboard panel, as illustrated in the lower view in Fig. 2. All components are mounted vertically, and insulated sleeving should be used where there is any risk of short-circuits. It should be noted, here, that the metal case of an ST141 transistor is common with its collector. The potentiometers are external to the board and are wired to it by way of short flexible unscreened leads. When assembly is complete, connect the battery into circuit and check that all the input circuits are working correctly by applying a signal and checking the output with an amplifier or earphone.

If all is well, the Veroboard panel may be assembled in a suitable case, this having a panel on which are mounted VR_1 to VR_4 and S_1. The potentiometers should appear, on the panel, in the same order as they do in Fig. 2, and shortest wiring will be achieved if the Veroboard is positioned such that copper strip "g" is nearest the panel. Four coaxial input sockets and one coaxial output socket may be fitted at the rear of the case, and the inputs and output should be connected to these via screened cable, the braiding of which is earthed to the negative battery supply line. In the case of input Channels 2 and 3, the screened cable runs from the input sockets to VR_2 and VR_3 only. A metal case is to be preferred, whereupon this should also be bonded to the negative supply line.

The Veroboard panel may be secured to a metal surface by passing 6BA screws through the two 6BA clear holes shown in Fig. 2. Small rubber or p.v.c. grommets are passed over the 6BA screws on the underside of the board. These grommets then act as insulators and also space the underside of the board away from the metal surface. Care should be taken to trim the inner copper strips on the Veroboard away from the edges of the 6BA clear holes to ensure that there is no risk of these short-circuiting to the mounting screws.

COMPONENTS

Resistors
(All fixed values ½ watt high-stability)
R_1 100kΩ 5%
R_2 330kΩ 5%
R_3 100kΩ 5%
R_4 330kΩ 5%
R_5 5.6kΩ 10%
R_6 5.6kΩ 10%
R_7 5.6kΩ 10%
R_8 5.6kΩ 10%
R_9 1.2kΩ 5%
VR_1 5kΩ potentiometer, log track
VR_2 10kΩ potentiometer, log track (see text)
VR_3 10kΩ potentiometer, log track (see text)
VR_4 5kΩ potentiometer, log track

Capacitors
(All capacitors are electrolytic)
C_1 1μF, 15V wkg.
C_2 50μF, 12V wkg.
C_3 1μF, 15V wkg.
C_4 50μF 12V wkg.

Transistor
TR_1 ST141 (Sinclair)
TR_2 ST141 (Sinclair)

Switch
S_1 s.p.s.t. on-off switch

Battery
B_1 12 volt battery

Miscellaneous
Veroboard panel, 0.15in matrix, $3\frac{7}{8}$ by $1\frac{1}{8}$in, see Fig. 2
4 pointer knobs
5 coaxial sockets
Case, panel, screened wire, etc.

400,000 INTEGRATED CIRCUITS

Business Computers Ltd. have placed an order with Mullard Ltd. for 400,000 DTL integrated circuits.

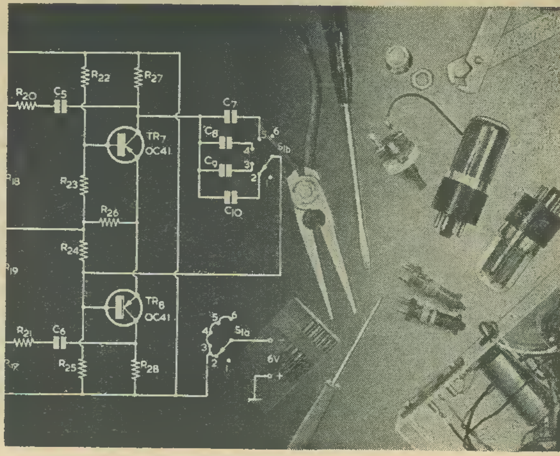
The circuits will be made at Mullard Southampton Works, and used by Business Computers Ltd. in their SADIE and SUSIE range of desk-top computers.

The circuits are from the Mullard FC range of DTL types and comprise gates, buffers and flip-flops. They operate from a 6V power supply, have a noise margin of typically IV and propagation delays of approximately 25ns. Enscapsulation is all plastic, 14-lead dual-in-line.

SUGGESTED CIRCUIT No. 221

BROAD-BAND SIGNAL INJECTOR

by G. A. FRENCH



SERVICE ENGINEERS AND EXPERIMENTERS may have, from time to time, noticed the surprisingly loud crackles which are produced by a.m. receivers with ferrite rod aerials if continuity tests happen to be carried out alongside them. A typical example can occur when, for instance, a coiled up length of flex is checked for continuity by means of the low-ohms range of a multi-testmeter.

The writer decided to investigate this effect to see whether it could be put to practical use. The result of his experiments is given in this month's "Suggested Circuit", and it consists of an inexpensive device which, equipped with a probe coil, is capable of injecting a signal modulated by an a.f. tone over the entire medium and long wave bands of any a.m. superhet receiver incorporating a ferrite rod aerial. All that is required is that the probe coil be positioned fairly close to and in line with the ferrite aerial rod inside the receiver. In all the instances checked by the author, adequate pick-up was given with the coil positioned *outside* the receiver cabinet.

The usefulness of this device for servicing work will be at once apparent, and suggested applications are given at the end of the article.

INITIAL WORK

The writer proceeded, with the present "Suggested Circuit", from the starting point where crackling occurred in a nearby receiver when continuity tests were made alongside it. The loudest crackles occurred when the leads of a relatively inexpensive multi-testmeter on its low-ohms range were applied to a coiled-up length of wire. Testmeters in this class frequently allow quite large currents to flow when measuring low values of resistance, and in this case it was found that the current provided by the testmeter was of the order of 20mA.

The writer next checked whether the same results could be obtained if a battery having a series resistor limiting the current to around 20mA were similarly applied to a coiled up length of wire, and found that the effect was just the same. As was to be expected, loudest crackling occurred when the coil of wire was in line with, and broadside on to, the receiver aerial rod, as shown in Fig. 1. Furthermore the crackling was evident at good strength over all the medium and long wave bands. The crackling really consisted of a series of "clicks" from the receiver speaker, each "click" occurring at the instant when the battery was connected to the wire via the series resistor.

It followed from this that if the current to the coiled up wire could be interrupted at an audible frequency an audible tone would be produced in the receiver. A possible method of interrupting the current could consist of inserting a buzzer in series with the battery and the wire, but this idea was discarded because of the noise which would be produced by the buzzer itself.

It was next decided to check whether the current interruption could be achieved by electronic means, whereupon an obvious method of operation would consist of inserting the coiled up length of wire in the collector circuit of one transistor in a multivibrator running at audio frequency. Theoretically, this should provide a series of "clicks" at multivibrator frequency equivalent to those given by the direct electrical

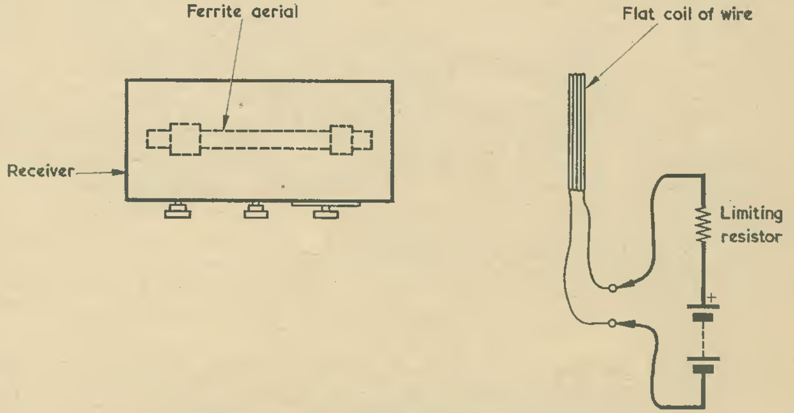


Fig. 1. As is explained in the text, maximum "crackling effect" in the receiver is given when the coiled up wire is positioned, in relation to the receiver internal ferrite aerial rod, in the manner shown here

connection with a battery, but it would be necessary to employ a transistor capable of bottoming very quickly when it switched on during the multivibrator cycle.

After a search through various transistor specifications, it was decided to use a BC168C as switching transistor. The BC168C is an inexpensive silicon n.p.n. transistor having a cut-off frequency of 300Mc/s, an h_{fe} of 450 to 900, a maximum collector current rating of 100mA and a maximum dissipation of 180mW. In practice, the BC168C proved to be eminently satisfactory and is incorporated in the working injector circuit which will shortly be described. BC168C transistors are available incidentally, from Amatronix, Ltd.

As a final point before dealing with the circuit, it was decided to start off with a current of 20mA in the coiled wire, as was used with the battery and resistor checks of Fig. 1, and then alter this as required. It so transpired, however, that a current of 20mA was quite satisfactory and that there was no need to change it. There is no magic in this 20mA figure, of course, and the same results are feasible at currents above or below it.

THE CIRCUIT

The complete circuit of the broad-band signal injector appears in Fig. 2. Here, what we have previously referred to as a coiled up length of wire now achieves greater respectability by being described as the "probe coil". This is L1, and it appears in the collector circuit of the BC168C, TR1. When, during the miltivibrator cycle, TR1 switches on, it causes a pulse of current, limited to around 20mA by R1, to flow through L1.

The remaining transistor in the multivibrator is TR2. It is desirable for this transistor to be also capable of operating at a high frequency so that its collector potential rises quickly on switching off, and another BC168C is employed here.

The remainder of the circuit follows standard multivibrator principles. It will be noted that, whilst the cross-coupling capacitors C1 and C2 both have the same value, R is ab four times larger than R3. The length of time a multivibrator transistor is off during the cycle depends upon the product of the cross-coupling capacitance and series supply resistance which connect to its base, and the product figures for TR1 is four times that for TR2. Thus, during the cycle TR1 is off for four-fifths of the time and is on for only one-fifth of the time. In consequence, the battery is only called upon to provide the 20mA probe coil current for one-fifth of the cycle so that, whilst TR1 still produces the requisite number of current pulses per second in the probe coil, overall battery current is reduced and battery life is extended. With the prototype circuit, the actual current drawn from the battery was approximately 7mA.

The multivibrator runs at a frequency of about 1kc/s. The tone reproduced by the receiver to which the signal injector is coupled consists of a dominant 1kc/s note with harmonics. Heterodynes are also given if modulated transmissions are tuned in on the receiver.

Capacitors C1 and C2 in Fig. 2 should be paper plastic foil. C3 may be paper or plastic foil, or ceramic.

An important point which has not yet been mentioned is that, in common with most silicon transistors, the BC168C has a relatively low reverse base-emitter voltage rating. The maximum reverse V_{eb} forthis transistor is 5 volts only. Since the base of a transistor in a multivibrator can take up a reverse potential equal to the supply voltage, appropriate precautions have to be taken to prevent breakdown. In the present design the risk of breakdown is avoided by the simple process of using a battery voltage lower than the maximum reverse V_{eb} of the transistors. *A supply potential greater than the 3 volts shown in Fig. 2 must not be used with this circuit.*

Capacitor C3 is merely a bypass component and maintains a low r.f. impedance across the supply lines to counteract increased internal resistance in the battery as it ages. It was found, with the prototype, that an output was still provided when the supply voltage was as low as 1.5. However, output amplitude was much lower at this voltage than at 3 volts, and it is recommended that the battery be replaced when its terminal voltage on load is 2.5 or less.

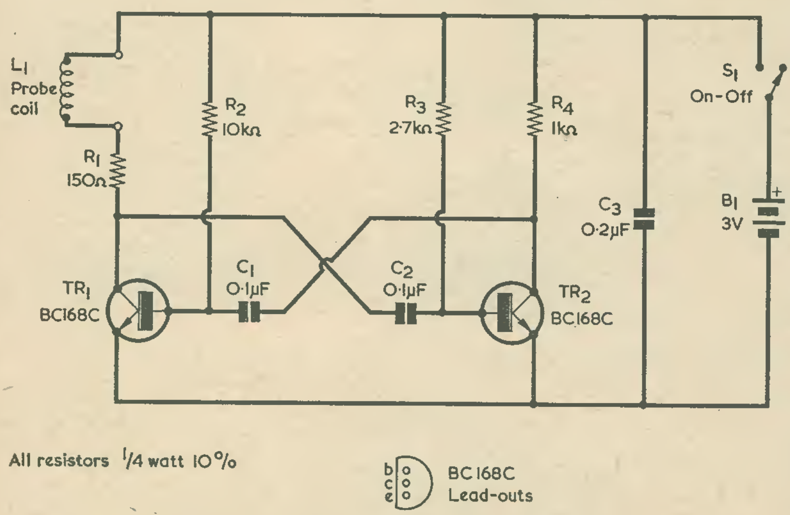


Fig. 2. The circuit of the broad-band injector

THE PROBE COIL

The probe coil is not at all critical and a wide variance in turns and dimensions is possible without any significant falling-off in performance. After checking a number of different coils, the one finally used with the prototype consisted of 25 turns of 12 s.w.g. p.v.c. covered connecting wire, this being made up into a flat scramble-wound self-supporting coil as shown in Fig. 3. There was no significant improvement when coil diameter was increased to some 6 in or when it was reduced to 1½ in, nor when turns were varied from 20 to 30. A slightly improved performance results if thicker wire is used, whereupon a suitable choice would be given by a single wire of the type employed in lighting flex. Naturally, the thicker wire makes the coil somewhat bulkier, but not to an excessive degree. It would be preferable to avoid employing a thinner wire than the 12 s.w.g. used with the prototype. About 20 ft of wire are required for the coil.

In practice the coil can be made up by the simple process of winding the wire round the hand, removing it and then taping it up as illustrated in the diagram. The multivibrator components and battery can be mounted on a small piece of Paxolin or metal, to which the coil is connected via its own wire ends. The lead length between the coil and the multivibrator circuit should not exceed 8 in.

Checks were carried out with probe coils wound on a ferrite rod. These were by no means as effective as an air cored self-supporting coil.

APPLICATIONS

To use the signal injector, this is first switched on and its probe coil brought up to one end of the receiver cabinet, so that the coil is in line with, and broadside on to, the internal ferrite rod aerial. If the receiver is serviceable it should then be possible to hear the 1kc/s tone from the injector at good strength over all the medium and long wave bands. The prototype was checked with two transistor receivers and with a mains valve radio having a ferrite rod aerial, and in all cases the 1kc/s tone came through loudly over the entire coverage of the medium and long wave bands. The signal tended to be a little weaker on the medium wave band than on the long wave band, but it was still more than adequate for checking purposes. In all instances the probe coil was positioned outside the cabinet of the receiver concerned and all the receivers were commercially-made superhets of standard domestic type.

As a matter of interest, the circuit was also checked with a mains valve superhet having unscreened air-cored aerial coils. The 1kc/s signal was heard at reasonable strength over both medium and long wave bands when the probe coil was held close to these aerial coils, although the coupling was not as effective as that to the receivers having ferrite rod aerials.

The signal injector offers a wide range of uses for servicing work. After it has been assembled and checked out, the constructor should initially familiarise himself with the performance it gives in conjunction with receivers known to be operating correctly. It may then be used to check unserviceable receivers for such faults as oscillator failure over part of a band, poor tracking and general low sensitivity. The injector will be particularly useful for padding adjustments at the low frequency end of a band in cases where such adjustments are made for maximum signal strength and normally require that the tuning capacitor be continually rocked. When the injector is brought into use it is merely necessary for the adjustment to be made for maximum 1kc/s tone from the speaker. In this case the probe coil should be positioned some distance from the receiver ferrite aerial, so that the 1kc/s tone is just audible. The same technique may also be used for signal frequency trimming and padding operations in receivers which exhibit pulling between signal and oscillator frequencies.

In cases when a receiver draws a reasonable current from the battery but is otherwise "dead", the injector may be used to insert a powerful signal into the aerial circuit. The a.f. and i.f. stages can then be checked through with the aid of a signal tracer.

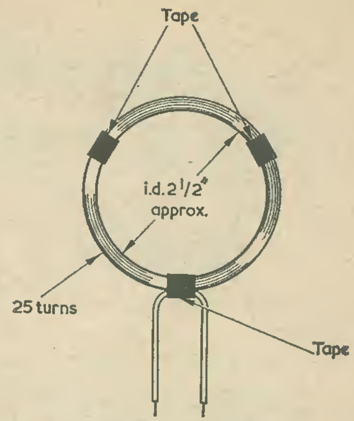


Fig.. 3. Details of the injector probe coil

EMI COLOUR TV MARKETING IN U.S.A.

Electric and Musical Industries Ltd. (EMI) and International Video Corporation (I.V.C.) have announced a joint marketing agreement whereby I.V.C. will sell EMI colour television cameras and broadcast equipment in the U.S.A.

John Read, EMI Managing Director, and Donald F. Eldridge, I.V.C. President, said the agreement will open the way to a broad exchange of technical information that will enhance the colour camera technologies of both companies.

The two companies will introduce a 3-tube colour television camera for broadcast use, developed by EMI for the U.S.A. market. This new camera will be priced in the U.S.A. at about 72,000 dollars. The EMI 4-tube camera type 2001, currently in extensive use in Europe and United Kingdom, will also be marketed by I.V.C. in the U.S.A. The cameras will be shown at the National Association of Broadcasters Convention in Washington D.C. during March.

EMI, the broadly based electronics and entertainments group, is one of the largest manufacturers of television cameras in Europe. In the two years since the introduction of the EMI 4-tube camera type 2001 over 200 have been sold including a large number to the British Broadcasting Corporation.

I.V.C., a three-year old Sunnyvale, California company, has developed and marketed a line of lower-cost colour television cameras for broadcast and closed circuit use and also manufactures colour videotape recorders currently being sold by Bell & Howell, R.C.A. and Singer-General Precision Systems. I.V.C. colour cameras, which sell for from 14,000 dollars to 23,000 dollars, are in use in a number of U.S.A. television stations.

"EMI cameras have the highest combined performance and reliability characteristics of any camera in the world", Eldridge said. "The addition of EMI cameras to the I.V.C. product line makes I.V.C. the only company in the U.S.A. to market a full range of colour television cameras", he added.

SHORT WAVE AERIAL AND CHANGEOVER SYSTEM

by

L. SAXHAM

A simple item of receiver ancillary equipment is the aerial changeover unit. Many short wave listeners use more than one aerial, these often being changed over by the laborious method of first removing the unwanted lead-in from the receiver aerial terminal and then connecting the wanted lead-in in its place. To obviate this process, and to provide an indication of which aerial is in use, the changeover unit described here was constructed. A long wire aerial system which may be used with the changeover unit is first described.

As he progresses in the hobby of short wave listening, the operator soon comes to realise that an additional aerial to that normally in use, either vertical or horizontal and possibly oriented in a different direction — and also of a length resonating at a different frequency — is a necessity. In this manner, the aerial best suited for operation over the band of frequencies being tuned can then be selected at will. This entails, for ease of operation, the construction of a switching unit which will effectively change over one aerial feeder (or lead-in) for another. Where this is done, the unwanted aerial lead-in should be connected to earth. Such a unit was constructed by the writer and is described in this article.

An additional feature provided in the author's changeover unit is that both aerial lead-ins may be switched into circuit at the same time. The operator can therefore choose at will no less than three differing aerial arrays.

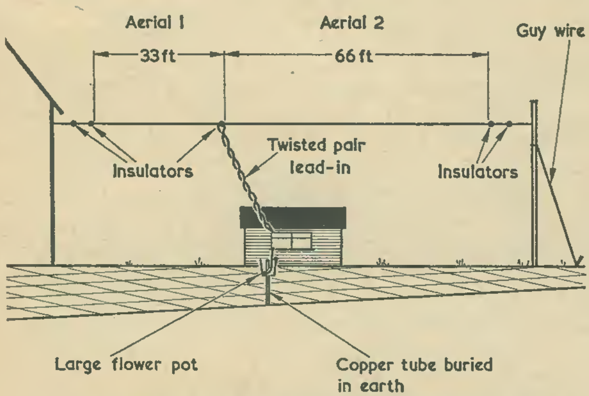


Fig. 1. The array shown here consists of two separate aerials which may be switched into circuit individually or together by the changeover unit. The earthing system consists of a copper tube passing through a large flower pot — into which water is poured from time to time

THE AERIAL SYSTEM

Fig. 1 shows the aerial installation in use by the writer and from this it will be seen that the whole array is a Double Inverted L long wire system. Twisted flex lead-ins are taken from the respective top wires at their inner ends and fed into the operating position, where they are each terminated in a coaxial socket. The sockets are mounted on a small piece of aluminium which is secured to the shack wall and connected direct to an earth rod in the surrounding soil. From this aerial input panel, connections are taken to the changeover unit via 75Ω coaxial cable.

Aerial 1. This consists of a half wave wire resonating at a natural frequency of 14.2Mc/s approximately, its length being 33ft. It is therefore ideal for use when operating over the 14Mc/s amateur band. As a full wave array, the resonant frequency is approximately 28.4Mc/s and this part of the system is used when covering the 28Mc/s band.

Aerial 2. This top wire is cut to resonate at a natural frequency of 7.1Mc/s approximately as a half wave array and is therefore ideally suited for operation over the 7Mc/s amateur band or as a quarter wave aerial over the 3.5Mc/s band.

Aerial 3. To bring this aerial into circuit, both lead-ins are fed into the aerial tuning unit or receiver. The top length is 99ft. and this resonates, as a halfwave, at 4.7Mc/s, this being suitable for use over the 3.5Mc/s amateur band. For the Broadcast band enthusiast, it represents a good aerial for operation over the frequencies around 5Mc/s where are to be found the low powered African, Asian and S. American stations. As a quarter wave array, the resonant frequency is approximately 2·35Mc/s, this making it an effective aerial when operating over Top Band (1.8–2Mc/s) or the shipping bands.

The top wire should consist of 14 guage hard drawn enamel covered copper wire. When the two inner lead-in connections are made, the outer enamel covering of the top wire should be removed by

Continued on page 563

RC/DS/24

RADIO CONSTRUCTORS DATA SHEET 24

AMATEUR Q CODE

The Table lists Q signals used by amateurs and taken from the international Q signal code. A Q signal has the interrogative meaning if it is followed by a question mark.

QRG	Will you tell me my exact frequency (or that of ....)? Your exact frequency (or that of ....) is .... kc/s.
QRH	Does my frequency vary? Your frequency varies.
QRI	What is the tone of my transmission? The tone of your transmission is .... (amateur, T1 — T9).
QRK	What is the readability of my signals? The readability of your signals is .... (amateur, R1 — R5).
QRL	Are you busy? I am busy (or I am busy with ....). Please do not interfere.
QRM	Are you being interfered with? I am being interfered with.
QRN	Are you troubled by static? I am troubled by static.
QRO	Shall I increase power? Increase power.
QRP	Shall I decrease power? Decrease power.
QRQ	Shall I send faster? Send faster (.......... w.p.m.).
QRS	Shall I send more slowly? Send more slowly (.......... w.p.m.).
QRT	Shall I stop sending? Stop sending.
QRU	Have you anything for me? I have nothing for you.
QRV	Are you ready? I am ready.
QRX	When will you call me again? I will call you again at .... hours (on .... kc/s).
QRZ	Who is calling me? You are being called by .... (on .... kc/s).
QSA	What is the strength of my signals (or those of ....)? The strength of your signals (or those of ....) is .... (amateur S1 — S9).
QSB	Are my signals fading? Your signals are fading.
QSL	Can you give me acknowledgment of receipt? I give you acknowledgment of receipt.
QSN	Did you hear me (or ....) on .... kc/s? I heard you (or ....) on ....kc/s.
QSO	Can you communicate with .... direct or by relay? I can communicate with .... direct (or by relay through ....).
QSP	Will you relay to ....? I will relay to ....
QSU	Shall I send or reply on this frequency (or on ....kc/s)? Send or reply on this frequency (or on ....kc/s).
QSV	Shall I send a series of V's on this frequency (or on ....kc/s)? Send a series of V's on this frequency (or on ....kc/s).
QSY	Shall I change to transmission on another frequency? Change to transmission on another frequency (or on ....kc/s).
QSZ	Shall I send each word or group more than once? Send each word or group twice (or .... times).
QTH	What is your location? My location is ....
QTR	What is the correct time? The correct time is ....

MAY—*Another exciting issue*

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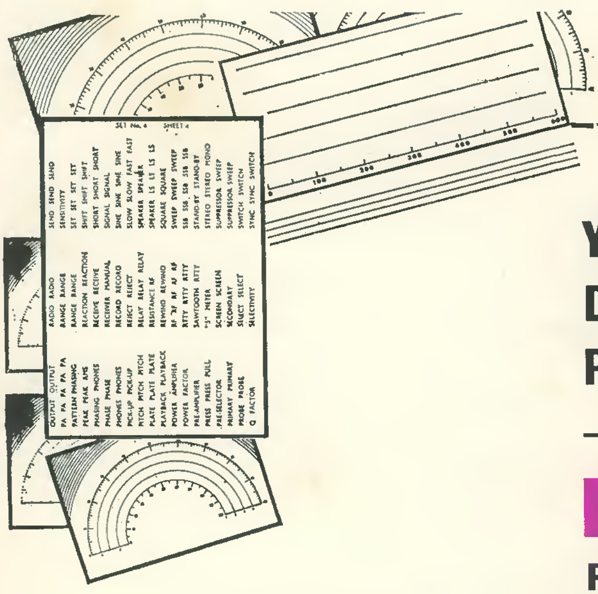

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SHORT WAVE AERIAL and CHANGEOVER SYSTEM

Continued from page 560

scraping with a penknife, the copper wire tinned and the solder joints made. These joints should then be painted with bituminous paint to form a weather seal. The weight of the lead-in wires should be taken up by the insulator, and this may be made from a rectangular length of thick Perspex. The centre insulator used by the writer is made up of two Bib 'Flex Shorteners,' the top wires being terminated at the hooked ends. The two lead-in wires are fed individually through two ⅛in. holes drilled through the bodies of both shorteners. See Fig. 2.

For those who do not have the space to erect an aerial system like that shown, it can easily be scaled down by 50%, Aerial 1 then being 16.5ft. and Aerial 2 33ft. The top wires then become quarter waves for the 14.2 and the 7.1Mc/s frequencies.

It is of importance with this or any other short wave aerial system that a good earth connection is made available. Tests have shown that lack of an efficient earthing system greatly affects the efficiency of the long wire aerial and this effect is particularly noticeable on the lower frequencies, such as 1.8 to 2Mc/s, for example.

The author's earthing system, as shown in Fig. 1, consists of a copper tube buried in the earth immediately adjacent to the shack, such tubing being available from most builders merchants. That obtained by the writer was 4ft. in length and 1in. in diameter, this being buried some 3½ft. into the soil and passing through the hole in a large flower pot. (The hole may have to be enlarged in some instances). The rim of the flower pot is just above the soil surface. It is important that the soil adjacent to the earthing tube be moist in order to make a good electrical contact and from time to time, especially during dry weather, a jug of water is tipped into the flower pot — the water then draining through the pot hole into the surrounding earth. The earth lead connected to the top of the copper tube should have a greater thickness than the aerial top wire or lead-ins and two lengths of the 14 guage hard drawn copper wire are used here, these being twisted together. Both wires are soldered together at one end and are then connected to the aluminium panel on which the coaxial aerial sockets are mounted by way of a solder tag bolted to the panel. At the other end they are similarly soldered together, and are then soldered to the earthed copper rod. This latter joint should be protected from the weather in the same manner as are the lead-in wire connections. The earthing wire should be as short and direct as possible. The length of copper wire required for the earth connection is, of course, a little greater than twice the distance over which the twisted wire runs.

OTHER CONSIDERATIONS

Aerials designed to operate over the short wave ranges should be erected as high as is possible in individual circumstances and should be clear of earthed objects such as metal drain pipes, guttering or trees, etc. Factors such as aerial height, the earthing system and conductivity of the soil, among others, all enter into the final efficiency of the system.

The directivity of a long wire type aerial is 'broadside on', that is, at right angles to the top wire. Thus, an aerial erected in the North to South orientation would exhibit maximum efficiency when receiving signals from the East or West. For maximum world coverage, the long wire aerial should be oriented in a straight line such that one end points towards 78° East of true North.

The front panel of the completed changeover unit PL1 is at the left and PL2 at the right

THE AERIAL SWITCHING UNIT

The circuit of the switching unit is shown in Fig. 3. In this, S1(a), (b), (c), (d) serve the purpose of selecting the required aerial and earthing the unwanted aerial. A small heater transformer is incorporated in the unit to power the two panel lights PL1 and PL2, these indicating the aerial in use. These lights are switched into circuit by S1(e) and S1(f).

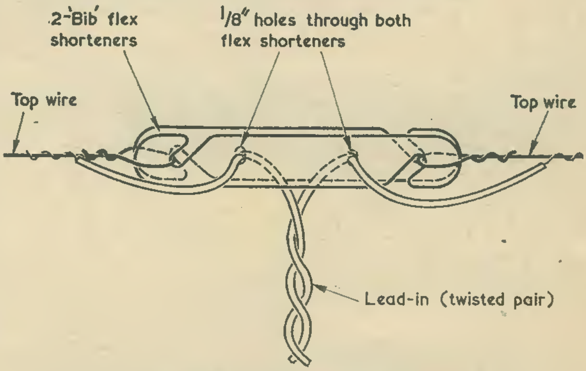


Fig. 2. The method of using two Bib "Flex Shorteners" to support the down leads. One of the "Flex Shorteners" is oriented through 180° on its long axis, so that its hook slots appear at opposite edges to those of the other

In position 1, S1(a) connects Aerial 1 to the output. There is no connection to Aerial 2 at S1(b). Similarly, no connection is made at S1(c), whilst S1(d) connects Aerial 2 (the aerial not in use) to chassis and earth. At S1(e) PL1 is brought into circuit and lights up, whilst at S1(f) no connection is made.

In position 2, there is no connection at S1(a), this rendering Aerial 1 inoperative. Aerial 2 is connected by S1(b) to the output, whilst at S1(c) Aerial 1 (unwanted) is connected to chassis and earth. No connection is made at S1(d). At S1(e) the panel lamp PL2 is connected to the 6.3V supply and lights up, indicating that Aerial 2 is in use.

In position 3, both aerials are brought into use. At S1(a), Aerial 1 is selected and connected to the output whilst at S1(b) a similar condition exists. At S1(c) and S1(d) no connection is made. At S1(e), PL2 remains connected, whilst at S1(f) PL1 is brought into circuit; thus both panel lamps light up when Aerials 1 and 2 are both in use.

In the prototype, PL1 is coloured green whilst PL2 is red. The light circuits switched by S1(e), (f) are, of course, a luxury feature and add to the cost of the unit, particularly with respect to the heater transformer. For those who do not require this section of the unit it could easily be omitted, the aerial in use then being indicated on the front panel with a pointer knob in the more usual manner.

The switch must of course be of very high quality — see Components List. With the prototype the switch consisted of two wafers, each wafer comprising a 4-pole 3-way section, made up from a Radiospares Maka-Switch kit. This is obtainable from retailers only and *not* direct from Radiospares.

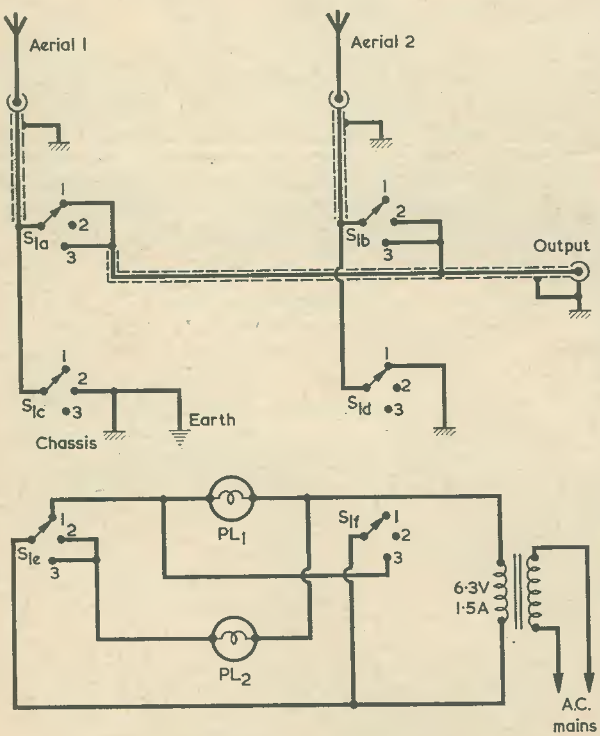


Fig. 3. The aerial switching and indication circuits of the changeover unit

If the panel light circuit is eliminated, the switch may be a 4-pole 3-way type.

To summarise the switching operation, position 1 of the switch brings Aerial 1 into circuit whilst Aerial 2 is earthed. PL1 lights up.

On position 2, Aerial 2 is selected, Aerial 1 is earthed and PL2 lights up.

On position 3, both Aerials 1 and 2 are selected and both PL1 and PL2 light up.

CONSTRUCTION

Drilling centres for the front panel (the lid) of the diecast box are given in Fig. 4. This panel is shown with components mounted in the accompanying illustration. An extra hole, not shown in Fig. 4, is

COMPONENTS

AERIAL CHANGEOVER UNIT

Cabinet
Eddystone Diecast Box, type 6357P, 7½ x 4½ x 3in. (Home Radio Cat. No. E903)

Heater Transformer
Douglas type MT140CT, 6.3V, 1.5A. (H. L. Smith & Co., Ltd.)

Switch
Radiospares 'Maka-Switch', standard assembly, 2 banks, each 4-pole, 3-way (see text). (H. L. Smith & Co., Ltd.)

Panel Lamp Assemblies
2 off type LES (1 red, 1 green) 6.3V, 1.5A. (H. L. Smith & Co., Ltd.)

Miscellaneous
Knob, p.v.c. covered wire, PK screws (4 off) etc.

Rubber Feet
4 off, grey. (H. L. Smith & Co., Ltd.)

Panel Sign Transfers
Set No. 3

AERIAL SYSTEM

140ft. 14 guage hard drawn enamel covered copper wire. (Chas. H. Young Ltd.)

Aluminium
4 x 2½in.

Miscellaneous
6BA nuts & bolts, earth tags, bituminous paint
2 off Bib Flex Shorteners (H. L. Smith & Co., Ltd.)
Twisted flex (high quality), clear p.v.c. covered. Length to suit
2 off coaxial sockets and connectors
4 off Aerial end insulators (Chas. H. Young, Ltd.), 170-172 Corporation St., Birmingham, 4

EARTH SYSTEM

2 lengths 14 guage copper wire (spare from above length)
Copper rod — see text
Large flower pot

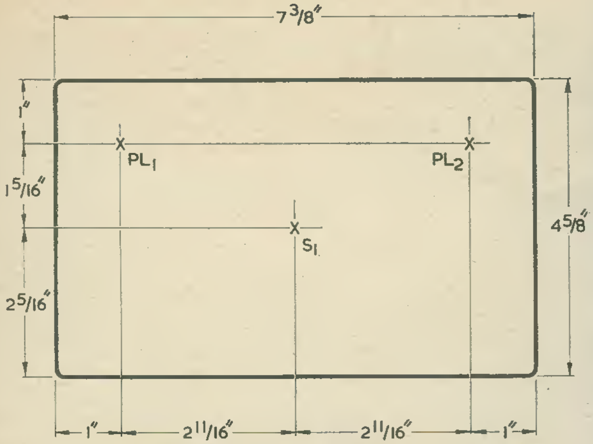


Fig. 4. Drilling centre details for the diecast box front panel

required for the panel locating lug of the switch. This is vertically above the switch bush-mounting hole, and its final position may be adjudged with the aid of the component itself.

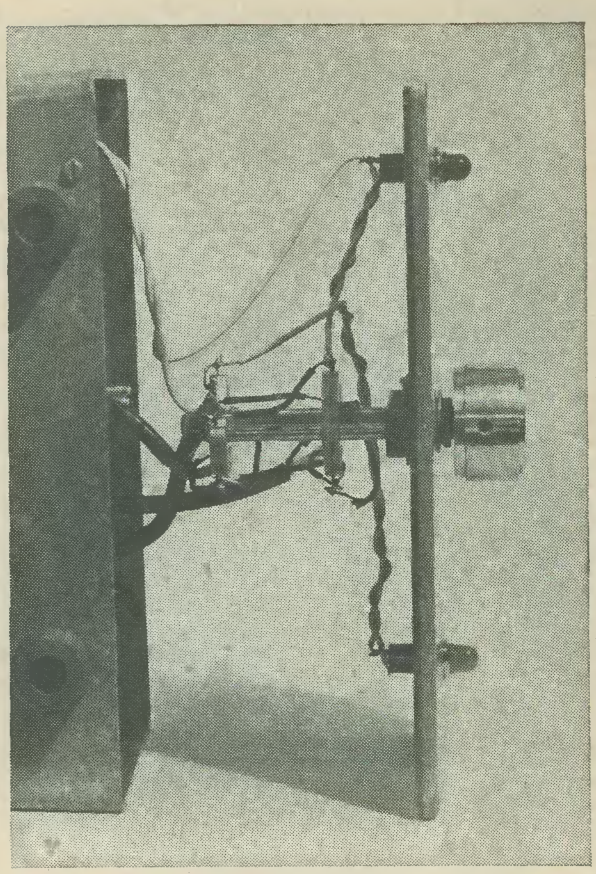
The rear of the box should have four holes, three of which are for the entry of the coaxial aerial input leads and for the output coaxial cable to the receiver or aerial tuning unit. The fourth hole is for the mains input lead, this hole being fitted with a suitably sized rubber or p.v.c. grommet.

The heater transformer is secured at the left hand side of the box, behind PL1, being bolted directly to the bottom of the case. The connection from the heater transformer secondary to the switching circuit should be made via a twisted flexible pair, this being sufficiently long to enable the panel to be removed and rested on the bench. This lead is tucked into the left-hand corner of the box when the panel is fitted, being kept well away from the aerial wiring. S1(e) is on one wafer of the switch and S1(f) on the other, their contacts being on the side nearer PL1. S1(a) to S1(d) then use contacts on the PL2 side of the switch wafers. Note that one pole on each wafer is unused.

It should be added that, in the prototype, there is not the slightest trace of mains hum in the aerial output.

To avoid interaction between the aerial leads, the two aerial inputs and the output lead should consist of 75Ω coaxial cable, the braiding of which is earthed to the unit case. A suitable earth connection may be obtained by fitting a 6BA solder tag under the head of one of the switch "side struts". The remaining connections are made with p.v.c. covered tinned copper wire.

When wiring the mains input cable to the heater transformer primary take great care to ensure that all mains connections are adequately insulated from each other and from the inside surface of the box.


The front panel removed, showing the switching assembly

Before attempting assembly of the switch, the maker's instructions, enclosed with each shaft assembly, should be carefully studied. It is helpful when wiring up, to have a continuity tester of some sort on hand in order to ascertain the correct contacts for each section of the switch.

FINAL DETAILS

Once completed and tested, the diecast box may be painted or sprayed to the colour choice of the individual operator. The prototype shown herewith was sprayed a light blue using Yukan Self-Spray enamel applicator (see advertisement at the rear of this issue). Panel-Sign transfers are then applied to the panel face once this is dry. The four rubber feet can be secured to the underside of the box by means of four PK self-tapping screws. ■

TOP BAND TRANS-ATLANTIC TESTS

During these recent tests, arranged by W1BB, our listening post has been burning some early morning oil and reports conditions as varying from good on some occasions to downright bad on the last test—March 2nd. The Dx stations listed from "across the pond" were:– K1PBW, K2GAL, K2GNC, K8BBI, KV4FZ, VE3QU, W1BB/1, W2BP, W2EQS, W2FJ, W2IU, W3FET, W3IN, W3TV, W7NMJ, WA8EMJ, W8AH, W8ANO and W8JIN.

NEWS . . . AND .

The Belling-Lee Concord back-of-set aerial pre-amplifier shown in its expanded polystyrene pack (left), together with the attractive two-colour sleeve.

CONCORD BROAD BAND PRE-AMPLIFIER

A new transistorised pre-amplifier that will improve picture quality on black and white and colour television receivers has been developed by Belling & Lee.

Technically CONCORD is a back-of-set Ultra Broad Band Pre-Amplifier. What it actually does is to take the signal coming down from the aerial array and to boost it to give a better picture. In most cases it will sharpen contrast, reduce 'snowstorm' noise effects, and, on colour sets, will give a better colour quality.

Installation is simplicity itself, the small moulded grey case is merely hooked onto the back of the receiver and a few connections made, including one to an electrical point. Consumption of electricity is small, about the same as an electric clock, and for this reason the manufacturers suggest that it is left on permanently.

CONCORD can in no way damage the set or shorten its life, and in fact its use could give sets that are failing, a new lease of life.

Local radio retailers should have the device soon and Belling-Lee recommend that viewers ask their dealers for advice on the usefulness of CONCORD in their area and obtain from them the necessary co-axial plug and lead. It is expected that the selling price will be just over seven pounds.

CONCORD is suitable for all areas and all channels and is said to be particularly useful in fringe and difficult reception areas.

Operating on all channels, it is of course ideal for VHF/FM reception, and will be of particular interest to the stereo radio listener.

CAMP FOR ELECTRONIC ENTHUSIASTS

On 2nd, 3rd and 4th May 1969 a camp will be held at Polyapes Camp Site, Oxshott (N.G.R. TQ131597) for all members of the Scout Movement who have an interest in any branch of electronics.

The full programme has yet to be finalised but it is hoped to include demonstrations, talks and discussions on the following: Hi-fi equipment, recording, model control, short wave listening and amateur radio. Further details from

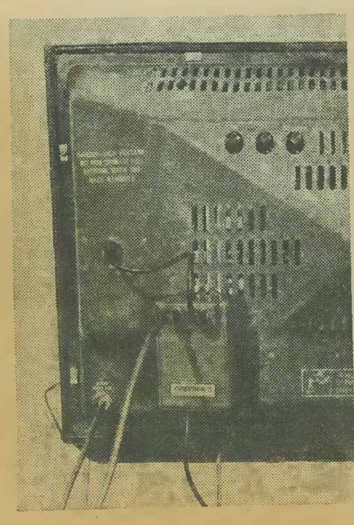
J. A. Carter,
c/o Baden-Powell House,
Queensgate, London, S.W.7.

CLOSER TV SHOTS

A million dollars' worth of new British zoom lenses designed and made by Rank Taylor Hobson, Britain's leading lens exporter were recently ordered by the Radio Corporation of America.

As George Short, one of our regular contributors (see p. 585) pointed out in a BBC broadcast this new zoom lens goes one better than anything else. Although no bigger than the zoom lenses in use in standard TV cameras, it can get closer to the scene than ever before, without sacrificing any of its long-shot capability. It can get so close, optically speaking, that it can fill the whole screen with one eye.

Can we now look forward to an orgy of bristling eyebrows and twitching lips?



Concord shown installed.

. . . COMMENT

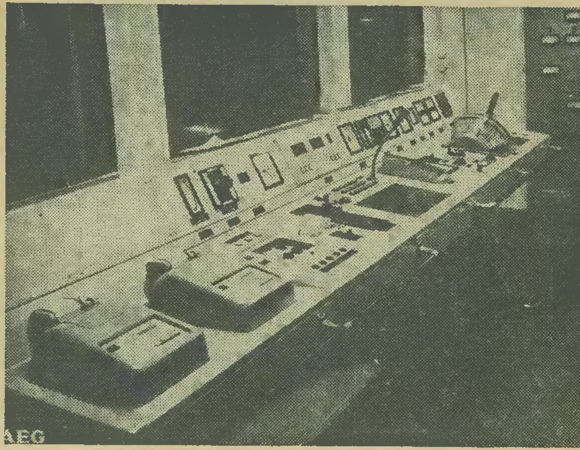
THE BRITTEN SPY CASE AFFAIR

Those of our readers who are Radio Amateurs and many others who have some knowledge of the amateur radio scene, will no doubt have been quite amazed at the suggestions made after the Britten spy case, that participation in this sphere of interest indicates a security risk amongst those engaging at the same time in duties with H.M. Forces or certain Government establishments.

There have been other spy cases revealed to the public gaze during recent years, in which the equipment used to communicate in secret with 'the other side', was far more sophisticated than that ever found in a radio amateur's shack, and the rapidity with which "amateur radio pirates" get spotted by legitimate radio amateurs and brought by them to the attention of the law, would have left, we would have thought, no doubt at all in the minds of the Security Commission appointed to look into the Britten affair, that the amateur radio bands were the least likely of channels to be used for this sort of practice!

Surely the reference to amateur radio in the Britten case came about initially because it was used as the means by which the foreign agent made the first approach to his victim. If you want to pick up an acquaintanceship with someone, it is usual to try and do so via some common interest, be it dogs, gardens, cameras, cars or what have you. One might equally well suggest that because specialist branches of photography are exceedingly useful to spy techniques, that anyone with an interest in photography should be regarded as a security risk! In this particular instance, the common interest happened to be amateur radio.

However, it is good to see that the Radio Society of Great Britain has been quick off the mark in drawing attention to the indignation of all radio amateurs at the implications contained in this Report.



KIENZLE DIGITAL PRINTERS AS SHIPS AID

Several British and foreign shipping companies have chosen the Kienzle digital printer to provide a continuous printed record of bridge telegraph commands. Kienzle printers have so far been installed to record ships heading, engine movements and revolutions and other information relevant to the command of the ship.

Pitch roll and vibration have no effect on the operation of the printer. Digital information of all types can be printed out at up to 3 lines per second, each line consists of up to 16 characters.

ROBOTS

From time to time, on TV and at exhibitions, we see quite good examples of robots of one sort and another. These are, nowadays, wonderful examples of mechanical and electronic ingenuity. The word "Cybernetics" has been coined to label the science of 'feedback control' necessary to enable the mechanical reproduction of human functions to operate in as automatic a way as possible. Electronics comes to the rescue of the designers of "robots" in enabling this 'feedback mechanism' to be more easily designed than was possible in the days when only mechanical methods were available.

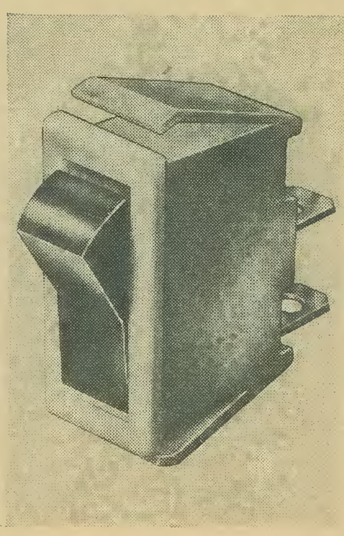
It occurred to us that there may be readers of this magazine who have experience in this field, and who may in fact have constructed "robots" of one kind or another. We should be very interested to hear from any such readers.

NEW RANGE OF SNAP-IN ROCKER SWITCHES

A new type of rocker switch is now being manufactured by Carr Fastener Co. Ltd., of Stapleford, Nottingham. The switch is for snap-in application into a 1.112in. (28.2 mm) by 0.425in. (11.5 mm) rectangular hole in material within the thicknesses of 0.031in. (0.8 mm) to 2.080in. (1.6 mm). The switch is for operation at 13 amps. 250 volts A.C. and is provided with blade connections for use with snap-in connectors.

A useful feature of these switches is that they can be supplied in any colour combination of body and knob.

The switches can be ganged in one hole, and in this instance it is sometimes necessary for the switches also to be linked electrically. The Company are manufacturing a linking bar for this purpose, this part has a self-retaining push-on action for connection to the blades.



INTEGRATED CIRCUIT STEREO AMPLIFIER

by

L. McNAMARA, B.Sc.

Using two integrated circuits type PA237, this stereo amplifier module has input sensitivity in each channel of 8mV for 2 watts output. The whole amplifier may be assembled on a printed circuit board measuring 3¼in. by 2in. only

"THOSE WHO ARE NOT NOW CONSIDERING THE design of equipment using integrated circuits are already behind the main flow of American technology".

This statement is to be found, not in any 1969 reference, but in the 1965 edition of the American "Motorola Semiconductor Data Book". It is therefore imperative that European industry endeavour to remain competitive in this field, and equally important for the vigour of amateur activity in electronics here that enthusiasts be familiar with recent developments in this field. A healthy consumer demand will encourage the provision of even more advanced electronic products for the amateur market. The amateur press has played a valuable part in keeping its readers informed, especially in the recent past as manufacturers expanded outside the computer field which provided the first mass market for integrated circuits and began to introduce types suitable for linear amplification, and therefore applicable to the average amateur's projects, such as r.f. or a.f. amplifiers. This article is intended as a report on one such linear integrated circuit, recently introduced, with emphasis on its economy, reliability, and ease of application, in the hope that readers will be encouraged to take up the integrated circuit as the new opportunity in their hobby which it really is.

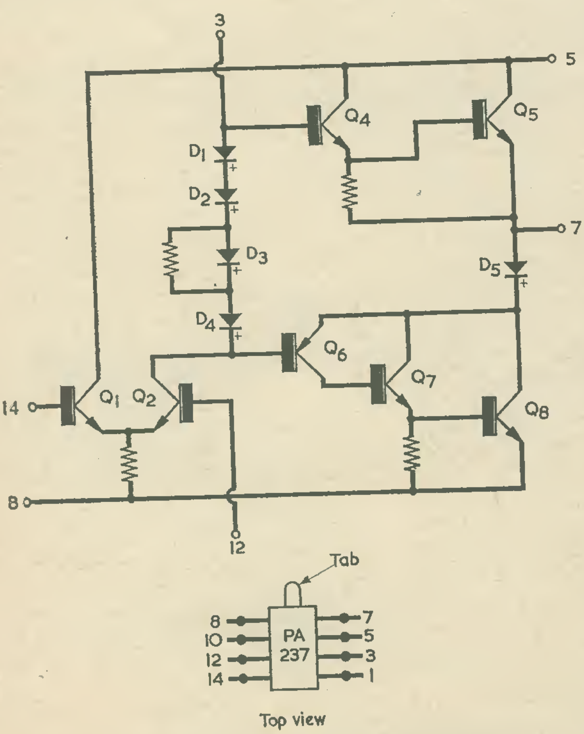
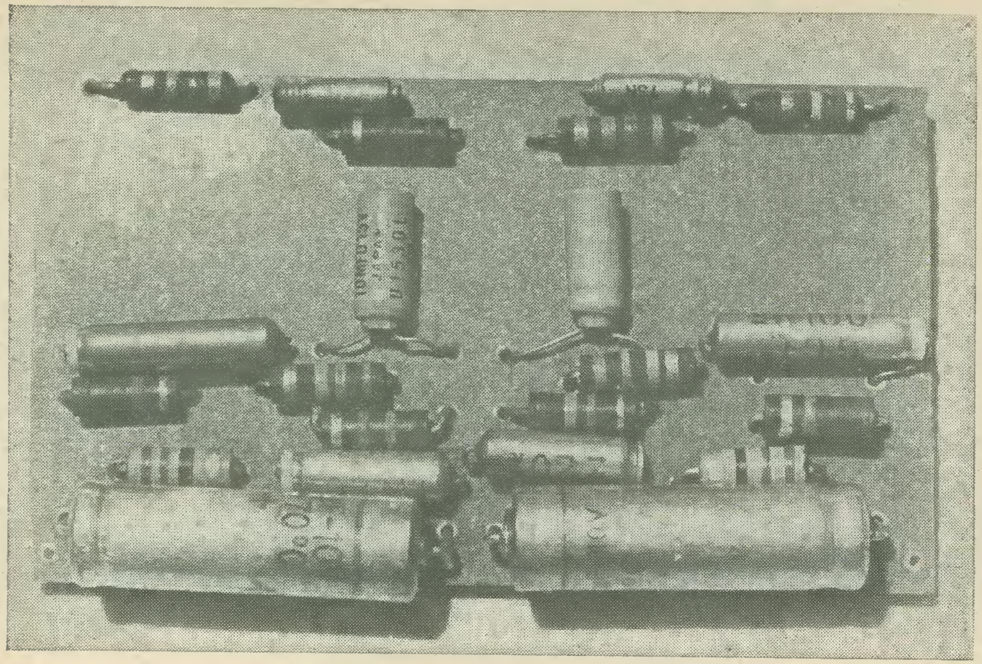


Fig. 1 The internal circuitry in the PA237 2 watt integrated a.f. amplifier

I.C. TYPE PA237

The circuit in question is the General Electric (U.S.A.) type PA237, the latest in a series of similar power output i.c.'s issued by that company. In an integrated circuit, the dissipation permissible in the output transistors can be increased by using junctions of greater area diffused into the monolithic silicon crystal from which the device is formed, but the limitation of maximum operating temperature of the unit as a whole still remains. Since the package adopted for earlier i.c.'s provides a degree of thermal

PA237 Characteristics (in test circuit similar to Fig. 2)	
Audio power output	2 watts
Signal input for 2 watts output, R6=0	8mV
Signal input for 2 watts output, R6=6.8kΩ	120mV
Efficiency at 2 watts output	52%
Output quiescent current	3mA min. 15mA max.
Input impedance	40kΩ
Output impedance	0.85Ω
Noise level	–75dB



Top view of the prototype stereo amplifier

COMPONENTS

Resistors

(All resistors $\frac{1}{8}$ watt 10%)
R1, R8 390kΩ
R2, R9 47kΩ
R3, R10 18kΩ
R4, R11 330kΩ
R5, R12 47kΩ
R6, R13 see note below
R7, R14 22Ω
(R6, R13 are chosen to provide the gain required by the particular application, within the limits specified in the Table.)

Capacitors

C1, C6 2μF electrolytic, 6V wkg.
C2, C7 0.002μF
C3, C8 10μF electrolytic, 6V wkg.
C4, C9 500μF electrolytic, 15V wkg.
C5, C10 0.1μF

Integrated Circuits

Two integrated circuits type PA237 (General Electric, U.S.A. — see text.)

Speakers

Two 15Ω speakers

Printed Circuit

Printed circuit board (see text).

insulation, we find that there is a temperature rise in operation of 140°C per watt of dissipation in a TO-5 can, and 150°C per watt in an epoxy dual in-line package. Because junction temperature in an operating silicon semiconductor device may not exceed 125°C, the limitation to power levels under 1 watt is obvious.

The General Electric design team have broken this barrier by mounting the silicon chip directly on a metal tab, which serves at once as an earth connection to the substrate and as a heat sink. The tab is soldered to an external metal foil — the copper cladding of the printed circuit board on which the circuit is mounted will serve — and it is then found

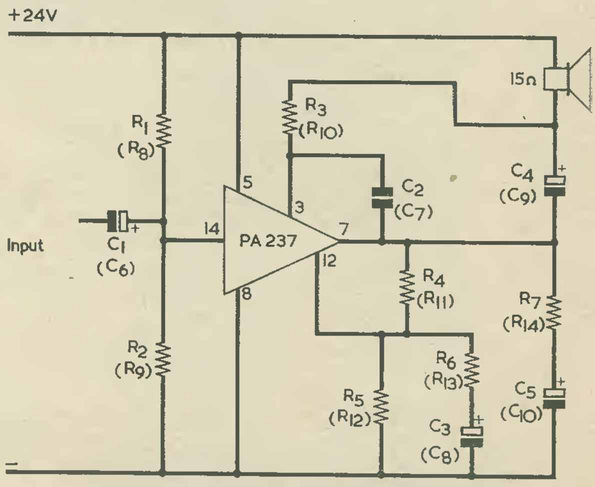


Fig. 2. Practical working circuit incorporating the PA237. With R6 deleted, as described in the text, this forms one channel of the complete stereo amplifier

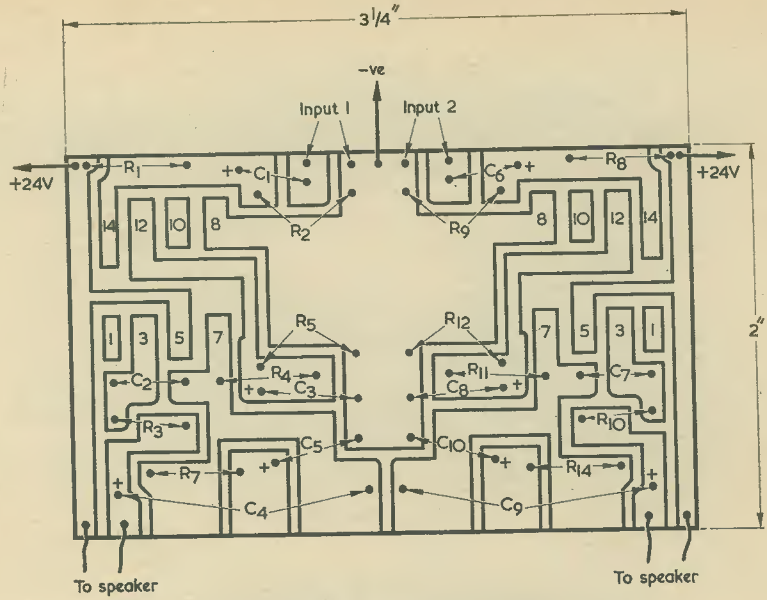
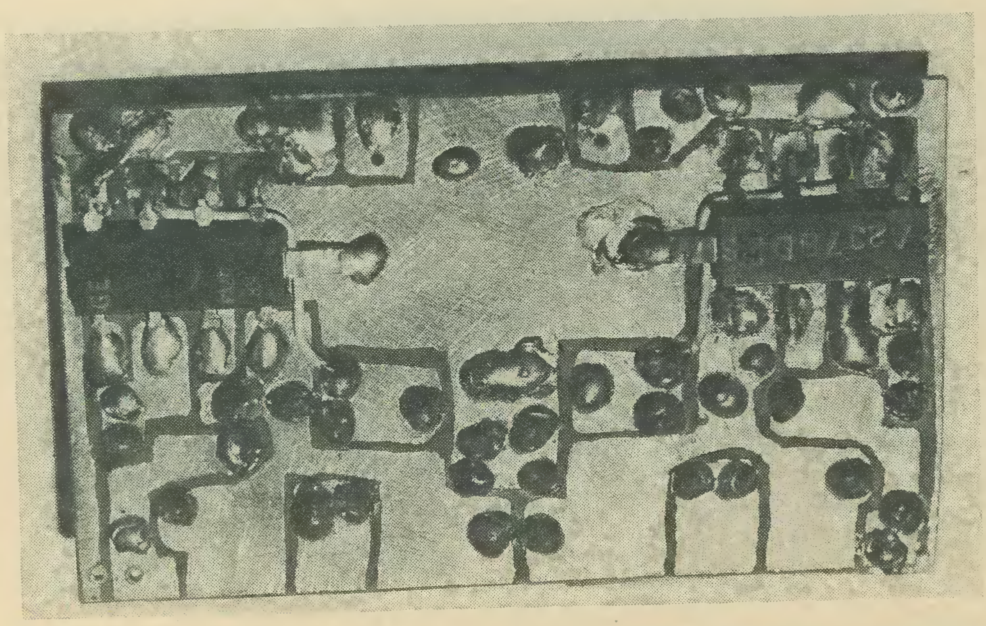


Fig. 3. The printed circuit pattern used for the prototype. This is reproduced full scale and may be traced, if desired

that the circuit can be rated to provide an output of 2 watts.

Naturally, power output is only one of the parameters considered when designing a practical circuit, and the table gives results as attained in a test circuit similar to that of Fig. 2, illustrating the actual performance of the device. The relatively high input impedance is the result of the mode of operation of the input transistor Q1 (see Fig. 1) which acts as an emitter follower. Q2 "sees" the signal voltage produced across the emitter resistor common to Q1 and Q2, and amplifies it in the common mode. The amplified signal is then applied to the bases of Q4 and Q6. It should be noted that these transistors are of opposite polarity, Q4 being n.p.n while Q6 is a p.n.p. device. This is essential if the output transistors are to be driven with opposite-phased signals for operation in a class B



The copper side of the amplifier board. The rectangular PA237 integrated circuits may be seen in the upper section mode. The output, then, is from a push-pull arrangement, with two identical compound pairs, Q4–Q5 and Q7–Q8 in a series-connected single-ended arrangement. The diodes D1 to D4 eliminate cross-over distortion, in that the potential drop across them is greater than the sum of the emitter-base voltages of Q4, Q5 and Q6 by an amount sufficient to maintain a finite forward bias on the bases of both Q4 and Q6 at all times.

A distortion curve, showing the performance of the Fig. 2 circuit with R6 at 6.8kΩ, appears in Fig. 4. The output is 2 watts at all frequencies, and distortion does not exceed 2% at any point.

PRACTICAL CIRCUIT

In a practical circuit, such as that shown in Fig. 2, a few external components are required in addition to those integrated into the PA237 chip. A power supply of up to 24 volts maximum is connected between pin 5 and pin 8. Pin 3 permits the connection of a collector load for the driver transistor Q2, and a feedback loop through pin 12 can be applied to the same transistor. The pin numbering is that employed in the manufacturer's specifications, and reflects the fact that the integrated circuit package is a development of the standard 14 lead dual in-line epoxy package, with the addition of the heat sink tab and the elimination of redundant connections. The output is developed at pin 7, and is applied to a 15Ω loudspeaker through a 500μF capacitor. A 22Ω resistor and a 0.1μF capacitor, R7 C5, provide tone correction, while base bias and feedback to pin 12 are supplied by the potential divider R4 R5. It will also be noted that the collector transistor of Q2 is taken to the coupling capacitor side of the loudspeaker rather than to the positive line. This connection results in bootstrapping of R3 with a consequent enhancement of gain.

Fig. 2 gives the circuit of one half of the stereo amplifier made up by the author. This stereo amplifier comprises two identical amplifiers employing the circuit of Fig. 2, whereupon it requires two integrated circuits type PA237. The component references in brackets apply to the resistors and capacitors in the second amplifier.

PROTOTYPE AMPLIFIER

The prototype stereo amplifier was assembled on a printed circuit board measuring 3¼in. by 2in., with two PA237's. The photographs show views of the component and copper sides of this amplifier whilst a diagram illustrating the copper pattern is given in Fig. 3. Note that the amplifier is operated in the condition where R6=0 (see Table) giving an input sensitivity of 8mV. In consequence, R6 does not actually appear in the circuit and capacitor C3 connects directly across R5. The same comments apply to R13, C8 and R12 respectively. In the photograph, incidentally, C3 (C8) and R5 (R12) are transposed from the positions shown in Fig. 3, and this alternative positioning may be found advantageous if the electrolytic capacitors employed are somewhat bulky in size.

Should it be desired to fit resistors in the R6 and R13 positions, with a consequent reduction in sensitivity, the positive ends of C3 and C8 should be raised from the board and the resistors inserted in series.

The PA237 in the second channel, on the right, is fitted upside down. The i.c. pins are soldered flat on to the copper pattern, and do not pass through holes in the board.

Readers will already be familiar with the procedure for etching the desired conductor pattern on to the copper foil of a blank Paxolin-copper laminate, using cellulose paint to protect the pattern from the ferric chloride solution. (A ready-made board is available from Tremaine T.S. Ltd., 18 Warwick Road, Rainham, Essex.—Editor).

If the amplifier is to be driven continuously at its full overall output of 4 watts an extra heat sink is needed. This can consist of a rectangular copper fin measuring about 1in. by 2in., with its 1in edge soldered to the centre of the large area to which the PA237 tabs are soldered. This fin should project at right angles from the copper side of the board.

The actual assembly follows standard procedure, with the resistors being mounted on the board first, then the capacitors, and finally the semiconductors. The area reserved as a heat sink for the i.c.'s is clear; this should be tinned before the semiconductor devices are mounted, since the solder layer will increase the thermal conductivity in this area and, therefore, the efficiency of the heat sink. Further it will enable a good electrical and thermal connection to be made to the tabs on the i.c. with a single short application of a hot clean soldering iron. This is a useful point since the chip is mounted directly on the tab within each i.c. package, and it is not desirable to expose it to thermal stress for longer than necessary.

The usual precautions should be taken when testing the completed amplifier. These include monitoring of the current drawn from the power supply, which should be of the order of 25mA when no signal is applied, rising in the manner characteristic of a class B audio amplifier as the volume is increased. Further, care should be taken not to short-circuit the output of either channel of the amplifier, since dissipation is limited by the external load, and a short time in operation with a short-circuited output could well damage the i.c. concerned. Similarly it is inadvisable to attempt operation with a loudspeaker of lower impedance than specified. Aside from these obvious precautions, and the care required in any electronic assembly task, the constructor should find the operation easier and success more certain than the construction of an equivalent unit using discrete transistors and components, bearing in mind that the precision of the i.c. manufactur-

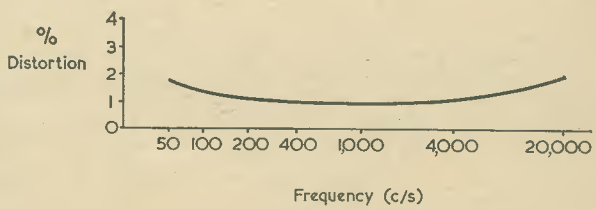


Fig. 4. The relation between frequency and distortion for a single PA237 at 2 watts output

ing process already ensures close to perfect matching of the transistors in each channel, and between the two channels for proper balance. Finally, success in this project should encourage a greater interest in further applications of the widening range of linear integrated circuits now available.

ACKNOWLEDGEMENT

The assistance of the General Electric Company (U.S.A.) is acknowledged by the author, and it is pointed out that the Company accepts no responsibility in connection with the application of information supplied.

EDITOR'S NOTE

The input impedance of each half of the stereo amplifier is 40kΩ with a sensitivity of 8mV for a power output of 2 watts. A higher input impedance, with corresponding loss of sensitivity, may be achieved by the simple process of inserting resistors in series with C1 and C6. Thus, a series 470kΩ resistor in each channel will afford an input impedance of about 500kΩ with a 2 watt sensitivity of 100mV. It may be necessary to add a small capacitance across each series resistor to maintain high frequency response. Input gain and balance controls are fitted between the source of stereo signals and input capacitors C1 and C6 (or the series resistors, if used). In the condition where R6 = 0, the PA237 offers a considerable degree of gain, and it would be advisable to screen input wiring positioned close to the board.

The PA237 is available from Jermyn Industries, Vestry Estate, Sevenoaks, Kent. ■

DESIGN FOR UNIVERSAL CAR RADIO

by

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

Intended for the advanced constructor, the circuit design described in this article is for a medium wave car radio capable of operating from either 6 or 12 volt batteries, regardless of which battery terminal is earthed. Ingenious circuitry enables efficient a.g.c. operation to be achieved in what is essentially a t.r.f. receiver

The author recently had a request from a daughter who lives in a warm climate to make her a car radio for use in the family Volkswagen. It was mentioned that the day would come when the car would be exchanged for a new one, of unspecified make, and that it would be useful if the radio could be transferred without modification.

This specification produced some interesting problems. First, there is the question of ambient temperature, which could, in the proposed instance, reach 50° C on occasions when the car is parked in the sun. Secondly, and this is not a problem peculiar to foreign parts, the car is used for most of the time in and around a large city, so that signal strength from the local stations varies over a wide range from one minute to the next. Thirdly, all but recent Volkswagens use 6 volt batteries with negative to chassis — whereas most other cars have a 12 volt supply with the positive terminal at earth potential.

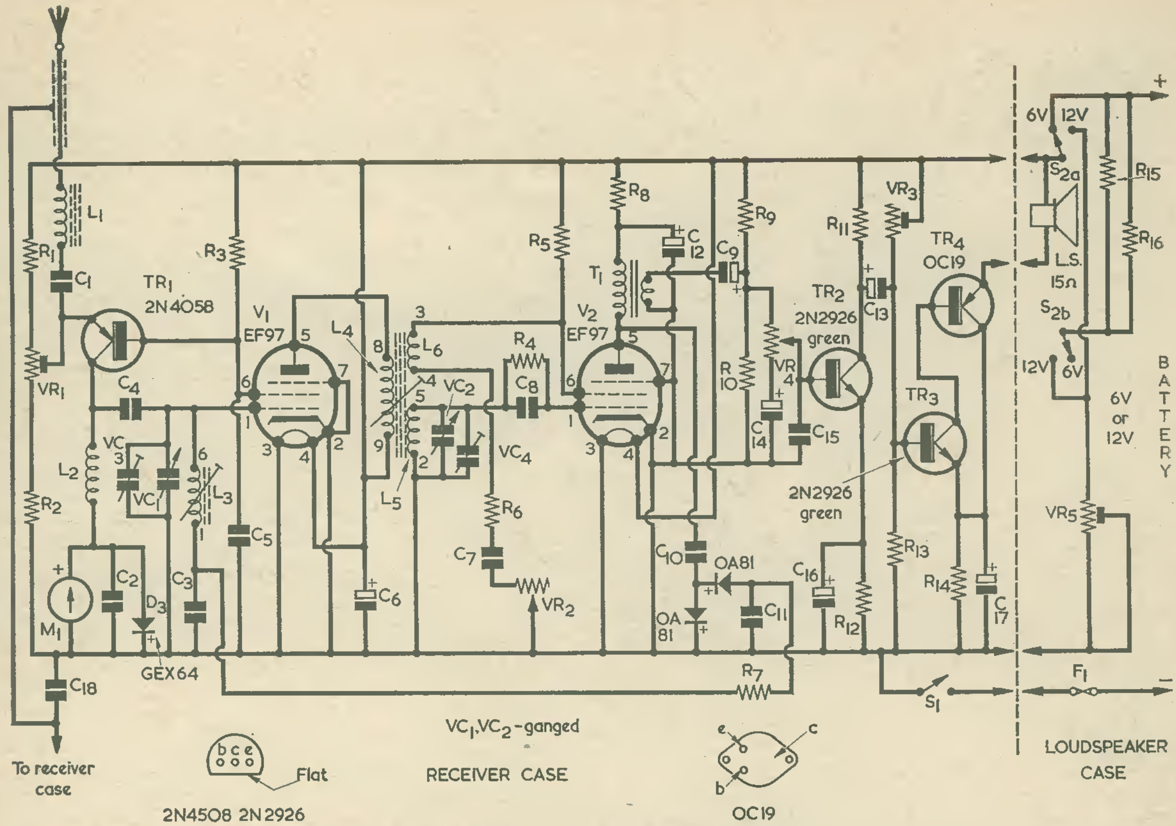
Judging from the number of Volkswagens to be seen on English roads, not to mention certain other foreign cars and a fair sprinkling of the older Fords, there would still seem to be a demand for a car radio which will function from a 6 volt battery, but which could accept 12 volts by the turn of a suitably hidden switch. Also, the majority of car owners in this country use their radios in conditions which demand a very efficient a.g.c. system. Admittedly, temperatures of 50° C are rare indeed in Great Britain, but cars are often taken abroad, and it is the author's experience that many car radios are subject to loss of efficiency, and even instability when switched on in a parked car on a hot day. It therefore seemed worthwhile to describe for this journal the design which materialised from the specification.

It is not recommended that a car radio be the first project to be built by a beginner, and the description which follows will therefore be theoretical, details of layout being left to constructors who have some previous experience. The prototype was built in two separate metal cases, one for the receiver and one for the speaker (together with several heat-dissipating resistors). An important practical point is that a metal chassis should not be used for the receiver. The receiver controls and other components must be mounted on plywood or Paxolin so that no d.c. contact is made with the metal case.

CIRCUIT OPERATION

If the accompanying circuit diagram is studied it will be seen that TR1 is a silicon p.n.p. transistor, connected in the common base mode as a radio frequency amplifier. A type is chosen which has an exceptionally low leakage current even for a silicon device, and which, partly as a result of this low leakage current, develops a high amplification factor (minimum h_{fe} 100, maximum 400) when passing only 100μA collector current. The combination of silicon semi conductor and common base amplification means that the transistor is only slightly affected in performance by changes of temperature. Also, the development of high amplification at a low value of collector current makes the transistor very sensitive to a.g.c. voltage changes. (TR1, together with TR2 and TR3, was obtained from Amatronix Ltd.)

The aerial is fed to the emitter of TR1 through L1 and C1. L1 is a choke consisting of 35 turns of 32 s.w.g. enamelled wire closewound on a 1in. length of ⅜in. ferrite rod, and its function is to prevent cross modulation by powerful short wave transmitters, these being especially troublesome when the receiver is used near the coast. C1 isolates the aerial from the battery. Base bias is provided by the voltage drop through R3, which is the screen-grid dropping resistor for the second r.f. stage, V1. Emitter bias is set by the network R1, VR1, R2. The values of these components are such that, when TR1 is passing 100μA, this current is an appreciable portion of the total current passing through the network. But when a.g.c. causes the current through TR1 to drop to a very low level, that current is very small compared with the total in the network. As a result, with no signal, or a weak signal, there is a degree of d.c. negative feedback which helps to compensate for the effect of the battery's voltage rising while on charge. But with a.g.c. operative on a strong signal there is virtually no feedback, so that the a.g.c. system



Circuit diagram of the Universal Car Radio

COMPONENTS

Resistors
(All fixed values ¼ watt 10% unless otherwise stated)

- R1 2.2kΩ
- R2 6.8kΩ
- R3 8.2kΩ
- R4 1MΩ
- R5 8.2kΩ
- R6 3.9kΩ
- R7 470kΩ
- R8 1kΩ
- R9 6.8kΩ
- R10 1kΩ
- R11 1kΩ
- R12 1kΩ
- R13 1kΩ
- R14 1Ω ½ watt
- R15 15Ω 5 watt wirewound
- R16 15Ω 5 watt wirewound
- VR1 5kΩ pot. preset linear
- VR2 25kΩ pot. log
- VR3 10kΩ pot. preset linear
- VR4 5kΩ pot. linear, with S1
- VR5 250Ω pot. preset linear, 3 watt

Capacitors

- C1 200pF
- C2 0.1μF
- C3 0.1μF
- C4 200pF
- C5 0.1μF
- C6 1,000μF electrolytic, 9V wkg.
- C7 200pF
- C8 270pF
- C9 100μF electrolytic, 6V wkg.
- C10 2,000pF
- C11 2,000pF
- C12 100μF electrolytic, 9V wkg.
- C13 100μF electrolytic 9V wkg.
- C14 10μF electrolytic, 6V wkg.
- C15 0.1μF
- C16 100μF electrolytic, 6V wkg.
- C17 5,000μF electrolytic, 6V wkg.
- C18 0.1μF
- VC1, VC2 365 + 365pF twin-gang, Type O (Jackson Bros.)
- VC3 15pF trimmer
- VC4 15pF trimmer

Inductors

- L1 See text
- L2 2.5mH r.f. choke, Type CH1 (Repanco)
- L3 Miniature Dual-Purpose Coil (valve type) Blue, Range 2 (Denco)
- L4, 5, 6 Miniature Dual-Purpose Coil (valve type) Green, Range 2 (Denco)

- T1 Driver transformer type LT44 (Eagle)

Semiconductors

- TR1 2N4058
- TR2 2N2926 Green
- TR3 2N2926 Green
- TR4 OC19
- D1 OA81
- D2 OA81
- D3 GEX64 (CV2310) (Henry's Radio Ltd.)

Valves

- V1 EF97
- V2 EF97

Switches

- S1 s.p.s.t., combined with VR4
- S2 2-pole 2-way, toggle

Tuning Indicator

- M1 Balance and tuning meter type SB105 (Eagle)

Fuse

- F1 1-amp cartridge fuse, with holder

Miscellaneous

- Loudspeaker, 15Ω impedance
- 2 B7G valve holders
- Tuning drive and knobs, as required
- Cases, etc. (see text)

remains efficient. It is obvious that a.g.c. will not function well if a high degree of negative feedback is applied simultaneously.

The collector load for TR1 is the tuned circuit given by L3 and VC1 in parallel with the r.f. choke L2. The coupling winding provided on coil L3 is not used. The tuned circuit is in the grid circuit of a valve, V1, and its Q is therefore maintained at a high level. At the same time, TR1 finds a high impedance in its collector circuit, which results in good voltage amplification. Voltage amplification is what is required here, since the following stage, a valve, is also a voltage amplifier.

Meter M1 is a tuning indicator. It is not a vitally necessary component, but the very efficient a.g.c. means that tuning with accuracy is not always easy. It will be found that advancing the reaction control, VR2, when a local station is tuned in, will cause no increase in volume but will be immediately noticeable in the meter. Accurate tuning is indicated by minimum reading. In the case of the specified meter (which is a centre zero type normally employed as a stereo balance or f.m. tuning indicator) this is shown by the needle being as near centre as possible. A meter with a full-scale deflection of 100μA is required by the circuit, but by using the specified component, which offers an attractive front panel appearance and which has a deflection of 50μA, with a suitable diode as a protective shunt, equally good performance is obtained. The diode should be as specified for best results, as it has a low forward resistance, though an OA73 can be used if the GEX64 is difficult to obtain. The protection offered by the diode is particularly useful in the event of the current through TR1 rising because of a large increase in ambient temperature.

R.F. voltage for a.g.c. is taken from the anode of V2, the primary of T1 acting effectively as a load for this purpose as well as a load for the a.f. voltage. D1 and D2 form a voltage doubler for a.g.c., which is fed back to the grid of V1 through the filter given by C11, R7 and C3. It will be clear that as the amplification offered by V1 is reduced by the negative a.g.c. voltage applied to its grid, so will screen-grid current fall, and there will be a decrease in the voltage drop through R3. In fact, V1 functions as a d.c. amplifier for a.g.c. voltage, and a small change in voltage on the control grid of V1 will cause a larger change in voltage on the screen-grid, and hence on the base of TR1. Current through TR1 will therefore decrease as a.g.c. voltage increases, and its amplifications will fall.

V2 acts as a leaky grid detector. As it is a pentode it has a high output impedance, but with this particular valve and under the conditions obtaining in the circuit this impedance is not as high as usual, a figure of about 60kΩ being normal. In these circumstances, the primary of the transformer specified for T1 will give quite a suitable load, especially as the volume control circuit which follows it has been designed so that the load across the secondary is never more than some 830Ω at any setting, this representing a shunt across the primary of approximately 20kΩ. The secondary centre-tap of T1 is ignored.

Regeneration is obtained from the screen-grid of V2, the reaction control being VR2 and the reaction winding L6.

(The two coils, L3 and L4, L5, L6 must be mounted so that there is no inductive coupling between them. They could be positioned on either side of the 2-gang capacitor with their axes at right angles. Alternatively, they may be fitted in the metal containers in which they are supplied, these functioning as screens. —Editor.)

TR2, the first a.f. transistor, is a high gain silicon n.p.n. component, connected as a common emitter amplifier and coupled to a similar second stage incorporating TR3, TR3 is directly coupled to the germanium p.n.p. output transistor TR4, this being connected as a common collector device. Thus, the collector load for TR3 is kept reasonably high, and a 15Ω speaker gives a good match without the use of an output transformer. The circuit also disposes of the need for an inter-stage coupling transformer. R14, with a large capacitor across it to avoid negative feedback of the signal, gives a good degree of stabilisation and in any event, TR4 is operated well within its limits. The output stage has proved to be thermally stable even at an ambient temperature of 55°C. TR4 needs to be mounted on a small heat sink, a surface area of 2in by 2in being sufficient.

S2 enables the receiver to be operated from a 12 volt supply. When S2 is in the position marked '6V' the positive terminal of the 6 volt battery is connected direct to the positive line of the receiver, but by switching to '12V' R15 and R16 drop the voltage to a suitable level. The preset resistor VR5 is used for final adjustment to compensate for small discrepancies in the resistance values of R15 and R16.

SETTING UP

No signal generator is necessary for setting up, but a testmeter is required. For the first adjustment the battery should be fully charged and on charge, either by means of having the car engine running or by using a charger. A 6 volt battery is required. Alternatively, if necessary, the 6 volts can be taken from a tapping on a 12 volt battery through a crocodile clip.

Switch S2 to '6V' put VR1 to its half-way position, and set VR2 so that all its resistance is in circuit. With the testmeter connected between the emitter of TR4 and the loudspeaker, adjust VR3 to give a reading of 225mA. Next, connect up the aerial, set the tuning control so that no signal is coming through and adjust VR1 so that full scale deflection (needle over to the left) is given in M1. This corresponds to an actual current of about 100μA. When the battery is no longer on charge it will be found that the reading will drop somewhat. (The imported tuning indicator specified for M1 is sometimes referred to as having a "100μA movement". If difficulty is experienced in obtaining the f.s.d. reading just referred to, temporarily replace M1 and D3 with a testmeter switched to a suitable current range to find the position of VR1 which corresponds to 100μA collector current in TR1.—Editor.)

For the next adjustment the battery need not be on charge. The core of L3 should be adjusted nearly all the way in, and the core of L4, L5, L6 about a quarter of the way out. This is necessary as the effect of L3 inductance on its tuned circuit is reduced a little by the presence of L2. Tune to a station near the high frequency end of the scale and adjust trimmers, VC3 and VC4, for best results. Tune to a station near the low frequency end of the scale and adjust the cores for best results. Repeat the process two or three times for the best compromise.

During the final adjustment the battery should not be on charge, and if it has recently been on charge should have its voltage reduced to normal by switching on the headlights for a couple of minutes. S2 is switched to '12V' 12 volts is applied to the receiver from the battery, VR5 is adjusted to its half-way position and the testmeter, set to give a clear reading of 6 volts is placed across VR5, which is then adjusted until 6 volts is shown. This voltage will rise to about 7 volts when the 12 volt battery is on charge, which is the approximate voltage given by a 6 volt battery on charge. This last adjustment must *not* be made if any fault has prevented the 225mA reading being provided in the earlier adjustment. Failure of TR4 to pass the requisite current would result in insufficient voltage being dropped across R15 and R16, and this could put an overload on the valve heaters. For the same reason the receiver must never be switched on with the loudspeaker disconnected.

It may be found that with a 12

volt supply, particularly when it is on charge, there is instability at a very low audio frequency when the volume is turned full on. This is because R15 and R16 tend to form a common supply impedance for the audio stages whilst C6 offers insufficient bypassing effect. In this event, C6 may be augmented by a 5,000μF capacitor which can conveniently be mounted in the speaker case. Alternatively, VR5 may be adjusted to slightly reduce the available voltage. Any consequent loss of output when the battery is not on charge can be tolerated as there will be plenty in hand when the car is stationary.

PERFORMANCE

The receiver will give good results from a large number of stations without the use of reaction, but the a.g.c. effect is more pronounced when reaction is employed and even on local stations it is recommended that VR2 should be set to give this effect. On weak stations the use of reaction will be found to give a marked increase in sensitivity, though, as there is a large amount of straight r.f. amplification within the circuit, the boost will not be so marked as with some simpler designs.

Overall current consumption is about 830mA. A 1 amp fuse for F1 has proved satisfactory.

As mentioned earlier, the prototype uses two separate cases, the circuitry being divided as indicated by the dashed line in the diagram. The case for the receiver is internally lined with "Contact" to prevent the possibility of short-circuits, and is coupled to the receiver through C18 so that batteries with either positive or negative earth may be used without the case becoming alive. Home Radio (Components) Ltd. sell suitable cases, in kit form, in very many different sizes (these being listed in the Home Radio catalogue under "Universal Chassis" over Cat. Nos. CU1 to CU220) so that a wide variety in layout design and speaker size is possible.

Care should be taken to see that the controls do not touch the case, and ventilation holes must be provided in *both* cases. Ventilation for the loudspeaker case is needed since R15 and R16 will become quite hot when a 12 volt supply is used. It will be seen that 4 leads join the two units together, and that the battery leads are taken from the speaker case, which also houses S2 and VR5. The latter two controls are mounted at the rear—well out of the way of prying fingers! ■

DIMMED HEADLIGHTS WITH A DIFFERENCE

by
T. R. BALBIRNIE, B.Sc.

How to obtain headlight dimming with an automatic self-cancelling facility

THE DIMMED HEADLIGHT SYSTEM FOR CARS IS becoming very popular. It is certainly a safety feature and a worthwhile addition. It has been widely agreed that headlights should be operating all the time the car is in motion yet dipped headlights are often too bright for town use. It has been established that pedestrians judge the distance and speed of approaching traffic far more effectively from headlights than from sidelights alone.

LIGHT DIMMING

By the system to be described, light from dipped headlamps can be reduced for town driving. For his first experiment some time ago, the author included a high dissipation resistor in the dip filament circuit to dim the lights. This resistor was home-made and could be short-circuited as required with a panel switch to obtain ordinary dipped operation. The whole system was very successful, a useful point being its extreme simplicity. The circuit is given in Fig. 1. Only one drawback emerged which prompted the author to re-examine and to modify it. This would have been unimportant for the driver who is a memory man but the author is not. Imagine that the car is being driven through town under dimmed conditions. Now we drive out of town and operate the dipswitch for "high beam". After a while we swing into a narrow, dark minor road and dip our lights for an approaching car. Of course, the headlights then come on "dim" because we have forgotten that the switch was left in this position.

It is easy to see that here we have a potentially dangerous situation. If the driver can always remember to switch to "bright dip" when he leaves town the problem need never arise, but the purpose of the author's modifications to the circuit is to make the dimming system self-cancelling. The new circuit,

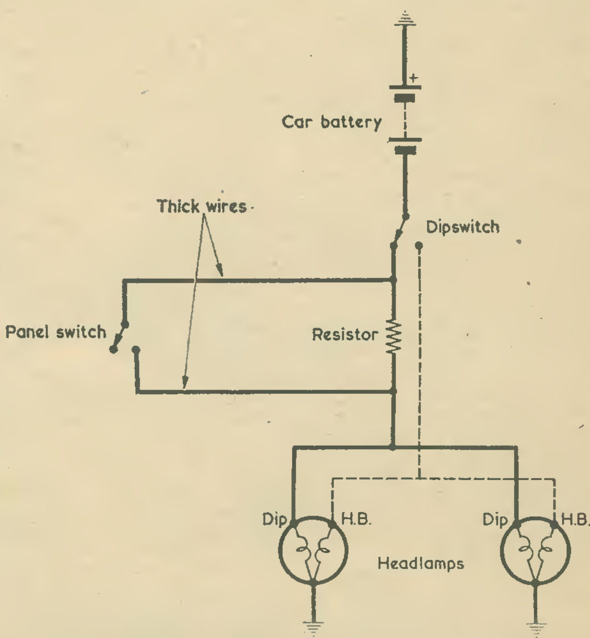


Fig. 1. The original dimming circuit. The panel switch enables the resistor to be inserted in series with the dip filaments

shown in Fig. 2, ensures that whenever high beam headlights are used the dimming facility is cancelled and the dipped headlights will always come on bright.

Fig. 2 shows two push button switches "A" and "B". If the dipswitch is in the "dip" position, "A" will dim the headlights and "B" will brighten them. The relay RY1 has one pair of contacts normally open and one pair normally closed. The normally closed pair short-circuit the resistor R1 so that, when no current flows through the relay coil, the headlights operate bright. This is a "fail safe" feature as failure of the relay will ensure that bright dipping is always available—only the dimming effect is lost. If the dipswitch is in the "dip" position and button "A" is pressed, current is allowed to flow through the relay coil. The contacts "X" then open so that dipped headlight current has to pass through the resistor R1, while contacts "Y" close. These latter contacts short-circut button "A", locking the relay in the energised position and maintaining the dimmed condition. At any time the dimming can be cancelled by pressing button "B", interrupting the relay current and restoring bright dip. Whenever the dipswitch is operated for high beam the relay current is similarly interrupted and the dimming function cancelled.

COMPONENTS

The push button switches can be small neat types of low current handling capacity. One is a push-to-make and the other a push-to-break type. Suitable types are readily available through home-constructor channels.

The relay employed by the writer is a 12 volt component and is one of a "cheap lot" obtained for experiments and other applications. The normally open contacts "Y" have only to handle the energising current for the relay whilst the normally closed contacts "X" carry about 2 amps in the lighting circuit. (Relays suitable for applications of this nature are normally available through surplus channels, with suppliers' stocks varying from time to time. Readers having difficulty may note that a 300Ω 12 volt relay with 4 make contact sets and 1 changeover contact set, all rated 3-5 amps, is available from G. W. Smith & Co. (Radio) Ltd., 3 Lisle Street, London, W.C.2. The unwanted contact sets of this relay need not, of course, be wired into the circuit.—EDITOR).

The high dissipation resistor R1 is easily made but requires careful adjustment to obtain the required degree of dimming. Perhaps a suitable resistor could be bought but it would have to be at least a 20 watt type.

The wire for the author's resistor was obtained from an old electric fire element but other similar resistance wire could be used. If a 1 kilowatt element is used designed for 240 volts then its resistance will be about 60Ω. A good starting value for R1 is 1Ω and the length of resistance wire can be calculated as one sixtieth of the total length. Under these conditions the wire will carry about the same current as it does when used as a fire and so it would glow red hot. This is not good for the present purpose and a better plan is to select four times the calculated length and wind it double on the former. This gives the same resistance but spreads the heat. The former is a short length of the original element former and can be mounted between two metal brackets secured to a block of insulating material. Mountings holes pass through these brackets into the central hole of the former, and also act as terminals. The resistor should not, however, be finally made up and mounted until the length of resistance wire needed for the particular car in which it is to be fitted has been experimentally determined.

It is most important to select a suitable mounting position for the resistor, since it must be kept clear of anything which might be damaged by the heat produced. The best position is probably under the bonnet in a well ventilated position. The relay should be mounted nearby, suitably housed against the elements. The relay could be mounted behind the panel with the buttons inside the car but then thick

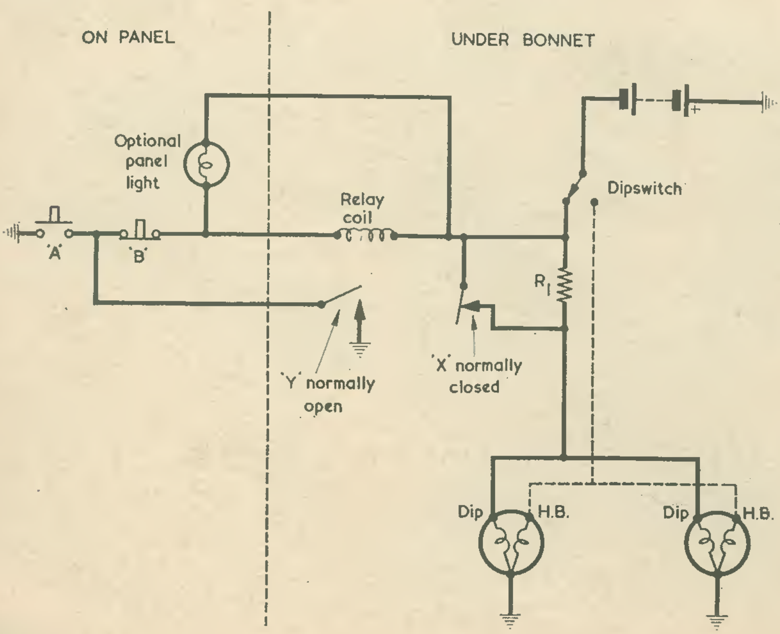


Fig. 2. Improved circuit, in which dimming is automatically cancelled when main filaments are selected

wire would have to be used from the resistor to the panel because it would have to carry the whole of the dipped headlamp current without much dimming and without itself overheating. If the relay is near the resistor then thin wires only need pass to the buttons, as only relay coil current is carried by them.

Don't forget to use wire specially made for car wiring. Radio men often use whatever wire is available and under stress and vibration it sometimes breaks after a few thousand miles. The break in the dip filament circuit need not actually be done by cutting. There will probably be a bunch of snap connectors handily placed. The car manual will make an easy job of locating them and finding the right connector from the colour code.

As a final touch, a panel light could be included which would glow when the headlamps were dimmed. This would be a 12 volt type of low wattage rating wired as shown.

CALCULATIONS

The following *approximate* calculations (which ignore changes in filament resistance when operating under dimmed conditions) give an idea of what is required of the resistor.

Assume 36 watt dip filaments and a value of 1Ω in R1. Then, the total dipped headlamp power is 72 watts, giving a current from the 12 volt supply of 6 amps. This corresponds to a resistive load of 2Ω. With the filaments dimmed due to the insertion of R1 the total load resistance rises to 3Ω, and the current from the 12 volt battery falls to 4 amps. Thus, relay contacts "X" must switch 2 amps (6 minus 4) whilst the resistor must be able to carry 4 amps. Dissipation in R1 (from I^2R) is 16 watts.

RADIO CONSTRUCTOR CROSS-WORD

Compiled by W. M. Fraser

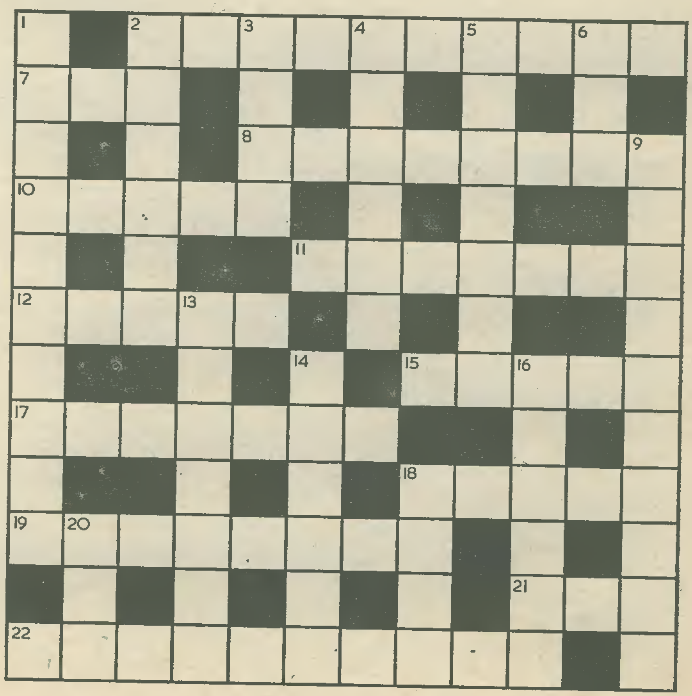
Check your radio and electronic knowledge with this (fairly) simple puzzle. The solution appears on page 584.

Clues Across

1. The fate of the mismatched input signal (10).
7. Necessary for operation of 2 Down (3).
8. These determine feedback polarity (8).
10. Conducive to partition noise (5).
11. And start again! (5, 2).
12. A Koomans is one example (5).
15. Often used to prolong thyratron lifespan (5).
17. Chassisless construction, perhaps (7).
18. Can be expressed in nepers (5)
19. Stretch that single turn (8).
21. It moves, in the micro-wavemeter (3).
22. Location of low frequency beacons (5, 5).

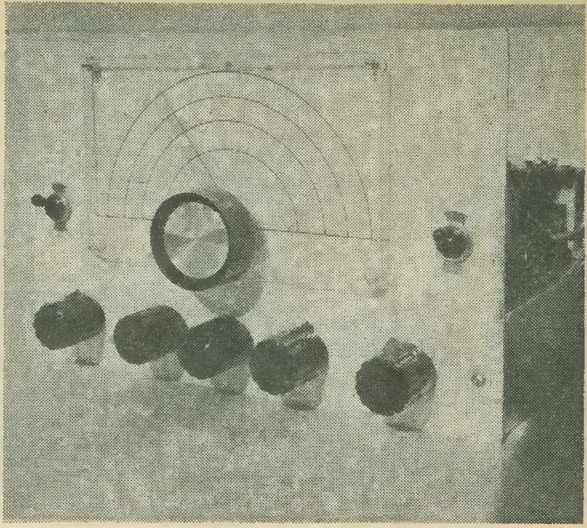
Clues Down

1. Aspired to become the first waveguide (4, 6).
2. A switch to protect the transmitter (4, 1, 1).
3. Means of current diversion (4)
4. Sign of a contented twin feeder (2, 4).
5. Provided by a B-scope (7).
6. 6.25 x 10^{11} electron volts (3).
9. Prior to autochanging (3, 7).
13. Only one needed for monostatic radar (7).
14. Proving phase for design cerebration (6).
16. Base features of a 6V6 chassis? (6).
18. A comparatively lengthy period in the Blocking Oscillator (4).
20. Assists in the tea-room calculations (3).



Cover Feature

FIVE-VALVE AMATEUR ALL-WAVE RECEIVER



by

F. G. RAYER, Assoc. I.E.R.E., G3OGR

Offering an impressive performance, this 5-valve receiver incorporating a b.f.o. covers 30Mc/s to 550kc/s with a high degree of sensitivity. The use of plug-in coils eliminates the complications of range switching. A particularly valuable feature is a built-in aerial circuit Q-multiplier, this providing considerably increased gain and freedom from second channel interference

THIS IS QUITE A COMPACT RECEIVER CAPABLE OF very good results. It is primarily intended to cover 30Mc/s to 550kc/s, or about 10 to 550 metres, in four bands. Long wave coils can be added if complete coverage is required.

There are several controls in addition to those normally encountered and reference to the circuit in Fig. 1 will clarify the purpose of these. They help in giving good reception of weak signals as well as in the reception of c.w. and s.s.b. transmissions.

ALL-BAND COVERAGE

For easy all-band coverage without switching, plug-in coils from the Denco Miniature Dual-Purpose Range are used, L1 being in the aerial circuit and L2 in the oscillator circuit. Each waveband is tuned by placing a Green coil in the L1 holder and the matching Red coil in the L2 holder.

VC1 and VC2 provide the usual ganged tuning capacitor, this operating with a 2-speed drive and calibrated dial. VC3 is a panel aerial trimmer control, allowing the aerial circuit to be peaked on all frequencies. All oscillator coils have a fixed trimmer, C6 so the only trimming adjustment needed is given by VC3.

The triode V1 is a regenerative stage, or aerial circuit Q-multiplier. All the L1 coils are t.r.f. types with a regeneration winding, and feedback is controlled by VC4. For most general reception requirements VC4 can be left near minimum capacitance, allowing normal superhet performance on all bands. When, by increasing capacitance in VC4, V1 is brought towards the point at which oscillation commences, there is a considerable increase in sensitivity and the aerial circuit, trimmed by VC3, peaks much more sharply. This brings up signals otherwise too weak for reception, and also increases the second channel rejection given by L1. For maximum possible results, VC4 is operated in the same way as with a t.r.f. receiver reaction control, and is closed just sufficiently to bring V1 to the point where further regeneration would cause oscillation.

V2 is the frequency changer stage. Each oscillator coil fitted in the L2 position requires a different padder capacitor "P". The coils are so made that the padders can be wired to different holder tags, and are then automatically brought into circuit when the appropriate coil is plugged in. The receiver tuning ranges, together with padding capacitor information, are shown in the accompanying Table.

If long wave coils (Denco Range 1) are also to be used, a 110pF 2% silver-mica capacitor is connected from pin 5 to chassis. Also, the grid connection for the Range 1 Red coil is to pin 7 and not pin 1 as with the other coils, whereupon pins 1 and 7 of the L2 coil holder will need to be connected together.

Gain in the heptode section of V2 may be reduced by VR1. This is helpful with strong s.s.b. signals, and also occasionally at other times, as when using headphones. As is explained later, no a.g.c. on-off switch is provided.

The pentode section of V3 is the i.f. amplifier, one of its diodes being used for detection and a.g.c. A.G.C. bias is applied to both V1 and V2 via R7. VR1 is the audio gain (volume) control, and V4(a) is one half of a double-triode, with R10 having a high value to provide contact-potential bias. V5 is a small output pentode.

V4(b) is the b.f.o. triode. For a.m. reception, S1 is open and the b.f.o. is inoperative. Closing S1 brings the oscillator into use, the coil L3 being tuned by VC5. C15 couples V4(b) to the diode of V2 and allows a heterodyne beat to be produced for c.w. reception. V4(b) also provides carrier insertion for s.s.b. reception. The coupling via C15 is such that the b.f.o. output does not increase the a.g.c. voltage excessively.

The current drain of the whole circuit is quite small, and h.t. is obtained from a half-wave secondary on T2, using a contact-cooled rectifier and the smoothing circuit given by C24, C25 and R17.

PREPARING THE CHASSIS

The components are assembled on an aluminium chassis measuring 10in by 7in by 2in deep. Figs. 2 and 3 gives the essential drilling dimensions. It is best to finish drilling before fixing any components. The i.f. transformers require clearance holes for the tags and also a central hole for the lower core adjustment. L3 has only a single core, so can be adjusted from above or below. Sleeving can be placed on the tags of L_3 and the i.f. transformers. When these items are fitted, be sure the numbered tags appear as in Fig. 3.

The valveholders and coil holders will, when fitted, take up the orientation shown in Fig. 2. Their holes may conveniently be made with the aid of a chassis cutter. Note that two holes are needed for the passage of wires to T1 and T2. A third hole (not shown) is required under S1 for the leads to this switch. All these holes should later be fitted with grommets. A large hole is also needed for C24, C25, and two small holes for the wires to VC1 and VC2.

The ganged capacitor VC1/VC2 must be about $\frac{1}{8}$in. clear of the chassis surface, so washers are needed on its fixing bolts. The panel measures 10 by 6½in, and this should be marked in line with the ganged capacitor spindle, to provide a centre for the drive fixing. The ganged capacitor specified has a spindle which is approximately 1in above the chassis surface when mounted. Should a component be used having a higher spindle a higher panel will be needed to take the drive. Holes for the drive are positioned with the aid of the template provided with the drive. The panel is secured by the bush mounting nuts of the lower controls.

A 2-way socket strip is used for speaker connections, and a single terminal mounted directly to the chassis for the earth connection. The aerial socket is a single insulated type. A 2-way socket strip for aerial and earth connections would also be suitable.

When the valveholders and coil holders are mounted, fit 6BA solder tags under the securing nuts at the points marked "MC" in Fig. 3.

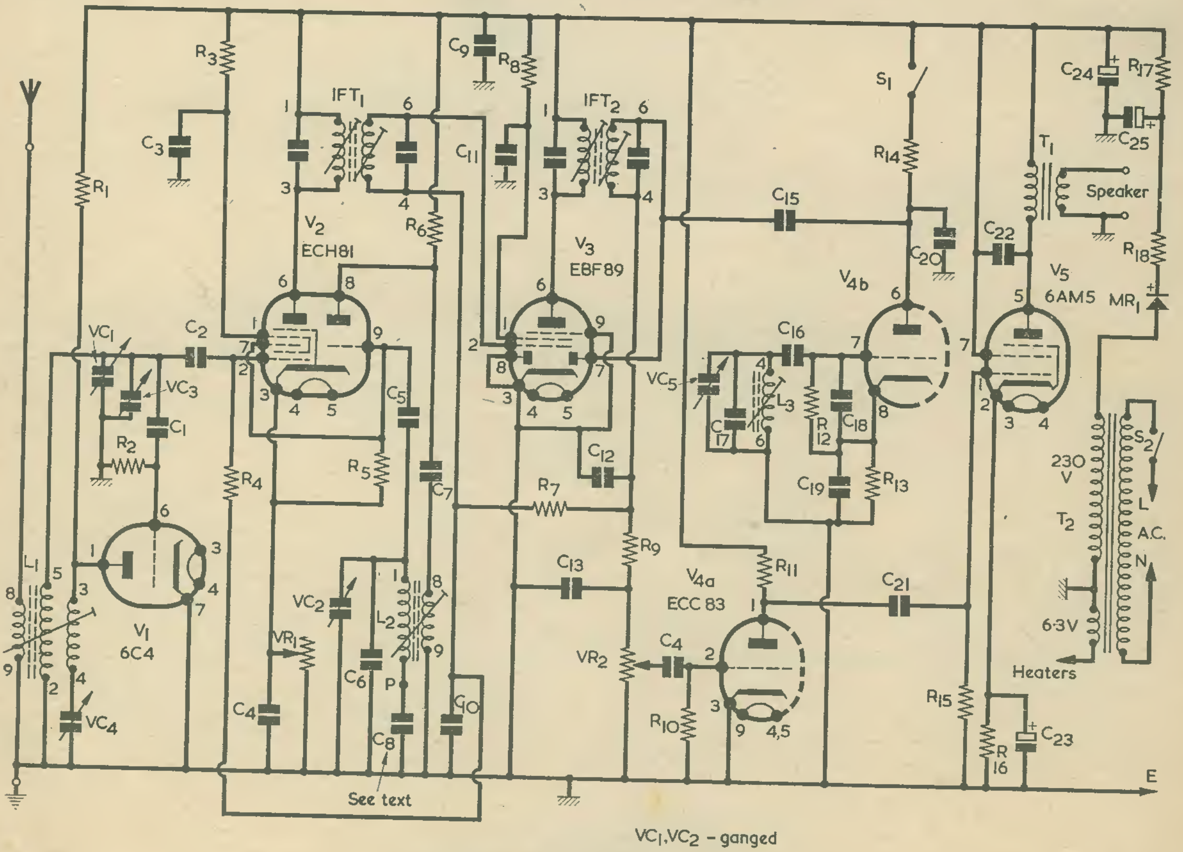


Fig. 1. Circuit diagram of the Five-Valve Amateur All-wave Receiver

Table

Coil range and padding details

Range	Frequency coverage	Padding capacitance and coil holder pin
2	1,500-550kc/s	350pF, pin 2
3	4.5-1.6Mc/s	1,000pF, pin 3
4	12-5Mc/s	3,000pF, pin 4
5	30-10Mc/s	No padder, pin 6 to chassis

ABOVE CHASSIS WIRING

Leads from S1 pass through the chassis to R14 and C24 positive (h.t. positive line). VC1 is connected to tag 5 of L1 holder, and VC2 to tag 1 of L2 holder.

Secondary connection from T2 are taken to the speaker sockets. The primary connections pass to h.t. positive and V5, tag 5.

A 3-core cord is required for mains connections, and is best taken to a 13A plug fitted with a 3A or other small fuse. At the receiver, the conductors are soldered to a tagstrip, as in Fig. 2. Earth connects to chassis, neutral to the primary of T2, and the live conductor to S2.

UNDER CHASSIS WIRING

Fig. 3 shows all connections, but a few points should be noted. VC3 and VC4 lie partly over V1 and L1 holders, so are not fully drawn in Fig. 3. It is best to fit them after wiring the holders.

Use short, direct connections to valveholders and coilholders. The heater circuit can be wired first, running its leads against the chassis. The wire ends of resistors and capacitors must be shortened, so that these items are near the tags required. This is particularly important with C1, C2, R2, C3, C5 and C7 and all padders.

The valveholder for V3 must have a central spigot, earthed as in Fig. 3, or this stage may oscillate in

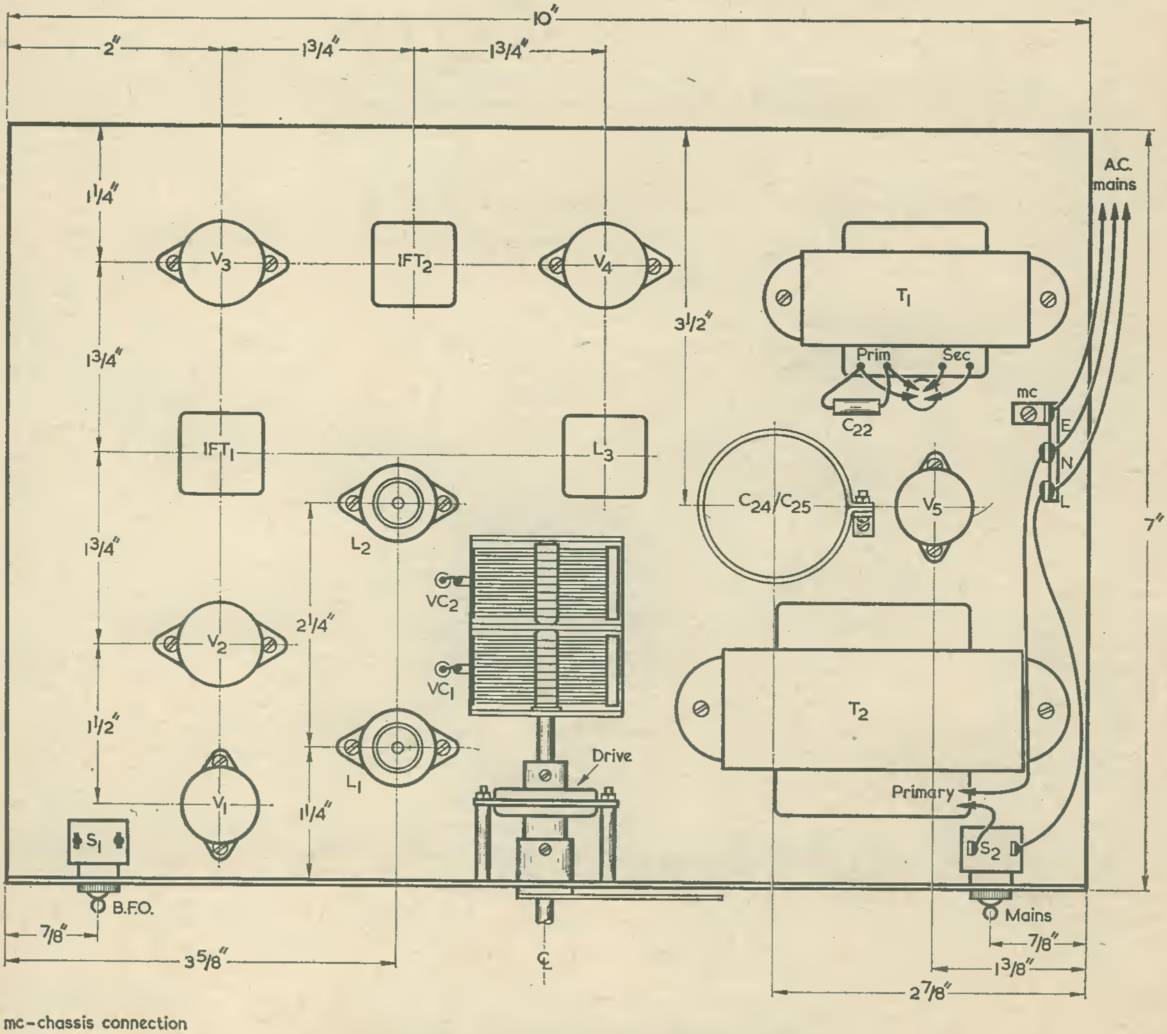


Fig. 2. Layout and wiring of components above chassis. Note that the positions shown for the primary and secondary tags of T1 will vary with different transformers

the absence of a.g.c. bias.

If the leads from VR2 and C14 run against the chassis, they need not be screened. C24, C25 are in a single can, the can being common negative and earthed by its fixing clip to the chassis. Burr should be removed from fixing holes for the contact cooled rectifier, so that it lies flat on the chassis side.

B.F.O. STAGE

V4(b), L3, VC5, and associated components provide the b.f.o. stage. R14 is supported by an insulated tag, and S1 completes the h.t. circuit to R14 when the b.f.o. is required.

VC5 is mounted on a bracket, and its spindle is

COMPONENTS

Resistors

(All fixed values $\frac{1}{4}$ watt 10% unless otherwise stated)

R1 47kΩ $\frac{1}{2}$ watt
R2 1MΩ
R3 22kΩ 1 watt
R4 1MΩ
R5 47kΩ $\frac{1}{2}$ watt
R6 22kΩ 1 watt
R7 1MΩ
R8 47kΩ
R9 100kΩ
R10 10MΩ
R11 220kΩ $\frac{1}{2}$ watt
R12 100kΩ $\frac{1}{2}$ watt
R13 10kΩ
R14 47kΩ $\frac{1}{2}$ watt
R15 470kΩ
R16 680kΩ 1 watt
R17 2.7kΩ 2 watt
R18 100Ω $\frac{1}{2}$ watt
VR1 25kΩ potentiometer, linear track
VR2 1MΩ potentiometer, log track

Capacitors

C1 35pF silver-mica
C2 100pF silver-mica
C3 0.05μF paper or plastic foil, 350V wkg.
C4 0.01μF paper or plastic foil, 150V wkg.
C5 47pF silver-mica
C6 18pF silver-mica
C7 200pF silver-mica
C8(a) 350pF 2% silver-mica
C8(b) 1,000pF 2% silver-mica
C8(c) 3,000pF 2% silver-mica
C9 0.25μF paper or plastic foil, 350V wkg.
C10 0.25μF paper or plastic foil, 150V wkg.
C11 0.01μF paper or plastic foil, 350V wkg.
C12 100pF silver-mica or ceramic
C13 100pF silver-mica or ceramic
C14 1,000pF paper or plastic foil, 150V wkg.
C15 2.5pF nominal (see text)
C16 100pF silver-mica
C17 400pF silver-mica
C18 500pF silver-mica
C19 500pF silver-mica
C20 100pF silver-mica or ceramic
C21 0.01μF paper or plastic foil, 350V wkg.
C22 0.01μF paper or plastic foil, 500V wkg.
C23 25μF electrolytic, 25V wkg.
C24 16μF electrolytic, 350V wkg.
C25 8μF electrolytic, 350V wkg.
VC1, VC2 365 + 365pF 2-gand variable, type 02 (Jackson Bros.)
VC3 50pF variable air-spaced
VC4 75pF variable air-spaced
VC5 75pF variable air-spaced
(N.B. C24 and C25 are in a single can. VC3, VC4 and VC5 may be Jackson Bros. type C804 or similar.)

Inductors

L1 Denco Miniature Dual-Purpose Coils, Green, Ranges 2, 3, 4 and 5
L2 Denco Miniature Dual-Purpose Coils, Red, Ranges 2, 3, 4 and 5
L3 Screened coil type SL/Y (Electroniques)
IFT1, IFT2 I.F. transformers type IFT.11/465 (Denco)
T1 Mains pentode output transformer, ratio from 60:1 to 80:1, for 3Ω speaker
T2 Mains transformer; secondaries 230V 45mA, 6.3V 1.5A; Cat No. TM26A (Home Radio)

Valves

V1 6C4
V2 ECH81
V3 EBF89
V4 ECC83
V5 6AM5

Rectifier

MR1 Contact cooled half-wave rectifier, 250V 50mA

Switches

S1 s.p.s.t. toggle
S2 s.p.s.t. toggle

Drive, Knobs

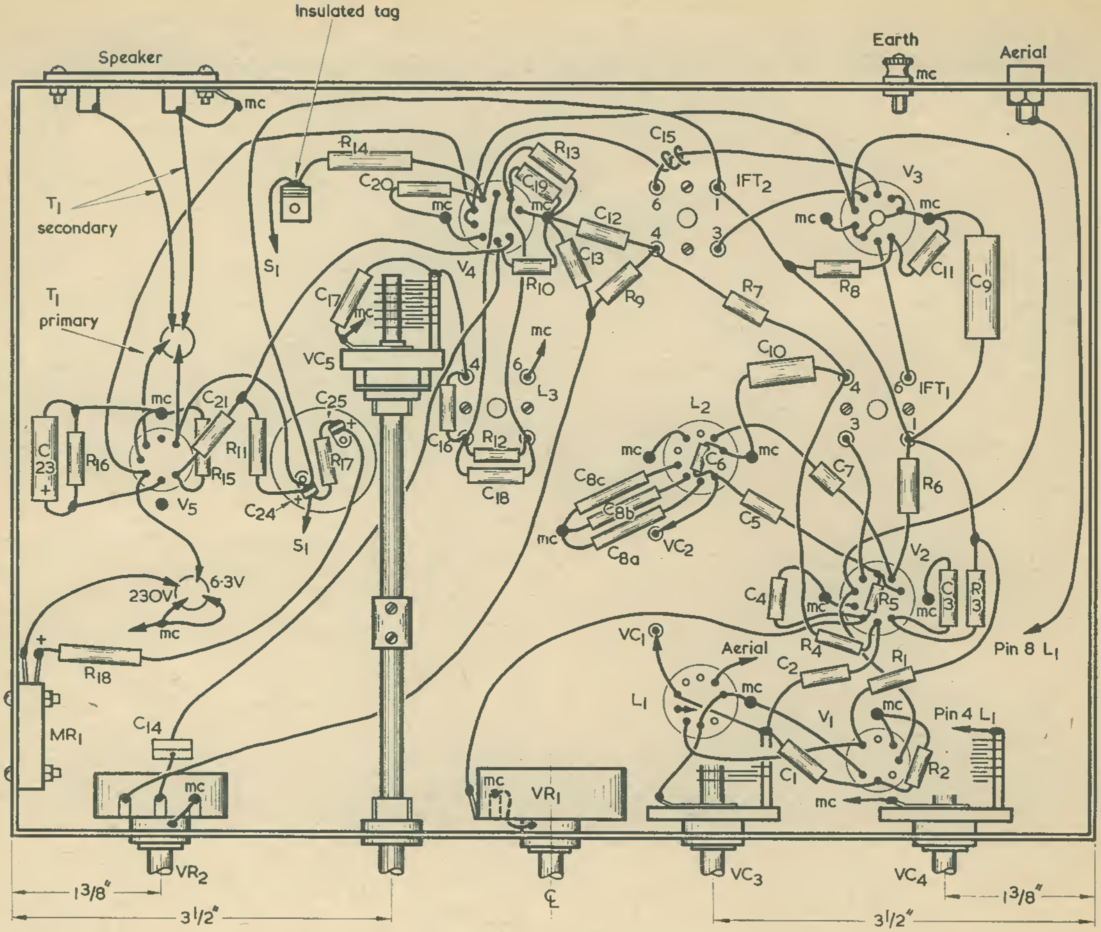
Dial drive type SMD2/BK (black knob) or SMD2/WH (white knob) (Electroniques)
Five lin dia. knobs

Valveholders, Sockets

Three B9A valveholders, with centre spigots and skirts
Two B9A valveholders, without skirts (for L1 and L2)
Two B7G valveholders, without skirts
2-way speaker socket strip
Insulated aerial socket

Miscellaneous

Earth terminal
Bracket (home-constructed), $\frac{1}{4}$in shaft, shaft coupler, panel bush (all for VC5)
3-way (one earthed) tagstrip
Single insulated tag
14 6BA solder tags
Chassis, 10 by 7 by 2in
Panel, 10 by $6\frac{1}{2}$in



mc - chassis connection

Fig. 3. The wiring and components below the chassis

extended by a coupling and $\frac{1}{4}$in diameter rod, which passes through a panel bush as in Fig. 3.

The b.f.o. coil L3 has four tags. Tags 4 and 6 connect to the winding, tag 6 being earthed to chassis. The remaining tags are used as anchor points for R12, C16 and C18. They have no internal connections inside the coil can.

C15 is specified as 2.5pF nominal, and it can be a ceramic capacitor of this value or a 10pF trimmer which is later adjusted for best results. However, a physical capacitor is not really necessary and adequate coupling is given by wrapping insulated connecting wire for about two turns round the lead from tag 6 of IFT2, as shown in Fig. 3.

After all wiring has been checked, the receiver can be aligned and tested. The alignment and operating details which follow are suitable when no signal generator is available. But should such an instrument be to hand, it can of course be utilised in the usual way to set the i.f. cores, and band coverage on each range. It should be remembered that the i.f. transformer cores will be set to approximately their correct positions at the factory and that these cores should not therefore be touched before alignment commences. This point considerably eases alignment problems if a signal generator is not to hand.

I.F. ALIGNMENT

When setting up the i.f. transformer cores, a proper insulated tool should be used. Temporarily set VR1 so that most or all of its resistance is in circuit, and clip a testmeter, switched to a 10mA or similar range, across C4, with negative to chassis. Set VC4 to minimum capacitance.

It is probably best to select a steady medium wave transmission. As this is tuned in, the meter reading should fall. Tune the signal correctly and also adjust VC3 for minimum meter reading. The four i.f. transformer cores are then rotated carefully, as needed, for minimum meter reading. This should be repeated with a weak signal, which can be obtained by removing the aerial, or using only a short wire. The i.f. transformer cores then need no further adjustment, but the meter may be left connected for the present.

COIL CORES

The brass threaded rods of the coil cores are generally fully in when the coils are packed. Initially, each can be unscrewed so that about $\frac{1}{4}$in. to $\frac{3}{8}$in. projects at the top.

Deal with each pair of coils (Green for aerial and Red for oscillator) separately. To retain dial calibration, the oscillator cores should be locked with 6BA nuts. The medium wave coils can be adjusted first. Tune in a transmission around 1500-1000 kc/s and peak VC3 for minimum V2 cathode current, as shown by the meter. Tune towards the low frequency end of the band. Select a suitable signal, and rotate the core of L1 for lowest meter current, leaving VC3 untouched. It should now be possible to tune over the whole band with good results, although VC3 may need slight readjustment at any one point for maximum possible signal strength.

Should band coverage at the low frequency end of the band be unsuitable adjust the core of L2 to correct this, and readjust the core of L1 to suit.

Deal with other bands in the same way. Usually, VC3 should have quite a sharp tuning peak, somewhat towards the fully open position.

After all the coils have been aligned, the testmeter may be disconnected from C4.

Q-MULTIPLIER

When a range has been aligned as described, the effect of slightly closing VC4 can be tried. With a weak signal tuned in accurately, closing VC4 should increase signal strength and the sharpness of tuning obtained with VC3. This continues until a critical point is reached. Closing VC4 beyond this point results in a sudden drop in volume or loss of signals, as V1 commences to oscillate.

When attention is given to a small band of frequencies, such as an amateur band, VC4 will need little adjustment, except to boost extremely poor signals. VC4 may also be left nearly fully open for general reception. Otherwise, VC4 needs readjustment when considerable changes are made in frequency or when coils are changed, exactly as with a t.r.f. receiver reaction control.

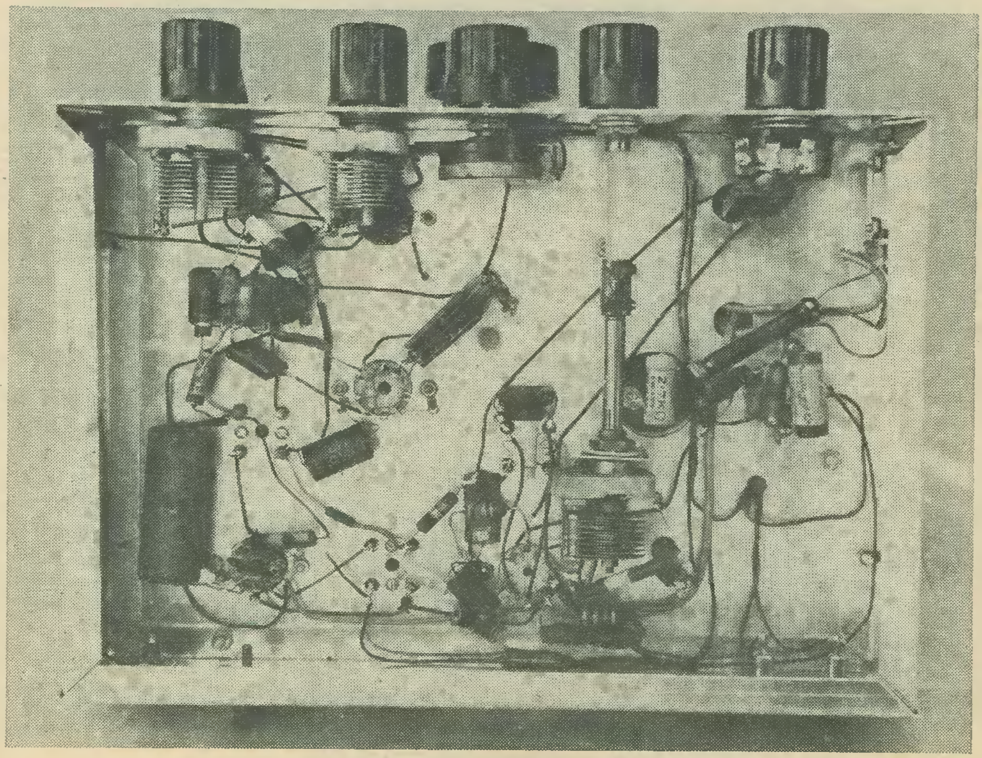
Regeneration is somewhat influenced by aerial loading. If the aerial is long it is helpful to place a small preset variable capacitor in series with the aerial lead at the receiver. A maximum capacitance of around 50pF is sufficient.

Correct adjustment of VC3 and VC4 will allow the aerial circuit to tune very sharply. Sensitivity was measured at 21 Mc/s and was sufficiently good to allow a signal of 1 microvolt to be copied, using a loudspeaker.

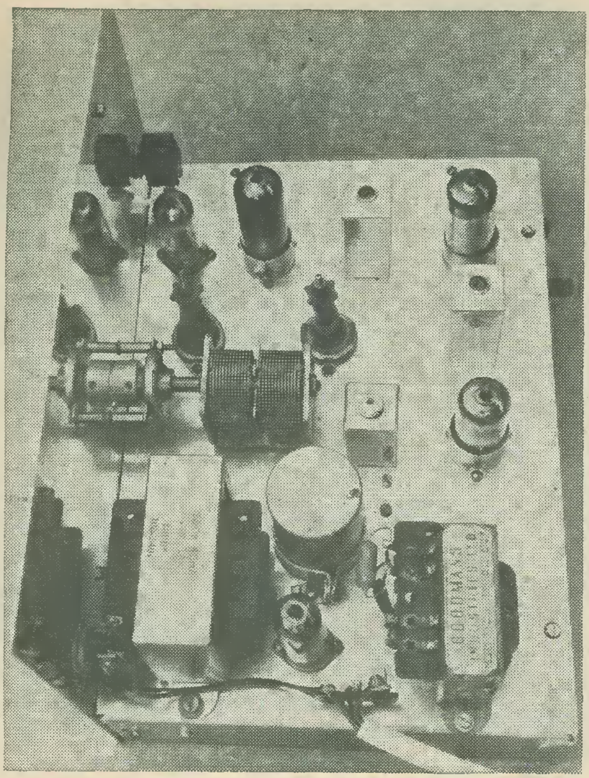
B.F.O. OPERATION

Component values in the b.f.o. stage are chosen to allow VC5 to adjust the b.f.o. a few kc/s on each side of the receiver intermediate frequency. To set up the b.f.o. after construction has been completed, carefully tune in a transmission, close S1, set VC5 half closed, and rotate the core of L3 until a heterodyne whistle is heard and drops in frequency until it is almost inaudible. A beat note can then be produced and adjusted in pitch by opening or closing VC5.

For c.w. reception, adjust VC5 to put the beat frequency oscillator above or below the intermediate



Wiring below the chassis is neat, and raises few constructional problems



Despite the relatively small size of the complete receiver, there is no overcrowding of components, as this upper view illustrates

frequency and to obtain an audio tone giving best readability.

For single sideband reception tune the signal for about best volume with VR2 near maximum gain. Reduce volume with VR1. VC5 is then adjusted so that the b.f.o. provides the suppressed carrier. If the signals cannot be made intelligible, rotate VC5 through the zero heterodyne position to the other sideband position.

Failure to resolve s.s.b. signals with this type of circuit usually arises from having the received signal too strong at the detector. As the circuit stands at present it offers good results and it was not felt necessary to modify it by increasing b.f.o. injection. Nevertheless, the circuit can be so modified, if desired, by adding an a.g.c. switch to short-circuit C10 when a.g.c. is not required, whereupon C15 may be increased in value with a possibly improved performance with some s.s.b. signals. Increasing the value of C15 will necessitate a re-alignment of IFT2.

If, with the receiver in the unmodified state and using the twisted wire capacitor for C15 which is shown in Fig. 3, it is found that excessive a.g.c. voltage is produced when the b.f.o. is switched on, the capacitance can be reduced by slightly untwisting the outer wire. Again, a subsequent readjustment of IFT2 becomes necessary.

As a final point, the receiver should not be operated without a loudspeaker or similar low impedance load connected across the speaker terminals as, otherwise, excessively high a.f. voltages can appear in the anode circuit of V5.

■

RADIO CONSTRUCTOR CROSS-WORD SOLUTION

(See Page 577)

K		A	T	T	E	N	U	A	T	E	D
I	O	N		A		O		Z		R	
N		T		P	H	A	S	I	N	G	S
G	R	I	D	S		R		M			E
C		T			S	C	R	U	B	I	T
A	R	R	A	Y		S		T			R
N			N		T		C	H	O	K	E
U	N	I	T	A	R	Y			C		C
T			E		I		R	A	T	I	O
E	L	O	N	G	A	T	E		A		R
	E		N		L		S		L	I	D
L	O	R	A	N	S	I	T	E	S		S

SUTTON & CHEAM RADIO SOCIETY

The Sutton & Cheam Radio Society announce their 21st Annual Dinner and Ladies' Festival to be held at The Crown Inn, Morden, Surrey (just by Morden station at end of Northern Line Underground), on Saturday, April 12th, 1969. Reception at 6.30 pm.

The President of the R.S.G.B., Mr. J. W. Swinnerton, G2YS, has kindly accepted an invitation to attend as Guest of Honour, and it is expected that a number of other well-known personalities in the field of amateur radio will be present.

A really first-class evening, including cabaret, is planned and a heavy demand for tickets is anticipated. Please contact Roy Scott, G2CZH, 140 Seymour Avenue, Morden, Surrey, as soon as possible for bookings, at 35/- per person, and further information.

SIMPLE "IMPEDANCE CONVERTER"

by

G. W. SHORT

The simple circuit described here can be used to match a high impedance device such as a crystal pickup to a transistor amplifier having a relatively low input impedance

ALTHOUGH FIELD-EFFECT TRANSISTORS CAN PROVIDE very high input impedances (as much as a million megohms in some cases), the ordinary bipolar transistor is still the best device for matching moderately high impedances to low ones. The reason is basically economic: field-effect transistors cost around 10s., while suitable bipolar transistors cost around 3s. Ordinary transistors are also much less susceptible to damage by overload, and in the type of circuit discussed here they cause less distortion than do field-effect transistors.

The "impedance converter" shown in the accompanying diagram is almost the simplest possible circuit for the job. There is no "bootstrapping", no "Darlington pair", nothing tricky or expensive at all. Yet its input impedance is high enough for a wide range of purposes, being 2.7MΩ with an average BC109C or BC168C, and 2.5MΩ or 3.3MΩ with low or high-limit transistors. Its frequency response is flat from sub-audio to low radio frequencies, and it will handle input signals of 1V r.m.s. without overloading. In addition, it is very insensitive to supply-voltage variations; the prototype worked quite happily from 1.5 to 50V, the only ill-effect being a reduction of signal-handling capacity to 150mV at the low-voltage end of this range. Not bad for a total of six components, including the transistor. Both the BC109C and BC168C are available, incidentally, from Amatronix, Ltd.

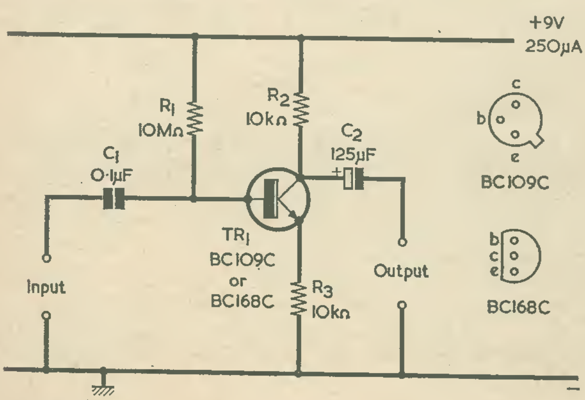
COLLECTOR OUTPUT

Constructors who are familiar with impedance converter circuitry will notice one unusual feature. The output is taken from the collector, not from the emitter as in the conventional type of circuit. There is a very good reason for this, which becomes clear when one examines how the conventional emitter-follower works.

The input impedance of a transistor connected as an emitter-follower is, as any text-book will tell you, roughly h_{fe} R_e where R_e is the load resistance in the emitter circuit and h_{fe} is the "beta" or small-signal current amplification factor of the transistor. In the present case h_{fe} is about 500 and R_e 10kΩ, so the theoretical input impedance is 5MΩ. The actual input impedance is less than this because there are two impedances across the input, one visible (the base bias resistor R1 and one invisible (the internal impedance between base and collector). Together these reduce the input impedance to 2.7MΩ.

Thus, as it stands, the circuit has a high input impedance, and it would appear that this should be the case whether the output is taken from the collector or from the emitter as in a true emitter-follower arrangement. But wait a minute! The 10kΩ load resistance is *not* the true load resistance in a practical working circuit, because it is likely to be shunted rather heavily by the input impedance of the next stage, and this shunting can have a drastic effect when the transistor is used as an emitter-follower. If, for example, the next stage had an input impedance of 2kΩ the effective load of the emitter-follower would be reduced to a mere 1.7kΩ and its theoretical input impedance would then be only 850kΩ—a very different figure from the original one.

No such reduction of input impedance occurs when the output is taken from the collector. In fact, there is a small increase as the load is reduced. (This is due to reduced internal voltage negative feedback via the base-collector impedance.)



COMPONENTS

Resistors

R1 10MΩ
R2 10kΩ
R3 10kΩ

Capacitors

C1 0.1μF
C2 125μF electrolytic, 10V wkg.

Transistors

TR1 BC109C or BC168C

CIRCUIT GAIN

To use the circuit in practice, we need to know its gain. In the case of a true emitter-follower the gain is near enough 1, but now that the short-comings of the emitter-follower have been discussed, we will think in terms of collector output, as in the diagram. What is the gain of this arrangement? This can be estimated, oddly enough, by first considering it as an emitter-follower; i.e. by ignoring R2 and estimating the "gain" from input to emitter. This is, of course, just under 1. It follows that a 1V input produces 1V across R3, near enough. The signal current in R3 is therefore the current that flows in 10kΩ when there is 1V across it. This is 0.1mA, or 100μA. However, the current in R_2 is virtually the same as the current in R3, so the output voltage at the collector is the same as at the emitter. The "gain" is 1 to either output.

In practice, we are not likely to be interested very much in the voltage gain. The next stage will be current-driven rather than voltage-driven, and what we then want to know is how much signal *current* will pass into it for a given signal *voltage* at the input to the impedance converter. If the output terminals were connected together, all the output current would flow through this short-circuit. An input of 1V would cause an output of 0.1mA. In practice, we are more likely to be dealing with millivolts than volts, and the corresponding ratio is 0.1μA output for every 1mV input. Old valve hands will immediately realise that the stage has, therefore, a mutual conductance of 0.1mA/V or 0.1μA/mV.

So far as practical constructional points are concerned, the circuit offers few problems. The three resistors may be $\frac{1}{4}$ watt 10% types, whilst C_2 should have a working voltage equal to or greater than that of the supply. Since the input is at high impedance it will be necessary to use a screened input lead. It may also be necessary to screen the complete stage if there is a possibility of hum pick-up by the input components and their wiring.

EMI TELEVISION IN CONCORDE

EMI Electronics closed circuit television equipment is being installed in Concorde prototypes 001 and 002 aircraft for a variety of applications. The layout of the Concorde is such that it is impossible for the pilot to observe the position of the main and nose undercarriage relative to the runway from the cockpit. This presents a problem during taxying, to ease which, two EMI one-inch vidicon camera heads are fitted to the nose wheel structure, outside the pressurised area, as standard equipment. One camera faces forward with a viewing angle of 90 degrees and one faces aft with a viewing angle of 65 degrees. They are connected by means of a special camera cable to a camera control unit located in the aircraft equipment rack. The pictures, which are easily selected, are fed to a special 6in. monitoring screen located by the captain's nosewheel steering control.

In the prototype aircraft the forward-looking nosewheel camera can also be used as a landing aid if required; to ensure the correct aspect ratio for this operation an existing 11-inch monitor has been especially adapted. The monitor has a very complex shape to enable it to be readily positioned in front of the captain at eye level.

For flight test purposes in 002 aircraft three EMI sub-miniature television cameras, based on the EMI camera type BC1103 which uses an EMI half-inch vidicon will be used in the small space available in engine nacelles to enable possible in-flight icing conditions to be observed. Special optical devices have been engineered to give the viewing angles required in the confined spaces available. Two EMI one-inch vidicon cameras can also be used to monitor various parts of the aircraft external surfaces so that they can be kept under observation. All five flight test cameras are controlled from one camera control unit with full remote control and camera selection facilities. Pictures can be selected for showing on two special 8in. monitor screens and can also be recorded on a video tape recorder.

The EMI television equipment operates from the aircraft power supplies, 115V 400c/s or 28V dc, employs the latest electronic techniques, and contains many safety features. The equipment has to be capable of withstanding very arduous environmental conditions and therefore uses rugged EMI $\frac{1}{2}$ and 1in. vidicons. It has been necessary to develop special interconnecting camera cable, sheathed in PTFE, to cope with the high temperatures to which it will be subjected. All of the equipment has to be manufactured and tested to meet the requirements of international airworthiness authorities. In the systems engineering of this specialised television equipment ruggedness, size, weight, reliability and simplicity of operation are important factors. Automatic sensitivity control operates over a very wide range of lighting conditions.

UNDERSTANDING RADIO

"MAGIC EYE" INDICATORS

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

by W. G. Morley

In last month's contribution to this series we concluded on the subject of a.g.c. then turned our attention to tuning indicators. We examined in detail the simplest of the electron-ray tube indicators, as exemplified by the 6U5G "Magic Eye". We saw that the 6U5G has a triode whose anode connects internally to a deflector rod. Around the upper end of the cathode is the target, this being coated with a fluorescent material which gives a green glow when bombarded with electrons. The deflector rod projects through a hole in the target and is parallel with the cathode. The triode anode connects to an h.t. positive supply via a resistor of the order of 1MΩ, whilst the target connects to the h.t. positive supply directly.

When there is zero voltage at the triode grid (with respect to cathode) the deflector rod is at its most negative potential and causes a wide angle of "shadow" in the green fluorescent display given by the target. If a negative voltage is applied to the grid, the deflector rod goes positive and the angle of shadow reduces.

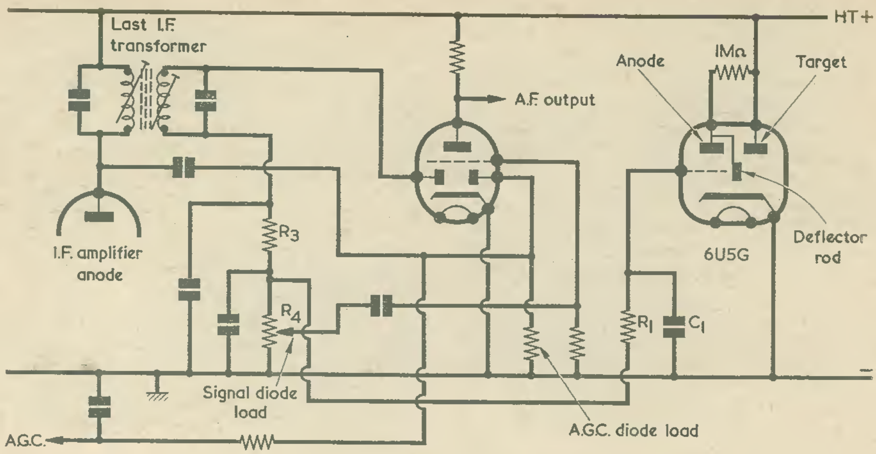
We shall now see how the 6U5G may be coupled to the circuits of a valve a.m. superhet receiver in order to function as a tuning indicator.

"MAGIC EYE" CONNECTIONS

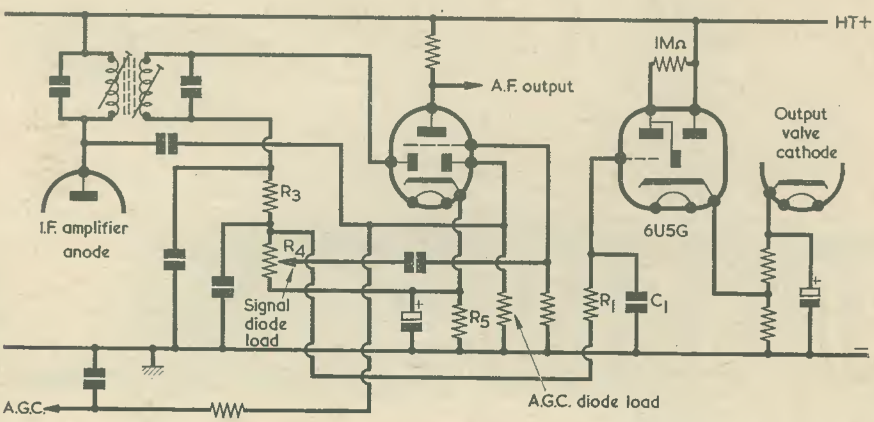
The "Magic Eye" is connected into the receiver by coupling the grid of its triode section either to the signal diode load, or to the a.g.c. diode load. The voltage obtained from these loads goes negative on receipt of a signal and causes the "Magic Eye" shadow angle to reduce, the shadow angle being at a minimum when the voltage is at its most negative, as occurs when the associated receiver is correctly tuned. If, however, the a.g.c. diode in the receiver is fed from the primary of the last i.f. transformer the negative voltage provided at the a.g.c. diode load does not increase as sharply, when the tuning capacitor approaches its correct setting, as does the negative voltage given (after the i.f. transformer secondary) at the signal diode load. With receivers having this type of a.g.c. circuit it is, in consequence, preferable to couple the "Magic Eye" triode grid to the signal diode load. It is also preferable to couple the "Magic Eye" to the signal diode load if the a.g.c. diode has a voltage delay. If, in this last instance, the "Magic Eye" were coupled to the a.g.c. diode load it would offer no indications when receiving weak signals having insufficient amplitude to overcome the a.g.c. delay.

Let us next examine three typical examples of the manner in which a "Magic Eye" tuning indicator is connected into a receiver circuit. To start off with, Fig 1(a) illustrates a 6U5G "Magic Eye" coupled to a detector circuit in which the a.g.c. voltage is obtained from the primary of the last i.f. transformer, but where there is no voltage delay. It is assumed that the two diodes are part of a double diode triode, the triode section of which is an a.f. voltage amplifier.

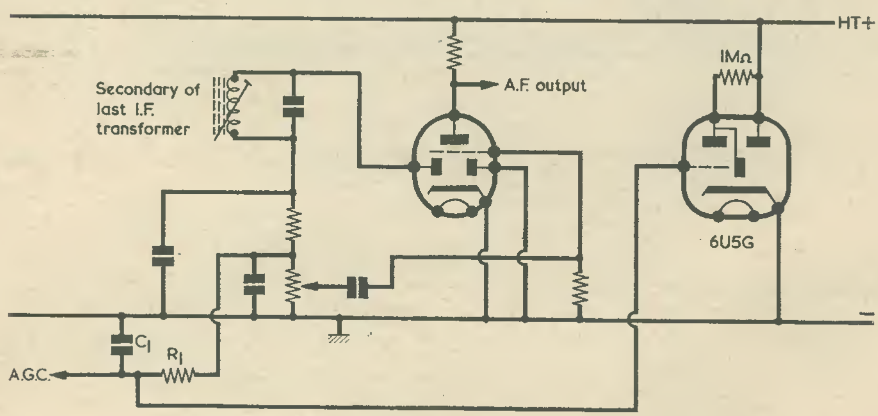
In Fig 1(a) it is preferable to couple the 6U5G triode grid to the signal diode load R4 (which also happens to be the volume control) for the reason just discussed. We cannot, however, connect the "Magic Eye" triode grid directly to the load because its shadow angle would fluctuate in sympathy with the amplitude modulation on the signal being received, with the result that the shadow edges would become blurred. In consequence, the "Magic Eye" triode grid is connected by way of resistor R1 and capacitor C1. The resistor is of the order of 2 to 3MΩ, and the capacitor has a value which offers a low reactance at audio frequencies. This could be, typically, 0.05μF. Only the direct voltage component of the detected signal now appears at the "Magic Eye" triode grid and the shadow edges are clear and free from blurring. A little care has to be taken in selecting the values of R1 and C1, since R1 causes additional a.c. loading across the signal diode load. (A.C. loading was discussed in the last November and December issues). R1 requires a value considerably in excess of that of the diode load to reduce this effect and, in practice, the figure



(a)



(b)



(c)

of 2 to 3MΩ just mentioned is satisfactory. A further point is that C1 should not have an excessively high value or the "Magic Eye" will be sluggish in indicating changes in voltage across the signal diode load. The value of 0.05μF just instanced gives time constants of 0.1 or 0.15 seconds respectively with R1 at 2 or 3MΩ, and these are satisfactory in practice.

Fig. 1(b) illustrates a signal and a.g.c. diode circuit in which the a.g.c. voltage is obtained from the primary of the last i.f. transformer as before, and in which the a.g.c. system is delayed. The a.g.c. delay is given by the voltage dropped across the cathode bias resistor R5 due to the current drawn by the triode section of the double diode triode. Once again, it is preferable to obtain the control voltage for the

"Magic Eye" from the signal diode load but we now have the complication that, in the absence of signal, the direct voltage provided by R4 is positive of chassis due to the voltage dropped across R5. We cannot now connect the "Magic Eye" cathode direct to chassis, and we return it instead to a point in the receiver circuit which is positive of chassis by the same potential as appears, under no-signal conditions, at the signal diode load. This process can be carried out very conveniently by connecting the "Magic Eye" cathode into a tap in the cathode bias resistance for the receiver output valve, as illustrated. The output valve draws a considerably higher cathode current than does the "Magic Eye", with the consequence that the voltage at the tap in its cathode bias resistance remains nearly constant despite variations in "Magic Eye" cathode current. In the absence of signal, the "Magic Eye" triode grid is now at zero potential with respect to its cathode. When a signal is received the voltage on the signal diode load goes negative, as also does the "Magic Eye" triode grid, whereupon the "Magic Eye" shadow closes. The circuit of Fig. 1(b) works in exactly the same way as does that of Fig. 1(a) with the exception that the cathodes of both the double diode triode and the "Magic Eye" are taken positive of chassis by the same voltage. In practice, it would be advisable to choose component values such that the "Magic Eye" cathode is slightly more positive (say by half a volt) than the double diode triode cathode. This obviates the risk, due to component tolerances and variations in cathode current from valve to valve, of the "Magic Eye" cathode going negative of its triode grid under no-signal conditions. In such a case grid current would flow in the "Magic Eye" triode, reducing the sensitivity of the signal diode for weak signals.

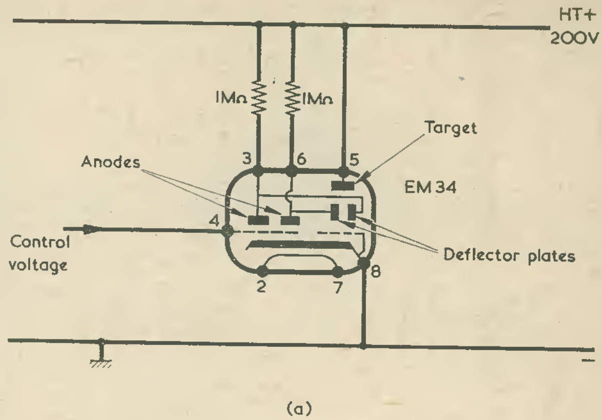
When discussing Fig. 1(b), we have referred to the connection of the "Magic Eye" cathode to a "tap" in the cathode bias resistance for the output valve. This "tap" is obtained, of course, by replacing the normal single fixed resistor in the output valve cathode circuit by two fixed resistors having appropriate values. We could also have obtained the positive voltage for the "Magic Eye" cathode by having two fixed resistors in series between the h.t. negative and positive lines, the cathode connecting to their junction. But these resistors would have to draw about the same standing current as the output valve, and this alternative method of operation would have been wasteful of h.t. current.

In both Figs 1(a) and (b) the "Magic Eye" control voltage is taken from the upper end of the signal diode load resistor, R4. It could alternatively be taken from the upper end of the filter resistor, R3, where a slightly higher control voltage is available.

Fig. 1(a). A signal and a.g.c. diode circuit in which the a.g.c. diode is fed from the primary of the last i.f. transformer. The "Magic Eye" control voltage is taken from the signal diode load

(b). The circuit of (a) with an a.g.c. delay voltage introduced. The cathode of the "Magic Eye" is returned to a steady positive potential equal to, or slightly greater than, the a.g.c. delay voltage

(c). A simpler arrangement in which a common diode appears in both the signal and a.g.c. circuits. The control voltage for the "Magic Eye" is taken direct from the a.g.c. line



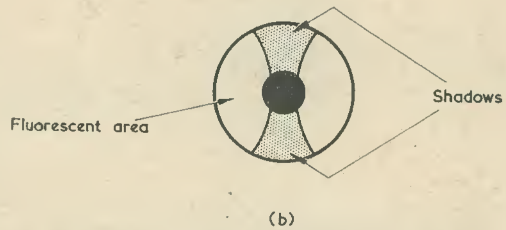


Fig. 2(a). The Mullard EM34 electron-ray tube in a working circuit

(b). The EM34 produces two shadows, one of which closes at a lower negative control voltage than the other

However, since R3 is normally much lower in value than R4, the increase in control voltage is marginal only. Indeed, with a sensitive receiver, where strong signals may cause the "Magic Eye" shadow angle to close almost completely, it could be desirable to use the slightly lower voltage available from R4.

In a conventional receiver layout, the "Magic Eye" will be positioned quite some distance away from the signal diode components. To prevent instability caused by feedback to earlier stages, R1 and C1 of both Figs. 1(a) and (b) should be mounted close to the diode components, this precaution being particularly necessary if the control voltage is taken from the upper end of R3. The lead from the junction of R1 and C1 to the "Magic Eye" triode grid can then be of any reasonable length and will not normally result in instability if it should happen to pass near unscreened wiring or components in the preceding stages.

Fig. 1(c) shows a circuit in which a common diode provides both the a.g.c. voltage and the detected a.f. signal. Since there is no a.g.c. delay in this circuit, and since the a.g.c. voltage is obtained from the secondary of the last i.f. transformer, we may obtain a control voltage for the "Magic Eye" triode grid from the a.g.c. line. We do this by the simple process of connecting the "Magic Eye" triode grid direct to the a.g.c. line after the first filter resistor. R1 and C1 in Fig. 1(c) are the usual filter resistor and capacitor employed in an a.g.c. system and they serve the secondary function of providing a steady direct voltage for the "Magic Eye," as did R1 and C1 of Figs. 1(a) and (b). This direct method of connection can be employed with any other a.g.c. circuit provided that the a.g.c. diode is fed from the secondary of the last i.f. transformer and there is no a.g.c. voltage delay.

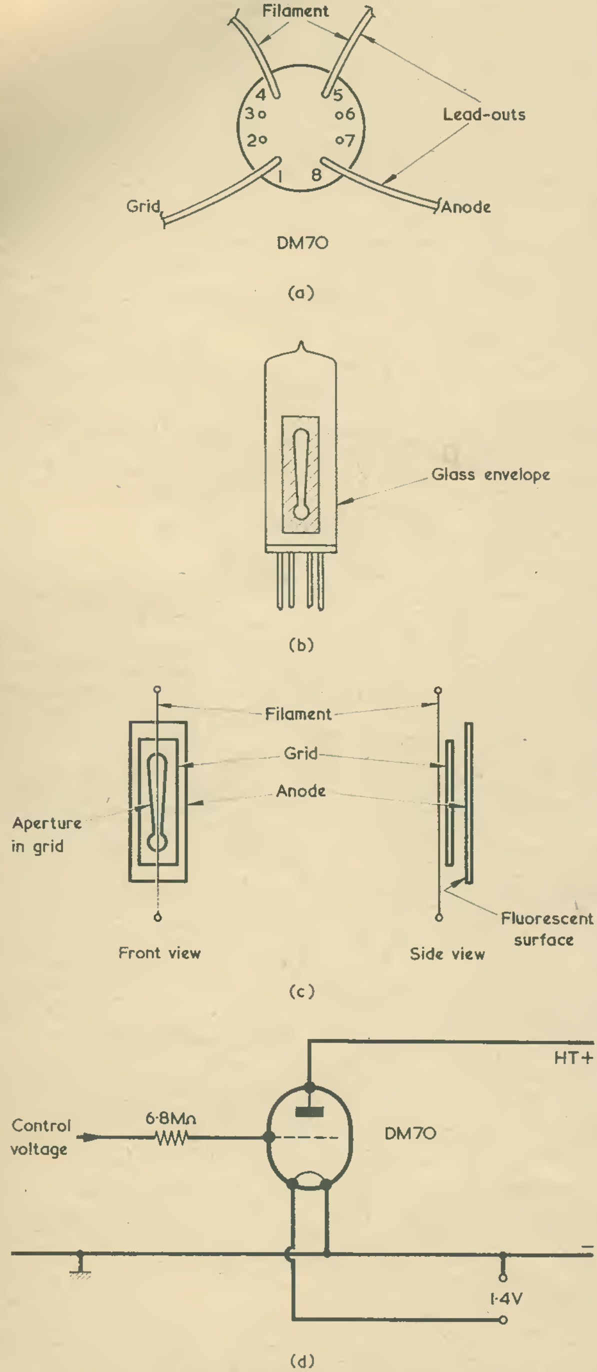


Fig 3(a). Lead-outs of the DM70. There are no external leads at positions 2, 3, 6 and 7

(b). External appearance of the DM70

(c). The internal electrode structure of the DM70

(d). The DM70 connected in a working circuit

The three circuits we have examined are all suitable for a.m. valve superhets having the requisite signal and a.g.c. diode circuits. As will have been noted, the addition of the "Magic Eye" requires little in the way of extra components. At an h.t. voltage of 200, the target current drawn by the "Magic Eye" type 6U5G is only 3mA, whilst its anode current is 0.2mA. (Both these figures apply for a grid voltage of zero and a shadow angle of approximately 90°.) These currents are relatively low, and the 6U5G target may be connected direct to the h.t. positive line of a receiver having conventional power supply circuits. The heater of the 6U5G is rated at 6.3 volts, 0.3 amps.

The usual method of fitting the 6U5G or any similar tube is to mount it so that the target is visible through an aperture in the receiver front panel. Flexible leads from the receiver chassis then carry the heater, h.t. and triode grid connections to its valveholder. The 1MΩ fixed resistor between target and anode can be connected at the appropriate valveholder tags.

OTHER ELECTRON-RAY TUBES

Later versions of the basic "Magic Eye" indicator have been produced, and we shall next consider two of these which represent general design techniques.

Fig. 2(a) shows the theoretical symbol for the Mullard EM34, together with the external connections required when it is used in a working circuit. An h.t. voltage of 200 is assumed. Like the 6U5G, the EM34 has a target, together with a common cathode for both the target and triode amplifier sections. In this case there is also a grid between the cathode and the target. This grid is internally connected to cathode and stabilises emission to the target. In the triode section to the left is a single control grid and *two* anodes giving, in effect, two triodes having a common grid. Each anode is connected to a separate deflector plate assembly which carries out basically the same function as the "deflector rod" in the 6U5G. There are two external anode resistors, both of 1MΩ. Like the 6U5G, the EM34 is on an octal base, and the target is viewed from the end of the tube.

The internal structure of the tube is such that two shadows on opposite sides of the target are produced as illustrated in Fig. 2(b), one of these shadows closing to its minimum angle for a lower negative control voltage than the other. Under the circuit conditions shown in Fig. 2(a), both shadows are at a maximum angle of nearly 90° for zero triode grid voltage with respect to cathode. One shadow then closes to 5° at a negative grid potential of approximately 4.2 volts whilst the other closes to 5° at a negative grid potential of approximately 12.5 volts. The results are that the two shadows offer different "sensitivities", and that there is a relatively large degree of shadow angle closure even when the associated receiver is tuned to weak signals.

So far as power supply requirements are concerned, the heater of the EM34 is rated at 6.3 volts 0.2 amps. Target current at 200 volts h.t. and zero grid voltage is 550μA, this rising to slightly less than 1mA for minimum angle of both shadows. The current drawn by the two triode anodes is limited by the series 1MΩ resistors to appreciably less than 400μA for zero grid voltage.

Other electron-ray tubes employing a target and a triode, whose anode is connected to a deflection electrode, have been introduced. A further example is the EM84 which, for an h.t. voltage of 250, displays a column (viewed through the side of the glass envelope) having a length of approximately 21 mm when the triode grid voltage is zero, this shortening to zero length at a negative grid potential of 22 volts. With this tube the resistor between target and anode has a value of 470kΩ, and target current varies between 1mA and 1.8mA for maximum and minimum column length respectively. The EM84 has a heater voltage of 6.3 volts at 210mA, and is on a B9A base. The triode grids of both the EM34 and the EM84 connect into the receiver circuit in the same manner as the grid of the 6U5G shown in Figs. 1(a), (b) and (c).

An interesting electron-ray indicator functioning on somewhat different principles is the Mullard DM70. This is a subminiature device and its glass envelope has a diameter of 10 mm with a length (including seal-off pip) of approximately 44 mm. It has no pins, and connections are made to four lead-out wires which couple to a filament, a "grid" and an "anode". See Figs. 3(a) and (b).

The internal structure is illustrated in Fig. 3(c). The anode consists of a metal plate coated with fluorescent material which is viewed through an aperture in the grid, the aperture having a shape rather like an exclamation mark. The grid is a flat electrode, and mounted in front of it is the filament. When, as in Fig. 3(d), the anode is connected to a suitable positive h.t. voltage, and the grid has zero voltage with respect to one end of the filament, the resultant fluorescent display consists of a column and "dot", as shown in Fig. 4(a). Here, the column length is approximately 11 mm. If the grid is then made to go negative, it offers greater opposition to the passage of electrons from the filament to the anode. This opposition prevents the passage of electrons through the narrower part of the aperture, and the result is that the length of the column reduces, as in Fig. 4(b). If the grid is made to go still more negative the column length reduces again, as in Fig. 4(c). As the grid voltage goes further negative the reduction in column length continues until, finally, both the column and the "dot" are completely extinguished.

The DM70 was initially intended for use in valve battery portable receivers, and its maximum anode voltage, when the anode is connected direct to the h.t. positive supply, is 90 volts. At this voltage, anode current is 170μA for zero grid voltage. The DM70 filament rating is 1.4 volts at 25mA. With the 90 volt h.t. supply, the column and "dot" are completely extinguished at a negative grid potential of 10 volts. The DM70 may also be employed in mains receivers having higher h.t. potentials, provided that a suitable resistor is inserted in series with the anode. The presence of the resistor causes anode voltage to increase as anode current decreases (due to negative grid voltage) with the result that complete extinction occurs at a greater negative grid voltage.

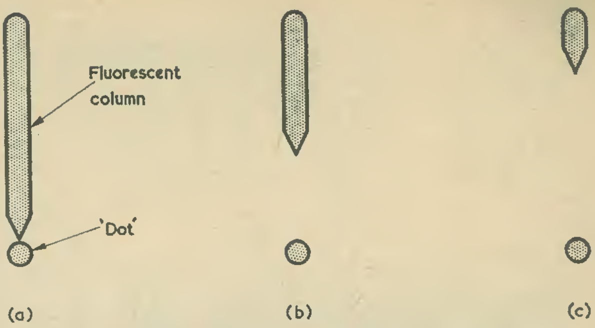


Fig. 4. The length of the DM70 fluorescent column decreases as negative grid voltage increases. (Both the column and "dot" are shown shaded here). In (a) there is zero grid voltage, whilst (b) and (c) illustrate the displays given by increasing negative grid voltage

Thus, with an h.t. voltage of 250 and a series anode resistance of 1.8MΩ, complete extinction of the column and "dot" takes place at a negative grid voltage of 34. It is recommended that the grid be connected to the source of control voltage (such as the junction of R_1 and C_1 in Fig. 1(a)) via a 6.8MΩ resistor.

The filament of the DM70 may be fed from a 6.3 volt a.c. heater supply via a 220Ω 1 watt resistor having a tolerance of ± 5%. In the 250 volt supply application just mentioned, the filament lead at position 5 should be that which is at chassis potential. For the 90 volt application, the filament lead at position 4 should be at chassis potential.

Electron-ray indicators have applications other than as tuning indicators. They may be alternatively employed as tape recorder level indicators or as null indicators in test equipment. In the tape recorder usage the control voltage for the electron-ray tube is obtained by rectifying the audio frequency voltage which appears at a suitable point in the tape recorder amplifier, the circuitry being arranged such that the tube gives a readily observable indication (such as complete closure of shadow angle) when the a.f. level is at the optimum amplitude for correct recording. Test equipment employing an electron-ray indicator may consist, typically, of measuring bridges which are intended to be adjusted for a zero voltage, or "null", reading. In both these applications, the main advantage given by the electron-ray indicator is that its triode grid draws virtually zero current from the circuit to which it is connected.

NEXT MONTH

We have now completed our discussion on electron-ray indicators and we shall turn, next month, to tuning indicators which incorporate a meter. If space permits we shall then carry on to the beat frequency oscillator.

OBITUARY

It is with regret that we record the death, on 7th March, of Alderman John Clarricoats, O.B.E., J.P., (G6CL), Mayor of the London Borough of Enfield, who was for many years secretary of The Radio Society of Great Britain and a pioneer of Amateur Radio. We extend to his widow and family our sincere sympathy. An appreciation will be published in our next issue.

In your workshop

Despite the fact that inexpensive multi-testmeters can nowadays be purchased at little more than the retail cost of the individual components, many constructors are interested in making up their own instruments. In this episode, Smithy describes a simple testmeter circuit which requires only one setting-up check against a second meter

"I PICKED UP," SAID DICK chattily, "quite a good bargain over the week-end."

Smithy gave a grunt of satisfaction as he filled in a further answer in his after-lunch crossword puzzle.

"Oh yes," he remarked absently.

"It was," continued Dick, "a pile of radio stuff which I bought from a mate of mine for a few bob only. The best thing in it was a 0-100μA meter which is in perfect condition. I was wondering if I could make up something useful in which I could incorporate it."

Smithy frowned at his puzzle and made no reply.

"As I was saying," said Dick, raising his voice, "I've got this 0–100μA meter."

The Serviceman looked up and glared at his assistant.

"Well?"

"Can you," asked Dick, "suggest what I should do with it?"

"I can," growled Smithy, "but I doubt whether it would be technically feasible."

"Would it, for instance," persisted Dick, "be worth-while using it in a home-made multi-testmeter?"

Disgustedly, Smithy threw his newspaper on to his bench.

"It looks," he grumbled, "as though that's another crossword puzzle I'll have to finish off at home in the evening. I never seem to be able to get through any lunch-break these days without interruptions from you. Anyway, to answer your question, you *could* use it as the basis of a home-made testmeter. Personally, I'm not always keen on suggesting that people make up their own multi-testmeters because you can nowadays buy quite good factory-built ones at very low cost."

"Still," said Dick eagerly, "a spare multi-testmeter *would* be useful to me for odd jobs at home and so on."

"Oh all right, then," replied Smithy resignedly. "Give me five minutes of peace and quiet and I'll dream up a testmeter circuit in which you can use that O–100μA meter of yours."

TESTMETER CIRCUIT

Obediently, Dick remained silent whilst Smithy pulled his notepad towards him and commenced to scribble out a few basic circuits and calculations. Eventually, the Serviceman turned over a fresh page of his pad and proceeded to draw a complete circuit diagram.

"Here we are, Dick," he called out, motioning his assistant over to his side. "This is the completed circuit. I've purposely kept everything as simple as possible in order to cut down on expense. But, even so, I must still point out that the completed job wouldn't cost a great deal less than a ready-made multi-testmeter if you bought all the components brand-new."

"Fair enough, Smithy," replied Dick. "But don't forget that many of the chaps who would construct a testmeter of this type will already have quite a few parts on hand. Also, some of them might like to build up their own testmeter as a purely instructional project."

"On those grounds," replied Smithy, "this circuit will be attractive. At any rate, take a gander at it now."

Smithy pushed his notepad towards Dick and indicated the complete circuit. (Fig. 1).

"Now," continued the Serviceman, "this circuit is built up around a basic 100μA panel-mounting meter which is calibrated in divisions from 0 to 100. The internal resistance of such a meter will, normally, be somewhere between 750 and 1,500Ω. There's a preset variable resistor, R1, which you adjust so that the total resistance of the meter plus that inserted by R1 becomes equal to 1,800Ω."

"That means," objected Dick, "that you'll need to have another meter to check that resistance."

"You *do* need another meter for setting-up R1" confirmed Smithy. "But it's only requirement is that it should be capable of reading 1mA, and the setting-up procedure is an extremely quick and simple one. I would think that most of the people who'd build up this multi-testmeter could obtain the second meter required for setting-up without too much difficulty. However, I'll return to the adjustment of R1 after I've explained the rest of the circuit. The circuit's main advantage, incidentally, is that, if you use the proper close tolerance resistors I've shown, all voltage and current ranges are automatically correct after R1 has been set up."

"Why is R1 adjusted to give a total resistance of 1,800Ω?"

"Because," said Smithy, "1,800Ω is a useful figure which should accommodate all the conventional 100μA meter movements you're liable to bump into, and because it makes the current shunt resistances come out at nice round values which are easy to obtain."

"Okey-doke," commented Dick equably. "What ranges does this circuit of yours offer?"

"The voltage ranges," said Smithy, "are 2V, 10V, 50V, 200V and 500V d.c., all of which should be capable of being evaluated quite easily from a meter scale graduated 0 to 100. For reasons of simplicity, there are no a.c. voltage ranges. The current ranges are 100μA, 1mA, 10mA and 100mA. There are two resistance ranges giving you useful readings from about 3MΩ down to about 10Ω. I could have introduced a resistance range giving useful readings lower than 10Ω, but that would have necessitated more complicated switching circuits than a low-cost design of this nature warrants. The resistance scales do not appear on the meter scale, of course, and you'll have to make up external calibration charts for these."

"The switching circuits," remarked Dick, examining Smithy's circuit critically, "certainly seem to be few and far between."

"That's all," replied Smithy cheerfully, "in the interests of simplicity and low cost! Instead of switches there are a number of sockets into which you plug the positive test prod lead for the range you require. A 'Common Negative' socket provides the negative connection for all ranges. Let's next have a look at how the circuits work. We'll start off with the voltage ranges first."

"Righty-ho," said Dick, settling himself comfortably on his stool. "I'm all ears."

"A noticeable deformity," returned Smithy, "on which a person of my delicacy would be loath to comment. Now, when switch S1 is set to 'V' we connect the positive side of the meter, via R1, to the chain of voltage multiplier resistors given by R2 to R6."

"That switch position," broke in Dick, "is not only marked 'V'. It's marked 'V and 100μA'."

"I know it is," snorted Smithy irritably. "And don't keep interrupting! Just forget the 100μA bit for the time being and concentrate on the basic voltmeter circuit. (Fig. 2). What we have here is the meter in series with R1, and we can look upon the two as representing a 100μA meter movement having a resistance of 1,800Ω. Now, what resistance causes 100μA to flow when 1 volt is applied across it?"

"Corluvaduk, Smithy," complained Dick, startled. "You don't half spring these questions on me! Well, from Ohm's Law, the resistance will be 1 volt divided by 100μA. Why, that's 10,000Ω!"

"Exactly," said Smithy. "As you rightly say, the resistance is 10,000Ω."

"Which means," chimed in Dick, "that our voltmeter will present a resistance of 10,000Ω per volt."

"Correct," commented Smithy, pleased. "Now the first voltage range is 2 volts and so we want 20,000Ω between the '2V' test socket and the common negative socket. This means that 100μA will flow when 2 volts are applied, causing the meter to read full-scale deflection. We've already got 1,800Ω in the meter plus R1 combination, so R2 needs to be 20,000Ω minus 1,800Ω. Which comes out as 18,200Ω. You can make that up quite comfortably with an 18kΩ and a 200Ω resistor in series. Both of these are obtainable as ½ watt 1% high-stability components from the popular mail-order houses."

"That's interesting," said Dick. "You don't have to hunt around for particular values of resistance, then?"

"Oh, no," said Smithy. "Apart from one resistor that's just a wee bit awkward, all the resistors consist of readily available ½ watt 1% high-stability components. Provided you don't heat them up excessively when you solder them into circuit, these resistors should all be within their tolerance after they've been wired in, whereupon no individual calibration or checking of ranges is

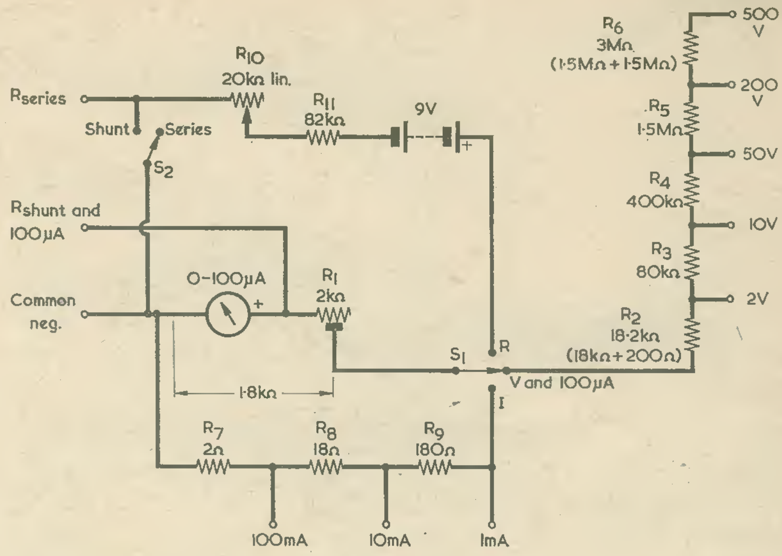


Fig. 1. Circuit diagram of the simple multi-testmeter devised by Smithy. The small circles indicate single insulated sockets into which the test prod leads are plugged to obtain the ranges indicated

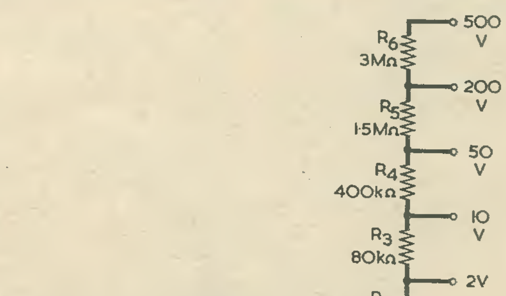


Fig. 2. The voltmeter section shown on its own. Sensitivity is 10,000 per volt

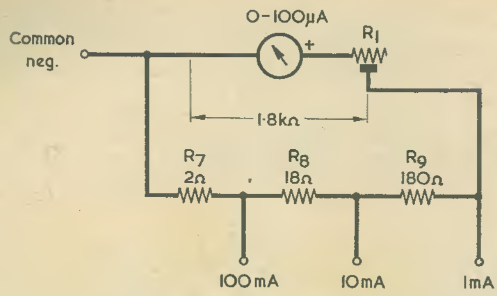


Fig. 3. The universal shunt provided by R7, R8 and R9 for the current ranges

needed at all. Well, that's settled the 2 volt range. The next range is 10 volts. Working from 10,000Ω per volt, we need an 80kΩ ½ watt 1% high stability resistor to bridge the 8 volt gap from the '10V' socket to the '2V' socket, and this gives us R3. The next step is a 40 volt step to the '50V' socket, with the result that R4 needs to be 400kΩ. There's then a 150 volt jump to the '200V' socket, whereupon R5 needs a value of 1.5MΩ. There's finally a 300 volt step to the '500V' socket and R6 requires a value of 3MΩ. This is best provided by two 1.5MΩ resistors in series, as a 3MΩ component may be difficult to obtain."

CURRENT RANGES

"It looks," said Dick enthusiastically, "as though this multi-testmeter design of yours is going to be a piece of cake to make up. What about the current ranges?"

"You obtain the 1mA, 10mA and 100mA ranges," replied Smithy, "by moving S1 to the 'I' position and plugging your positive test prod lead into the appropriate socket."

"The current shunt resistors," remarked Dick, "seem to be in circuit all the time."

"That's right," agreed Smithy. "They are given by R7, R8 and R9, and they make up what is known as a 'universal shunt'." (Fig. 3).

"I'm not too clear," said Dick, 'how the values you've shown for R7, R8 and R9 give you the actual current ranges."

Smithy pulled his note-pad towards him, selected a fresh sheet and took out his pen.

"Let's consider the ranges individually," he said. "We'll start off by saying that we select the 1mA range by inserting our positive test prod lead into the 1mA socket. We can then draw the situation which results like this. (Fig. 4(a)). As you can see, we have the meter and R1 on one side giving a total resistance of 1,800Ω, whilst on the other side are R7, R8 and R9, these giving a total resistance of 200Ω. Now, 1,800Ω is nine times 200Ω which means that nine times more current must always pass through the 200Ω side than through the 1,800Ω side. If the current going through the whole combination is 1mA, then 900μA of this will pass through the 200Ω side and the remaining 100μ will pass through the 1,800Ω side. Thus, the meter will give an f.s.d. of 100μA when 1mA passes through the meter and the shunt."

"Blimey," commented Dick, "that's neat. What about the 10mA socket?"

"If," said Smithy, "we put our positive test prod lead into the 10mA socket, the circuit changes to this. (Fig. 4(b)). On the shunt side we now have R7 and R8 in series, giving us a total resistance of 20Ω. R9 is now in series with the meter and R1, whereupon it moves over to the left hand side to give a total resistance of 1,800Ω plus 180Ω."

"This," said Dick dolefully, "is beginning to get complicated."

"No it isn't," stated Smithy. "The left hand side now adds up to 1,980Ω, which is ninety-nine times greater than 20Ω. The result is that ninety-nine times more current passes through the right-hand side than through the left-hand side. If we apply 10mA, then 9.9mA, or 9,900μA, goes through R7 and R8 and the remaining 100μA goes through the meter."

"You must," said Dick admiringly, "be a mathematical genius to have worked out these shunt values."

"It's quite simple to do actually," replied Smithy modestly. "Anyway, let's finish off by looking at the 100mA circuit. (Fig. 4(c)). In this case the right hand side is R7, on its own, giving 2Ω. On the left is the 1,800Ω of the meter and R1, plus R9 at 180Ω and R8 at 18Ω. That little lot adds up to 1,998Ω."

"Hell's teeth," ejaculated Dick. "That's exactly nine hundred and ninety-nine time 2Ω!"

"Just so," chuckled Smithy. "And the consequence is that, if we apply 100mA, 99.9mA flows through the shunt side and 0.1mA, or 100μA, flows through the meter side."

"I must," exclaimed Dick, "have heard everything now."

"Perhaps you can now see," commented Smithy, "why I plumped for 1,800Ω for the meter plus R1. This makes R8 and R9 come out at the nice round values of 18Ω and 180Ω, both of which are available in 1% ½ watt high-stability. The 2Ω, unfortunately, is the awkward resistor I mentioned a few minutes ago, and it's not readily obtainable as a single component in high-stability. You could, however, get 2Ω quite easily by putting four 8Ω hi-stabs in parallel. On the other hand, it would be cheaper to use a wirewound 2Ω here, and risk it's being within a fairly close tolerance of its nominal value, as most wirewound resistors are. R7 is the only resistor in the design which is at all difficult in this respect."

"I'm still amazed," said Dick, "at the way the resistor values in that universal shunt circuit work out to give you the exact individual shunt resistances."

"Ah," said Smithy. "Well, there's a basic way of working out universal shunt values which I'll now explain to you. You start off by settling on the lowest current range you require, which must be higher than the f.s.d. of the meter movement itself, and you then work out the value of the appropriate shunt needed for that particular range. If you call this value RS, you next make up a diagram like this. (Fig. 5). This circuit is for 4 ranges, each being multiplied by 10, but you can adapt the basic scheme for any other number of ranges or for any other multipliers."

Dick examined Smithy's sketch carefully.

"This is interesting," he remarked slowly. "And I can understand now how you chose the values of R7, R8 and R9. The total shunt you needed for the 1mA range worked out at 200Ω. You then gave R7 a value of 2Ω, which is one-hundreth of 200Ω. R7 plus R8 had to be one-tenth of 200Ω, which made R8 18Ω. After which, R9 *had* to be 180Ω to give you the full 200Ω."

"That's the idea," chuckled Smithy. "It's easy when you know how!"

RESISTANCE RANGES

"What," asked Dick, "about the resistance ranges?"

"There are two resistance ranges," said Smithy. "A series range for high resistance readings and a shunt range for low resistance readings. To select the series range you put S1 into the 'R' position, set S2 to 'Series' and plug your test prod leads into the common negative and 'R Series' sockets. You then have a very simple circuit consisting of the meter, R1, the 9 volt battery,

Continued on page 597

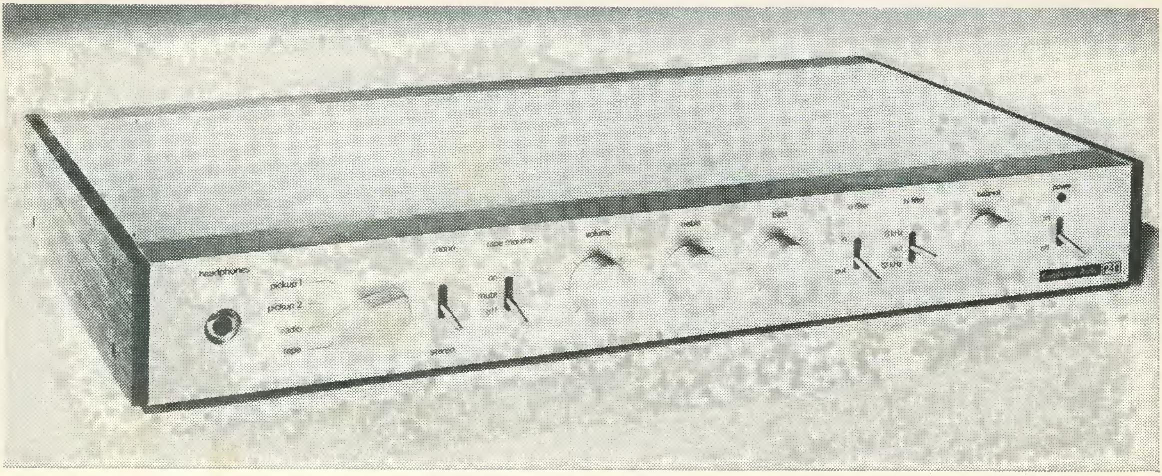
RADIO CONSTRUCTORS DATA SHEET 25

AMATEUR ABBREVIATIONS

AA	All after (word or group) — also: Artificial aerial
AB	All before (word or group)
ABT	About
ANT	Antenna
BC	Broadcast
BCI	Broadcast interference
BCL	Broadcast listener
BK	Break — also: Break in
BN	All between (word or group) and (word or group)
C	Yes
CANS	Headphones
CFM	Confirm — also: I confirm
CK	Check
CKT	Circuit
CL	I am closing my station
CO	Crystal oscillator
CUL	See you later
CQ	General call
CW	Continuous wave
DE	From (used in calling)
DF	Direction finding
DX	Distance (long distance reception)
ECO	Electron coupled oscillator
ELBUG	Electronic key
ER	Here
ES	And
FB	Fine business (excellent)
GA	Go ahead — also: Good afternoon
GND	Ground
HI	Laughter — also: High
HR	Here — also: Hear
HV	Have
K	Go ahead (i.e. transmit)
LID	Poor operator
MILS	Milliamps
N	No
ND	Nothing doing
NIL	I have nothing for you
NM	No more
NR	Number
NW	Now
OB	Old boy
OM	Old man
OP	Operator
OT	Old timer
PSE	Please
PX	Press
R	All received — also: Are
RCVR	Receiver
RIG	Station equipment
RX	Receiver
SA	Say
SED	Said
SIG	Signal
SKED	Schedule
SRI	Sorry
STN	Station
SW	Short wave
SWL	Short wave listener
TKS	Thanks
TMW	Tomorrow
TNX	Thanks
TU	Thank you
TVI	Television interference
TX	Transmitter
U	You
UR	Your
VFO	Variable frequency oscillator
VY	Very
WA	Word after (word or group)
WB	Word before (word or group)
WID	With
WL	Will — also: Well
WX	Weather
XMTR	Transmitter
XTAL	Crystal
XYL	Wife
YF	Wife
YL	Young lady
73	Best regards
88	Love and kisses

• TRADE NEWS •

NEW CAMBRIDGE HI-FI AMPLIFIER



The new Series P Transistor Stereo Amplifier from Cambridge Audio Laboratories

A REMARKABLE NEW HI-FI STEREO AMPLIFIER – capable for the first time of reproducing the entire dynamic range encountered on modern recordings – has been developed by Cambridge Consultants Limited, the scientific and engineering research and development group. The amplifier provides a dynamic capacity – the difference between the softest and loudest sounds that can be reproduced faithfully – over thirty times greater than the claims of other manufacturers, and is described by its makers as the most important step forward in hi-fi since the introduction of stereo.

Called the Series P Transistor Stereo Amplifier, the unit is marketed by Cambridge Audio Laboratories, of 6 Queen Street, London W.1, a member of the Cambridge Consultants Group. Announcing the new product, Mr. Tony Edwards, Cambridge Audio Laboratories Managing Director, said: "Our original brief was to find a patentable circuit technique which would enable us to produce a better amplifier for the same price as existing equipment, and knock the Japanese for six with a British product in this highly competitive field. We have been seeking to reproduce in the home exactly what is heard in the concert hall. We are confident that this has been achieved and can justly claim that the Series P Amplifier is the best of its type in the world."

"Comparable Japanese amplifiers retail at £160 or more," added Mr. Edwards, "and still leave much to be desired—the Cambridge Series P 80 costs £94, and the lower-rated P 40 is £65. Beautifully styled and with its advanced specification, our product is a winner."

The result of an extensive market survey, the amplifier's design was approved by a wide section of the trade. Shown in conjunction with eight other leading amplifiers, nearly 60% of those inspecting the range selected the Series P as having the best appearance.

Technically, the unit incorporates several radical design features which were developed and patented during a three-year research programme. The outstanding step forward is the new pre-amplifier circuit which prevents input overload — previously, variations in recording level from one record to another, combined with differences between pickups, had made this type of overload inevitable. Other innovations include a unique power amplifier giving wide frequency response and an unusually low level of distortion. The amplifier has straight-forward controls, a full range of facilities and is provided with complete protection against accidental short-circuit or other maltreatment.

Distributed through retail outlets, the Cambridge Audio Laboratories Series P Amplifier is marketed by a company whose management stems from the Cambridge Consultants stable—and that means a very high level of technical and organisational competence. ■

Continued from page 594

R11 and R10 in series. (Fig. 6(a)). Obviously, you'll get a different meter deflection for different values of resistance across the test prods,"

"I take it," said Dick, "that R10 is the zero-adjust control."

"That's right," confirmed Smithy. "Its a panel mounted control and you adjust it for f.s.d. with the test prods shorted together in the ordinary way. The total resistance in circuit with R10 inserting minimum resistance is the 82kΩ of R11 plus the 1.8kΩ in the meter and R1. So you'll automatically have to reject the 9 volt battery when its voltage falls below about 8.4 volts, because you won't then be able to get full-scale deflection when you short the test prods together. A brand-new 9 volt battery usually gives about 9.6 volts so that, if you calibrate the series resistance range for a nominal battery voltage of 9 the errors introduced on either side by a new battery or an exhausted battery are about the same."

"How do you calibrate the series resistance range?" queried Dick. "By measuring known values of resistance?"

"You can do," replied Smithy. "But in this case it's possible to *calculate* the meter readings, after which you make up a little calibration chart. If you assume a battery voltage of 9 volts and zero internal resistance in the meter, the circuit, after it has been zero-adjusted, simplifies down to a 9 volt battery in series with the meter and a 90kΩ resistor." (Fig. 6(b)).

"Oh, I see," exclaimed Dick. "If, therefore, you put 90kΩ across the test terminals you then get a total series resistance of 180kΩ. Which means that the meter will indicate 50μA."

"You've got the idea," commended Smithy. "About the highest value of resistance you could usefully read on the meter is 3MΩ. If 3MΩ were presented to the test terminals, the total series resistance becomes 3MΩ plus 9kΩ and this would give a meter deflection, as near as dammit, of 3μA. I would guess that about the lowest test resistance at the other end of the range that you could usefully read is 3kΩ, which would cause the total series resistance to be 93kΩ."

Smithy scribbled a quick calculation on his notepad.

"The resultant current," he resumed, "would be approximately 97μA. If you do a few sums like that you can soon make up a simple calibration chart." (Fig. 7).

"3MΩ to 3kΩ," commented Dick, "seems to be quite a reasonable range. How do you measure values of resistance lower than 3kΩ?"

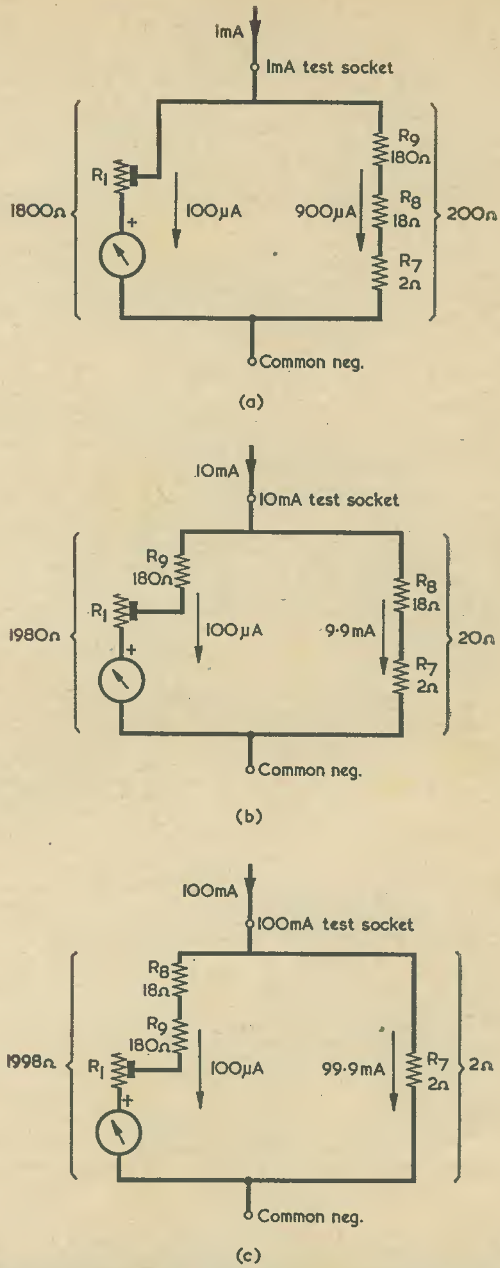


Fig. 4. Illustrating how the universal shunt provides the requisite resistance values when the positive test prod lead is plugged into the 1mA socket (a), the 10mA socket (b) and the 100mA socket (c)

"You leave S1 in the 'R' position," said Smithy, "put S2 to the 'Shunt' position, and put your test prods into the common negative and 'R Shunt' sockets. S2 does the same thing as we previously got by shorting the test prods together, whereupon the meter, after R10 has been set up, reads full-scale deflection. The values of resistance you put across the test prods then act as shunts across the meter movement." (Fig. 8).

"Blow me," said Dick, "that's a crafty scheme."

"It has the advantage of simplicity.'

"Just a minue, though," said Dick suspiciously. "That 'R Shunt' socket in your main circuit is actually marked 'R Shunt and 100μA."

"Ignore the 100μA business for the moment."

"All right, then," said Dick. "But I've now got another question! Can you make out a chart for 'R

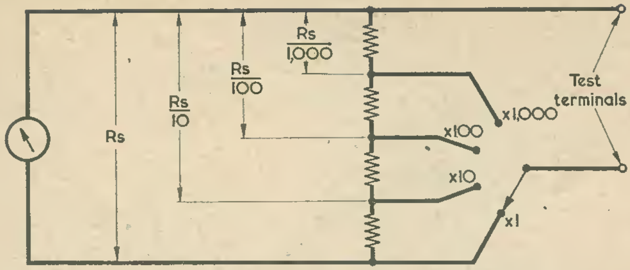


Fig. 5. How to calculate the values for a universal shunt. A current range selector switch is assumed here

Shunt' range like you can for 'R Series'?"

"Oh yes," replied Smithy, "but the calculations are a bit more fiddling, and you first of all have to know the resistance of the meter. If you assume a constant current of 100μA in the meter and whatever shunt you place across it, you can make fairly simple calculations and the error at the low resistance end will be a little greater than 1%, which isn't too bad for an instrument of this nature."

"Can you give some examples?"

'Well," said Smithy. "Let's assume that the meter has a resistance of 1kΩ. Then, a test resistance of 1kΩ will cause the meter to read 50μA, which gives you the first calibration point. You can then work from the equation

$$I_m = \frac{100\ R_t}{R_m + R_t}$$

where I_m is the current indicated by the meter, R_t is the test resistance and R_m the resistance of the meter. If you have a test resistance of 10Ω, you'll then get a reading in a 1,000Ω meter of — just a minute! — 0.99μA."

Smithy scribbled some further calculations.

"At the other end of the scale," he remarked, after a moment, "a 10kΩ resistor will give you a reading of 90.9μA. This still assumes a meter of 1,000Ω resistance."

"Blimey," said Dick, with a marked lack of enthusiasm. "If you've got to go through all these calculations, I'd prefer to make up a chart by measuring known values of resistance!"

"There is," agreed Smithy, "a certain amount of labour involved."

A sudden thought struck him.

"I've just remembered something," he remarked, "which should make the calculations considerably easier. Go over to the book-shelf and bring me our bound volume of *The Radio Constructor* for 1965-66."

Dick rose and brought the volume in question over to Smithy, who quickly looked at the index, then opened it up.

"Here we are," he said triumphantly. "Our calculations have all been partly done for us! There's a table in one of G. A. French's Suggested Circuits which meets our requirements exactly."

Smithy showed Dick the table in question.

"Now, this table," he continued, "applies to a meter calibrated from 0 to 100, as ours is, and having an internal resistance of 1Ω. If the meter has a higher resistance, you

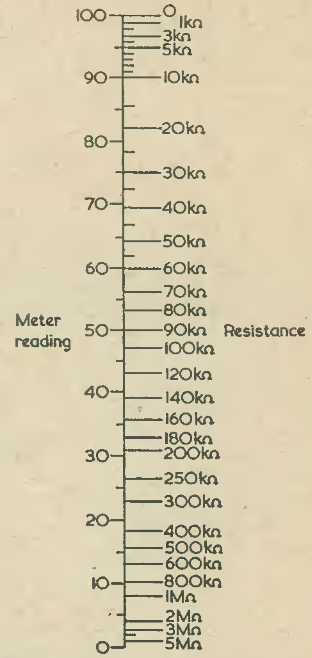


Fig. 7. Calibration chart for the high resistance range of the multi-testmeter. This may be copied or cut out, if desired

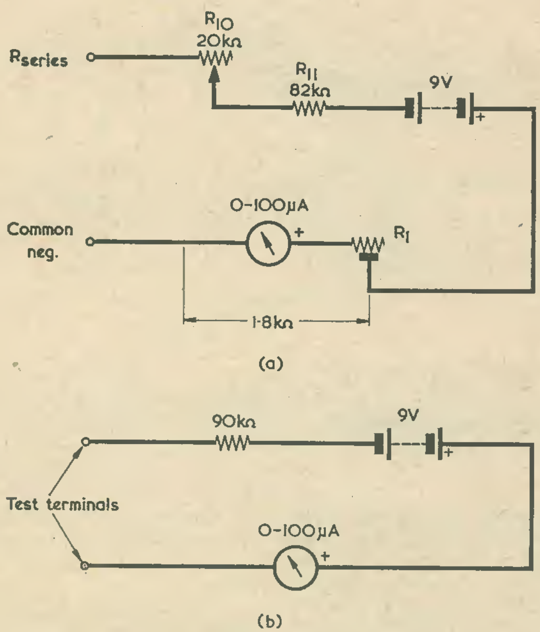


Fig. 6(a). Circuit of the high resistance measuring section of the multi-testmeter

(b). For purposes of preparing a calibration chart, the circuit may be reduced to this form. It is assumed that the meter has zero internal resistance

simply multiply all the resistance figures on the left by that resistance. So, with the 1,000Ω meter I assumed, a reading of 50 corresponds to 1,000Ω. At the same time, a reading of 0.99 corresponds to 10Ω and a reading of 90.9 to 10kΩ. Just as I got when I worked those figures out myself!"

"That *is* useful," remarked Dick, looking at the table with respect. "I suppose that, if you have a meter resistance of, say, 1,250Ω, you multiply all the figures in the left hand column by 1,250."

"Exactly," confirmed Smithy. "You now, therefore, have two choices for making up an 'R Shunt' calibration chart. You can either make up the chart by measuring known values of resistance. Or you can calculate them by using this table. In the second case, however, you've got to know the resistance of the meter movement, and I'll be talking about that in a few minutes."

LOW-CURRENT RANGE

"Well," said Dick keenly. "This multi-testmeter circuit certainly offers a whole lot of useful ranges."

"There's a further facility I haven't mentioned yet," stated Smithy. "The testmeter has a 100μA current range as well. I've included this because it's available with no extra circuitry and because it would be a pity to have a meter incorporating a 0–100μA movement if you couldn't use it to measure currents in that range. To measure currents in the 0–100μA range you simply put S1 to 'V and 100μA' and insert the test prods into the common negative and 'R Shunt and 100μA' sockets. This results in the test prods connecting direct to the 100μA meter with no shunts or resistance range components connected across it at all."

"Stap me," remarked Dick inelegantly. "That seems to have covered pretty well everything you can think of."

"That's true so far as facilities are concerned," replied Smithy. "But we must next carry on to a final important matter. This has to do with setting up R1, which is carried out by means of a simple current check. R1 should, incidentally, be a wirewound component of good quality."

"What's the simple current check?"

"After you've assembled the meter," said Smithy, sketching out a further circuit on his pad, "you fix it up in a simple circuit like this, in series with a monitoring meter capable of reading 1mA. (Fig. 9). S1 in the multi-meter is set to 'I' and the external circuit is connected to its common negative and '1mA' sockets. Also, R1 in the multi-testmeter is initially set to insert full resistance into circuit, as is the external variable resistor. The latter is then carefully adjusted so that the monitoring meter reads exactly 1mA. R1 in the testmeter is next adjusted for f.s.d. in the 100μA meter. Repeat these two adjustments to get them *exactly* right, then disconnect the external circuit. Your multi-testmeter is then set up for correct readings with a high level of accuracy for all voltage and current ranges."

"Gosh," gasped Dick. "Is that all that's needed?"

'That's all," affirmed Smithy. "The 9 volt battery used for the setting-up process can, incidentally, be the one employed in the multi-testmeter, it being temporarily removed for the setting-up operation. An important point is that you must not accidentally set the external variable resistor so that it inserts too little resistance into circuit or you'll pass excessive current through both meters. Start with the external variable resistor set to insert maximum resistance, then reduce it slowly and carefully."

Smithy looked at the Workshop clock.

"And that," he remarked, 'is that! It's well after time we started work again!"

"You haven't," protested Dick, "covered the business of finding the meter resistance in order to make up a shunt resistance range calibration chart."

"That's not too difficult a process," replied Smithy. "But I must first start off with a word of warning. If the 0–100μA meter you're using is specified as having a resistance which is equal to a round number figure of ohms, you should look upon this as a nominal figure only. These meters usually have a resistance tolerance of about 10% or so. To find the actual meter resistance, set the multi-testmeter up to read 'R Shunt' and connect a 2kΩ variable resistor across the test prods. Adjust this for exactly half-scale deflection, remove it and measure it on another meter. Its resistance will then be equal to the meter resistance. Alternatively, connect a 1kΩ 1% resistor across the test prods and note the precise reading in the meter. You can then calculate the meter resistance from the equation I gave you just now. This second method is the more accurate of the two, because it obviates errors introduced by the external

TABLE

Values of I_m for R_s from 0.01 to 10Ω with R_m = 1Ω. If R_m is other than 1Ω, multiply R_s by R_m. (Reproduced from 'Suggested Circuit No. 183—Fractional Resistance Measurements').

R_s (Ω)	I_m (% of f.s.d.)
0.01	0.99
0.02	1.96
0.03	2.91
0.04	3.85
0.05	4.76
0.06	5.66
0.07	6.54
0.08	7.40
0.09	8.26
0.1	9.09
0.2	16.7
0.3	23.1
0.4	28.6
0.5	33.3
0.6	37.5
0.7	41.2
0.8	44.4
0.9	47.4
1.0	50.0
2.0	66.7
3.0	75.0
4.0	80.0
5.0	83.3
6.0	85.7
7.0	87.5
8.0	88.9
9.0	90.0
10.0	90.9

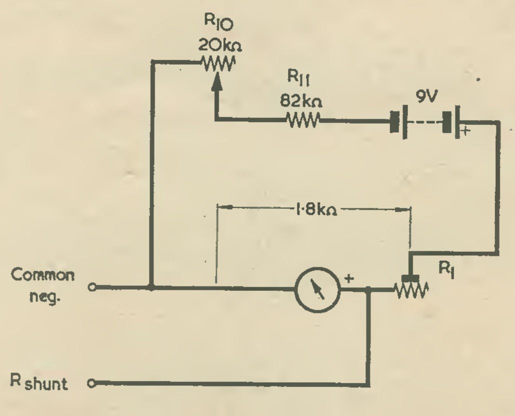


Fig. 8. The low resistance measuring section of the multi-testmeter

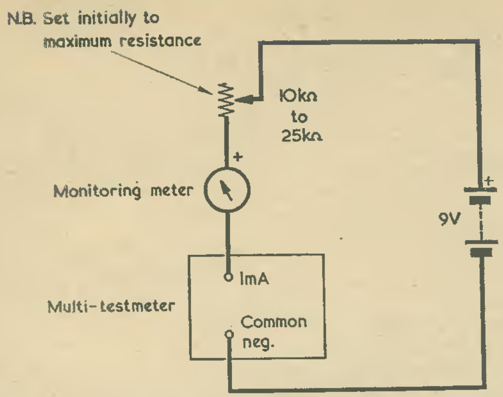


Fig. 9. The simple external circuit required for setting-up R1 in the multi-testmeter

meter, and it represents quite a respectable approach."

Decisively, the Serviceman tore the sheet with the multi-testmeter circuit diagram from his note-pad, and presented it to his assistant.

"Another respectable approach," he remarked, "will now be carried out by ourselves."

"In what direction?"

"Towards our benches," replied Smithy firmly, indicating the Workshop clock, which had now passed quarter of an hour beyond the end of lunch break, "where we can carry out some of the multi-testmeter work we're *paid* to do, mate!"

EDITOR'S NOTE

High stability ½ watt 1% resistors in the values specified by Smithy are available from Home Radio (Components) Ltd., and Henry's Radio Ltd. The 'Suggested Circuit' from which the table is taken is entitled 'Fractional Resistance Measurements' and appeared in our February 1966 issue.

1969 MULLARD DATA BOOK

Now available is the Mullard Data Book for 1969, this offering concise information on a very wide range of Mullard semiconductors, valves, TV tubes and components. For ease of reference, each of these has its own section which is printed on paper of different colour.

Equivalents and earlier types are listed in the valve section, replacement types in the TV tube section and "comparables" in the semiconductor section. "Comparables" are Mullard transistors and diodes which may be safely fitted in place of others of different manufacture (British and American), and more than 1,600 types are listed.

Information on the type nomenclature system used is given in all sections, together with useful servicing advice where applicable. The component section is the last in the book, and provides details on Mullard electrolytic, polyester, metallised foil and miniature foil capacitors, voltage dependent resistors, and n.t.c. thermistors.

The Mullard Data Book 1969 has 138 pages and is of handy pocket size (approx. 5in. by 4in.) with a durable cover. It is available through radio and TV retailers to electronics enthusiasts outside the trade, and the recommended retail price is 3s. 6d. per copy.

THAMES TV

Thames Television, as part of their equipment programme for colour, have placed further orders totalling nearly £200,000 with EMI Electronics Ltd. These include an additional quantity of the firmly established EMI Colour Camera Type 2001 bringing the total up to fourteen, seven of which have already been delivered, in addition to encoding equipment, vertical aperture correctors, and colour balance panels.

The new orders also include ten video switching matrices, each having 28 inputs and 6 outputs, for use in the new London studio complex to be built for Thames Television at the Euston centre. Four studio vision mixers with special effects are destined for Teddington and Euston. All the vision mixing and switching equipment is based on the well-established EMI modular system now in use with many broadcast organisations throughout the world.

AMATEUR RADIO AND RADIO AMATEURS

by

A. S. CARPENTER
G3TYJ

Our contributor lifts the lid a little on a fascinating way of life

ALTHOUGH LICENSED RADIO AMATEURS TEND TO take their hobby for granted, in many cases their interest was initially triggered off by a quite simple acquaintance with radio. The field of radio and electronics has always provided a unique hobby medium and will continue to do so for many years to come. The search after true high fidelity sound reproduction presents one fascinating angle; others include the construction of electronic equipment, radio receivers, test gear, and so on. Closely allied to these is the Radio Amateur's particular field, sharing as it does many contemporary aspects of the hobby.

WHAT MAKES RADIO AMATEURS TICK?

It is imagined sometimes that Radio Amateurs are highly technical people possessing a great deal of electronic know-how, but this is not completely true. Licensed Radio Amateurs are drawn from all walks of life, and priests, parsons, printers, policemen, etc., are found among their number. Others may be engaged in electronic pursuits far removed from the sphere of Amateur Radio.

They all have two things at least in common, however, these being that

(1) each has passed a simple Radio Amateurs' Examination (R.A.E.) and

(2) each, if he operates on a full licence, has passed the G.P.O. sponsored Morse code Test.

These tests are not difficult. The R.A.E. for example requires only an elementary level of technical knowledge and is concerned largely with operating aspects and the avoidance of interference to other radio services. The Morse test, too, is entirely straightforward and requires the applicant to receive and to send a simple message at no greater speed than 12 words per minute; the fact that many would-be radio amateurs have learnt the code and passed the Test when past retirement age is sufficient comment!

No examination or test is necessary of course if it is desired to listen-in only; probably the majority of licensed operators started out by being SWL's (Short Wave Listeners) anyway.

SWL-ing is undoubtedly a fascinating pastime in its own right; and its activities may range from seeking out rare Dx on the h.f. bands — when the ability to read Morse code is useful — to listening to U.K. stations and "Locals" enjoying a rag-chew on the lower frequencies.

Initially the Amateur jargon may sound odd and comments such as "Will QSY h.f. to clear QRM . . .", or "QSP best 73 your XYL and new 'harmonic'" may at first be puzzling although later readily understood. Quite often the SWL will feel, after a short time has elapsed, the urge to participate in transmitting activities as well.

TUNING TO RADIO AMATEUR TRANSMISSIONS

Transmitting amateurs are restricted to the use of certain well defined frequency bands and an operator must not allow his transmission to pass outside the band edges.

The normal type of broadcast bands receiver is rarely of much use for Dx listening and the reason is apparent from a study of the accompanying Table, which shows the l.f. and h.f. bands allocated to Radio Amateurs. (A number of v.h.f. and u.h.f. bands are also allocated for Amateur usage.)

TABLE

L.F. and h.f. Amateur Bands

Band Mc/s	Often referred to by Amateurs as:
1·8–2·0	"One-sixty" metres (Top Band)
3·5–3·8	"Eighty" metres
7·0–7·1	"Forty" metres
14·0–14·35	"Twenty" metres
21·0–21·45	"Fifteen" metres
28·0–29·7	"Ten" metres

Some broadcast bands receivers do carry a short wave range — say 15 to 50 metres — and although with care it may be possible to locate the 20 or 40 metre Amateur bands, resolving signals is likely to be problematic due to a cramped scale and the relative coarseness of the tuning drive. The whole 40 metre band may take up only ⅛in. of scale length on such a receiver and it would thus be very difficult to locate and tune in individual signals. Sophisticated receivers designed purely for Amateur work are usually restricted coverage types. In the Star SR550 receiver, for example, a full 5in. scale length is assigned to each Amateur band; additionally a reduction drive mechanism for tuning simplifies operation further. Various forms of electrical and mechanical "bandspreading" are well known in Amateur circles and are essential for serious work.

Early attempts at SWL-ing hardly warrant the purchase of an expensive receiver and many of the available general coverage ex-Service sets are capable of excellent results. For example, the Marconi CR100 or B28, or the HRO, are very good, and suitable specimens are quite often obtainable at relatively low cost. Also, suitable designs for inexpensive "home-brew" receivers appear in *The Radio Constructor* from time to time.

No matter what type of receiver is used, a good aerial must be erected and connected up. There is no need to be beguiled by the claims of advertisers here, because a 133ft. long wire, end-fed, will suit excellently for all Amateur bands from 10-160 metres. If this length is too great for the space available, 67ft. will also prove useful — or even 33ft. in difficult locations. If the wire is placed fairly high and can run in a N-S direction superb results can be expected!

ON BECOMING "AIR-BORNE"

No doubt many s.w.l.'s never become licensed transmitting amateurs, either because they do not persevere and take the G.P.O. Morse Test or are chary of sitting the R.A.E. They are, however, quite happy to remain s.w.l.'s and enjoy their own particular side of the hobby. It cannot be over-stressed nevertheless, that neither of the required examinations is difficult; usually determination and perseverance are the prime requirements.

What then are the minimum main additional requirements to become "Air-borne"? They are:

(1) A receiver capable of tuning over the Amateur band or bands to be used.
(2) A transmitter capable of emitting signals in the Amateur band or bands selected.
(3) A simple wavemeter or other device capable of indicating that signals are being radiated in the appropriate band in use.
(4) A suitable aerial.
(5) A properly designed log book.

"IT COSTS TOO MUCH"

The excuse that Amateur Radio is a costly hobby is untrue. What cost is involved to become usefully "Airborne"? Here the type of emission to be used must be first decided, and there are three main types to choose from.

(1) A1 — c.w. Morse code by keying the transmitter.
(2) A3 — Fone. Speech amplitude modulating the transmitter.
(3) A3A — s.s.b. Single sideband speech transmission with reduced carrier.

Types 1 and 3 are used principally, but not entirely, for Dx or medium range contacts. Type 2, once very popular, is now used mainly for short range working, mobile, and so on.

Single sideband is a mode with many adherents but it has the disadvantage of requiring fairly expensive and sophisticated apparatus. It can thus hardly be recommended to a newly-licensed operator about to get his feet wet! This leaves c.w. (A1) or fone (A3) as inexpensive alternatives: once again a decision is required.

If the local or semi-local rag-chew type of QSO is to be the main interest initially, a simple l.f. bands phone transmitter is all that is required; should European and Dx contacts be required a simple 50-watt c.w. rig will do the job excellently. The effective simplicity of c.w. transmitters still remains a challenge to s.s.b. apparatus, for c.w. can get anywhere that s.s.b. can! Cost-wise there is no comparison; a 4-band c.w. rig can be hand-built in a matter of weeks for less than £15. An s.s.b. outfit is likely to cost at least many times more than this amount and would probably have to be purchased ready made. Additionally, c.w. transmissions can be easily read via a simple receiver if fitted with a beat frequency oscillator; s.s.b. reception demands the use of a high-performance (and thus expensive) receiver.

To sum up it can be said that Amateur Radio need not be an expensive hobby at all unless you want it to be!

IS IT WORTH WHILE?

This is a question for individual answer. If the Amateur bug *does* bite, you can bet it will be a long time before you recover!

The thrill of working Dx, the enjoyment of a friendly natter over the air, the pleasure of meeting old, and making new, friends of similar tastes from other walks of life — these are all part of the advantages. You may even go "Mobile" and visit some of the mobile rallies held throughout the country during the summer. Additionally, in the winter time you can have lots of fun building items of gear — or just reading about them!

Incidentally, and whilst talking about reading, you will find the following inexpensive books of considerable use. These are "Radio Amateur Operator's Handbook", "Guide to Amateur Radio" and "Radio Amateurs' Examination Manual". The first of these is published by Data Publications, and the last two by the Radio Society of Great Britain, 35 Doughty Street, London, W.C.1.

The R.S.G.B. also has available tapes and e.p. or l.p. records for Morse practice. ■

CONFERENCE ON SIGNAL PROCESSING METHODS FOR RADIOTELEPHONY

A review of the processing methods available for radiotelephony transmission, and a study of the techniques required to match transmission methods to the requirements of the information to be sent and the characteristics of the propagation path, are the objects of a conference to be held in London from the 19th to 21st May, 1970.

The conference, entitled 'Signal Processing Methods for Radiotelephony', is being organised by the IEE, in association with the Institution of Electronic & Radio Engineers and the Institute of Electrical & Electronics Engineers (UK and Republic of Ireland Section).

Offers of contributions (not exceeding 2,000 words) for consideration for inclusion in the conference programme will be welcomed by the organising committee. Those intending to submit contributions should send a 250-word synopsis to the IEE Conference Department before the 25th August, 1969. The full manuscripts will be required by the 29th December, 1969.

Registration forms and further details of the conference will be available in due course from the IEE Conference Department.

BREAKTHROUGH IN ELECTRONIC NAVIGATION

A breakthrough in long-range air navigation has been achieved as a result of technical co-operation between Britain's National airline, B.O.A.C. and SGS (United Kingdom) Ltd., manufacturers of microcircuits — electronic components integrated on pinhead size chips of silicon.

Long-range air navigation has been assisted for some time by a system known as 'Loran'. This system is based on comparisons of low-frequency radio signals that follow the curvature of the earth and therefore theoretically, travel right around it. The radio signals are transmitted by fixed land stations.

However, in areas some distance from the fixed stations reception was often too weak to effectively aid flight navigation. B.O.A.C. for example, found that cover in the North Atlantic was inadequate. After discussion between B.O.A.C. and SGS engineers, a low-noise tuned coupler was devised. Special silicon components were designed by SGS for this aerial coupler, which amplifies the signal in the aerial before it is fed to the long-range navigational equipment.

The practical result, from B.O.A.C.'s point of view, will be to reduce operational work load on the flight decks of its fleet of airliners by giving 'Loran' coverage in areas where previously it was not available.

In the meantime B.O.A.C. have made the design of the 'Loran' coupler freely available to other airlines and already SGS have received enquiries for components from Transports Aero Portugese, Lufthansa, Scandinavian Airlines System, Air France, U.A.T., Quantas and many other world airlines.

The components will be manufactured in the SGS factory at Falkirk, Scotland. This, Britain's most modern microcircuit factory employs some 1,000 people and makes use of advanced automated production techniques specially developed by the SGS research and development laboratories. Monthly output of microcircuits from this factory is already over 400,000.

Radio Topics

By Recorder

WHEN DOES A RADIO OR TV SET wear out?

This is a question calculated to bring a wan smile to the faces of some of the smaller radio retailers who have to deal with customers demanding service on receivers which have had many, many years of use. The difficulty, of course, is that there really is no reliable yardstick by way of which it can be stated that a piece of electronic equipment has "worn out". Some models seem to keep playing for ever whilst others give nothing else but trouble after they have been running for only a few years.

WHAT WEARS OUT?

It would be interesting to try and analyse what exactly does cause a radio or TV set to fall into the "worn out" category so that it is not worth any further repair, and we can do this by examining the individual classes of components in the set.

If the set involves valves these, of course, come top of the list. In general, valves become unserviceable for one of two reasons. Either the cathode loses its emission or something happens to the valve (e.g. ingress of air or internal short-circuit which causes it to be in a different state to that in which it left the factory. The same comments apply to the c.r.t. in a television receiver.

Capacitors come next including, in particular, electrolytic capacitors. It is safe to say that even the highest grade of tantalum electrolytic has a finite life, and that this can be shortened considerably by excessive ambient or operating temperatures. On the other hand, modern capacitors other than electrolytic can have an exceptionally extended life. In the old days, the larger values of fixed capacitors used paper dielectric and the paper capacitors of the time were notoriously prone to "leakiness" due to the ingress of moisture. Modern plastic foil capacitors, because of the very nature of the dielectric, can have a very much longer life. Mica capacitors, similarly, are potentially capable of a very long life as also are ceramic capacitors which have been properly encapsulated.

Let's next turn to resistors. Here we have a component which can, with the years, exhibit marked symptoms of old age. The most commonly employed resistor in radio and TV receivers is the carbon composition type and this can definitely cause a lot of trouble as time goes by. The usual shortcomings in performance are shifts in value or open-circuits, and the process may, again, be accelerated by high temperatures. However, modern high-stability resistors should, with the years, be free at least from shifts in value. Wirewound resistors are used much less frequently than are carbon composition resistors and are much more reliable. They do not shift in value, but they can, occasionally, go open-circuit in time even when operated well within their dissipation ratings. Wirewound resistors using very thin resistance wire are the most likely offenders. As an interesting side-line here, I encountered an instance some years ago where a percentage of brand-new 0.1 amp heater droppers had gone open-circuit after having been in a factory store for a year or so before being fitted into sets. These were of the type protected by a cement-like encapsulation, and the reason was that the encapsulating material itself, was attacking the wire. Had the droppers been wired up and been allowed to pass current for a short while all would have been well, as the normal heat dissipated by the wire would have finally "cured" the encapsulating material!

If we next turn to inductive components it would seem that, with some exceptions, these could have almost unlimited life. The exceptions are inductors wound with very fine wire (which are liable to become open-circuit in time in a similar manner to wirewound resistors employing very thin wire) and inductors which have to withstand high pulse voltages, such as TV line output transformers and deflector coils. Given good impregnation and, where applicable, the correct choice of enamel covering for the wire, all other inductive components should continue in working condition for a very long period indeed.

MECHANICAL WEAR

All the components I've mentioned up to now either have, theoretically, an almost limitless life or are liable, because of their nature and construction, to deteriorate with time.

We now come to components which are liable to become faulty due to *mechanical* wear, these being switches, variable resistors, variable capacitors and tuning drives and mechanisms. All of these have, inevitably, a life which is limited eventually by mechanical wear. Another item which has to withstand considerable mechanical wear and tear is the loudspeaker, but it says much for the design of this component over the last twenty years or so that the loudspeaker is usually one of the most reliable parts of a receiver.

Finally, there is environment. There is nothing so disheartening as taking the back off a receiver and finding its innards covered with a layer of dust together with those sticky deposits which seem to find their homes in radio and TV sets. Again, heat causes most of the trouble. As an extreme instance of what I mean, examine a small valve TV receiver. This keeps cool by convection, as you can readily prove by blowing cigarette smoke at the bottom of its back when it is well warmed up. That smoke will come out of the back top in hardly any time at all. When you have this domestic version of a factory chimney working away all the time, it is little wonder that impurities in the surrounding air are drawn in by the convection current, to become lodged on the insides of the receiver itself. If these impurities build up across insulating surfaces, then trouble is very liable to occur.

It follows from what we have just discussed that a modern radio or TV receiver which is stated to be "worn-out" is most likely to be suffering from a combination of troubles, these being contributed by those components which are the more liable to give trouble with time. Let's list them.

They are valves, the c.r.t. in TV receivers, carbon composition resistors, paper and electrolytic capacitors, wirewound resistors and indicators incorporating thin wire, inductors which have to withstand high pulse voltages, all components apart from the loudspeaker which involve mechanical operation, and all insulating surfaces likely to be affected by domestic dirt and grease.

Quite a list, isn't it? There are certainly enough potential variables here to make it extremely difficult to arrive at a decision as to whether an old set is "worn-out" or not, and the retailers and service engineers faced with this problem have my sympathy.

That list didn't include semiconductor components, such as solid-state diodes and transistors. I excluded them because I don't consider that semiconductor components are liable to deteriorate with age. It is true that they fail on occasion but, provided that they are not overheated or overrun, such failure is liable to occur at any time.

This being so, it would be interesting to see whether it is possible to think in terms of a domestic radio or TV receiver which, quite simply, just doesn't wear out at all. To start off with, it would use transistors and semiconductor diodes throughout. All resistors would be high-stability except those having to dissipate relatively high powers, and the latter would be wirewound types which did not use extremely fine wire. The design would, for similar reasons, avoid using inductors wound with very thin wire. When we come to capacitors we encounter our first snag. Transistor a.f. and bypass circuits call for electrolytic capacitors, and we would have to keep these to a minimum by suitable circuit design. The remainder of the capacitors could be mica, ceramic or plastic foil. The tuning mechanism should be kept as simple as possible to reduce mechanical wear, and we would have to accept the use of mechanically operated components such as switches and variable resistors. We could overcome the dirt problem by completely enclosing all the components, apart from those which dissipate heat, in a metal or plastic box. Any heat dissipating components could be enclosed in a second box made of metal, which could also act as a heat sink.

It is, of course, impossible to make a receiver having limitless life. But if we followed the lines I've just described we *would* have a set which would not "wear out" in the normal sense of the phrase provided that, from time to time, we replaced its electrolytic capacitors, its switches and its variable resistors. If we attempt the same technique with a TV set we have also, from time to time, to accept replacement of the line output transformer, deflector coils and cathode ray tube.

A receiver of this nature would not be entirely free from failure, of course, and there would still be the risk of occasional catastrophic failure in its "long-life" components, as well as in the components whose life is accepted as being limited. But the set could never be classified as "worn-out" as are so many of our present-day sets after five to ten years' usage.

TESTING CAPACITORS

Talking of "leakiness" in paper capacitors reminds me that there is a dodge for testing these components which you may find of value. Provided that the capacitor has an adequately high working voltage, you simply connect it momentarily across any convenient d.c. supply of 200 volts or so (keeping your fingers well away from the leads!). After a moment or two you then apply the two leads of the capacitor to a flat piece of metal. If you get a spark as the capacitor discharges then its insulation resistance is satisfactory for all normal purposes. The discharge spark shows up best if you apply the two leads to a piece of metal having a shiny reflective surface, and even capacitors with values as low as 0.002μF give a spark on discharge which is quite noticeable when the ambient lighting isn't too bright. It would probably be better to avoid carrying out this test with capacitors larger than 0.25μF.

The value of this simple test is that it can indicate very low leakage currents in the capacitor. After the capacitor has been charged, it can only discharge via its own leakage resistance so that, if a fat discharge spark is obtained, it would then be safe to assume that the time constant of the capacitance and leakage resistance (microfarads times megohms) is greater than the time between charge and discharge. Thus, should a 0.01μF capacitor give a good discharge spark two seconds after being charged, its leakage resistance must be greater than 200MΩ.

DRAUGHT DETECTOR

There was, I regret, a misprint in my contribution in the January issue, this appearing despite my having corrected it on the galley proof. In the draught detecting device described at that time, R1 of Fig. 2 should initially be adjusted to insert minimum resistance, and not maximum as was printed.

To finish off this month, I'd like to tell you briefly about the service engineer who tried to fit a Philips line output transformer into a Ferguson TV.

The TV set rejected it. ■

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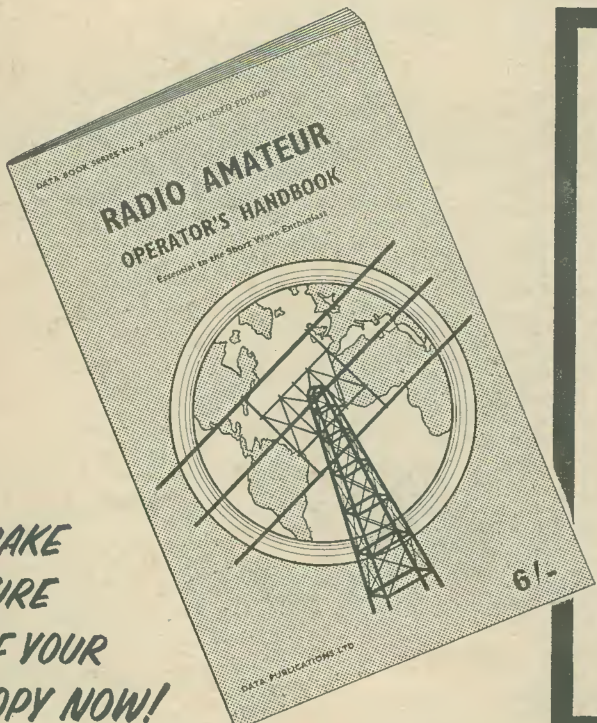

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Continued on page 608

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20L1	13/–	ECH42	10/–	PC900	8/3	U191	12/6	AF115	3/–	OC28	5/–
20P4	18/6	ECH81	5/9	PCC84	6/–	U251	16/–	AF116	3/–	OC30	5/–
30C15	13/6	ECH83	8/–	PCC85	6/6	U301	11/–	AF117	2/9	OC35	5/–
30C17	12/6	ECH84	7/–	PCC88	9/9	U404	7/6	AF119	3/–	OC36	7/6
30C18	8/9	ECL80	6/6	PCC89	9/6	U801	18/–	AF125	3/6	OC38	11/6
30F5	13/6	ECL82	6/–	PCC189	9/6	U4020	6/9	AF127	3/6	OC41	10/–
30FL1	15/–	ECL83	9/–	PCF80	6/6	UABC80	5/9	AF139	11/–	OC44	2/–
30FL12	16/–	ECL86	8/–	PCF82	6/–	UBC81	7/–	AF180	9/6	OC45	1/9
30FL14	12/6	EF22	12/6	PCF84	8/–	UBF80	5/9	AFZ12	5/–	OC46	3/–
30L15	13/9	EF37A	7/–	PCF86	9/–	UBF89	6/9	ASY29	10/–	OC70	2/3
30L17	13/–	EF41	9/6	PCF801	7/–	UC92	5/6	BA115	2/8	OC71	2/–
30P4	12/–	EF80	4/6	PCF802	9/–	UCC84	8/–	BA129	2/6	OC72	2/–
30P4MR	17/6	EF85	5/3	PCL82	7/–	UCC85	6/6	BA130	2/–	OC75	2/–
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30PL13	15/–	EF183	6/–	PCL86	8/6	UCH81	6/6	BCY10	5/–	OC78D	3/–
30PL14	15/–	EF184	6/–	PEN45DD	12/–	UCL82	7/–	BCY12	5/–	OC81	2/–
AC2PEN	19/6	EH90	6/6	PFL200	12/–	UCL83	10/–	BCY33	5/–	OC81D	2/–
AC2PENDD	19/6	EL32	3/6	PL36	9/6	UF41	9/6	BCY34	4/6	OC82	2/3
CL33	18/6	EL33	12/–	PL81	7/3	UF42	9/–	BCY38	5/–	OC83	2/–
CY31	7/6	EL41	9/3	PL82	6/6	UF80	6/9	BCY39	4/6	OC84	3/–
DY87	5/9	EL84	4/6	PL83	6/6	UF85	6/9	BFY50	4/–	OC123	4/6
E88CC	12/–	EL95	5/–	PL84	6/3	UF86	9/–	BFY51	4/–	OC169	3/6
EABC80	6/–	EM80	5/9	PL500	12/–	UF89	6/3	BFY52	4/6	OC170	2/6
EAF42	8/9	EM81	6/9	PL504	12/6	UL41	9/6	BF163	4/–	OC171	3/4
EB91	2/3	EM84	6/–	PL509	28/9	UL84	6/6	BY100	3/6	OC172	4/–
EBC41	8/6	EM85	11/–	PL802	15/–	UM80	5/–	BY126	6/6	OC200	4/4
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SMALL ADVERTISEMENTS

Continued from page 607

TO CLEAR. 3000V d.c. 0.5μF capacitors, 2½in. x 1⅛in x 6in. with porcelain insulators, 3/6d. each. 88H toroid coils, new, wax covered, 5/- each. Heathkit Balun Coil set, B–1U, assembled, £5. "Ful-Fi" pick-up, mono crystal cartridge, Type TC8M, 10/-. Box No. F352.

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Continued on page 609

SMALL ADVERTISEMENTS

Continued from page 608

FOR SALE: Large quantity radio components, approx. £300 worth. The lot for £75. Also two Faber-Castell slide rules Nos. 1/98 and 1/54, £3/10/- each, if two bought together one other free, plus books about slide rules. Also a number of radio books for sale. Please send for list. Pierce, 80 Railway Road, Rock Ferry, Birkenhead, Cheshire.

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FOR SALE: Back numbers of *The Radio Constructor*, Vol. 15, No. 12 to Vol. 22 No. 1 inclusive at 2/- each, or offers. Also *Wireless World* 1963 to 1968. Evans, 29 Tycehurst Hill, Loughton, Essex.

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Continued on page 610

SMALL ADVERTISEMENTS

Continued from page 609

FOR SALE: Codar CR.45 mains t.r.f., 150kc/s–30Mc/s. New in January. Still perfect. £8. Write: "Invararey", Queen's Road, Tipton, Staffs.

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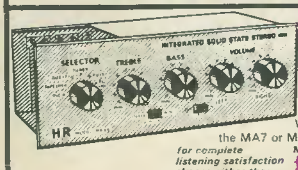

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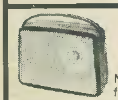

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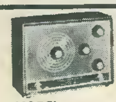

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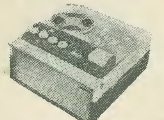

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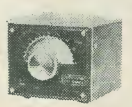

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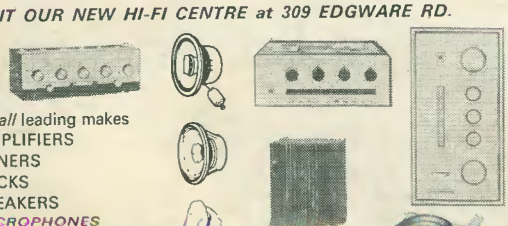

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