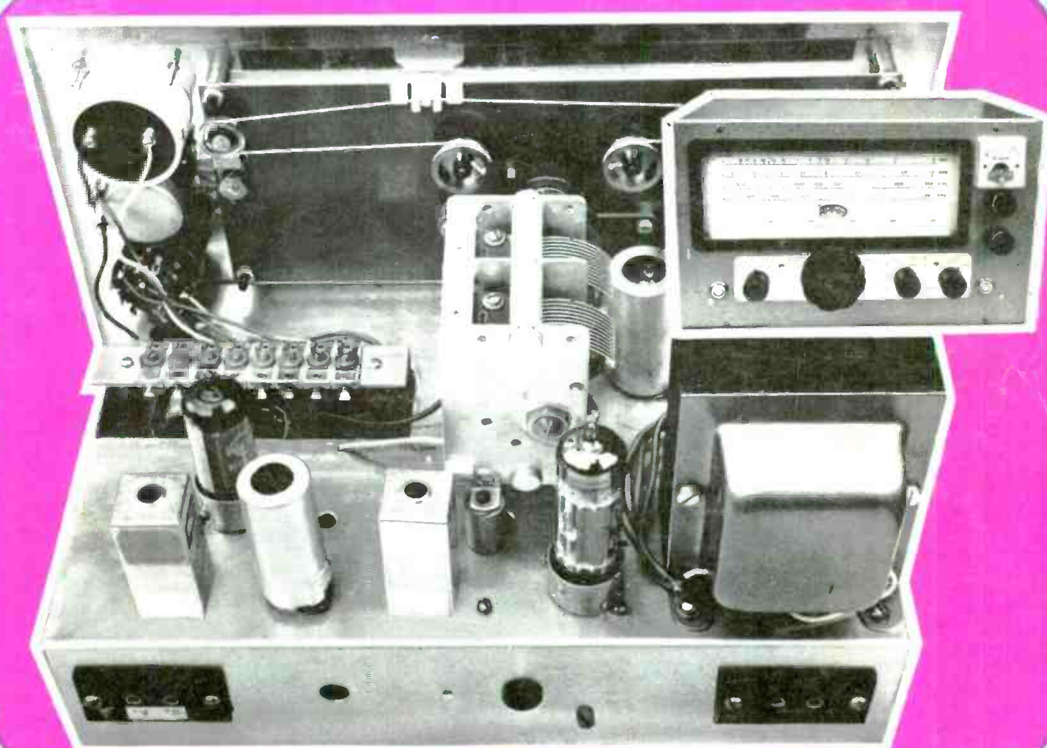
THE
RADIO CONSTRUCTOR

Vol. 25 No. 3 OCTOBER 1971 20p



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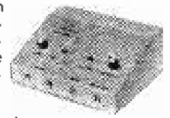

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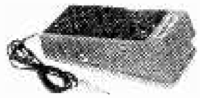

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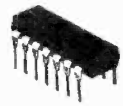

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UIC04 – 12 × 7404N	50p	UIC70 = 8 × 7470N 50p	UIC90 – 5 × 7490N 50p
UIC05 – 12 × 7495N	50p	UIC72 = 8 × 7472N 50p	UIC92 – 5 × 7492N 50p
UIC10 – 12 × 7410N	50p	UIC73 = 8 × 7473N 50p	UIC93 – 5 × 7493N 50p
UIC20 – 12 × 7420N	50p	UIC74 = 8 × 7474N 50p	UIC94 – 5 × 7494N 50p
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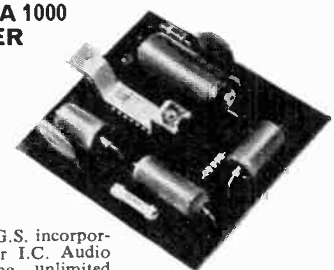

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BP944	Dual 4-input NAND expandable buffer without pull-up	13p	12p	11p
BP945	Master-slave JK or RS	25p	24p	22p
RP946	Quad, 2-input NAND	12p	11p	10p
BP948	Master-slave JK or RS	25p	24p	22p
BP951	Monostable	65p	60p	55p
BP962	Triple 3-input NAND	12p	11p	10p
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BP9094	Dual Master-slave JK with separate clock ..	40p	38p	35p
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BP 702—72702	D.I.L.	14	G.P. OP Amp (Wide Band)	53p	45p	40p
BP 709—72709	D.I.L.	14	High OP Amp	53p	45p	40p
BP 709P—µA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP 711—µA711	TO-5	10	Dual comparator	58p	50p	45p
BP 741—72741	D.I.L.	14	High Gain OP Amp (Protected)	75p	60p	50p
µA 703C—µA703C	TO-5	6	R.F.–I.F. Amp	43p	35p	27p
TAA 263—	TO-72	4	A.F. Amp	70p	60p	55p
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NOVEMBER ISSUE WILL BE PUBLISHED ON NOVEMBER 1st

SOUND OPERATED CAMERA FLASH

by

M. G. ARGENT

Intended for use with portable electronic flash guns, this unit is capable of triggering off flash at very low levels of sound

THIS IS AN AID FOR THE PHOTOGRAPHER AND enables him to utilise the high speed of the electronic flash to produce impact-triggered photgraphs. Due to the fast switching of thyristors, or silicon controlled rectifiers as they are also called, it is now possible to switch apparatus remotely within microseconds of the initial triggering pulse.

CIRCUIT OPERATION

The circuit is given in Fig. 1, and is basically an amplifier used to amplify the monitored sound, and a trigger circuit to operate the electronic flash.

The sound to be monitored is picked up by the crystal microphone (a crystal microphone insert was used by the author) and amplified by TR1, a high gain common emitter amplifier. C1 is used to block d.c. from the microphone, whilst R9 compensates for microphones having different output levels.

C2 blocks d.c. from RV1. A low noise transistor BC109 is used for TR1, as the overall circuit has a large signal gain, and hence any noise in the first stage will be amplified by TR2 and TR3, with the possibility of spuriously triggering off SCR1. This is the reason why RV1 is inserted after TR1, thereby reducing noise at lower settings of required sensitivity.

The output from RV1 wiper is fed by way of C3 to the base of TR2 which, in turn, is directly coupled to TR3. High gain is achieved by feeding the signal at TR3 emitter via C4 to the junction of R4 and R5.

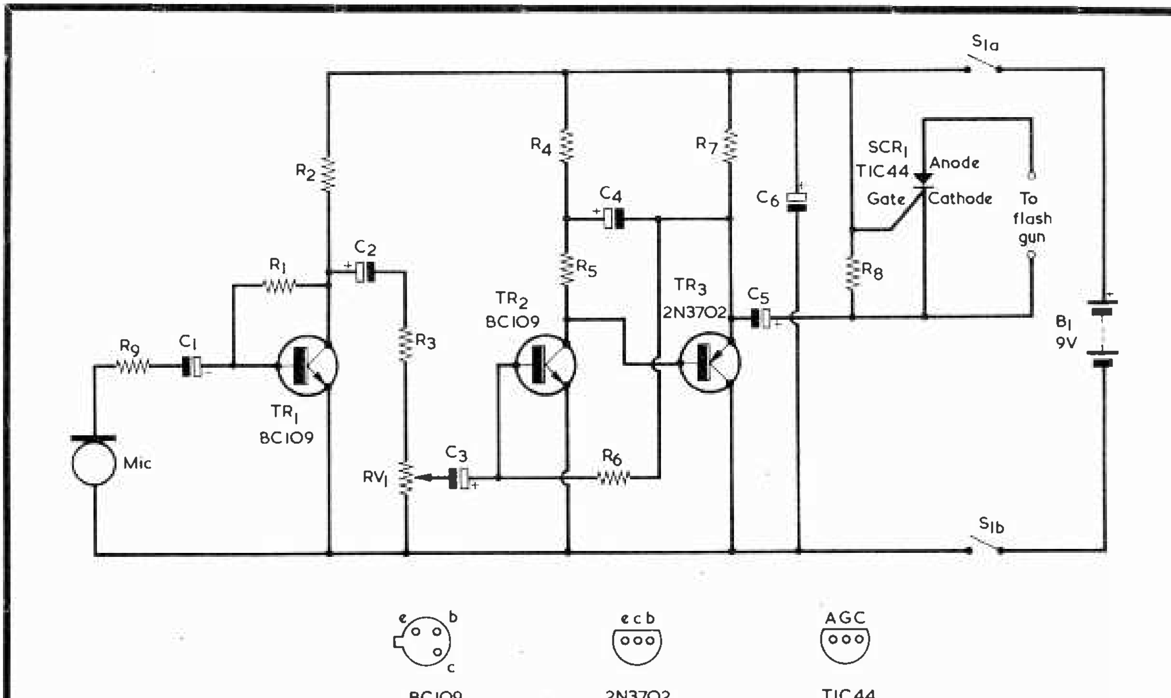
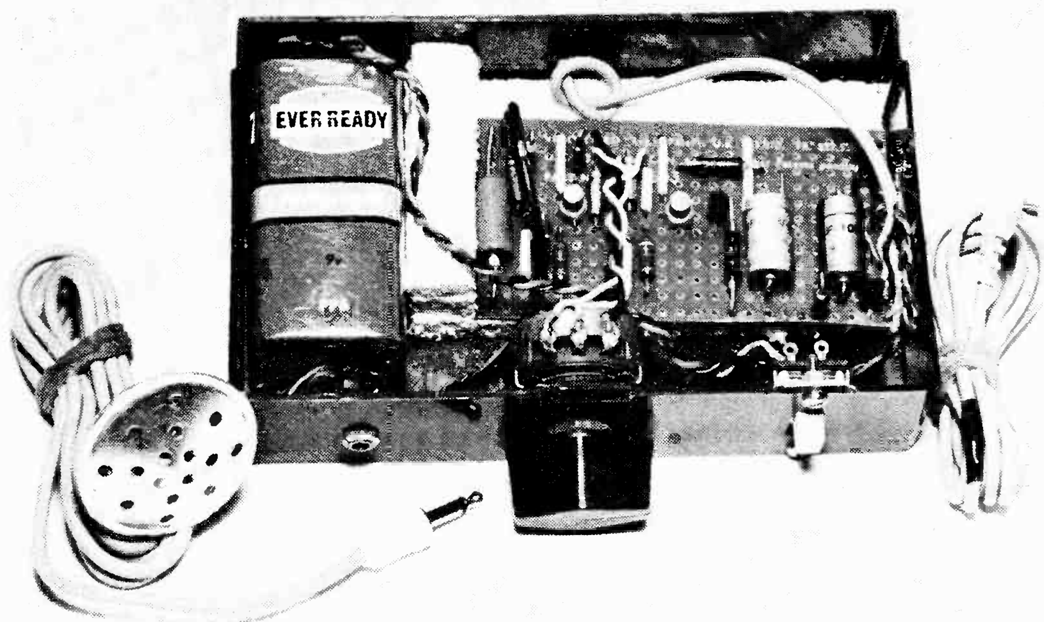


Fig. 1. The circuit of the camera flash unit



The prototype flash unit. The lead to the flash gun passes through a hole at the rear of the case

COMPONENTS

Resistors
(All fixed values $\frac{1}{8}$ watt 10%)

R1	270kΩ
R2	5.6kΩ
R3	3.3kΩ
R4	2.2kΩ
R5	4.7kΩ
R6	560kΩ
R7	4.7kΩ
R8	470Ω
R9	150kΩ
RV1	10kΩ potentiometer, linear

Capacitors
(All capacitors 10V wkg.)

C1	4μF electrolytic
C2	4μF electrolytic
C3	4μF electrolytic
C4	125μF electrolytic
C5	200μF electrolytic
C6	100μF electrolytic

Semiconductors

TR1	BC109
TR2	BC109
TR3	2N3702
SCR1	TIC44

Switch
S1(a)(b) d.p.s.t. slide switch

Battery
B1 9-volt battery

Microphone
MIC1 Crystal microphone or insert

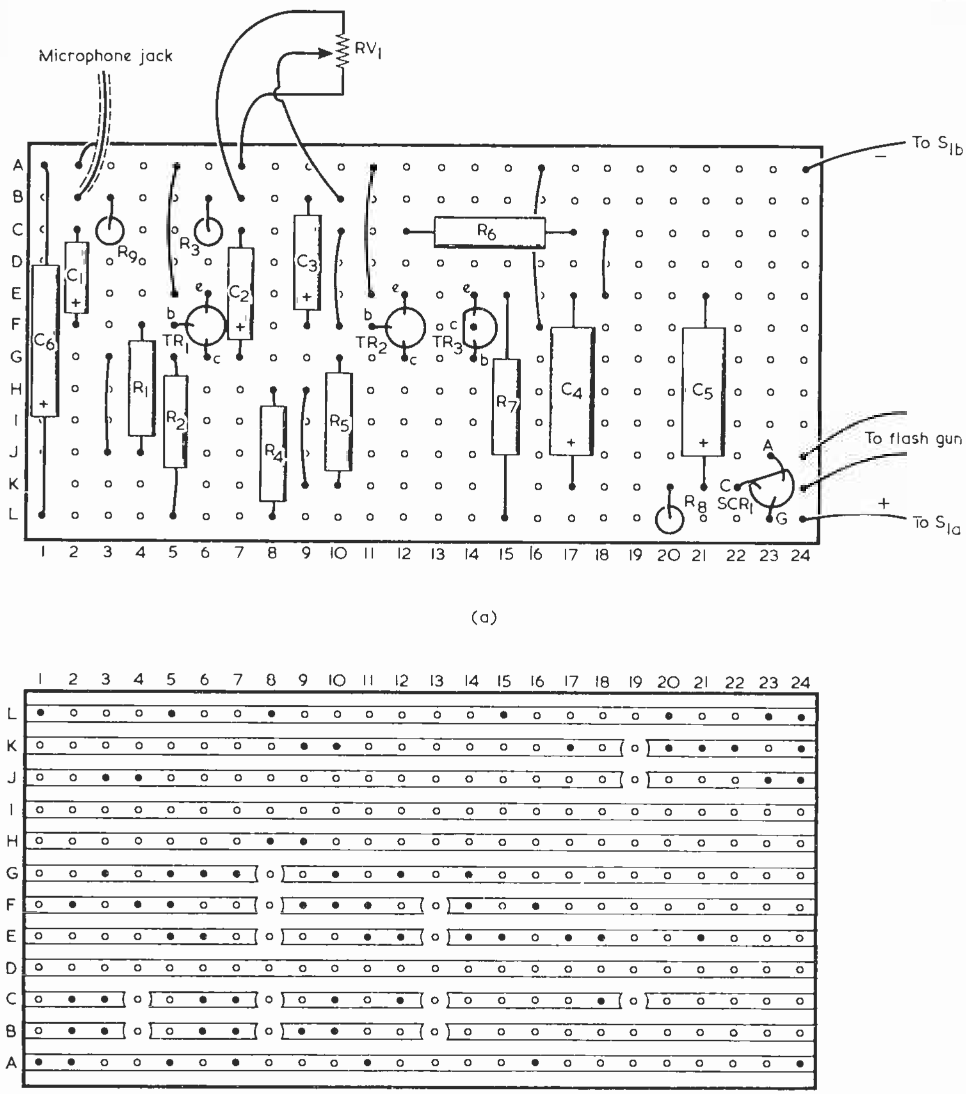
Miscellaneous
Veroboard, 0.15in. matrix, $1\frac{7}{8}$ x $3\frac{5}{8}$in. (see Fig. 2)
Miniature jack and plug
Pointer knob
Flash gun extension lead (see text)
Screened lead for microphone
Plastic case, or similar

This feedback is in phase with the signal present at TR2 collector, and hence as the a.c. voltage at both ends of R5 is equal in phase and practically equal in amplitude, little a.c. current will flow through it. This makes the resistance of R5 appear, to a.c., as having a much higher value than the actual resistance, namely 4.7kΩ. This technique is known as 'boot-strapping' and gives the circuit a higher voltage gain for a.c. without upsetting the d.c. conditions.

D.C. stability is achieved by biasing TR2 base from TR3 emitter. This, being negative feedback, gives good stability against temperature variations.

The output from TR3 emitter is applied via C5 to SCR1. At first glance the circuit used may seem an unconventional way to trigger a thyristor, but as the gate and cathode are across R7 so far as a.c. is concerned, it follows that the presence of a signal voltage across R7 of sufficient amplitude will trigger off SCR1. Only positive signals on the gate, with respect to the cathode, will trigger a thyristor, and one might think of using a diode in series with the gate to eliminate the negative signals. However, as no harm will come to the thyristor with their presence, there is no point in including the diode, especially when extra amplification would be required to overcome the voltage drop across it.

The thyristor employed in the prototype is a Texas Instruments TIC44. It was obtained from A. Marshall and Sons Ltd., 28 Cricklewood Broadway, London, N.W.2.



(b)

Fig. 2(a). Component side of the Veroboard
(b). The copper side of the Veroboard. The strips are cut at the points indicated

Total current consumption from the 9 volt supply is 4mA.

CONSTRUCTION

No trouble should be experienced in construction if the layout is followed carefully.

The complete unit is built on a piece of 0.15in. Veroboard with 24 holes one way and 12 the other, as shown in Figs. 2(a) and (b). Fig. 2(a) gives the component layout, whilst Fig. 2(b) shows the reverse side and indicates the points where the copper strips are cut. This is done using a small drill or the special spot face tool.

The unit was housed, together with a PP6 battery, in a plastic case measuring $5\frac{3}{4}$ by $3\frac{1}{2}$ by $1\frac{1}{2}$in. deep, pieces of polystyrene ceiling tile being employed to keep the Veroboard in position. Any similar housing can be used for units built up to the circuit. A miniature phone jack is fitted for the microphone, and the latter couples to the unit via screened lead.

FLASH GUN CONNECTION

The standard portable flash guns available, which plug into the camera for operation off the normal camera shutter, require two terminals of the plug to be short-circuited together to fire the flash. With the present unit this is achieved electronically by the thyristor.

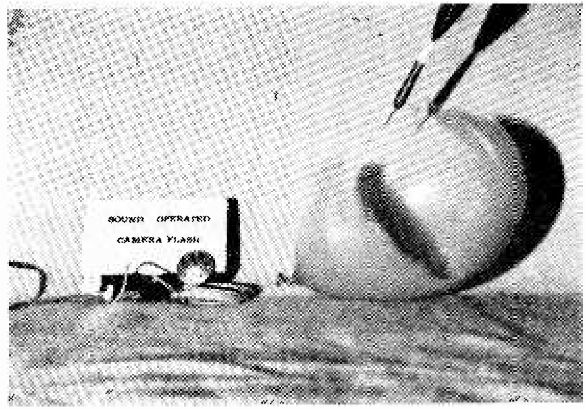
Firstly, an extension lead for flash guns (which is available from most chemists and photograph shops) is purchased. It will be seen that there are male and female connectors at each end of the lead. One of the connectors fits the plug on the flash lead. The connector on the other end of the extension lead is not required and can be cut off, after which the two wires are bared back. What now remains is a lead which plugs into the existing lead on the flash gun, and which has two bare wires at the other end. These two wires are now connected to the thyristor anode and cathode, at holes J24 and K24 of the Veroboard.

For the thyristor to fire, when a signal is present across the gate and cathode, the correct polarity must be applied across the anode and cathode. With the flash gun used for the prototype, the positive lead of the flash gun was the inside contact of the plug, the negative lead being the outer casing. It is the positive lead which is connected to the anode and the negative to the cathode.

If incorrect polarities are connected across the thyristor anode and cathode no harm will result, and the unit will just not operate. The easiest course consists of connecting up the flash gun with the centre contact of the plug to the anode and the outer contact to the cathode, and if the unit does not operate reversing them. An earpiece temporarily connected across R8 will monitor any sound picked up by the microphone, and hence prove that the amplifier section (TR1, TR2 and TR3) is working.

The flash gun used by the writer is the Japanese SUNPAC DC3. This is in no way special, and is readily available. The design is common to the majority of electronic flash guns.

Practically any portable *electronic* flash gun can be operated by the circuit. Bulb type flash units, of the type which require a replacement bulb after every flash, are not suitable due to the high surge current drawn. They could be used if a higher rating thyristor were employed, but this would reduce the sensitivity. Also, their speed is very slow compared with the electronic versions, which operate within one thousandth of a second.



Here, the sound operated flash has enabled the camera to photograph the balloon in the process of bursting

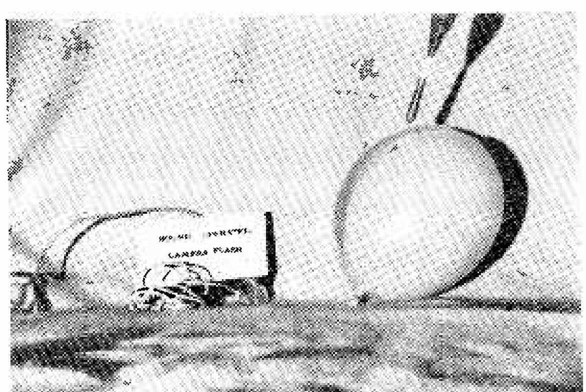
TESTING

Always remember to switch the unit on before connecting the flash gun, as there may be a spurious operation of the flash during switch-on.

Two of the accompanying photographs show the unit in operation. In one photograph, the flash operated at a suitable time to catch the balloon collapsing.

The other photograph of the balloon, in which the balloon is still intact, gives an ideal example to emphasise the speed of the unit. In this picture the microphone was placed near the balloon and the unit set up so that the flash operated at the slightest sound. Note that the flash fired as soon as the dart touched the balloon, even before the balloon had a chance to burst.

On maximum sensitivity, the prototype operated at the flick of the fingers from the other side of the room.



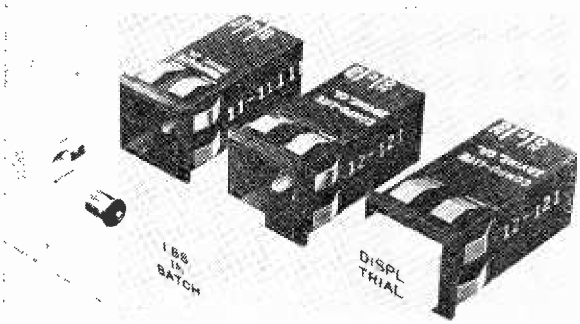
At a higher sensitivity setting, the camera photographs the dart as it enters the balloon

EDITOR'S NOTE

It should be pointed out that the author has applied for a patent on the device described in this article. ■

NEWS . . . AND .

HIGH QUALITY LOW COST SWITCHES



Competitively priced yet with many features previously associated only with high priced products, a new range of illuminated multi-pole Compu-Lite Series 11 push button switches from Guest International Limited of Brigstock Road, Thornton Heath, Surrey, are ideal for use in virtually any application from computer systems to domestic appliances.

Designed for front panel fixing they are fully enclosed and sealed and switch up to 5A at 250V. Typical life is 2 million switching operations and each switch is programmable in that one pole is switched in before the remaining poles make contact – a particularly desirable feature in communications and digital applications. Special gold contacts are available for low-level switching.

Versatility within the range enables a wide range of coloured bezels and screen split or full legends to be supplied, and a number of different switching actions is also available.

Where space is at a premium, a useful feature of the complete Compu-Lite range is the very small amount of space taken up behind the panel – maximum depth is only 1½in. All Series 11 switches can be made available with AMP-type terminals.

THE COMPUTER AND EDUCATION

Much is being done in the field of computers and their relevance to education, and the value of computer-aided instruction is now generally appreciated and the potential of the next step, computer-managed instruction, is now being recognised. Therefore, it is not surprising to find the computer and its educational uses the central theme of the British Computer Society's 1971-72 Educational Yearbook.

The section on computer-aided instruction and computer-managed instruction commences with a paper by Dr. A. Molnar, National Centre for Educational Research and Development, United States Office of Education, Washington.

Monsieur J. Donio, Director of Research, Institut de Recherche en Information et en Automatique, Paris, considers the growth of computers in world markets and how they have affected our lives; so making the point that the computer must become an integrated part of our educational activity.

Dr. K. Zinn, Centre for Research on Learning and Teaching, University of Michigan, shows how the small number of instructional programming languages that existed five years ago have expanded into at least forty different dialects!

In addition to all the information on computer-aided instruction, the BCS Educational Yearbook also contains standard reference sections on: the educational activities of the BCS Regional Boards: the development of the BCS qualifications: a list of computer courses offered by schools, colleges, universities and private organisations: a comprehensive coverage of all educational activities of the International Federation for Information Processing.

Educational Yearbook 1971-72 is published by The British Computer Society, 29 Portland Place, London, W1N 4AP, price £1.75 plus 25p post and package.

VARTA INTRODUCE RANGE OF TRANSISTOR RADIO BATTERIES TD U.K.

VARTA AG, one of the largest battery manufacturers in Europe, with a new marketing subsidiary company in the U.K., namely VARTA Batteries Limited, announce the introduction of several new battery types, for transistor radio and other applications, to their range.

These batteries made in West Germany are high quality products with high performance being a major characteristic.

Specially designed for power demanding equipment, the four transistor radio battery types have exceptionally long life. Developed in Hanover and Stuttgart, to compete with Europe's best, the exceptional qualities of these VARTA batteries have already established their popularity in Europe.

They are factory sealed and arrive by fast container service via Rotterdam and Harwich. Attractively designed and presented, they will easily be recognised by the familiar blue and yellow label that has already established VARTA batteries in the United Kingdom.

. . . COMMENT

IN BRIEF

● British radio communications systems costing over £100,000 are to be installed in helicopters operating in the Italian mountains by the Carabinieri.

The order was recently placed by the Italian Government with Marconi-Elliott Avionic Systems and will be built at Basildon, Essex.

● A.P.T. Electronic Industries Ltd., of Chertsey Road, Byfleet, Surrey have produced a leaflet on their multi-socket Distribution Panel, LKU-413, a recent addition to their well-known Letrokit range. Copies of the leaflet which gives full technical data are available on request.

● Stephen Hearst, who as Head of Arts Features for BBC Television was responsible for the award-winning series 'Civilisation', has been appointed Controller of Radio 3.

● Nigerian short wave transmitters will be using the prefix 5N5 during October, in commemoration of the 11th Anniversary of Independence. Stations expected to be active are: 5N2AAE: AAJ: AAK: AAV: AAU: ABG: and ABH. It is hoped that 5N5BSN (Scouts) will be active during the Jamboree week-end.

● The Independent Television Authority's first VHF local relay station has been brought into programme service at Pendle Forest, Lancashire. This station will improve the reception of Granada 625-line colour/black-and-white programmes for about 150,000 people living in Nelson, Colne and parts of Burnley.

The ITA plans to build about 450 local relay stations over the next eight years to supplement the coverage of main high-power UHF stations.

● A course on evening lectures on video recording systems commences at Norwood Technical College, Knight's Hill, London, S.E.27 on 19th October. Course Fee is £2.

● The first holder of EMI's Research Fellowship in electronic engineering, Dr. Donald E. Hirst, B.Sc., Ph.D., recently completed three years of his appointment at Brunel University, Uxbridge, Middlesex. To mark the occasion, Dr. Hirst gave a presentation of some of the university's research topics to EMI scientists and senior staff during a day long seminar at the university.

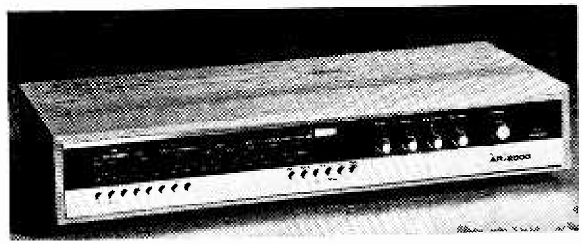
● There will be a London Area Rally for model aircraft enthusiasts who are members of the S.M.A.E. and R.A.F.M.A.A., on 17th October at R.A.F. Wyton, Nr. St. Ives, Huntingdonshire. For details of the radio control event sent S.A.E. to M. Dilly, 20 Links Road, West Wickham, Kent.

● The Millbank Electronics Group, manufacturers of audio and communications equipment, have moved to a new 5,000 sq. ft. factory and administrative headquarters at Bellbrook Estate, Uckfield, Sussex. Tel: Uckfield (0825) 4166.

● Sir Martin Ryle, Director of the Mullard Radio Astronomy Laboratory, has been awarded one of the Institute of Electrical and Electronics Engineers highest honours, the Martin N. Liebmann Award.

The award was made for his application of aperture synthesis to extend the capabilities of radio telescopes.

HEATHKIT AR–2000 TUNER-AMPLIFIER



Heath (Gloucester) Limited announce an outstanding new Tuner-Amplifier kit. Designated Model AR-2000 this Tuner-Amplifier has been designed by Heath (Gloucester) Limited especially for the British and European Hi-Fi markets.

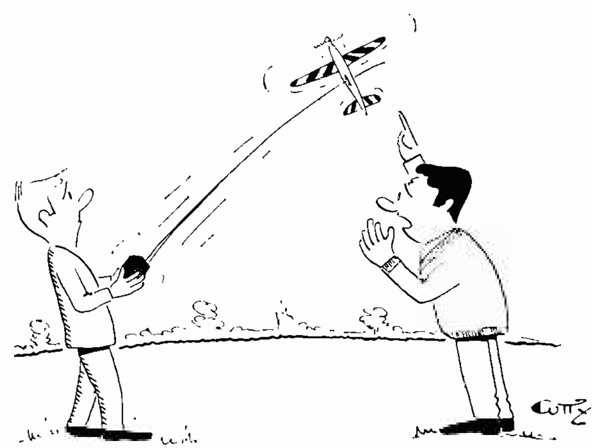
Its main features are listed here:–

Output power 20 watts r.m.s. per channel
LW, MW, SW, and FM stereo
All solid-state
Completely new styling
F.E.T. front end F.M. Tuner
I.C. stereo decoder.
FM IF uses I.C.'s and ceramic filters

With this specification and direct-from-factory kit price of only £89.90 plus £7 for a teak or walnut cabinet this is clearly an exciting new addition to the well known Heathkit range of hi-fi equipment. This kit, like all Heathkit products, includes an extremely comprehensive construction manual, making it easy to build the kit without the need for any technical knowledgs or special skills.

For further details write to:–

Heath (Gloucester) Limited, Bristol Road, Gloucester GL2 6EE.



"You're flying it too low!"

WIDE RANGE LOW FREQUENCY SIGNAL GENERATOR

by

P. CAIRNS, M.I.P.R.E., R.Tech.Eng., G31SP

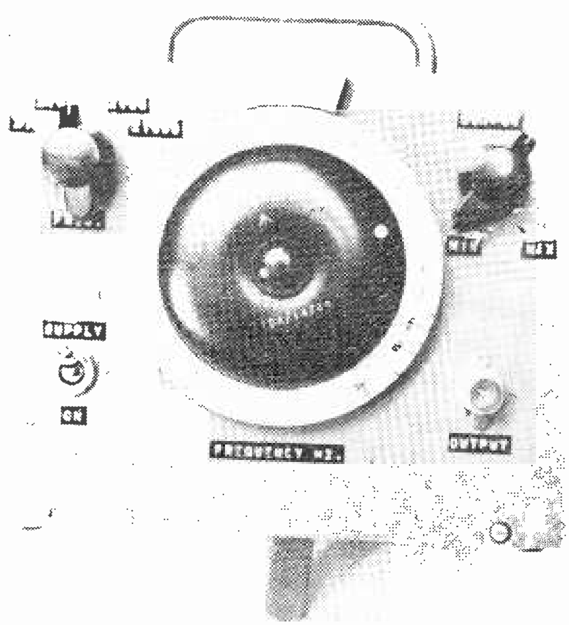
Incorporating thermistor stabilisation, this Wien bridge circuit offers a constant amplitude sine wave output at frequencies from 15Hz to 150kHz in four switched ranges. An oscilloscope is required for calibration if the latter is to be precise, whilst rough calibration can be carried out with the aid of the graph given

THIS ARTICLE DESCRIBES AN EXTREMELY WIDE range l.f. transistor signal generator. Its principal features are wide frequency coverage in four decade steps, good frequency stability and waveform, simple construction at moderate cost, and internal battery operation. Other features are extremely compact layout using standard components, ample output voltage for most test purposes, and very low output impedance with constant amplitude control over the whole frequency range. The specification is given in Table I.

CIRCUIT OPERATION

As can be seen from the circuit diagram of Fig. 1 and the Components List, the instrument uses the minimum number of components consistent with good specification and reliable performance. The circuit is basically a Wien bridge oscillator with emitter follower output. To function correctly the Wien bridge circuit must meet certain requirements. Such a circuit consists of a very high gain amplifier, which must have high input impedance and low output impedance with R–C coupling between output and input to provide the positive feedback necessary to maintain oscillation. The time constants of this feedback are usually made of a variable nature to provide variations in frequency of oscillation. The gain of the amplifier must also be substantially independent of frequency over the range of operation envisaged. This entails a very low output impedance so that the shunting effect of the R–C feedback network has negligible effect on the output. Again, the high input impedance is required to prevent the bridge network being loaded by the amplifier. Also, the phase shift through the amplifier must be strictly controlled so as to maintain oscillation over the complete frequency range. The total phase shift over the complete amplifier and bridge circuit must always be zero or a multiple of 2π radians.

These requirements are met by the circuit shown in Fig. 1. TR1 and TR2 form the first stage of the amplifier, these being connected as a Darlington or super-alpha pair so as to achieve a very high gain, R3 being the load resistor. The output from this stage is d.c. coupled into the base of TR3 which forms the



Front view of the signal generator. An ex-W.D. dial and drive were used for the prototype

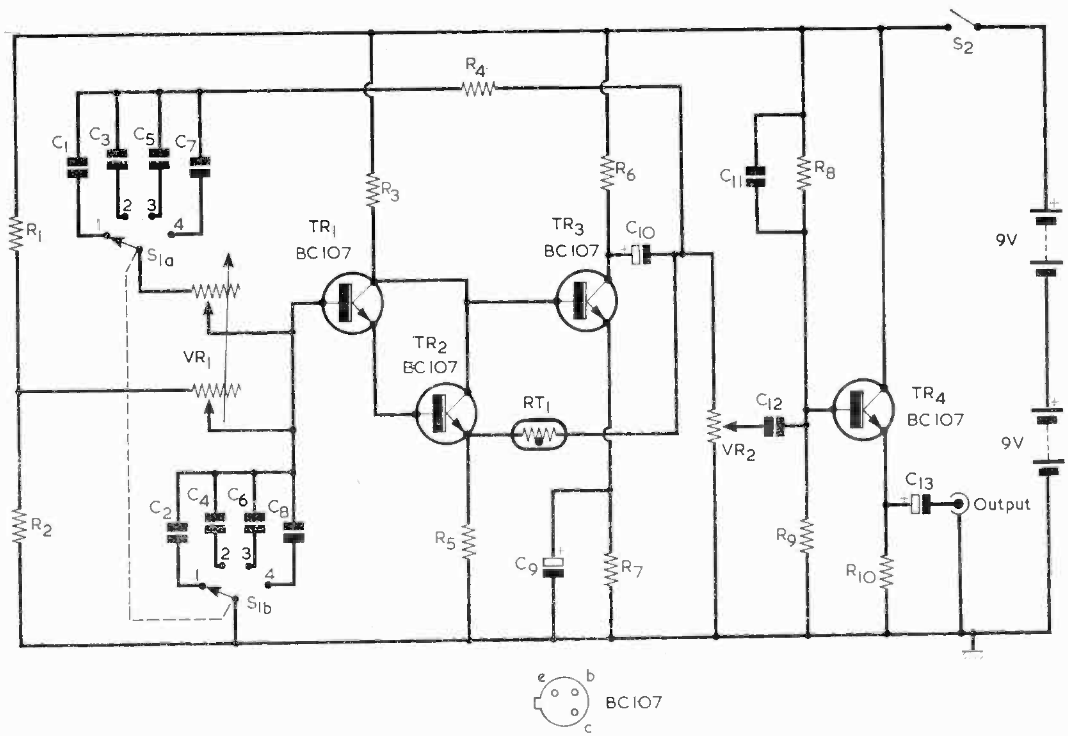


Fig. 1. Circuit diagram of the wide range l.f. signal generator

COMPONENTS

Resistors
(All fixed values ½ watt 5%)

R1	4.7kΩ
R2	620Ω
R3	2.7kΩ
R4	1.8kΩ
R5	270Ω
R6	470Ω
R7	820Ω
R8	33kΩ
R9	33kΩ
R10	1kΩ
VR1	10kΩ + 10kΩ twin gang potentiometer, log
VR2	10kΩ potentiometer, linear

Thermistor
RT1 S.T.C. type R54 (Henry's Radio Ltd.)

Capacitors
(See text for tolerances of C1 to C8)

C1	1μF polyester or polycarbonate
C2	1μF polyester or polycarbonate
C3	0.1μF polyester or polystyrene
C4	0.1μF polyester or polystyrene
C5	0.01μF polyester or polystyrene
C6	0.01μF polyester or polystyrene
C7	1,000pF silver-mica
C8	1,000pF silver-mica
C9	100μF electrolytic, 12V wkg
C10	100μF electrolytic, 12V wkg
C11	470pF silver-mica or ceramic
C12	2.2μF Mullard miniature foil
C13	100μF electrolytic, 25V wkg

Transistors
TR1 – TR4 BC107 (Mullard)

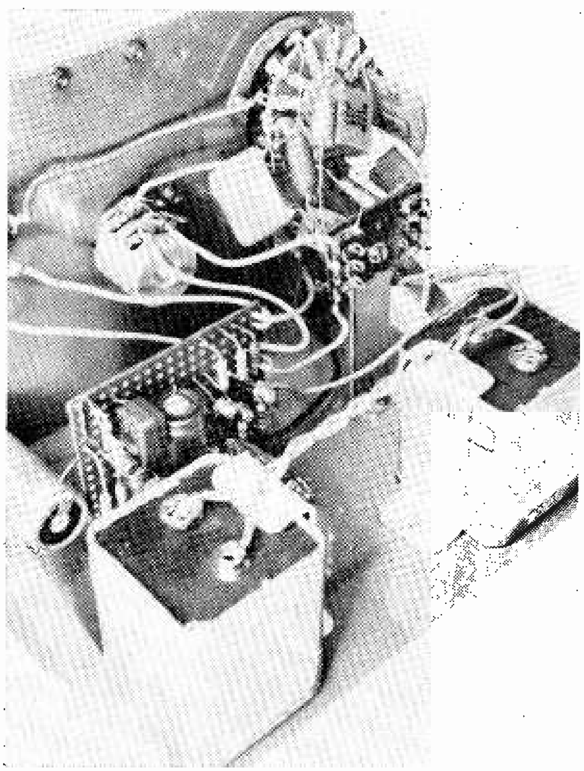
Switches
S1(a)(b) 2-pole 4-way Yaxley
S2 s.p.s.t. toggle

Batteries
2-off 9-volt batteries type PP7 or equivalent

Miscellaneous
Veroboard, 0.15in. matrix (see Fig. 3)
Coaxial socket
2-off pointer knobs
Drive and dial (slow-motion or direct as required)
Material for panel, chassis, struts and brackets
Cabinet type W, 8 x 6 x 6in. (H. L. Smith & Co. Ltd.)

second stage of the amplifier. The d.c. coupling between stages prevents unwanted phase shift. R6 is the final load resistor, the output being taken from this via the blocking capacitor C10. The emitter resistor R7 is bypassed by C9 to maintain the overall stage gain. A small measure of voltage feedback is applied to the emitter of the first stage via the divider network given by R5 and RT1. RT1 is a thermistor whose resistance varies inversely with the current flowing through it. This allows amplitude control to be maintained and also keeps the circuit stable under varying conditions of frequency change. The action of the thermistor is therefore extremely important to the functioning of the circuit as a whole.

Feedback is also applied from the same C10 output via R4 to the principal bridge network consisting of VR1 and C1 to C8, these all being variable and thus providing the wide range of frequencies covered.



Rear view of the generator. Note the capacitors connected between the range switch and the tagboard behind it

Correct d.c. working conditions for the first amplifier stage are also provided by divider R1 and R2, and as these components are interconnected with the bridge network they also affect the frequency of oscillation. Following conventional practice, fine frequency shift control is the function of the twin gang potentiometer VR1, while the coarser ranges, in this case decade steps, are selected by means of switched capacitors C1 to C8 in the alternate limbs of the bridge network. By using logarithmic potentiometers for VR1 the normal non-linear exponential type of scale which would result from a C and linear R time constant is obviated and a more even overall calibration scale is obtained.

The signal output is also taken from C10 to the amplitude control VR2, then via the blocking capacitor C12 to the base of the emitter follower output stage, TR4. The purpose of this stage is to provide a very low output impedance while presenting a reasonably high input impedance to the amplifier output circuit. It thus performs the function of an impedance matching circuit, isolating the final output and load from the actual oscillator circuit. R8 and R9 form a d.c. divider for the base of TR4, C11 being included for h.f. compensation. The final output signal is developed across the emitter load R10 while C13 provides d.c. blocking to the output socket.

The d.c. supply, which is isolated by S2, is obtained from an internal battery supply. Two batteries of the type used for transistor radios are connected in series. Types PP7, RR7, VT7 or similar are quite suitable, the current drain being only in the 25mA region.

TABLE I

Specification

Frequency coverage:	15Hz to 150kHz in four decade steps. Range 1, 15Hz – 150 Hz. Range 2, 150Hz – 1,500Hz. Range 3, 1.5kHz – 15kHz. Range 4, 15kHz – 150kHz.
Stability:	Change in frequency for ±10% change in supply voltage is less than 1%.
Output:	5 volts peak-to-peak ±1db over entire frequency range; continuously variable from zero.
Output impedance:	Less than 500Ω.
Supply:	18 volts d.c., 25mA, from internal batteries.
Dimensions:	8in. wide, 6in. high, 6in. deep.

CALIBRATION ACCURACY

A single dial calibration is used for all four ranges. The accuracy of the calibration on individual ranges will naturally depend on the accuracy of capacitors C1 to C8 and also the accuracy of matching between similar pairs. While 5% types have been specified, 1% or 2% types are naturally preferable, though they are of course more expensive. If a capacitor measuring bridge is available, capacitors which are low in value can always be "padded up" by the addition of smaller values in parallel. The 5% tolerance specified should prove adequate for most everyday applications, however. If high accuracy is essential, the only answer is the use of more expensive higher tolerance components. In this respect it may be added that all the capacitors specified for C1 to C8 are available from Home Radio at 1% tolerance, whilst the 0.1μF and 0.01μF values are also available at 5% tolerance.

The extent of overlap on each range is controlled by R4. The value quoted for R4 should provide an overlap of approximately 10 to 15% using average components in the bridge network. Should the range overlap be not quite unity or if a larger overlap between ranges is required, a slight adjustment to the

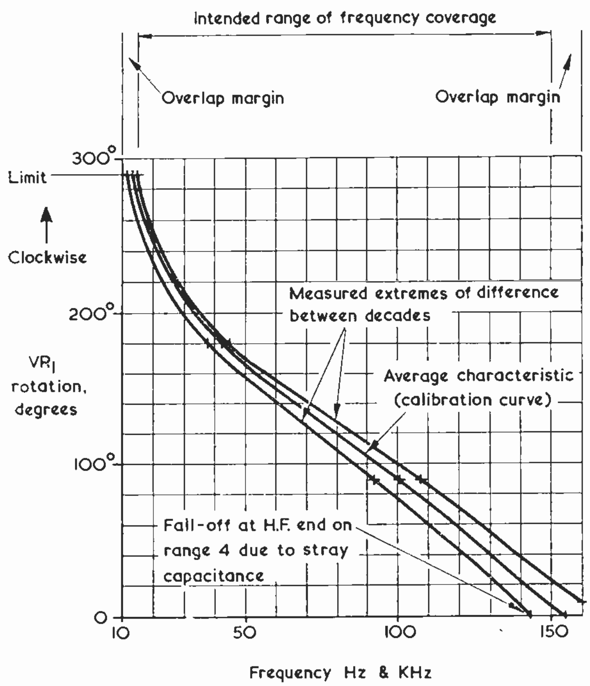


Fig. 2. Calibration curves for frequency versus rotation in VR1, as obtained with the prototype

value of R4 will effect the necessary alteration. Reducing R4 gives a wider range of overlap and vice versa.

The curves in Fig. 2 show frequency versus rotation of VR1 in the basic circuit as calibrated, together with the minimum and maximum calibration errors and deviations encountered between ranges due to differences in tracking. The actual tolerances on capacitors used by the writer, and with which the curves were made, were measured. They are as follows: Range 1, 1μF, −3% and −4%; Range 2, 0.1μF, −0.02% and −1.5%; Range 3, 0.01μF, +3.5% and −0.5%; Range 4, 1,000pF, −0.25% and −0.1%.

The actual range of the generator can be extended to at least a further decade if required (i.e. up to 1.5MHz). The only drawback is that the existing calibration scale would no longer be accurate as the range and spread would become effectively smaller due to the increased effect of stray and self capacitance in relation to bridge capacitance. This fall-off in frequency due to stray and self capacitance is already slightly noticeable at the upper end of Range 4, at 150kHz. This can be seen in the curves in Fig. 2 and in the list of measured frequency limits given in Table II. To maintain accurate calibration another scale would very likely be required for the fifth decade if it were added. It may be of interest however that the writer has had the circuit working in excess of 4MHz. It therefore offers plenty of scope for those who like to experiment a little.

TABLE II

Voltage and Frequency Measurements

(All voltage readings on 20kΩ per volt meter with respect to negative line.)

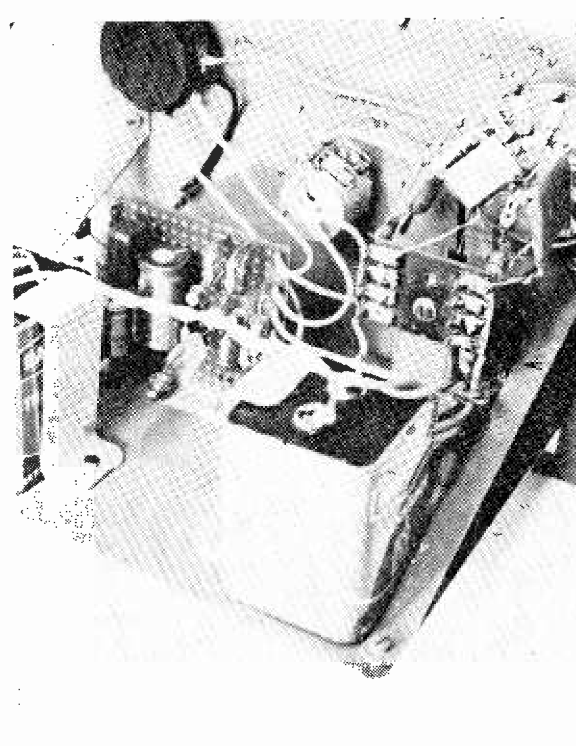
Supply: 18V. Current drain: 24.7mA.
TR1: emitter 1.6V; base 1.9V; collector 8.8V.
TR2: emitter 0.9V; base 1.6V; collector 8.8V.
TR3: emitter 8.3V; base 8.8V; collector 13.55V.
TR4: emitter 7.85V; base 8.15V; collector 18V.

Minimum and maximum frequencies measured:
Range 1, 14.5Hz – 162Hz;
Range 2, 135Hz – 1,570Hz;
Range 3, 1.325kHz – 15.5kHz;
Range 4, 12.75kHz – 145kHz.

CONSTRUCTION

The construction of the instrument is quite straightforward and should offer no difficulties. All components except the switched bridge capacitors and C13 are mounted on a piece of 0.15in. Veroboard approximately $2\frac{3}{4}$ by $2\frac{1}{2}$in. This makes construction much simpler and neater while also helping to standardise the final result with regard to specification. The Veroboard layout with full details is given in Fig. 3. Outgoing flyleads should be soldered to the appropriate points before the board is mounted vertically to the chassis by means of a small aluminium angle bracket. Strip M is at the bottom and, since this is at chassis potential, it may be in contact with the angle bracket.

The chassis can be simply made from a piece of aluminium sheet with a lip bent along the front edge for mounting to the front panel. Side struts can be fixed between front panel and chassis for added



Another view of the rear. The thermistor may be seen between the two batteries

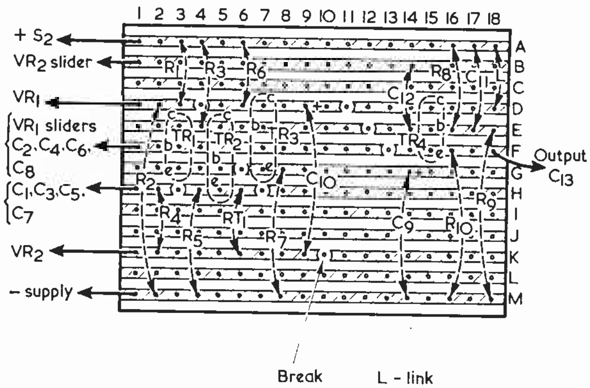


Fig. 3. The Veroboard layout, as seen looking at the copper side of the board

strength. Fig. 4 shows the complete chassis layout, together with all relevant dimensions. The bridge capacitors are connected directly between the switch contacts and a tag strip or tagboard mounted above the chassis by means of a bracket. C13 is connected directly between the Veroboard and the output socket. The two 9-volt batteries are mounted on the rear of the chassis, simple retaining clips being made from a strip of aluminium.

The front panel should be drilled and have all panel components fitted before being mounted into position. Front panel details and dimensions are given in Fig. 5. The type of dial and drive assembly used is a matter of individual choice. While a simple direct drive with pointer scale is quite adequate, a good-quality slow-motion drive with a complete dial assembly is much better though, of course, more expensive. The author employed a surplus slow-motion dial, its scale being calibrated from 14 to 155. The positions of the decade switch, S1, are designated "X1", "X10", "X100" and "X1000".

Interconnecting wires should be as short and direct as possible. One point which requires mention is the wiring of VR1, this being a logarithmic type potentiometer. This component should be wired up with the common junction from the base of TR1 connecting to the two centre tags (wiper arms) of VR1, and with the two separate connections from S1(a) and the junction of R1 and R2 passing to the open end of each potentiometer track which, with standard log potentiometers, is at the anti-clockwise end of rotation. These connections can be seen in Fig. 4. This method of connection helps to obviate the cramped exponential type of scale calibration which would result if linear potentiometers were used. When wired up as described, the control and dial should give an increase in frequency when rotated anti-clockwise. The layout and appearance of the completed instrument can be clearly seen in the photographs.

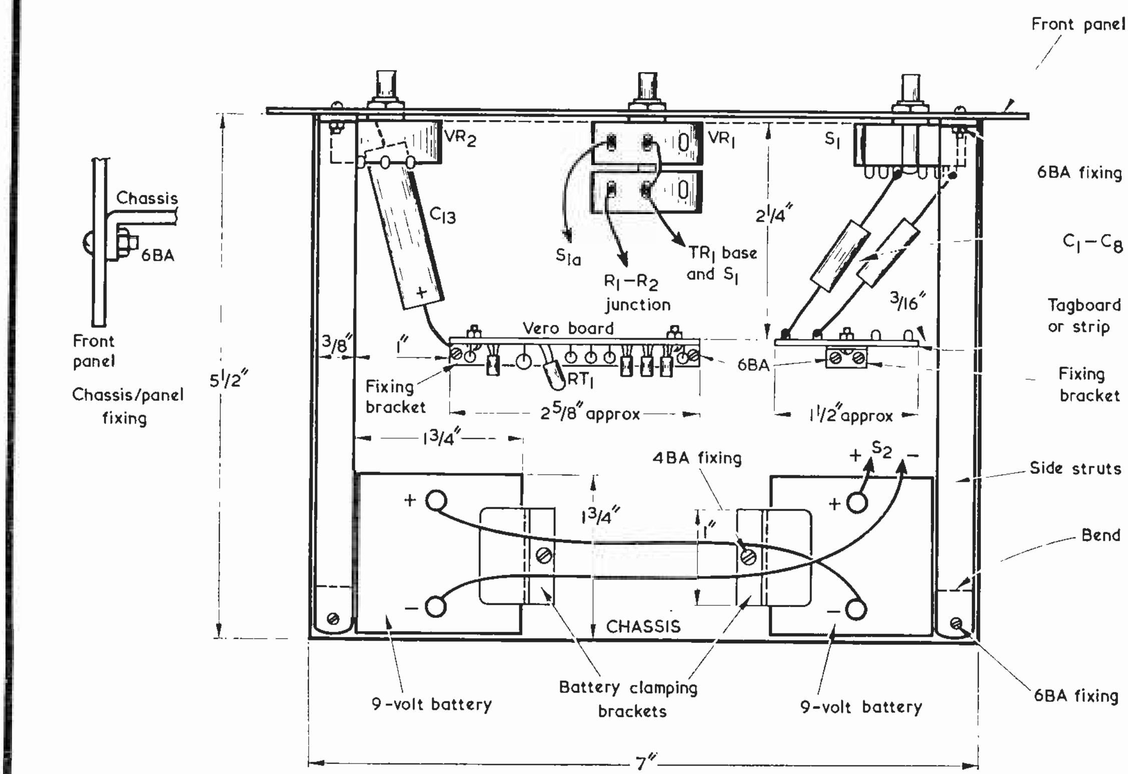


Fig. 4. Layout of the major components on the chassis. Also given are the main dimensions

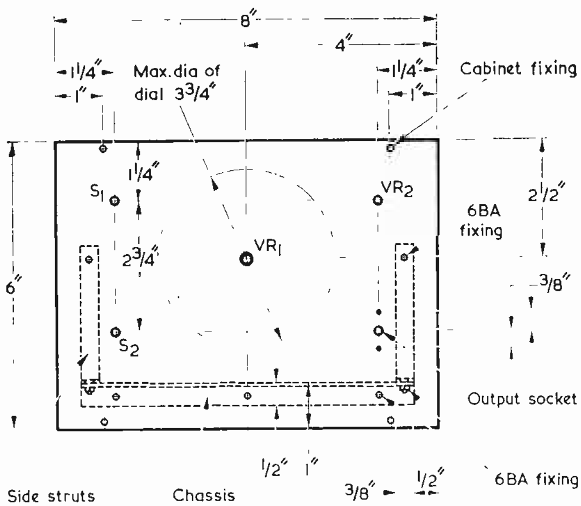


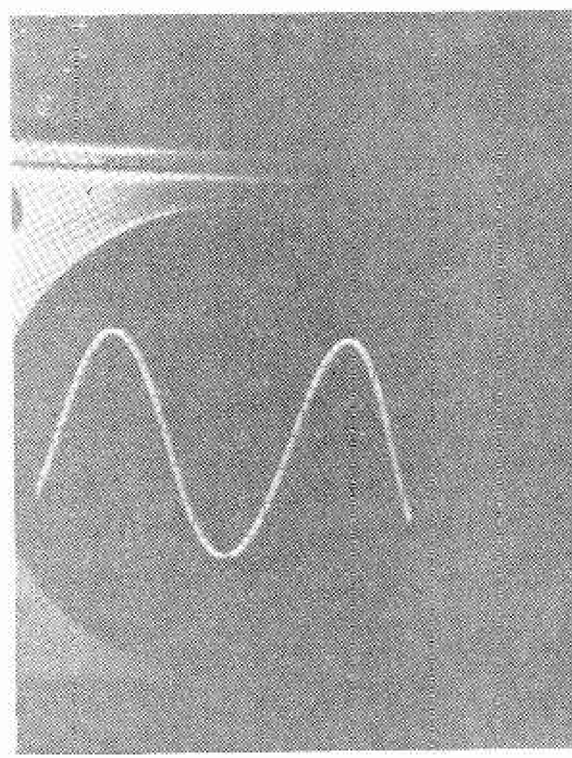
Fig. 5. The front panel layout

TESTING AND CALIBRATION

Testing and calibration of the generator depend very much upon what instruments are available. An oscilloscope is almost a necessity while if another l.f. generator can be borrowed for calibration purposes the work becomes quite straightforward. When first switched on the generator should be allowed 15 to 20 seconds to settle down, this being necessary because of the thermal time constant of the thermistor. To check that the instrument is working correctly connect an oscilloscope to the output socket. Ensure that the resultant signal displayed is a good sine wave and that its amplitude can be varied between zero and the maximum quoted by means of VR2. Then swing VR1 over its full range and check that the output remains constant within the limits quoted over all four decade ranges. If no oscilloscope is available a headphone connected to the output will give an audible check that the generator is working on Ranges 1, 2 and 3. Range 4 will be too high in frequency for an audible check. VR2 should vary the volume of the audible tone from zero upwards. In the event of difficulty and for future reference, voltage measurements are included in Table II. Typical output waveform oscillograms can be seen in the accompanying photographs.

Having checked that the generator is working correctly, there only remains the calibration. If an oscilloscope is not available there is no simple alternative and the only practical method is to transfer the calibration curve shown in Fig. 2 to the scale on VR1 by means of a protractor, measuring off degrees of rotation in terms of frequency. Such a method is of course rather inaccurate as, due to differences within tolerances in component values, scale differences will occur both in frequency limits and frequency spread.

If both an oscilloscope and a signal generator are available there should be no problems. The generator to be calibrated is connected to the Y input of the oscilloscope and the generator used as the calibration source to the X input, the time base being switched off. This allows the use of Lissajous figures for calibration. Set the Y plate generator switch S1 to Range 1 and VR1 to one extreme of rotation then swing the X plate generator over the expected frequency range, say, 10 to 200Hz. The X and Y sensitivities should be adjusted to give similar deflections on the screen in both X and Y axes. When the two frequencies coincide the resultant trace will be a stationary circle. Note this frequency. Next set VR1 to its other extreme and repeat. Again note the resultant frequency. These two figures give the total frequency swing, which should be slightly greater than the nominal range. Now set the calibration generator to some definite frequency near the lower end of VR1 limit, say, 15Hz, then carefully adjust VR1 until the circular trace is observed. When this is completely stationary the two frequencies are identical. This point is now marked on VR1 scale. Next set the calibration to a higher frequency, say, 20 or 25Hz, and repeat. The complete scale should be calibrated in this way up to the next decade, i.e. 150Hz. Mid-calibration points can be made in steps to suit individual choice and the type of scale used. 25Hz steps are normally adequate,



Output waveform at 100Hz

though 10 or 5Hz steps will provide a fuller scale. The tracking between ranges can be checked if desired by switching to Ranges 2, 3 and 4, and repeating the tests on a few spot points on the scale calibration. Any slight differences in tracking between ranges can be noted for future reference.

If no generator can be begged or borrowed for calibration purposes but if an oscilloscope is still available, a reasonable calibration can be made using the 50Hz mains as a standard and working with Lissajous figures. A low voltage 50Hz supply is connected to the X input, the output from a filament or other low voltage transformer being quite suitable. With Range 1 selected by S1, adjust VR1 until the circular trace is obtained. This will indicate the 50Hz point on the scale. Decrease the frequency selected by VR1 until a pattern with two peaks in the vertical plane is obtained; this is the 25Hz point (first subharmonic). VR1 is then increased until a two peak pattern appears in the horizontal plane, this being the 100Hz point (second harmonic). A further increase in frequency will produce a three peak pattern (third harmonic), this being the 150Hz point. These points provide the principal calibration marks on the scale. The patterns are illustrated in Fig. 6.

Now switch to Range 2 and reduce VR1 until the third harmonic is found at the lower end of the scale. This is the 150Hz point on that range but can be marked as 15Hz on the scale as the oscillator is now

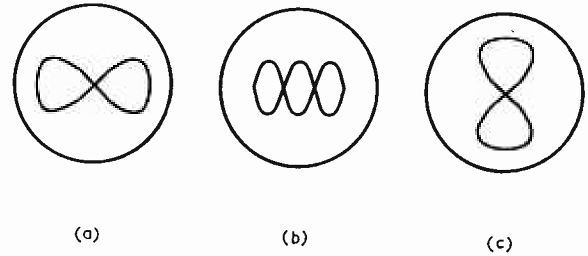
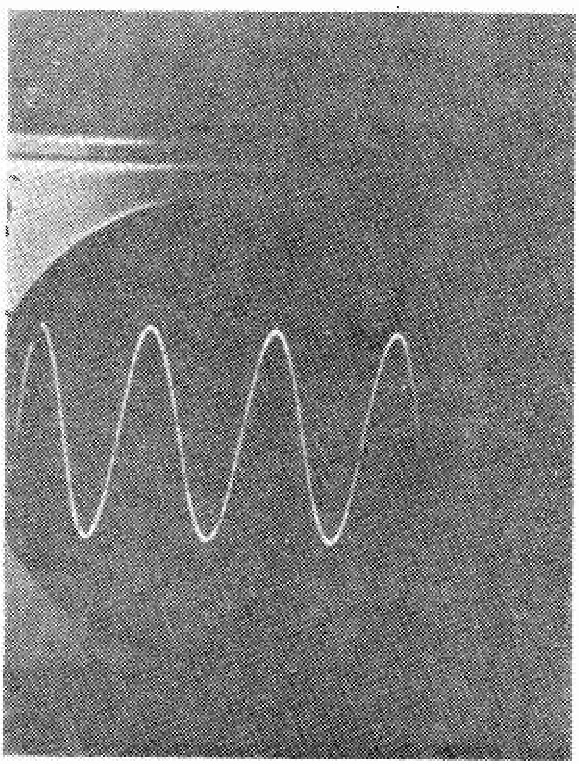


Fig. 6. The Lissajous figures given for different frequency relationships. In (a) the vertical frequency is twice the horizontal frequency, whilst in (b) the vertical frequency is three times the horizontal frequency. In (c) the vertical frequency is half the horizontal frequency



This trace, given at 100kHz, indicates the same clean sine waveform

working at a higher decade level. Increase VR1 until a four peak pattern is observed. This is the 200Hz point, which is marked on the scale as 20Hz. Similarly, a five peak pattern is given at 250Hz; this should correspond with the 25Hz mark already made from the lower decade calibration. Any slight difference between these two points gives the error between the first two decade ranges.

The remainder of the scale is calibrated in a similar manner, the six peak pattern being marked as 30Hz, the seven peak pattern as 35Hz and so on. The upper end of the scale will be more difficult to calibrate due to the difficulty of maintaining the trace stationary for sufficiently long to count the peaks on the screen trace.

Calibration by spot wheel pattern is simpler at the upper end of the scale. Here, a circular trace is obtained by injecting equal amplitude 50Hz signals which are 90° out of phase into the X and Y inputs. See Fig. 7. The output from the signal generator is then injected into the Z modulation input on the oscilloscope. The resultant number of spots on the circular trace are then counted and computed to give the particular harmonic in relation to 50Hz.

Calibration with the aid of the 50Hz mains is not quite as accurate as when another signal generator is used as a calibration source since it tends to take in the errors between the first two ranges. For most everyday purposes, however, it should prove adequate enough.

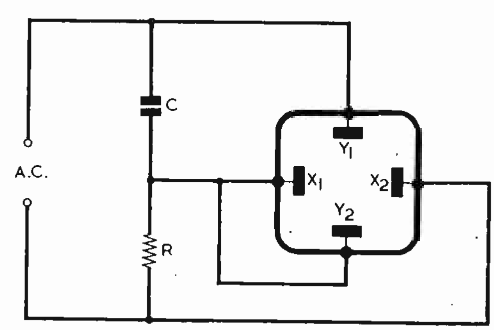
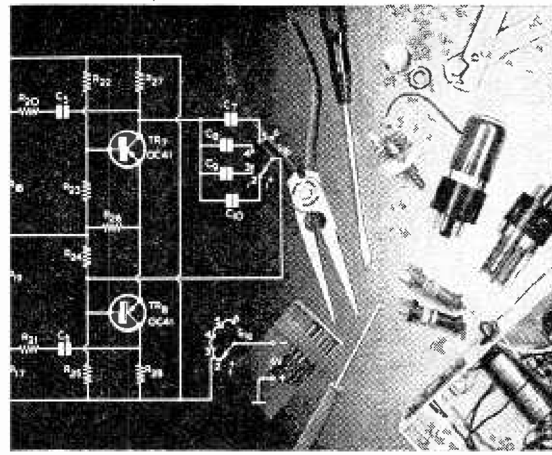


Fig. 7. Obtaining a circular trace on an oscilloscope. The reactance of C must be equal to the resistance of R. At 50Hz, suitable values are 0.2μF and 16kΩ respectively

The completed instrument should be found both simple and reliable in use, and will meet many applications in all branches of audio and ultrasonic work. Its compact size and the use of internal batteries make it equally useful in both field work and on the test bench. ■

SOLID - STATE 'RELAY'



by G. A. FRENCH

THE GREAT ADVANTAGE OFFERED by the electromagnetic relay as a switching device is that its actuating circuit (i.e. the circuit which causes current to flow in its coil) is completely isolated from the circuit or circuits which it switches. Apart from this consideration, very many of the tasks carried out by a relay can be carried out equally well, or better, by solid-state semiconductor devices, these offering the benefit that no mechanical movement of contacts is involved. With these devices, however, it is impossible to separate the actuating and switched circuits from each other unless special isolating circuitry is incorporated.

This month's 'Suggested Circuit' describes a semiconductor switching device offering facilities similar to those of a relay, and which also achieves complete electrical isolation between the actuating and switched circuits. The device can also be made to operate by direct application of the mains supply to the actuating circuit, the switched circuit having no direct connection whatsoever to this supply. The switched circuit may operate at d.c. potentials up to 30 volts, and at currents up to 0.5 amp. The circuit has some minor experimental features, which will be discussed later, and is intended for use by the more experienced constructor who is capable of adapting it as required.

RELAY CIRCUIT

A simple relay application, in which the relay has one set of normally-open contacts, is shown in Fig. 1. Until a suitable supply is connected to the relay coil the contacts remain open. They close when an energising supply is applied to the coil.

The solid-state equivalent which forms the basis of the present article appears in Fig. 2. In this case the energising supply is applied to the pilot lamp PL1 which, together with photoconductive cell PC1, is mounted in a light-proof case. Since there is no direct connection between the pilot lamp and the circuit around the photoconductive cell, the desired isolation between actuating and switched circuits is achieved.

When PL1 is not illuminated the photoconductive cell exhibits a high resistance, of the order of 1MΩ or more. In consequence, the voltage across R2 is lower than that at which forward base-emitter current can flow in TR1, and this transistor is cut off and passes leakage current only. In its turn, the voltage across R3 due to this leakage current is below base-emitter turn-on potential in TR2, and this second transistor is similarly cut off. A negligibly low leakage current flows in the load which appears in the collector circuit of TR2.

If the actuating supply is connected to PL1 the bulb becomes illuminated and PC1 exhibits low resistance. Under conditions of bright illumination this resistance can be lower than 300Ω. Current now flows in limiting resistor R1 and the base-emitter junction of TR1. An amplified current flows in the base-emitter junction of TR2, causing this transistor to become fully saturated. The full load supply voltage, minus a fraction of a volt which is lost across the bottomed TR2, is now applied to the load. The currents flowing through R2 and R3 under these circumstances

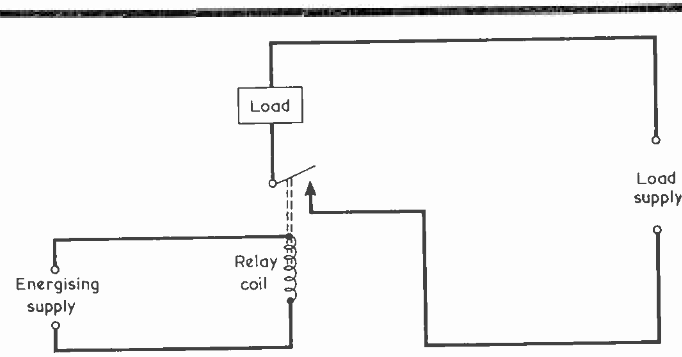


Fig. 1. A simple relay circuit

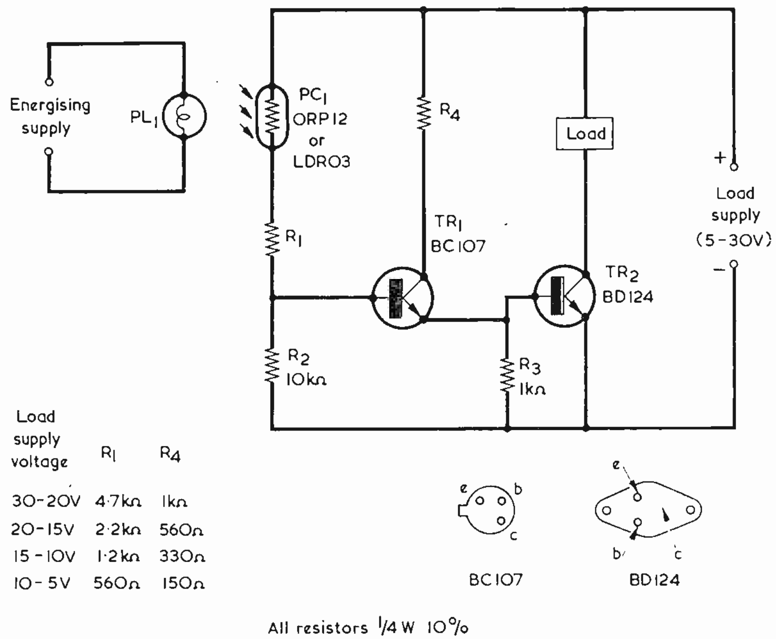


Fig. 2. The solid-state 'relay'. PL1 and PC1 are enclosed in a light-proof box

are much lower than those flowing in the base-emitter junctions of the transistors, and the two resistors can be ignored.

When the energising supply is disconnected from the bulb, this extinguishes. The photoconductive cell once more exhibits a high resistance, whereupon TR1 and TR2 become cut off and the circuit reverts to its former state. Thus, the circuit achieves the same function as the relay of Fig. 1, but it does so without mechanical movement of switch contacts. If the semiconductors are operated well within their maximum ratings the arrangement of Fig. 2 should have a far longer useful life than the relay of Fig. 1, and it requires no maintenance (such as periodic cleaning of contacts, etc.) whatsoever.

CIRCUIT RATINGS

To examine the usefulness of Fig. 2 it is necessary to consider the ratings and performance data of PC1, TR1 and TR2. The BC107 specified for TR1 has a maximum collector voltage rating of 45 volts, as also has the BD124 in the TR2 position. It would seem reasonable, therefore, to make an arbitrary choice of 30 volts maximum for the load supply potential, since this provides a generous safety margin by leaving an adequate voltage level 'in hand'. A minimum load supply potential of 5 volts is also specified. Operation is possible below this voltage, but it may be found that TR2 does not fully bottom at load currents around 0.5 amp.

Next to be considered is the power dissipation permissable in PC1. For temperatures of 40°C or less this is quoted as 200mW maximum, and at 50°C it is quoted at 100mW maximum. In this instance it would seem sensible to work to a maximum figure around 50mW. In use, greatest dissipation occurs in PC1 when it exhibits a resistance which causes the voltage across its terminals to be half the supply voltage. At this resistance the base-emitter junctions in both TR1 and TR2 will be conductive whereupon, ignoring the relatively small voltages dropped in these junctions, it can be assumed that PC1 and R1 are connected in series directly across the load supply lines. The resistance in PC1 which causes half the supply voltage to appear across it is then equal to the value of limiter resistor R1. With a load supply voltage of 30, the half supply voltage is 15 and this causes a dissipation of about 50mW in a resistance of 4.7kΩ. In consequence, R1 is specified in Fig. 2 as 4.7kΩ for load supply voltages of 20 to 30, and to corresponding values causing about the same dissipation in PC1 at half supply voltage for lower load supply potentials.

Next to be examined are the current gain figures for TR1 and TR2. The lowest hFE figure quoted for the BC107 is 110 and that for the BD124 is 25. The lowest theoretical current gain for the two transistors in tandem is therefore 110 by 25, or 2,750 times. However, it is desirable for the BD124 to be very hard on when it applies the load supply voltage to the load, and this argues a base current in TR2 that is significantly higher than that which is just sufficient to allow the load current to flow. In consequence, and taking up also practical losses due to transistors operating at voltages other than those for which hFE figures are quoted, a factor of ten times overall is realistic, whereupon a good operational margin would be given by saying that the solid-state 'relay' switches on reliably when the desired load current is 275 times (say 300 times) greater than base current in TR1 when PC1 is illuminated. This figure is justified from experience with the prototype circuit, particularly at low load supply voltage figures. For load currents of 0.5 amp the base current in TR1 therefore needs to be 300 times smaller, i.e. 1.7mA. The values chosen for R1 ensure that a current in excess of this figure can flow when PC1 is fully illuminated.

We turn next to dissipation in TR2. At 30 volts load supply voltage the maximum load current of 0.5 amp (when TR2 is hard on) is given by a load resistance of 60Ω. Maximum dissipation occurs in TR2 when half the supply voltage appears between its emitter and collector and in the present instance this will be equal to 15 volts times 0.25 amp (the latter being the collector current at half supply voltage) or 3.75 watts. The maximum quoted junction temperature for a BD124 is 175°C and its thermal resistance from junction to case is 7.5°C per watt. The BD124 is in an SO-55 encapsulation which has a thermal resistance, case to heat sink, of 0.5°C per watt without a mica washer or 1.5°C per watt with a mica washer. Assuming, under worst conditions, an ambient temperature of 50°C and no mica washer, the requisite heat sink thermal resistance to air (Rth) can be calculated from 3.75 watts = (175−50)/(7.5 + 0.5 + Rth). This works out at a thermal resistance from heat sink to air of 25°C per watt. With a mica washer, the figure becomes 24°C per watt. A flat heat sink about 1½in. square would be more than adequate for TR2.

A component not mentioned up to now is R4. The function of this resistor is to limit power dissipation in TR1 reasonably well below its maximum specified value of 300mW. It is calculated under half supply voltage conditions for the instance where PC1 inserts lowest resistance into circuit.

It will be appreciated from the above that the circuit of Fig. 2 provides very conservative operating conditions for all components. This point becomes even more evident when it is realised that PC1 and TR2 have power dissipation evaluated for the half supply voltage condition whereas, under normal operation, PC1 and TR2 will only pass through this condition momentarily as the 'relay' changes from the 'off' state to the 'on' state and from the 'on' state to the 'off' state. The only component which can possibly approach a relatively high dissipation level is TR1. In any case, and as is explained later, dissipation in TR1 can be reduced in practice by adjustment of the value of R4 to suit specific load currents.

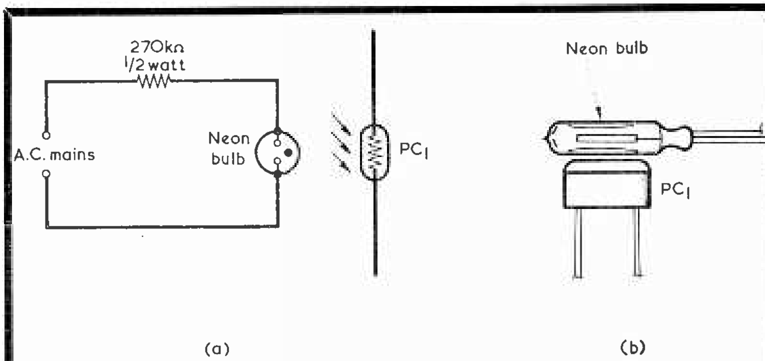


Fig. 5(a). The 'relay' may be actuated by a small neon bulb (b). The neon bulb should be positioned very close to the photoconductive cell

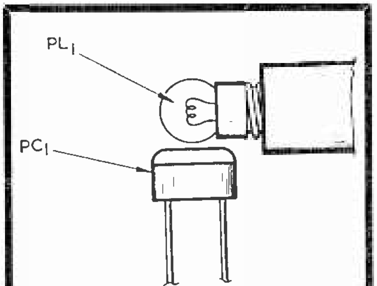


Fig. 3. The pilot lamp is positioned near the light-sensitive surface of the photoconductive cell

PRACTICAL POINTS

The choice of bulb for the PL1 position is not critical, although it is desirable to employ a type which does not draw excessive current. For the prototype circuit the writer used a 6 volt 60mA m.e.s. pilot lamp positioned close to the surface of the photoconductive cell, as shown in Fig. 3. This caused the photoconductive cell to be more than adequately illuminated when the full 6 volts was applied to the bulb, and it was found possible to actuate the 'relay' by running the bulb from a 3 volt supply, from which it drew approximately 35mA. Constructors wishing to take advantage of this fact may, if desired, experiment along similar lines. The bulb and the photoconductive cell are mounted inside a small light-proof case.

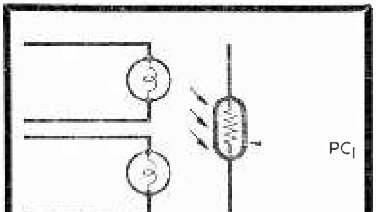


Fig. 4. It is possible to actuate the relay by more than one pilot lamp, if desired

It is interesting to note that the 'relay' can be operated by more than one bulb, as shown in Fig. 4. each of the bulbs being in reasonably close proximity to the light-sensitive surface of the photoconductive cell. The circuit then acts as an OR-gate since the 'relay' is actuated by any one or all of the bulbs.

The 'relay' may also be actuated by a small wire-ended neon bulb of the type which is available from Henry's Radio as Hivac type 16L or 34L, or from Home Radio under Cat. No. PL32A. The neon bulb, with a series 270kΩ resistor, may be run direct from the mains supply, as shown in Fig. 5(a). The neon bulb needs to be mounted very close to the ORP12, in the manner illustrated in Fig. 5(b). The illumination provided by the neon bulb is not sufficient to bring the ORP12 down to a very low resistance and the 'relay', when operated in this manner, may not be able to control load currents as high as 0.5 amp. Judging from the writer's experience, however, it should be able to cope with load currents of the order of 0.4 amp.

When the 'relay' circuit has been assembled and checked out, it is desirable to see whether it is capable of switching the particular load connected to it when the value of R4 is made approximately double that indicated in Fig. 2. If this can be done, the increased value of R4 should be retained in circuit. This increased value will result in reduced dissipation in TR1 and greater long-term reliability. The voltage across TR2 emitter and collector should be checked when the 'relay' is actuated. If it is less than 1 volt it may be assumed that TR2 is adequately bottomed. The actual voltage obtained will vary with different BD124's; with the prototype it was less than 0.2 volt. The leakage current in the BD124

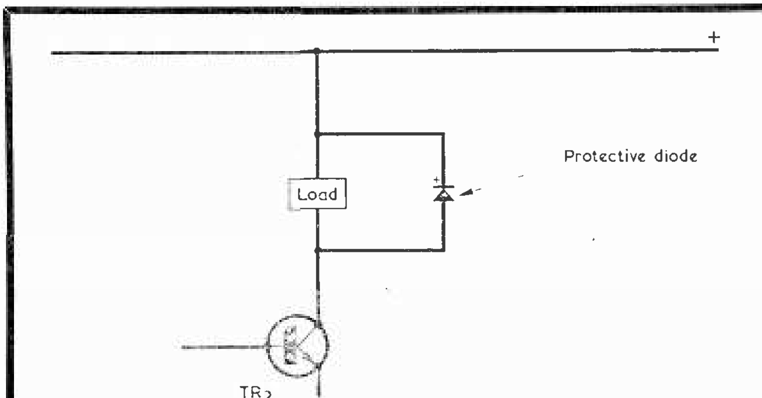


Fig. 6. If the load is inductive in character, a protective diode should be connected across it

when the 'relay' is not actuated should be very low. The writer found that, with the BD124 at room temperature, the leakage current caused no discernable deflection in the needle of a testmeter switched to read 0 – 50μA. This check was carried out at a load supply potential of 15 volts.

If the load switched by the 'relay' is inductive in character, it will be necessary to connect a protective diode across it to prevent the formation of a high back-e.m.f. voltage when TR2 cuts off. See Fig. 6. The diode may be any silicon rectifier having a p.i.v. of 50 or more, and a forward current rating of at least 0.5 amp. The Lucas type DD000 would be suitable.

As a final point it may be restated that the component values and performance figures quoted are all very conservative, as befits a device which is intended to exhibit a high level of reliability. Readers who care to experiment may find that particular 'relays' built up to the circuit are capable of switching load currents in excess of 0.5 amp. However, performance in this respect is dependent upon the characteristics of the particular transistors employed and cannot be reliably predicted. ■

RECENT PUBLICATIONS

A DICTIONARY OF ELECTRONICS, Third Edition. By S. Handel.
413 pages, $4\frac{1}{2}$ x $7\frac{1}{4}$in. Published by Penguin Books, Ltd. Price 45p.

It is pleasant to see a good book prove its success over the years. The reviewer has relied considerably on the first edition of "A Dictionary of Electronics", which appeared in 1962, both for journalistic and for engineering work. Now the dictionary is in its revised and enlarged third edition, having taken in the new words and terms which have appeared in the intervening time of nearly ten years. As Mr. Handel says in his introductory note to the new edition ". . . this is a long time in the life of a technology which is growing as fast as electronics".

The book, which is in the Penguin Reference Books range, has the familiar Penguin paperback format. All aspects of electronics are covered, including radio, radar, television, integrated circuits and computers. Entries appear alphabetically in normal dictionary form and cross-references are indicated by words or terms in italics. A non-technical reader can work, through the cross-references, from a complicated item to its simple basic concepts, these being expressed in 'standard dictionary' words.

The dictionary represents excellent value to anyone who is connected with electronics, be he student, amateur constructor or experimenter, engineer or technical writer; and Penguin Books are to be praised for presenting an outstanding reference book at such exceptionally low cost.

TEST YOUR KNOWLEDGE OF TELECOMMUNICATIONS. By L. Ibbotson, B.Sc., A.Inst.P., C.Eng., M.I.E.E., M.I.E.R.E. 94 pages, $4\frac{3}{4}$ x $7\frac{1}{4}$in. Published by Iliffe Books. Price 80p.

TEST YOUR KNOWLEDGE OF PHYSICAL ELECTRONICS. By T. Wilmore, B.Sc., A.R.C.S., A.Inst.P.
96 pages, $4\frac{3}{4}$ x $7\frac{1}{4}$in. Published by Iliffe Books. Price 80p.

TEST YOUR KNOWLEDGE OF APPLIED ELECTRONICS. By R. W. J. Barker, M.Sc., B.Sc., C.Eng., M.I.E.E.
96 pages, $4\frac{3}{4}$ x $7\frac{1}{4}$in. Published by Iliffe Books. Price 80p.

These three titles are the first in a series of revision texts designed to cover a first degree course in electrical engineering. They should also be suitable for H.N.C., H.N.D. and C.E.I. examinations. They are intended to provide revision only and are not presented as a first study course. A student using a "Test Your Knowledge" book should do so a little time before his examinations, whereupon he will soon find the strengths and weaknesses in his knowledge and understanding.

In each of the books questions are listed on the right hand pages. The reader then turns the question page to find the corresponding answers printed on its other side. Each question is followed by four suggested answers of which only one is correct. The reader selects what he thinks is the right answer, then consults the following page to check whether his choice is correct. In addition to showing the proper answer, the following page also gives explanatory text to augment the process of revision.

These useful little books are of small and handy size, and each contains some four to eight questions per question page. Not only are the books of assistance to the student, but they can also provide entertaining reading for the practising engineer who wants to check on his own knowledge of the subjects covered.

COLOUR TELEVISION PICTURE FAULTS. By K. J. Bohlman, A.M.Inst.E.
126 pages, $5\frac{1}{2}$ x $8\frac{1}{2}$in. Published by Norman Price (Publishers) Ltd. Price £2.50.

This well-presented book is intended to provide, with the aid of colour photographs taken under receiver fault conditions, a reference for technicians in the identification and repair of faults in colour television receivers. There are over 120 illustrations, including 88 colour photo graphs. The latter are reproduced extremely well and with a depth of detail and truth in colour that is more than adequate to demonstrate the fault being indicated.

The main section of the book is taken up by the photographs together with concise explanations of the faults they represent and the appropriate remedial action. Thirty picture faults are covered, these ranging from impure raster to the PAL switch operating on the wrong phase, and include misconvergence, absence of clamping pulses, loss of colour or bands of colour, Moire effect and 4.43MHz dot patterning. This section is followed by a useful appendix which gives colour bar waveforms, PAL decoder arrangements, u.h.f. channels, a fault-finding chart and details of colour television Test Card F. The book then finishes with an index.

"Colour Television Picture Faults" fills a gap which has been evident since the inception of colour television transmissions in this country, and will be of considerable help to all service engineers including, in particular, those who are just commencing or who are just graduating from monochrome to colour.

REMOVING ELIMINATOR HUM

by

G. W. SHORT

Battery eliminators reduce the running costs of transistor radios very considerably, but they can also introduce hum. This article describes a number of approaches which combat this problem

CONVERTING A BATTERY SET TO mains operation is on the face of things a simple operation, and one which in the long run can save a lot of money, since mains power is so much cheaper than battery power. However, there is no rose without a thorn, and in this case the thorn is mains hum, which can be quite a problem. This article describes how hum gets into equipment when it is converted to mains operation and shows how to overcome the problem.

ELIMINATOR TYPES

Before we get down to details, let's get one thing clear. There are two distinct types of battery eliminator, one with a double-wound step-down transformer and the other with no transformer, only some kind of 'voltage dropper' to reduce the mains to the required 9V or so. This article is concerned only with the first kind, that is the type which uses a double-wound transformer. The 'voltage dropper' type can be made cheap and very compact, but it suffers from the fatal flaw of not providing an output isolated from the mains. This is dangerous, and the non-isolated type of eliminator is not recommended for that reason.

Returning to the transformer type, then, a typical circuit is shown in Fig. 1. This example delivers a nominal 9V d.c. at up to 120mA, which is enough for nearly all portable transistor radios. As can be seen, it is just about the simplest arrangement possible: a full-wave rectifier charging a 1,000μF electrolytic 'reservoir' capacitor. Note that the transformer secondary voltage is 7–0–7V r.m.s. not 9–0–9V. This is because the d.c. output voltage is more than the r.m.s. input voltage. In theory, at zero load, i.e. no output current, the d.c. output is 1.4 times the r.m.s. input, which is 10V d.c. for 7V r.m.s. As the current taken from the unit increases, the output voltage falls, eventually approaching the r.m.s. voltage. With the MT7 transformer and other components as shown the output is 9V at 70mA approx. and 8V at the maximum rated output of 120mA. (The MT7 transformer is available from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey.)

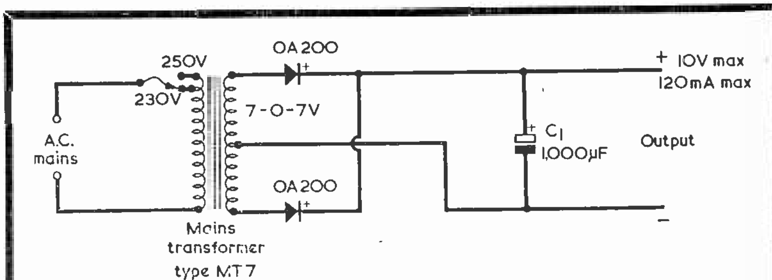


Fig. 1. Typical 9V battery eliminator circuit

MAINS HUM

We are concerned with mains hum, however. The most obvious source of hum in the case of Fig. 1 is simply the result of the imperfect smoothing provided by this simple circuit. At zero output current the d.c. supply is quite smooth, but as the current taken increases so the output becomes less and less smooth. Looked at on an oscilloscope, the output is seen to have a sawtooth ripple voltage superimposed on the d.c. The frequency is 100Hz – twice the mains frequency – because we are using full-wave rectification which charges C1 twice every mains cycle. Careful observation of the waveform shows that alternate cycles of the sawtooth are not quite the same size. This is because of unbalance in the resistances of the two halves of the transformer secondary, and it implies that there is a small 50Hz component mixed up with the 100Hz ripple.

It is usual to specify the amplitude of a ripple voltage as a peak-to-peak quantity, because this is easiest to measure. (The r.m.s. equivalent for a sawtooth wave is very nearly half the peak-to-peak value.) In the circuit of Fig. 1 the ripple rises to some 400mV peak-to-peak at full output. At lesser outputs the ripple falls more or less in proportion. Thus at half output (60mA) the ripple is about 200mV peak-to-peak, at 30mA it is about 100mV, and so on. If this ripple finds itself into the audio circuitry of a set powered by the eliminator it may be strong enough to cause hum. This is not, in fact, very likely in the average set, but it can happen.

If it does, what can be done about it? The simplest way to reduce ripple is to increase C1. Doubling the capacitance halves the ripple, and so on. This, however, is an expensive method where large amounts of extra smoothing are needed. To reduce the ripple to 10% of its initial value, for instance, would call for an extra 9,000μF. The working voltage must be at least 12V to allow for mains surges, so a bulky and expensive component is required.

LOW-COST ALTERNATIVE

What are the alternatives? It comes as a pleasant surprise to learn that in many cases a vast improvement is produced by adding to Fig. 1 one twopenny resistor! This is put in series with the non-earthy leg of the d.c. output, as shown in Fig. 2. The reason for the improvement is that many battery sets already have inside them a large value electrolytic capacitor (of a few hundred microfarads) across the battery. Its job is to decouple the battery when the latter is used and provide some measure of reservoir capacitance to help a class B audio output stage get along when the battery runs down. It is shown here as C2, and of course it reduces ripple by forming, in conjunction with R1, an extra RC smoothing filter section.

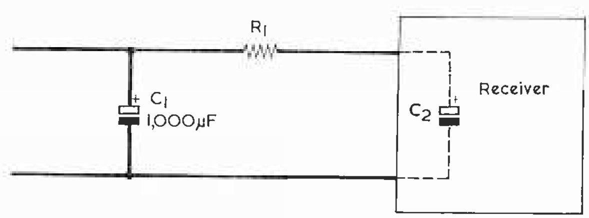


Fig. 2. Adding a series resistor (R1) improves smoothing if the receiver already contains the capacitor shown as C2

What value should R1 have? This depends on the current drawn by the set. If R1 is too large, too much voltage will be lost. If it is too small, not enough smoothing will be obtained. It is usually quite safe to sacrifice 1V, since a well-designed battery set will go on working when the battery voltage falls below 9V. If, then, the set takes 10mA, we can use 100Ω for R1 for the loss of 1V. And we can calculate the value of R1 which will drop 1V with some other current from the formula:

$$R1 = \frac{1,000}{\text{current in mA}}$$

where R1 is in ohms.

But what *is* the current? Battery sets nearly always have Class B audio amplifiers, and with these the current drawn depends on the volume. If the standby current (at zero volume) is 10mA, and the current taken at full volume is 100mA, do we make R1 10Ω or 100Ω?

The most likely answer is, neither. Some sort of compromise value will be best, so that a reasonable amount of smoothing is obtained without undue sacrifice of volume.

We could take the average of 10 and 100Ω, which is 55Ω. But this, it may well be felt, is a bit too high, since at 100mA it will drop 5.5V, which seems a lot. Something a bit less than 55Ω may be better.

At this point mathematics comes to our aid. Mathematicians recognise several different 'average values'. The one we just used is called the arithmetic mean. For our sort of compromise, however, a much better 'average' is the geometric mean. To find the geometric mean of two numbers you multiply them together and then take the square root of the answer. In our case we have 10 and 100Ω. The geometric mean of these values is the square root of 10 x 100, which is 31.6Ω. This is our compromise resistance.

The advantage of the geometric mean is that it compromises by giving a value which is proportionately wrong by the same amount at each end of the range of current. In our case, it gives an R1 which is 3.16 times too small at 10mA and 3.16 times too large at 100mA. (The arithmetic mean gave a value which was about two times too small at 10mA but 5.5 times too large at 100mA.) There is no guarantee, of course, that in particular cases the geometric mean will yield the best possible value for R1, but generally speaking it gives a much better one than the other 'average' does.

If there is no C2 in the set, or if the existing one is too small, an additional smoothing capacitor can be added. Once R1 is known, the value of C2 which will attenuate the 100Hz ripple by a factor of at least 10 (=20dB) is calculable, being approximately equal to $\frac{16{,}000}{R1}\mu F$ (R1 being expressed in ohms). So, if R1=100Ω, C2=160μF for 20dB ripple reduction.

What does this mean in terms of the amount of hum you actually hear? Subjectively, every 10dB reduction roughly halves the volume. So an extra 20dB of smoothing halves it twice, i.e. reduces it to a quarter of the original volume. In fact, the R1, C2 technique usually does slightly better than this, because it gives more than 20dB reduction of the harmonics of 100Hz which are present in the sawtooth ripple voltage, and which are more audible than 100Hz.

If further reduction is needed, C2 could be increased, but once again it turns out that this is the expensive way of doing things. It is better to use two RC smoothing sections, each with a resistance which is half the calculated value of R1.

DIFFERENT HUM ROUTE

Long before reaching this stage of complexity, however, we should be asking ourselves whether the hum isn't getting to our loudspeaker by some quite different route.

Whenever mains transformers or mains wiring are close to a circuit hum can be induced into that circuit. In high-impedance or low-level signal areas, a nearby live mains lead, however well insulated, can cause capacitive hum injection. Also, the magnetic field of a mains transformer can induce hum voltages into wiring and especially into nearby inductive components such as driver transformers, r.f. chokes, i.f. coils and ferrite aerials.

It is easy to find out whether this kind of hum is being picked up. All you do is separate the set from the eliminator on long leads. The farther apart they are the less hum there should be, and at a foot or more the hum, if induced, will have disappeared.

Having proved by this test that induced hum is the problem, how can it be dealt with? For a start, keep the mains wiring as far away as possible from audio circuitry. Orient the mains transformer so that no hum is induced into inductive components – a trial-and-error job.

If these things cannot be done, why not just keep the eliminator well away from the set? It is often possible to find space on the cabinet of a set for two miniature sockets to which the d.c. output of the eliminator can be fed by way of suitable plugs on a long lead. One plug and socket should be coloured red and the other plug and socket black to ensure that the eliminator is connected with correct polarity.

If hum is getting into a set via the ferrite aerial it may be possible to filter it out by adding a simple CR high-pass filter to the base circuit of the first transistor. The method is illustrated in Fig. 3, which shows the base circuit of a frequency changer transistor before and after modification.

It may be surprising to find that hum voltages in a ferrite aerial can cause trouble in a superhet. After all, 100Hz or 50Hz is rejected most efficiently by the i.f. transformer in the collector circuit! Unfortunately, by the time it gets there the damage is already done. What happens is that a strong hum voltage in the base circuit amplitude-modulates all

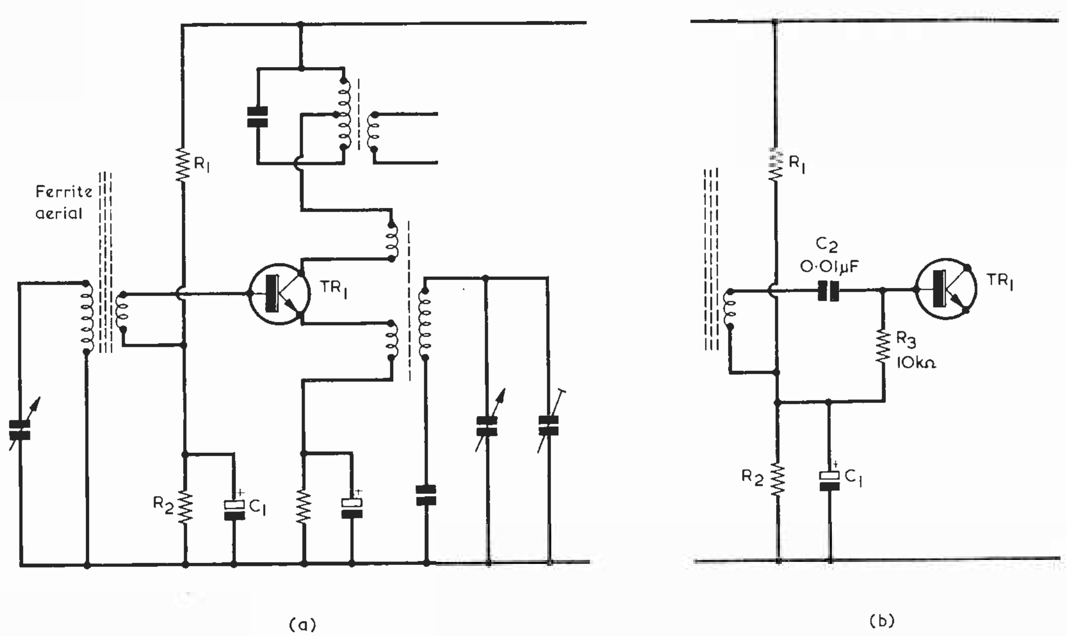


Fig. 3. Hum induced in a ferrite aerial can often be attenuated by a simple CR filter. The typical frequency changer in (a) is modified by the addition of C2 and R3 in (b). These allow r.f. signals to pass but block hum signals. R2 may have to be altered to restore the original collector current in TR1

the incoming signals. Thereafter the hum is impressed on the carrier frequencies, and gets changed in frequency and ultimately detected along with the wanted modulation.

Finally, there is a puzzling sort of hum which might be called power-lead hum. To see how it occurs, you have to remember that C1 in Fig. 1 is charged by the rectifiers in brief, high-current pulses. When the d.c. output is 100mA, these pulses might readily have a peak value of 500mA. Large currents like this can set up significant hum voltages in very low resistances such as the resistance of a connecting lead. To take an example, suppose a lead has a resistance of 0.01Ω. Nothing to worry about there, one would think. Yet 500mA in 0.01Ω sets up 5mV. If this gets into a low-level audio stage it will cause a loud hum. And it certainly can get in if the power-lead wiring is bad. Fig. 4 shows how it can happen. Here we have a typical low-level a.f. amplifier in a very bad wiring layout. Any hum voltage set up across connection AB is effectively in series with the input signal. It goes straight into the a.f. amplifier!

The remedy is obvious, once the cause of the trouble is known. Connect the earthy side of the a.f. signal source directly to point B, not point A. In other words, don't use a wiring layout in which leads which carry signals also carry the current from the rectifiers to the reservoir capacitor. Take the signal 'earths' directly to the earthy tag of the capacitor. This kind of hum is more likely to occur when a mains unit is built into original equipment than when it is used as a battery eliminator, but it is always as well to bear it in mind. ■

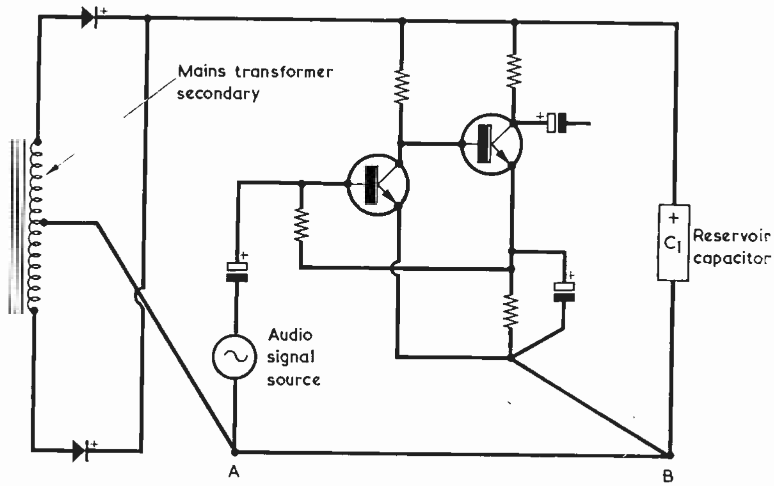


Fig. 4. 'Power-lead hum'. Any hum voltage in the connection between A and B finds its way into the audio amplifier

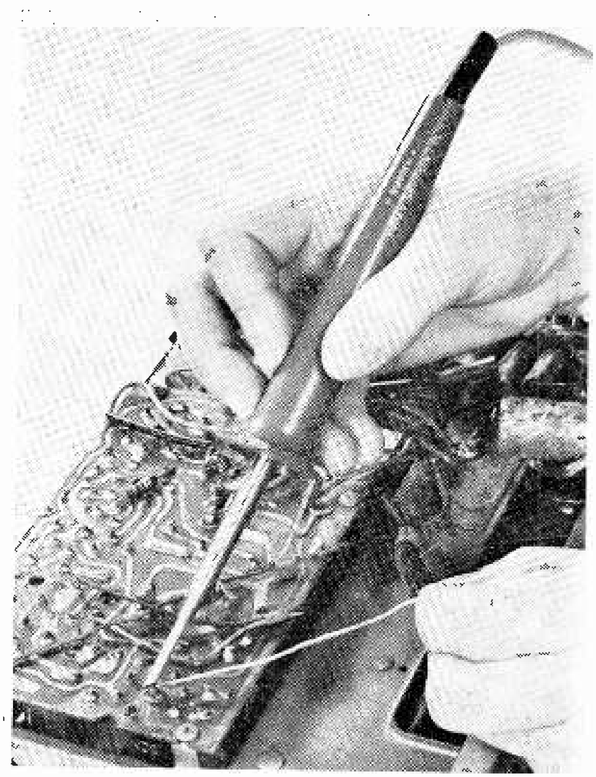
NEW PRODUCT –

ADCOLA 'INVADER' RANGE

A new range of lightweight, thermally controlled, electrical soldering instruments has been introduced by Adcola Products Ltd., Adcola House, Gauden Road, London, S.W.4. Described as the 'Invader' range, the new models incorporate a tried and proven element combined with a new 'pencil-slim' handle.

The handle, moulded in a self-extinguishing grade of Noryl plastic, has been designed to give operators a fine degree of control when soldering intricate circuits or contacts. The centre heat shield is rectangular in shape to allow the instrument to be placed securely on any surface without rolling, and the iron is balanced to ensure that the working bit is always clear of the surface. An integral hanging hook is moulded into the handle.

The 'Invader' range employs the reliable Adcola 'A' series element and existing replacement elements and spares can be used. The collet can also accommodate the complete range of 70 standard and special purpose bits. Standard 'Invader' models are available in seven stock voltages: 6V, 12V, 24V, 50/55V, 110V, 220V and 230/250V. Three collet sizes – ⅛in., $\frac{3}{16}$in. and ¼in. – are also available. Any specific bit temperature between 250°C and 410°C can be supplied at no extra charge.



The new Adcola 'Invader' soldering iron features close temperature control and a slim-line low-heat handle

NOW HEAR THESE

Times = GMT *Frequencies = kHz*

● **ECUADOR**
A new station reported heard is HCSA Quito, when signing off at 0200 on **6310.**

● **HAITI**
4VEH Cap Haitien has been heard on the regular **11835** channel (2.5kW) 25.35 metres, with a religious programme in English at 0130.

● **CLANDESTINE**
There are quite a number of such transmissions on the short waves these days. B. Walsh of Romford, Essex, logged and directed our attention to a station announcing as "Fala Radio Portugal Libre" at around 1855 and onwards, in Portuguese on approximately **15500.** We measured the channel as **15482.**

A later letter from B. Walsh informed us that the transmissions could be picked up on **11595** but that the **15482** channel was silent. Our informant tells us that an interval signal is radiated at 1855 and at 1925, consisting of seven notes played on an organ, repeated several times and followed by an unrecognisable anthem.

● **MEXICO**
XERMX, "Radio Mexico", on **21705,** is another of the 'catches' attributable to B. Walsh. Programming is in Spanish with typical Latin American music. Identifications are made frequently in Spanish, German and occasionally in English. We logged an identification in English at 2115. The frequencies 9705, 11770 and 17835 are used in parallel. The power is 100kW.

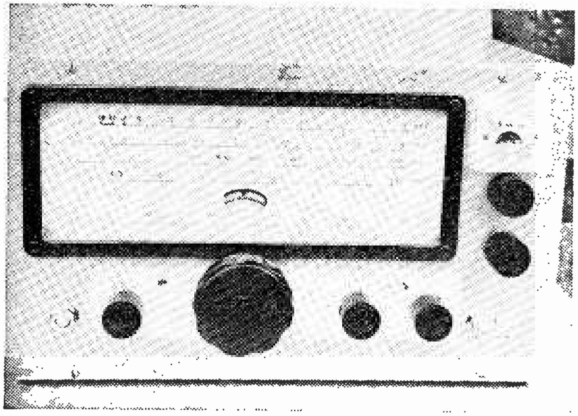
● **IRAN**
This country may be logged on **3778** (100kW) from around 1900, when a programme of Arabic-type music, with announcements in Farsi (Persian) were heard. Other channels used by Radio Teheran are – **7044, 12176** and **15084.**

● **SOUTH AFRICA**
Several channels in the LF bands are used by the South African Broadcasting Corporation (SABC) when radiating their local services. Dx'ers in the U.K. often report such transmissions. Listen on the following channels – **2326** (20kW) English Service; **2346** (20kW) Afrikaans Service; **2376** (20kW) National Commercial & All Night Service; **3250** (20kW) National Commercial & All Night Service; **3285** (20kW) English Service; **3320** (20kW) Afrikaans Service; **3965** (20kW) English Service and **3997** (20kW) National Commercial Service. Listen from 2100 onwards.

● **REUNION**
The Ile de la Reunion, a French possession in the Indian Ocean between Mauritius and Malagasy, is reported being heard by BADX (British Association of Dx'ers) on the regular **2446** channel, a Dx feat of no mean calibre. Programmes from the capital, St. Denis, can also be heard on **4807** if conditions are right. Both transmitters have a power of 4kW, programming is in French. Address for reports is – ORTF, B.P.309, St. Denis, La Reunion.

● **IRAQ**
Baghdad, the capital city on the banks of the river Tigris, may be heard on the LF bands on the following channels – **3235, 3240** and **3960.**

Acknowledgements:– BADX, Our Listening Post, SCDX.



The front panel of the Coil-Pack Communications Receiver

COIL
COMMUNICATI

This superhet receiver, covering lo
short wave bands from 1.8 to 18.75
s.s.b. signals in addition to standard
an S-meter and an exceptionally s
considerably eased by the use of a
A concluding article, to be publish
and s

THE USE OF A READY-MADE COIL-PACK GREATLY eases the construction of a multi-band superhet receiver, and avoids all the difficulty which may be found in wiring the many coils, together with the associated wave-change switch, padders and trimmers that are otherwise required. The receiver described here has a compact 4-band coil-pack, covering long, medium, and two short wave ranges. The latter provide reception of ordinary broadcast and Amateur frequencies from 18.75MHz to 1.8MHz, so including the 20, 40, 80 and 160 meter Amateur bands. Provision is made for c.w. and single-sideband reception, as well as for the usual a.m.

A quite compact cabinet houses the receiver, which employs an external speaker as is usual with this type of equipment. A tuning meter is fitted, and this is helpful for providing comparisons in signal strength, or for adjusting an aerial tuner or coupler, etc.

The receiver, as described here, will be found adequate for most purposes. The enthusiast who is always looking for a bit extra, and who is especially interested in the h.f. bands, can add a pre-selector or r.f. amplifier later. An article describing a suitable pre-selector amplifier is in course of preparation, and this will be published at a future date.

CIRCUIT DETAILS

Fig. 1 shows the complete circuit. For the benefit of anyone who has so far only constructed the simpler type of receiver, a brief description of the stages and other features should be of help.

Coil-Pack. This incorporates eight coils, eight trimmers and three padders, these being ready wired as a complete assembly which is mounted by the switch bush. It is only necessary to complete five connections to the pack, as in Fig. 1. 'Black' is the aerial connection, and 'Green' the connection to the aerial tuning capacitor VC1. 'Red' and 'Blue' are for the oscillator circuit, and 'Yellow' is the chassis return.

V1. This is the frequency-changer, and pins 8 and 9 connect to the triode section, used as oscillator. Signals pass to the heptode grid (pin 2) and the output from the heptode anode (pin 6) is taken to the first intermediate frequency transformer, IFT1.

I.F. Amplifier. V2 is the intermediate frequency amplifier, operating at 465kHz, and IFT2 is the second i.f. transformer.

D1 and A.G.C. The diode D1 provides detection of amplitude modulated, or a.m., signals. These are the ordinary long and medium wave transmissions, as well as ordinary short wave broadcast signals, and Amateur a.m. signals. D1 also provides an automatic gain control bias across R10. This bias increases with signal strength, and is applied to V1 and V2 through R9, R2 and the secondary of IFT1. The bias automatically reduces gain in these stages on the reception of strong signals, and thus helps to reduce the effects of 'fading'.

Tuning Meter. With no signals, the cathode current of V2 through R8 is at maximum. VR1 is then adjusted so that no potential exists across the tuning meter, which accordingly shows zero on the scale. Signals tuned in produce an a.g.c. voltage, as described, and the a.g.c. bias reduces the cathode current of V2, whereupon less voltage is dropped across R8. The circuit is no longer balanced, and the meter shows a reading which rises as signal strength increases. (The actual meter employed has a full-scale deflection of 1mA and has front dimensions of $1\frac{11}{16}$in. square. Suitable meters are available from a number of suppliers, including Henry's Radio, Ltd.)

PACK

)NS RECEIVER

and medium waves as well as the
Iz, is capable of receiving c.w. and
1. transmissions. Further features are
)oth dial drive. The construction is
ıdy assembled pre-aligned coil-pack.
next month, deals with calibration
ng-up

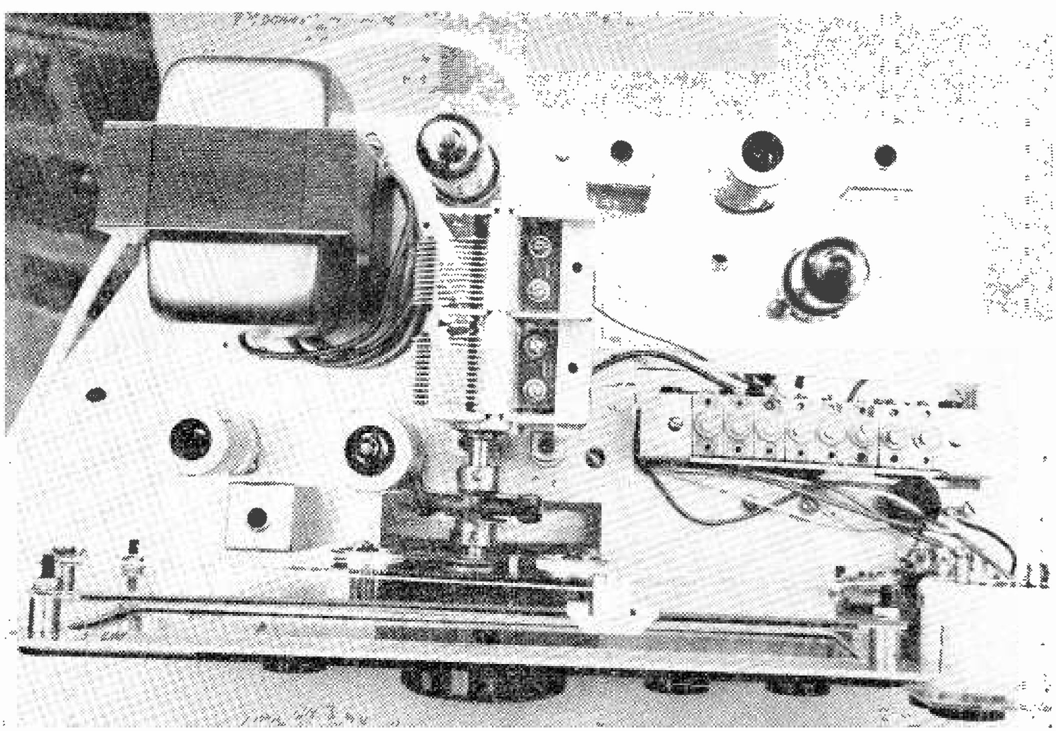
Cover Feature

PART I

by

F. G. RAYER,

Assoc.I.E.R.E., G30GR



Top view of the receiver. The eight coil-pack trimmers appear in a row behind the S-meter

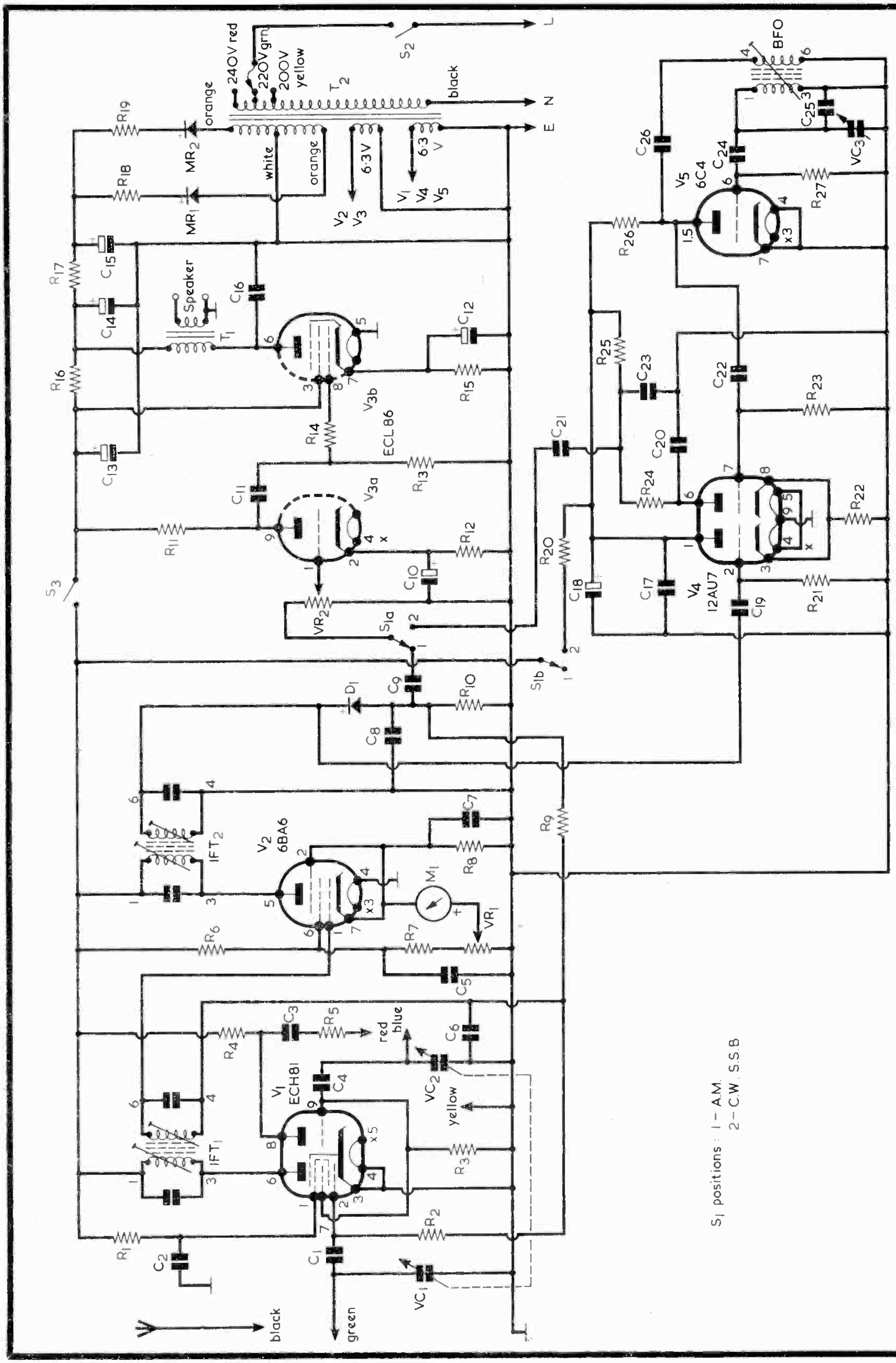


Fig. 1. Full circuit diagram of the Coil-Pack Communications Receiver

COMPONENTS

Resistors

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

R1	22kΩ
R2	1MΩ
R3	47kΩ
R4	33kΩ 1 watt
R5	150Ω
R6	27kΩ 1 watt
R7	68kΩ
R8	68Ω
R9	2.2MΩ
R10	270kΩ
R11	330kΩ
R12	4.7kΩ
R13	470kΩ
R14	47kΩ
R15	180Ω 1 watt
R16	2.7kΩ 2 watts
R17	1kΩ 5 watts
R18	100Ω 1 watt
R19	100Ω 1 watt
R20	22kΩ 1 watt
R21	100kΩ
R22	1kΩ
R23	100kΩ
R24	22kΩ
R25	47kΩ
R26	68kΩ
R27	47kΩ
VR1	500Ω potentiometer, wirewound linear
VR2	500kΩ potentiometer, log

Capacitors

C1	100pF silver-mica
C2	0.01μF disc ceramic, 350V wkg
C3	100pF silver-mica
C4	47pF silver-mica
C5	0.01μF disc ceramic, 350V wkg
C6	0.25μF paper or plastic foil, 150V wkg
C7	0.25μF paper or plastic foil, 150V wkg
C8	250pF silver-mica
C9	0.01μF paper or plastic foil, 150V wkg
C10	4μF electrolytic, 6V wkg
C11	0.01μF paper or plastic foil, 350V wkg
C12	100μF electrolytic, 15V wkg
*C13	16μF electrolytic, wire-ended, 450V wkg
*C14	8μF electrolytic, wire-ended, 450V wkg

*C13, C14 in single can.

C15	8μF electrolytic, wire-ended, 450V wkg
C16	0.01μF paper or plastic foil, 500V wkg
C17	0.01μF disc ceramic, 350V wkg
C18	8μF electrolytic, wire-ended, 450V wkg
C19	22pF silver-mica
C20	470pF silver-mica
C21	0.01μF paper or plastic foil, 350V wkg
C22	47pF silver-mica
C23	470pF silver-mica
C24	100pF silver-mica
C25	150pF silver-mica, 1%
C26	100pF silver-mica
VC1,2	2 x 500 pF (nominal) Jackson Bros. E2 gang, with feet (Cat. No. VC7, Home Radio)
VC3	15 pF varitable, Jackson Bros. type C804

Inductors

IFT1	I.F. transformer type IFT11/465 (Denco)
IFT2	I.F. transformer type IFT11/465 (Denco)
B.F.O. Coil	Type BFO.2/465 (Denco)
T1	Speaker transformer (Cat. No. TO46, Home Radio)
T2	Mains transformer; secondaries 250-0-250V 65mA, 6.3V 1A, 6.3V 1A (Cat. No. TM5, Home Radio)

Coil-Pack

Coil-pack type CP3/F

Valves

V1	ECH81
V2	6BA6
V3	ECL86
V4	12AU7
V5	6C4

Diode, Rectifiers

D1	OA81
MR1	FC116 or 18RA1-1-16-1 (Cat. No. MR32, Home Radio)
MR2	FC116 or 18RA1-1-16-1 (Cat. No. MR32, Home Radio)

Meter

M1	Miniature S-meter, 1mA, f.s.d. (see text)

Switches

S1(a)(b)	2-pole 2-way, rotary
S2	s.p.s.t. toggle
S3	s.p.s.t. toggle

Valveholders, Sockets

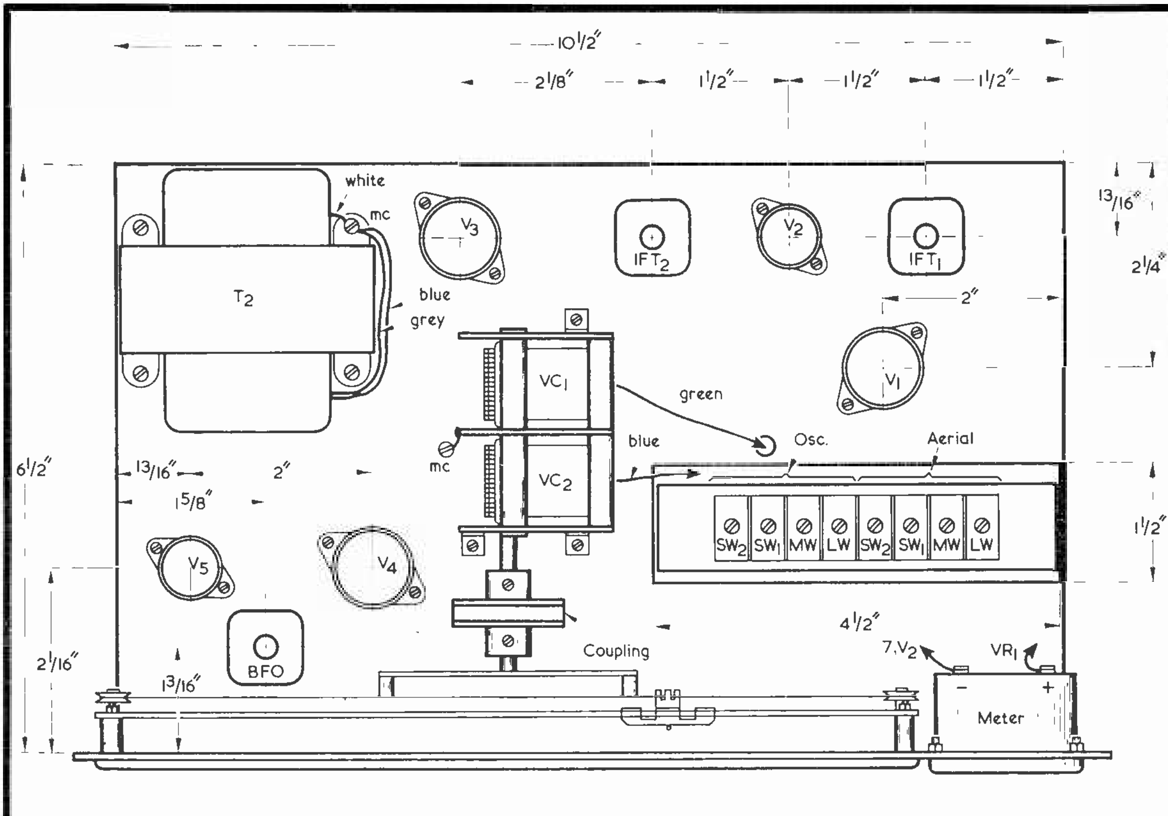
3 skirted B9A holders
1 B9A screening can (for V4)
2 skirted B7G holders
2 B7G screening cans
Aerial/Earth twin socket strip
Loudspeaker twin socket strip

Drives, Knobs

1 Slow-motion dial and drive type E898 (Eddystone)
5 black knobs (Cat. No. KN84C, Home Radio)
4 pointers (Cat. No. KN88D, Home Radio)
Flexible shaft coupler
Solid shaft coupler

Miscellaneous

1 chassis, type I, L 6½in., W 10½in., D 2in. (H. L. Smith & Co.)
1 case type W, 12 x 7 x 7in. (H. L. Smith & Co.)
1 2-way tagstrip
2 3-way (centre-earthed) tagstrips
2 4-way (1 earthed) tagstrips
4 plastic feet (Cat. No. Z146, Home Radio)
3-core mains lead
Bolts, nuts, connecting wire, etc.



mc – chassis connection

Fig. 2. Component layout above the chassis. The precise position of the 2-gang capacitor is found physically from the tuning dial and drive, the latter being positioned as shown in the photograph of the front panel

Audio Amplifier. V3 is a 2-stage amplifier, with VR2 acting as the volume control or audio gain control. Output is coupled to the external speaker by the speaker matching transformer T1. It should be noted that the receiver should not be operated without a speaker connected, as excessively high a.f. voltages can then appear across the transformer primary.

Product Detector. V4 is the product detector, and is employed for c.w. and s.s.b. signals only. With s.s.b. signals the carrier frequency, eliminated before transmission, is supplied by oscillator V5, and mixing in the double-triode V4 re-inserts this carrier so that audio output is available through C21. The performance of this type of detector for the reception of s.s.b. signals is much superior to that given by using a b.f.o. only, as was often done with the older type of communications receiver.

S1(a) selects the a.m. detector D1 or product detector V4, while S1(b) applies h.t. to V4 and V5. If desired the receiver may be built as shown but with V4, V5 and their immediate components omitted, and initially used for reception of ordinary a.m. signals only. V4 and V5 could then be added later, if wished, without disturbing existing circuitry.

Power Pack. The mains transformer T2 has two 6.3 volt 1 amp secondaries. One supplies the heaters of V2 and V3. The other supplies the heaters of V1, V4 and V5.

The h.t. secondary connects to two contact-cooled rectifiers, MR1 and MR2, and then to the surge limiting resistors R18 and R19. Smoothing for the anode circuit of V3 is carried out by C15, C14 and R17, while the screen-grid of V3 and earlier stages have additional smoothing, given by R16 and C13.

S3 interrupts the h.t. supply to the early stages only. This gives instant on-off switching, or a 'standby' position, with heaters at operating temperature. Such a feature is of most use when operating the receiver in conjunction with transmitting equipment, but it also allows V3 to be used as a 2-stage audio amplifier by taking the audio signal from a pick-up, Morse oscillator, or other equipment, to VR2.

S2 is the mains on-off switch.

CHASSIS PREPARATION

The positions of valveholders and other items can be seen from Fig. 2. The valveholder holes are best made with a screw-up chassis cutter – $\frac{5}{8}$in. holes are required for B7G valveholders and $\frac{3}{4}$in. holes for B9A. Valveholder orientation may be determined from Fig. 3. Mark, through each holder, fixing holes to drill for the 6BA bolts which will secure them later.

The coil-pack is set back 2in. to clear the drive,

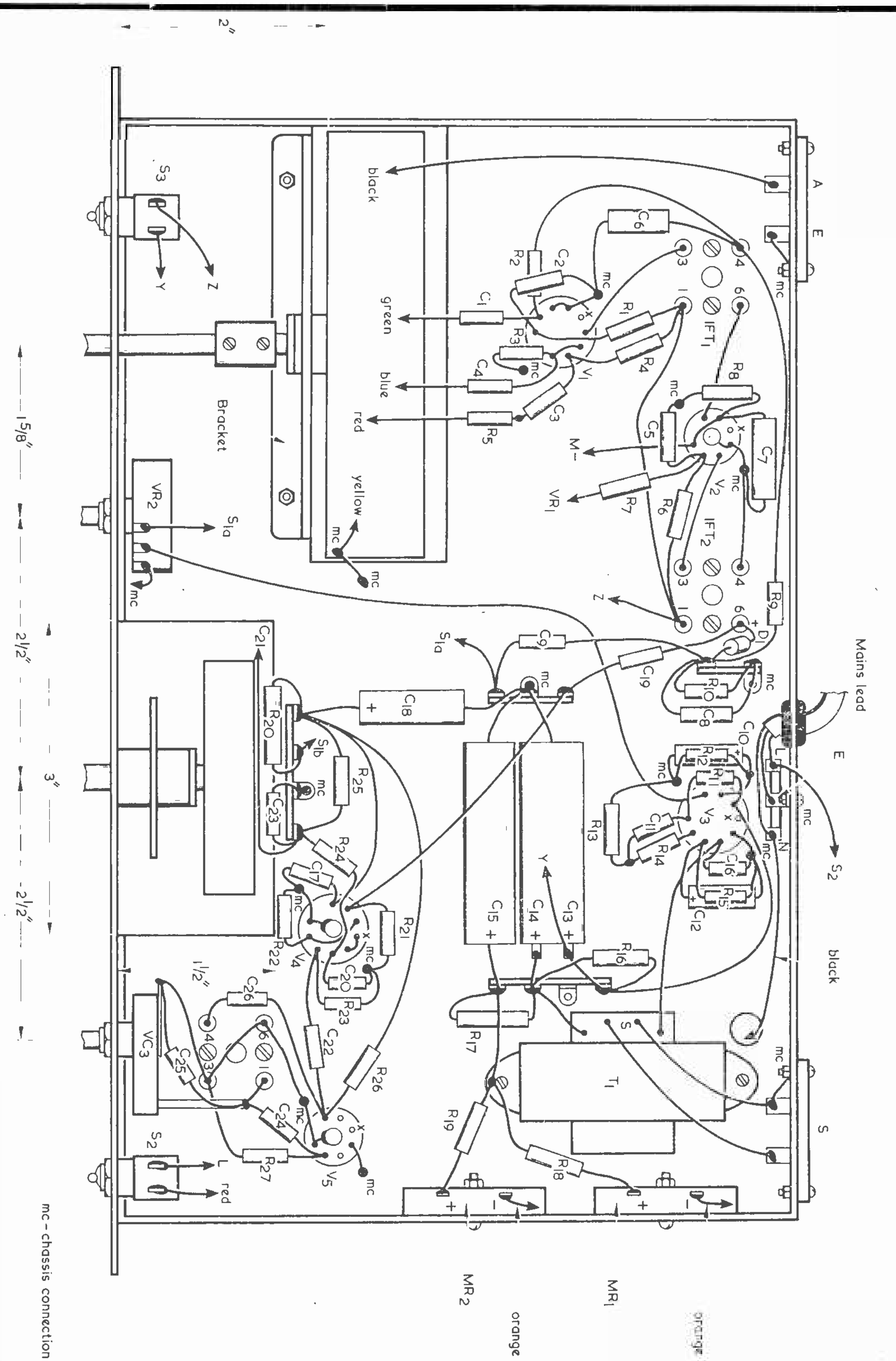
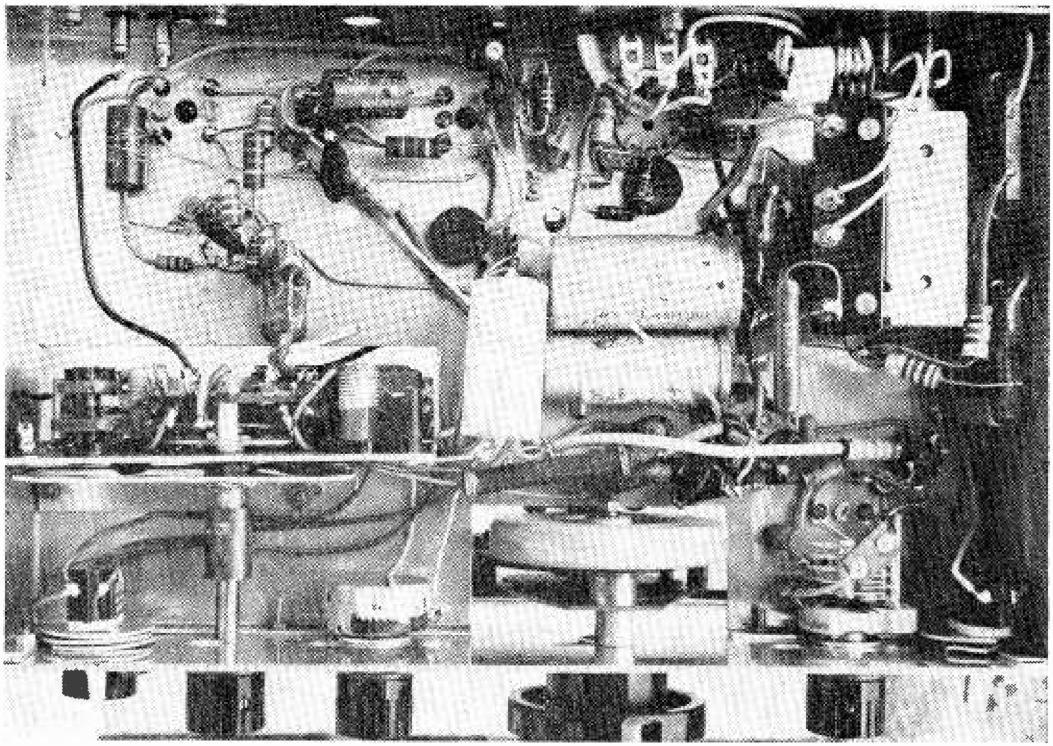


Fig. 3. Components and wiring below the chassis



Wiring and components below the chassis

and fits in an aperture measuring 4½in. by 1½in. This can be cut by drilling a row of small holes close together where necessary to enable a metal saw to be inserted, smoothing the edges afterwards with a file.

Drill holes for IFT1, IFT2 and the b.f.o. coil as illustrated in Fig. 3. Make sure there will be adequate clearance for the pins.

Holes are drilled or punched in the back runner for the socket strips and mains lead. Leads from T2 pass down through holes which are clear of T1 below. All holes through which wires pass, including those from R7 to VR1 and from the coil-pack to VC1, should be fitted with grommets.

An opening about 3in. by 1½in. is cut in the front of the chassis, to clear the drive flywheel. See Fig. 3. The chassis is a type with small front flanges, to which the panel is bolted.

If any small holes are missed, these can be drilled later. But the large holes should be made before mounting any components, and metal fragments should be cleaned away.

An important point is concerned with the output transformer T1. The type specified is available from a number of different manufacturers, and individual transformers may be supplied either with wire lead-outs or with tags. It is necessary to ensure that the transformer, when positioned as in Fig. 3, does not project below the bottom surface of the chassis, and if it has wire lead-outs this requirement should be satisfied without any further difficulty. If the transformer has tags, check that these will be well clear of contact with the inside of the metal case when the transformer is fitted. This may necessitate bending the tags down, and/or bending the tagstrip mounting. If clearance from the tags to the case is still likely to be small, a piece of thin Paxolin may be taped over them later, after connections have been made. In cases where this approach is not satisfactory, unsolder the coil lead-outs from the transformer tags and add lengths of thin flex to them, covering the joints with sleeving. Avoid putting strain on the lead-out wires. The lengths of flex can then connect to the appropriate circuit points in the receiver. Yet another alternative consists of mounting the transformer on the side runner of the chassis. One rectifier would then need to be moved a little neared to the front, whilst the other could be fixed in the position taken up by the speaker socket strip, the latter being shifted a little nearer the centre at the rear. It is doubtful whether these precautions will be needed in most instances, but it is of course necessary for the reader's attention to be drawn to them. The points just outlined should be checked before drilling the holes for T1, the rectifiers and the speaker socket strip. If doubt exists as to which connections are for primary and secondary, the primary will exhibit a resistance of several hundred ohms, as checked with a testmeter, whilst the secondary will have nearly zero ohms.

PANEL AND COIL-PACK

Holes for the drive are marked by using the paper template supplied with it. The large window is cut in a similar way to the coil-pack aperture, afterwards levelling to a scribed line with a file.

The tuning meter occupies a hole made with an adjustable washer or tank cutter, large screw-up punch, or by drilling a ring of small holes and finishing with a half-round file. Also drill or punch holes for the panel controls.

Note that the case listed is made in such a way that the bottom edge of the panel must lie about ½in. lower than the bottom of the chassis.

The drive is next fitted, and panel and chassis are bolted together. Carefully line up the spindle of the ganged capacitor with the drive, using spacers, washers or extra nuts to raise the capacitor. Couple up the drive and capacitor with the flexible shaft coupler. Mark and drill for the fixing screws. Solder blue and green leads to the lower fixed vane tags of VC1 and VC2, as in Fig. 2, then finally mount the capacitor. Check that the drive works freely. Connect a lead from the centre rotor tag to a tag bolted to the chassis, as in Fig. 2.

The coil-pack is mounted on a flanged bracket about 4in. by 1¾in. and with a ½in. flange. See Fig. 3. The bracket is fixed to the chassis by three bolts, for rigidity. A solid spindle coupler connects to a length of ¼in. diameter rod (which was actually unwanted excess from the spindle of the volume control).

A black lead from the coil-pack is run to the aerial socket, as in Fig. 3. The green lead from VC1 (Fig. 2) passes down through a hole in the chassis, and is soldered to the green tag of the pack, to which C1 is also soldered. See Fig. 3. The blue lead is for VC2, and C4 is also connected here. R5 is soldered to the red tag. A length of connecting wire is soldered to the yellow tag of the pack, and to the adjacent coil-pack chassis tag. From here, the lead runs to a nearby tag bolted to the receiver chassis.

The trimmers are above the chassis, as in Fig. 2, and the pack projects ¾in. above its surface, so that the cores of the four coils near the trimmers can be reached with a trimming tool above the chassis.

The controls VC3 and VR2 are fitted at the same horizontal level as the coil-pack spindle. The two switches are slightly lower and are level with each other. VR1 and S1 are on the same vertical line as the centre of the meter.

I.F. TRANSFORMERS, B.F.O. COIL

Mount the i.f. transformers so that the numbered pins appear as in Fig. 3. Sleeving may be put on the pins to avoid possible short-circuits due to fragments of solder or other causes.

As mentioned, the receiver can be built and used (for a.m. only) with V4, V5 and the accompanying items omitted, these being added as a later project.

MAINS TRANSFORMER

Bare and connect the white, blue and grey leads of the mains transformer to a tag bolted to the chassis, as in Fig. 2. Two orange leads emerge with the white lead. Pass these down through the chassis and solder them to rectifiers MR1 and MR2. These are contact-cooled rectifiers, bolted direct to the chassis.

Stout enamelled orange and pink leads emerge on the other side of the transformer. These are from the 6.3 volt windings. Take the pink lead through and solder it to pin 4 of V3. This winding also supplies the heater of V2. The orange wire runs to V4 heater tag, which is also connected to V1 and V5.

The primary leads are black, yellow, green and red. Take black to a tagstrip at the chassis rear, as in Fig. 3, used also to anchor the Neutral lead of the mains cord. For 240 volt mains, take red to S2. For 220 volt mains, use green instead, and for a 200 volt supply connect yellow to S2. Tape up separately the ends of the unwanted leads (e.g. green and yellow with 240 volt mains) so that they cannot come into contact with each other or other items.

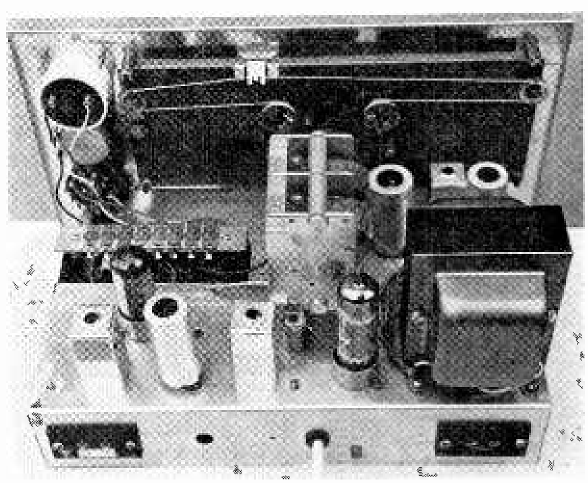
Connect S2 to L (Live) at the mains cord tagstrip at the rear of the chassis. Use a 3-core cord, with blue for Neutral, brown for Live, and green-yellow striped for Earth, running the latter to the receiver chassis, as in Fig. 3. The mains connection is best made with a 13 amp plug having a 2 amp or similar fuse. The mains cord should pass through a rubber grommet. All leads should be adequately insulated, especially where they pass through the chassis from T2.

RECEIVER WIRING

The wiring in Fig. 3 can next be carried out, and it is useful to have several colours of connecting wire or sleeving for the various circuits. Run heater and h.t. wiring against the chassis. Similarly deal with the wiring in the grid and anode circuits of V2, and the wires running to VR2 and S1(a).

The wire ends of resistors and small capacitors are cut so that they are reasonably short and direct.

A number of small tagstrips are used to secure various parts and leads. All the points marked 'MC' are connections to solder tags bolted to the chassis. Note the polarity of diode D1 and the electrolytic capacitors.



A top rear view. Note the spacing washer under the rear foot of the 2-gang tuning capacitor

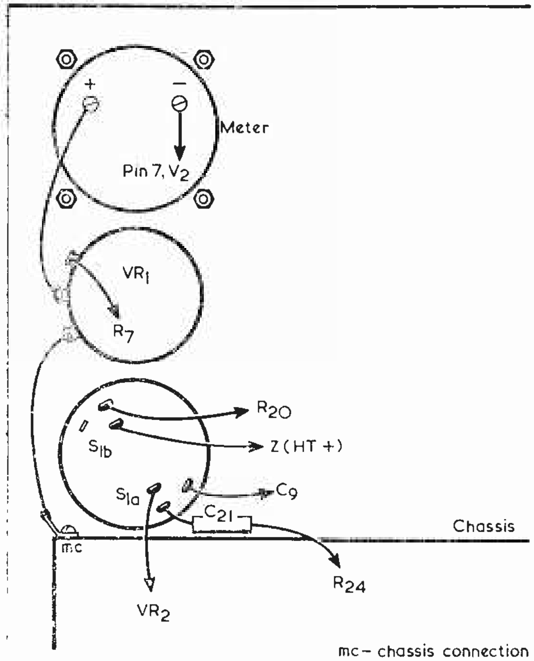


Fig. 4. Connections, above the chassis, to the meter, VR1 and S1

When wiring T1, identify the primary and secondary connections, if these are not marked, in the manner already discussed.

A.M./S.S.B.-C.W. SWITCH

Section S1(a) of this switch transfers the volume control VR2 from C9 (a.m. detector) to C21 (product detector). See Fig. 4. In the latter position S1(b) closes the h.t. circuit so that h.t. is applied to V4 and V5.

No screening of audio circuit was necessary, provided these were kept near the chassis when wiring S1(a) and VR2, etc.

TUNING METER

Fig. 4 shows connections for VR1 and the meter. Coloured leads run to pin 7 of V2, and to VR1 and R7.

The meter gives a reading when the receiver is first switched on, but falls back as the cathodes reach working temperature. With no aerial connected or no signal tuned in, rotate VR1 until the meter reads zero.

All receiver tuning meters, or S-meters, give an indication which depends on the strength of the signal at the aerial terminal of the receiver. This means that readings are *comparative*. A transmission which, for instance, gives a reading of S5 with a short indoor aerial may easily give S9 or over with an improved aerial.

Where any external means of tuning or matching the aerial will be used, adjust the tuner for maximum meter reading. This also applies to the tuning of a pre-amplifier. Where alternative aerials are available, the better aerial (for the particular frequency being received) will give the higher reading.

(To be concluded)

EUROCON '71

Over 170 papers from 20 countries are promised for the first EUROCON Convention, and it has already become a new international meeting of major importance. It will be held in Lausanne, Switzerland, on 18th to 22nd October, 1971.

The Convention subjects are information processing in large systems, long distance communications, solid state circuits, distribution of electric power, and biomedical engineering. In addition, this will be the first convention to give detailed consideration to electronic watches, which may well revolutionise the watch making industry within the next decade.

Special features of the Convention are student and tutorial lectures as well as survey papers in each subject for the non-specialist.

EUROCON 71 is organised by Region 8 of The Institute of Electrical and Electronics Engineers, and supported by national societies with a number of companies providing financial support. Further information is available from the EUROCON 71 Secretary, 24 Chemin de Bellerive, CH-1007 Lausanne, Switzerland.

The survey papers will be arranged in sequence, so that all of them can be attended by non-specialist participants and by students. Further student facilities are a much reduced registration fee, at least 12 tutorial lectures, and arrangements for accommodation in the homes of Swiss students.

The sessions on electronic watches include the choice of systems, time bases, circuitry, and display, and herald a change from the traditional precision manufacture of the mechanical watch to the wholly electronic watch.

The papers on display will cover techniques applicable to pocket size computers.

Papers on information processing in large systems cover the use of computers in traffic control, radio astronomy, high energy physics, space systems, metereology, and education.

Among the subjects covered by papers on biomedical engineering are ongoing research, health care systems, automated diagnosis, a television-computer system to study micro-organisms, implanted microelectronic devices, standards, safety, and education and training.

COMMUNICATION AND ELECTROLYSIS

by

D. P. NEWTON, B.Sc.

A simple communications system which establishes a link with the start of the nineteenth century

COMMUNICATION AND ELECTRICITY HAVE LONG been linked. We all know our debt to Marconi, Fleming, de Forest and Edison, and yet their work did not begin in a vacuum. Theirs was the century of the inventor – a few made it, most didn't. There was Salva who planned to use the twitch of a frog's leg as a detector of galvanism and so devise a communicator based on this. More recently we have Baird's television, only to be replaced by the more sophisticated cathode ray tube. But both contributed to the pool of knowledge; the basic idea was there. Salva, indeed, saw that the escape of gases at an electrode in electrolysis could be the basis of a means of communication, but this idea was dormant until von Sommering completed such a telegraph in 1809.

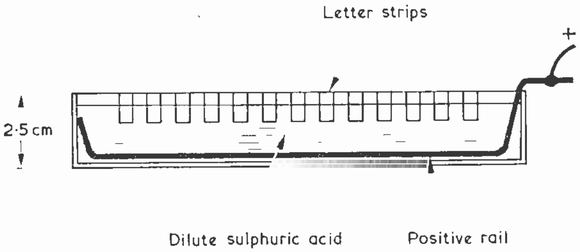


Fig. 1. Side view of the Perspex trough, illustrating the letter strips and positive rail

SIGNAL TRANSMISSION

Galvanism could be transmitted over considerable distances but the problem was one of how to make the signal apparent. Electricity was only incompletely understood and the relationship between magnetism and electricity was not well known until Oersted's work in 1820, so Wheatstone's telegraph was still in the future. Similarly, the discovery of radio waves was not to happen until 1888 with Hertz.

Von Sommering's ingenuity turned, therefore, to telegraphy by electrolysis. His final device had one wire for each letter of the alphabet situated in a line along the base of a tank containing acidified water. These wires could be made negative with respect to a bar in the liquid above them. When the appropriate switch was pressed, a column of bubbles would rise from the corresponding wire to the bar. In this way, he was able to send signals over considerable distances, independent of weather or time of day.

Such a device can be constructed fairly easily today. Figs. 1 and 2 show the receiver. A trough made from Perspex sheet about 3 to 5mm. thick is constructed with the dimensions given. Thirteen letter strips are made from copper foil, each being 6cm. by 0.5cm., and are shaped as in Fig. 3. These are glued along one side of the trough using a rubber-based glue. A brass rod, about 50cm. in length and 2mm. in diameter, is bent as shown in Fig. 1 to form the positive rail. The letter strips are labelled as in Fig. 2. Note that single strips represent the first half of the alphabet while two together represent the letters of the second half, apart from 'Z'. Any three may be taken for 'Z'. This allows the number of strips needed to be halved. The trough is now almost filled with dilute sulphuric acid.

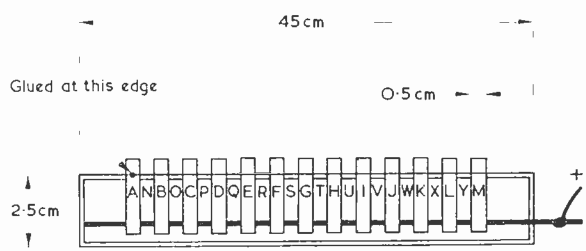


Fig. 2. This view from above shows the letters which the strips represent

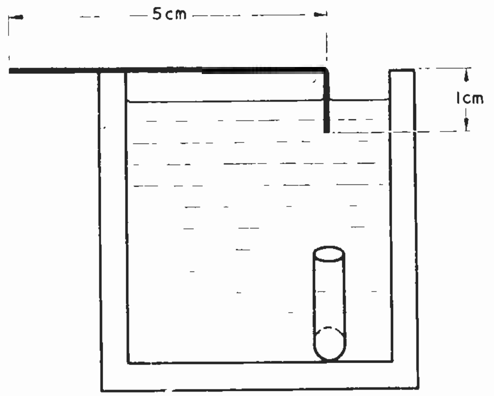
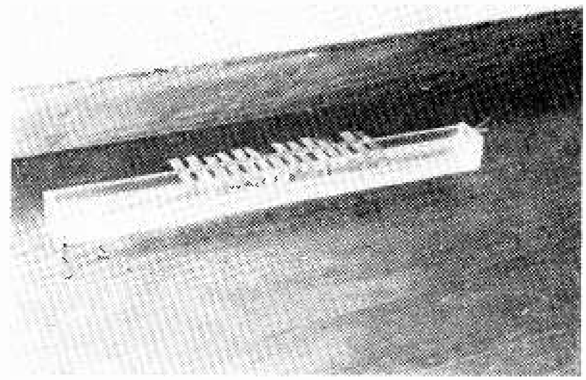


Fig. 3. The letter strips are shaped in the manner shown in this end view



A practical example of the receiver assembly

The sulphuric acid should be diluted to one part of concentrated acid in ten parts of water, and most chemists will provide this. Readers without experience of concentrated sulphuric acid should not attempt to carry out the dilution process themselves. Take all sensible precautions whilst handling the acid, ensuring that it is kept away from clothes, the body and, in particular, the eyes. Corrosion of the letter strips and brass bar is not great at this level of dilution and the trough can, in any case, be emptied and washed out after a period of use has been completed.

THE TRANSMITTTER

The transmitter consists of 13 switches, one pole of each being connected together, as in Fig. 4. These switches may be constructed from springy metal, as in Fig. 5. Alternatively, of course, normal switches purchased from a component retailer can be used. The switches are labelled in the same manner as the letter strips, a wire from each being connected to the corresponding letter strip by means of a wire terminated in a crocodile clip. The other side of the switches is connected to the positive rail via a 3-volt battery.

When a switch is pressed, bubbles appear at the corresponding letter in the receiver. For a letter such as 'S', the letters 'F' and 'G' would be pressed together. The diagrams show that the receiver is 'upside down' when compared with that of von Sommering. This proved to be a convenient arrangement since it allows strips to be easily replaced if damaged and it allows any build-up of gases around the cathodes to be dispelled by simply vibrating the free end. The distance between the transmitter and the receiver can be considerable, but this soon shows the disadvantage where fourteen wires are involved.

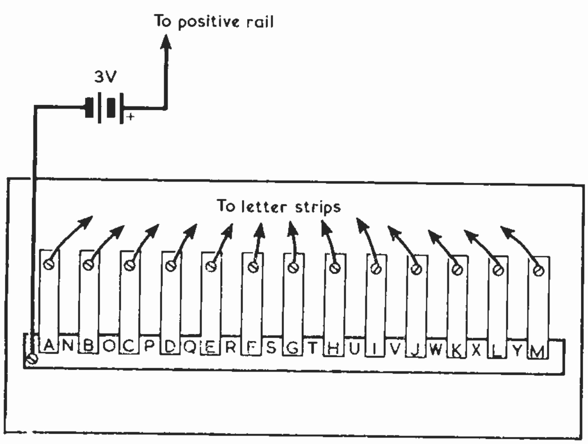


Fig. 4. A suitable construction for the transmitter. The switch strips are mounted on a base made of insulating material

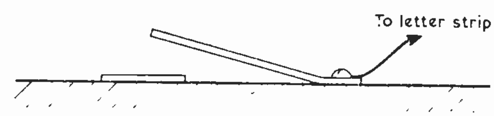


Fig. 5. How the switches of Fig. 4 are made up

Like Baird's equipment, von Sommering's telegraph was superseded and almost forgotten. In making such a model now we little appreciate the difficulties experienced at that time. The wires themselves had each to be carefully bound and insulated. Even batteries were uncertain and expensive pieces of equipment, still being stacked with dissimilar metals like the original voltaic pile. However, coming as it does from the times of George III, Napoleon and the birth of Dickens, the telegraph remains a fascinating idea and provides an amusing model. ■

'F.E.T. REFLEX RECEIVER'

In 'F.E.T. Reflex Receiver', which appeared in the August 1971 issue, the references should have included earlier articles describing the basic reflex circuit incorporated. These were 'Simplicity and Sensitivity with Two Transistors' and 'Simplicity and Sensitivity with Three Transistors'. They were both by Sir Douglas Hall, and were published in the April 1964 and November 1965 issues of *The Radio Constructor* respectively.

CURRENT SCHEDULES

Times = GMT *Frequencies = kHz*

★ ITALY

RAI now radiates three programmes daily in Russian. From 0330 to 0345, from 0535 to 0555 and from 1605 to 1625 on **6075** (60/100kW) 49.38 metres; **7275** (60/100kW) 41.24m; **9575** (60/100kW) 31.33m; **11810** (60/100kW) 25.40m and **11905** (60/100kW) 25.20m.

★ AUSTRALIA

The European Service of Radio Australia transmission from 0645 to 0745 may now be heard on **11765** (100kW) and on **15125** (100kW), 25.50 and 19.82 metres respectively. After 0745, the Asian and Pacific Services are radiated on these two channels. Another English transmission from R. Australia can be heard from 0700 to 0800 on **9680** (10kW) from Melbourne – if you are lucky!

Afternoon transmissions from the station at Darwin, directed to Asia, may be heard from 1500 to 1730 on **6055** (250kW) 49.55m and on **6100** (250kW) 49.18m.

★ CANADA

Radio Canada, with the new 250kW transmitters in service, can be heard with a programme in German from 1735 to 1815 on **15325** 19.58m.

★ GAMBIA

Radio Gambia has an extended schedule on the regular **4820** (3.1kW) 62.24m channel. From Mondays to Fridays 0630 to 0800, 1200 to 1300 and from 1700 to 2300. Saturdays from 0630 to 0900, from 1200 to 1400 and from 1700 to 2300. On Sundays from 0900 to 1400 and from 1700 to 2300.

★ ALBANIA

Radio Tirana may be heard with a programme in English from 0000 to 0028 on **9780** (50/500kW) 30.67m; from 0233 to 0252 on **6210** 48.31m and from 0100 to 0139 on **9780.**

★ CZECHOSLOVAKIA

Radio Prague radiates a 55 minute programme, in English, daily to Europe, New Zealand and Australia at 0700 as follows – **6055** (200kW) 49.55m beamed to Europe; **9505** (200kW) 31.56m beamed to Europe and the Far East; **11800** (100kW) 25.42m beamed to Europe and Far East; **15310** (100kW) 19.60m to Europe and Far East; **21690** (100kW) 13.83m to Europe and Far East and **21700** (100kW) 13.82m beamed to the Far East and Africa.

The Afro-Asian Service of Radio Prague, also of 55 minutes duration, to East Africa and Asia, is from 1530 to 1625 on **6055, 11990** (100kW) 25.02m, **15240** (100kW) 19.69m, **17840** (100kW) 16.82m and on **21735** (100kW) 13.81m.

To West and Southern Africa, from 1730 to 1825, on **5930** (100kW) 50.59m, **7345** (100kW) 40.85m, **9605** (100kW) 31.23m, **11990, 15240** and on **17840.**

★ GHANA

The Ghana Broadcasting Corporation has an English Service, beamed to Europe, from 2045 to 2215 on **9545** (100kW) 31.43m, with a newscast at 2045 and at 2100.

Acknowledgements:– Our Listening Post, SCDX.

LATE NEWS

Times = GMT *Frequencies = kHz*

★ AMATEUR BANDS

● PUERTO RICO

To get Zone 8 the hard way, why not brave the QRM of 'forty' and try around midnight for the CW signals of KP4CBI on, or around, **7042?**

● SURINAM

PZ1AD is a devotee of the key and his signals are often to be heard on 14MHz. Logged recently on **14035** at 2035.

● FAROE ISLANDS

Signals from these islands are not all that plentiful but OY2EL has been very active of late on **14065,** or thereabouts, using CW at 2000.

● LABRADOR

VO2AW is another CW man, listen at the 'high' end of the 14MHz CW band **(14098)** around 2000, to log this one.

● BRAZIL

Signals from Brazil are in profusion but at the CW end of 14MHz listen for PY7AHO on, or around, **14030** where he usually works strings of Europeans. One of the best 'fists' in Brazil.

● 21MHz

A recent short morning session at the CW end ended with the following 'in the bag', JA1ANG, JA1KRU, JA1MQM, JA1OMH, JA1QIJ, KZ5EK, PJ2RB, PZ1AV and ZS6AJS.

★ BROADCAST BANDS

● MAURITIUS

Forest Side is reported to have moved from the **4850** channel to that of **4895** (10kW), heard when signing off at 1830. From 1430 to 1830 (according to the schedule) the programme is in English and French, with news in English at 1800.

● INDIA

The new 250kW transmitters at Aligarh are radiating on the following channels - **9590, 11755, 11790, 11850, 11945, 15160, 15335, 15340** and on **17705.** Those at New Delhi radiate on **11740** and on **15205.**

● BOLIVIA

CP97 Radio Pirai, Santa Cruz de la Sierra, has changed from the 90 metre band frequency of **3320** to that of a 31 metre band channel, **9607** (1kW).

● NEW CALEDONIA

Noumea is reported by BADX on the old channel of **3355**, a move from the listed **7170.** Also in parallel on **4913, 9510** and **11710.**

● INDONESIA

BADX (British Association of Dx'ers) report a new RRI transmitter on **3900** around 1300, location – Palangkaraya.

● CEYLON

BADX also report that the Sinhala Service commences at 0000 on **3385.**

Acknowledgements:– BADX, Our Listening Post, SCDX.

THE 'MINIFLEX' MARK IV PORTABLE RECEIVER

by

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

Employing three transistors, including an f.e.t., this medium and long wave receiver provides a loudspeaker output level at the exceptionally low battery current of 3mA. Construction is compact, with all circuits built virtually around the loudspeaker itself

THIS IS A SMALL PORTABLE receiver using a further developed form of the author's Minflex circuit.* It is sensitive and selective, and the modest output is ample for those who use a receiver of this type for their own entertainment rather than as a source of annoyance to others. It gives continuous coverage from 190 metres to 2,200 metres.

An unusual feature of the design is the use of a field effect transistor in the output stage. As this device is fully loaded, in the present design, by less than 0.5 volt input, its gate is protected very simply by two silicon diodes connected back to back.

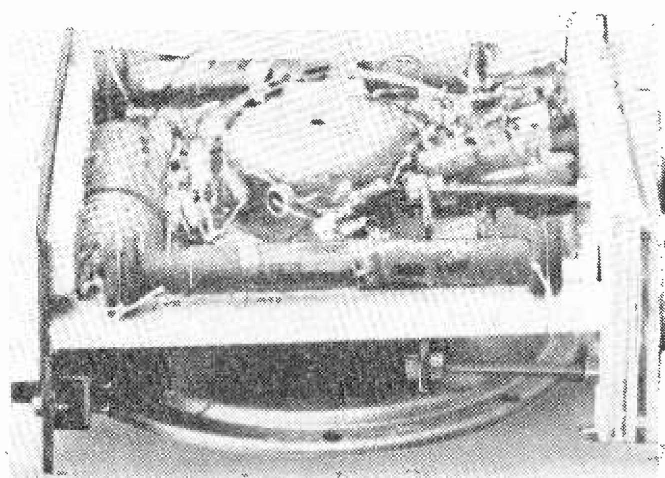
CIRCUIT DESIGN

The circuit is shown in Fig. 1. S1, the wave-change switch is in position for medium waves. The signal is picked up by L1, wound on a ferrite rod, and applied to the base of TR1 which is wired as a common collector device offering a high input impedance and allowing the whole of the tuned circuit to appear at the base. The output of TR1 is across R1 which is the input resistor for TR2, a common emitter high frequency amplifier. The further amplified output appears across the choke L3 and is demodulated by D1 – a high impedance selenium diode which must be used. *Do not attempt to use a silicon or germanium diode in this circuit.*

Audio signals now appear at the base of TR1 which, in conjunction with TR2, forms a super alpha pair resulting in a very low impedance across R2. Thus, it is possible to use a high step-up transformer between R2 and the input of TR3, giving a voltage gain of 25 times. Because of the damping of its windings by R2 and the output of TR2, this component will not introduce distortion.

Direct voltage to operate TR1 and TR2 is taken from the source bias current of TR3. This receiver has a very small appetite for batteries!

The original output transformer employed in the prototype is a Radiospares miniature valve type with a ratio of 50:1 and intended for use with battery valves of the DL94 type. This offers a load of about 8kΩ to the output of TR3. Since completing the design the writer has, however, learned that this particular transformer is liable to go out of production, and so he



Side view, illustrating how the platform and the front and rear panels appear in relation to the speaker

*Sir Douglas Hall, 'The "Miniflex" Dual Purpose Personal Receiver', *The Radio Constructor*, June 1968; Developing The "Miniflex" Circuit', *The Radio Constructor*, July 1968.

has checked alternative components for suitability. This article will, in consequence, describe the prototype circuit with the Radiospares transformer since, even if it is out of production, there may still be stocks on dealers' shelves or in constructors' spares boxes. At the end of the article instructions will then be given for an alternative output transformer arrangement, which can be used by readers unable to obtain the Radiospares transformer. It should be mentioned, incidentally, that Radiospares components can only be obtained via retailers. Radiospares do not deal direct with individual constructors.

Returning to Fig. 1, positive audio frequency feedback is made available by feeding back a small proportion of the amplified signal in the secondary of the output transformer to the gate of TR3. L4 prevents excessive feedback of the highest audio frequencies though the higher frequencies will still be favoured. This is an advantage in counteracting a loss of these frequencies which takes place due to sideband cutting when full radio frequency reaction is being used on weak stations. VR4 sets the degree of audio feedback to a suitable level at high settings of VR2. Setting back VR2, as will be done when receiving powerful stations, reduces the audio frequency feedback because of the damping of the primary of T1 by VR2 when this is set to a low level. It will be seen that VR2 functions as an audio frequency volume control in addition to being

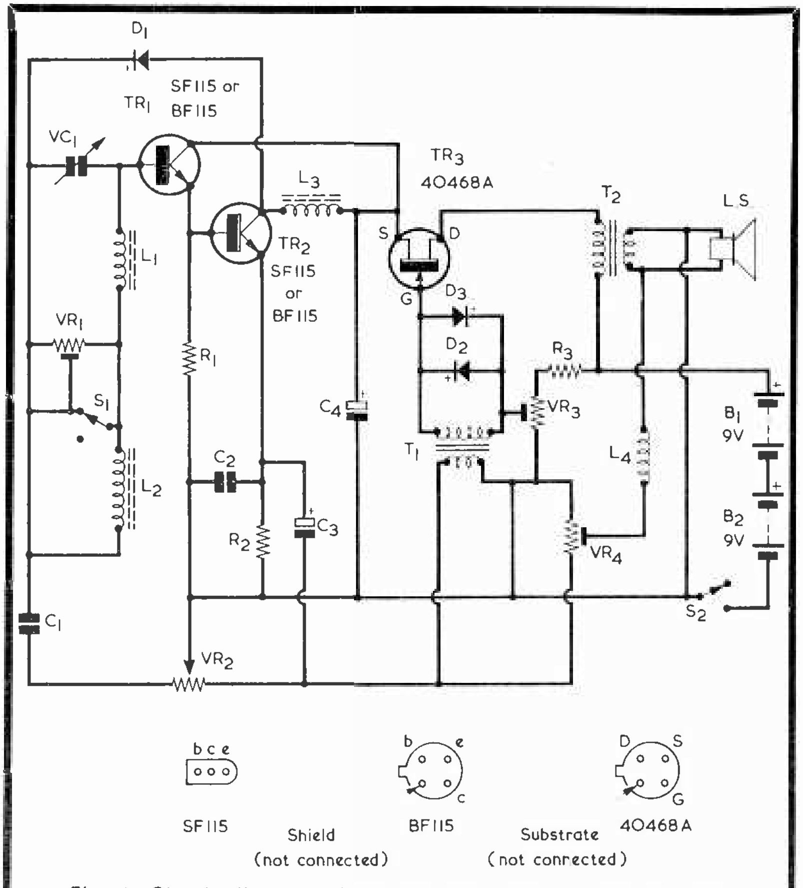


Fig. 1. Circuit diagram of the 'Miniflex' Mk. IV receiver. Note that the output stage incorporates an f.e.t.

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)
- R1 5.6kΩ
- R2 100Ω
- R3 150kΩ
- VR1 500kΩ potentiometer, miniature preset
- VR2 250Ω potentiometer (see text)
- VR3 25kΩ potentiometer, skeleton preset
- VR4 500Ω potentiometer, miniature preset

Capacitors
- C1 1,000pF silver-mica
- C2 0.1μF paper or plastic foil
- C3 320μF electrolytic, 2.5V wkg
- C4 320μF electrolytic, 2.5V wkg
- VC1 300pF variable, Dilemin (Jackson Bros.)

Inductors
- L1 (see text)
- L2 (see text)
- L3 2.5mH r.f. choke, type CH1 (Repanco)
- L4 19mH r.f. choke, type RFC7 (Denco)
- T1 Microphone transformer, type TT53 (Repanco)
- T2 Output transformer (Radiospares miniature valve type or Repanco types TT49 and TT46 – see text)

Semiconductors
- TR1, TR2 SF115 or BF115
- TR3 40468A
- D1 Half-wave meter rectifier type M3 (Henry's Radio)
- D2, D3 Silicon 'bias diodes'

Switches
- S1 slide switch, standard size
- S2 slide switch, standard size

Batteries
- B1, B2 9-volt batteries type PP4 (Ever Ready)

Speaker
- 3Ω moving-coil, 5in. diameter (see text)

Miscellaneous
- 2 ferrite rods, 4in. by ⅜in. dia.
- 2 knobs
- Epicyclic ball drive with flange, type 4511/F (Jackson Bros.)
- 18-way tagboard, Radiospares standard size (Cat. No. BTS10, Home Radio)
- Transistor holder
- Spindle coupler
- 2-off 2in. 4BA countersunk bolts
- ¼in. plywood, Paxolin, Perspex, Fablon or Contact, nuts, bolts, screws, etc.

a radio frequency reaction control.

Some of the radio frequency signal will bypass D1. This will appear at the bottom end of the tuned circuit, and C1 is chosen to give a suitable capacitive tapping into the circuit to provide reaction in the Colpitts configuration. The half of VR2 which connects to C1 varies the impedance between the bottom of the tuned circuit and the negative supply rail. All signals can be set at any value between zero and oscillation point.

Long waves are received with S1 in the open position, this bringing L2, on its own rod, into circuit. A damping resistor, VR1, is set so that oscillation starts with VR2 near maximum.

For best results TR1 and TR2 need to pass a current of about 3mA at a little over 2 volts d.c. Nearly all of the 3mA current passes through TR2. TR3 has its bias adjusted so that it passes 3mA, and TR1 and TR2 become the necessary source bias 'resistor' for TR3. They are consequently fed with 'free' current. As a little over two volts is more bias than the source of TR3 requires in order for this device to pass 3mA, a small amount of positive bias, of the order of one volt, is applied to the gate by means of the potentiometer network given by VR3 and R3, VR3 being adjusted so that the f.e.t. passes 3mA. If the Radiospares output transformer is used this will represent a drop of 0.75 volt across its primary, which has a resistance of 250Ω.

Although an 18-volt supply is used, the low current of 3mA allows very small batteries to be employed economically, and the cost of operating the receiver is low. A small battery passing 3mA will last more than twice as long as it would if it passed 6mA.

FRAME ASSEMBLY

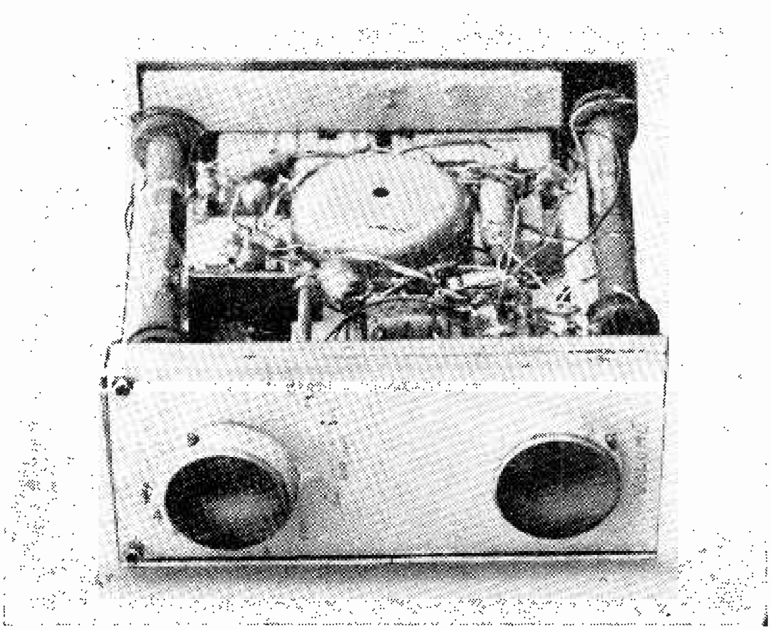
Construction should start with making the plywood and Paxolin pieces illustrated in Fig. 2, starting with the Paxolin plate for VC1 which is shown in Fig. 2(a). The two 6BA clear holes here are for mounting, later, the tuning capacitor VC1. The diagram shows these as being spaced by 0.6in. but, to be precise, the mounting centres for the capacitor specified are at 0.625in. The constructor is not expected to drill Paxolin to dimensions involving thousandths of an inch, but he will find it helpful to verge slightly on the generous side so far as the spacing between the two holes is concerned. The two 4BA clear holes are drilled at the points indicated; their positions do not have to be measured precisely.

When the Paxolin plate has been cut and drilled it should be put on one side and the plywood platform shown in Fig. 2(b) should be made. A fretsaw is the proper tool to use for all the cutting operations. The large central hole in the platform is for the speaker magnet and should be just slightly larger than the diameter of the magnet of the actual speaker to be used, in order that the platform can offer a reasonably tight fit on the magnet after several turns of Sellotape have been wound round it. The magnet of the speaker should have a diameter not greater than 1¾in., and preferably less. This is because the magnet hole in the platform, if too large, will too closely approach the adjacent corner of the 1in. by 1in. recess. In all instances, care has to be taken to ensure that an adequate amount of wood is retained at this point.

Next, cut the front panel, also of plywood, as shown in Fig. 2(c). The exact positions of the two holes for the 4BA bolts are found by using the Paxolin piece of Fig. 2(a) as a template. Fig. 2(c) looks at the front of the panel, and the Paxolin piece should be placed over it so that the centre of the large hole in the Paxolin is exactly over the centre of the largest hole in the plywood piece of Fig. 2(c). The 4BA holes can now be marked through onto the plywood panel. They are drilled out 4BA and then countersunk on the side nearest the reader, as shown in Fig. 2(c).

The Paxolin back, which carries S1 and S2 is cut as shown in Fig. 2(d). Slots for the switch slide dollies should be cut to fit, and the holes drilled for the fixing screws. The switches are fitted underneath the panel so that only the slide dollies and the heads of the mounting screws appear on the side shown in Fig. 2(d). The switches take up the approximate positions indicated in Fig. 2(d).

Now fit the tuning capacitor, VC1, to the Paxolin piece shown in Fig. 2(a). With the Paxolin piece as shown, the body of VC1 will be away from the reader, its spindle pointing towards the reader, and the two terminal strips of the capacitor at the top. Be careful to use short bolts to fix VC1 in place, or the component may be damaged. Now pass two 2in. long 4BA bolts, with countersunk heads, through the two countersunk holes in Fig. 2(c), with the heads towards the reader. Lock with nuts, one bolt passing through the locating lug on the epicyclic drive, which is mounted *behind* the panel in Fig. 2(c). Place about ¾in. of *insulated* ¼in. rod (which may be excess cut from a potentiometer spindle) in the bush of the drive, and push a brass spindle coupler on the other end of the insulated rod. Slide VC1, on its Paxolin piece, onto the ends of the 4BA bolts, having first threaded a second nut on each. Pass the spindle of VC1 into the coupler. The rear of VC1 should be just slightly less than 2⅛in. from the rear of the panel; if it is more, slightly reduce the length of the insulated rod accordingly and reassemble. Finally, put a third nut on each 4BA bolt and tighten up



Front view, showing the knobs for VC1 and VR2, behind which are the tuning scale and its Perspex cover

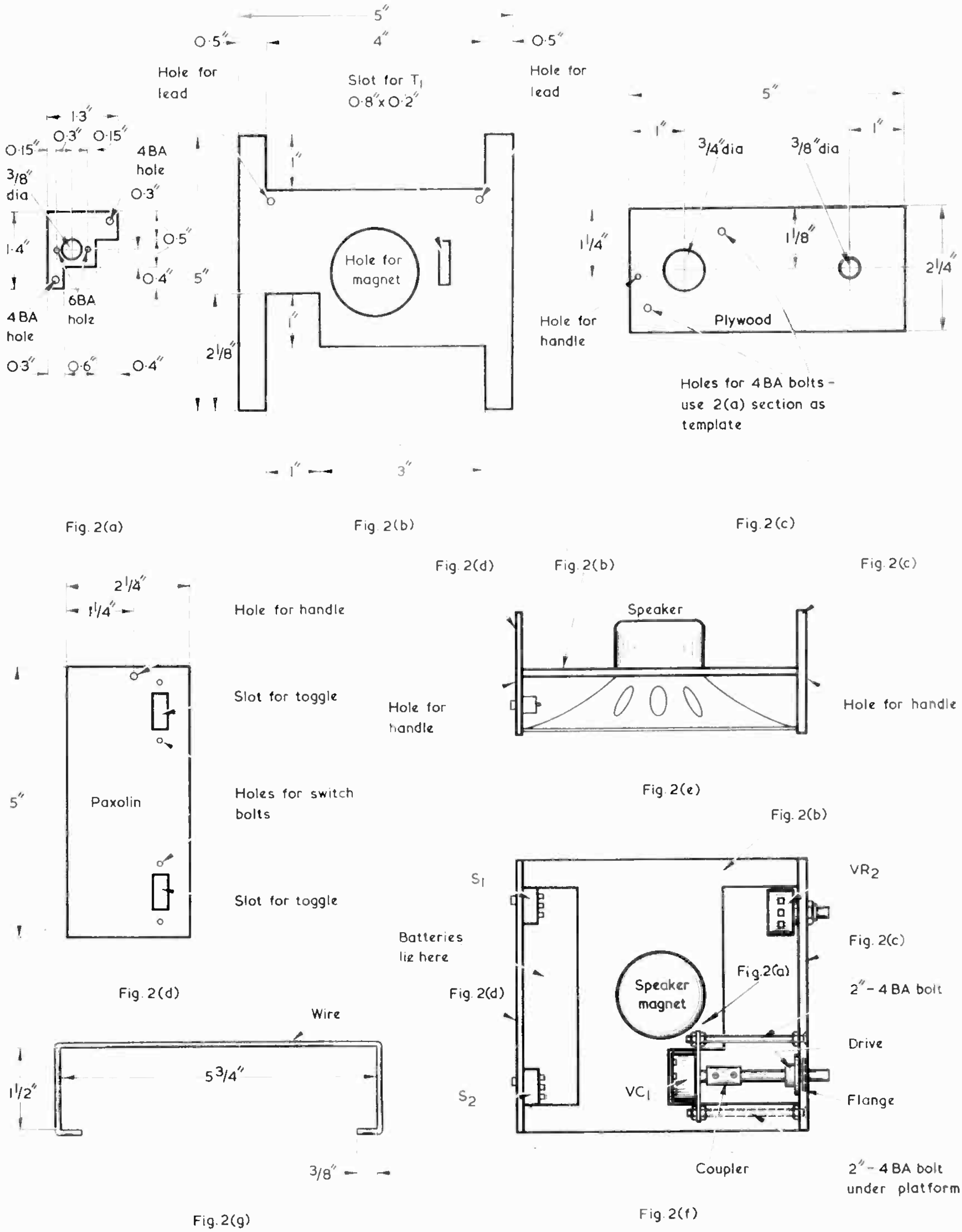


Fig. 2(a). The Paxolin member on which VC1 is mounted. (b). The main platform. (c). The front panel. (d). The rear panel. Switches are mounted at the approximate positions indicated. (e). Side view, showing the assembly in place on the loudspeaker. (f). Top view of the assembly and the speaker. (g). How the wire handle is made up the assembly. See Fig. 2(f).

Next, push the speaker magnet through the hole in the plywood panel of Fig. 2(b), and screw (or fit, using small angle brackets) the two pieces shown in Figs. 2(c) and (d) to the platform so that the assembly takes up the shape shown in Figs. 2(e) and (f). Fit VR2 as shown. Remove the speaker for the time being.

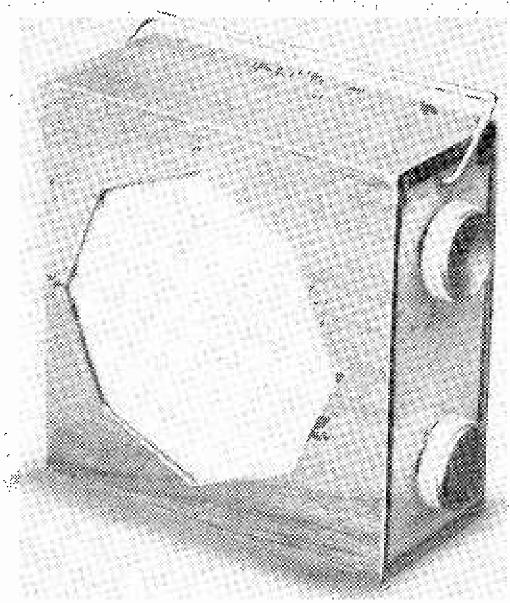
FITTING THE COMPONENTS

Turn next to Fig. 3. Two tagstrips are required, one with ten tags and the other with six. These were cut from a Radiospares standard size tagboard as the tags on this are shorter than on individual tagstrips. These portions of the tagboard are screwed into position with the aid of small woodscrews passed through suitably drilled holes. A piece of thin Paxolin sheet should be inserted under each strip to prevent the tag undersides touching the wood. Failing this, a layer of p.v.c. tape could be used provided care is taken not to overheat the tags. Next T1 is cemented into its slot. Assuming the use of the Radiospares output transformer, the mounting feet of T2 are soldered to the appropriate tags; note that this method of mounting also causes the first and third tags of the six-way tagstrip to be electrically connected together.

The other components may next be wired in as shown. For clarity, TR1, TR2, R1, R2 and C2 are shown in positions which would make it impossible for the batteries to be housed. These components must, in practice, be positioned so as to leave the battery space clear. Similarly, no wiring or tag connections must pass over or near the battery space. Again for clarity, the front panel is shown screwed into position, whilst the back panel is shown lying flat. A further point is that the long leads from VC1 and from the second tag from the left of the ten-way tagstrip to VR1 should, in practice, pass through the small hole through which the leads from L2 pass, and should not lie across the battery space as shown.

It is important that a transistor holder should be used for TR3. The leads of this semiconductor should not be soldered direct.

L3 should have a turn or two of Sellotape wrapped round its windings, and one of its leads will need to be extended by a length of single strand insulated wire, the negative lead of D1 being soldered to the extension point on the lead of L3. L3 needs to be oriented during setting-up, and if the size of the speaker magnet is such as to leave insufficient room for this to be done, the other lead may also be extended and L3 placed in a position behind



When housed in its case, the receiver presents a neat appearance

VC1. C1, D2 and D3 will each also require one of their leads to be extended.

L1 has 65 turns close-wound of 32 s.w.g. enamelled wire on a paper sleeve of a size which allows it to be moved on the rod. L2 is similarly wound on a paper sleeve and has 250 turns of 38 s.w.g. enamelled wire wound in a pile to a length of about 1½in. It is convenient for VR1 and VR4 to be miniature components, and VR3 a standard size skeleton component. The tags will then fit neatly to the relevant connecting points.

The two ferrite rods have rubber grommets at their ends which are tied with cord (not wire) round the arms of the platform. This method of mounting secures the rods adequately. Small cuts in the arms of the platform will hold the cord steady.

The lead which passes from the left hand tag of the speaker to the negative line should be soldered to the speaker tag, and one end of L4 should be soldered to the right hand speaker tag before the speaker is pushed into position. L4 lies between the speaker and the platform and it is advisable to wind a turn or two of Sellotape around its windings. Make sure that room is left for L4 as the speaker is pushed into position.

A strip of plywood about 4in. long and of a width dependent on the exact dimensions and positions of S1 and S2 should next be cut and bolted to the back panel to hold the batteries steady. This strip will need to be removed when the batteries are replaced.

SETTING-UP

Setting-up adjustments may now be carried out. Turn VR4 so that its slider is nearly, but not quite, fully anticlockwise. Set VR3 to half-way. Clip a voltmeter across the primary tags of T2. Switch on at S2 and adjust VR3 so that a reading of 0.75 volt is given.

Set S1 to select medium waves. Turn VC1 to near maximum capacitance. Adjust the angle of L3 so that oscillation starts with VR2 not less than about 180° from minimum. If this cannot be achieved, change round the connections to L1. Movement of L1 winding on the rod will act as an additional vernier control over the oscillation position.

Now turn VR1 to half-way and switch to long waves. Adjust VR1 so that oscillation starts with VR2 at the full on position when VC1 has its vanes fully enmeshed. Do not alter the angle of L3. The position of L2 winding on the rod will have little effect.

It is a normal characteristic of the circuit that when the receiver is first switched on and tuned to a weak signal at the high frequency end of the medium wave band, requiring a critical setting of VR2, there will be a tendency to spill over into oscillation during the first few seconds. The opposite effect may be noticed when listening to stations on the long wave band. The effect very soon passes

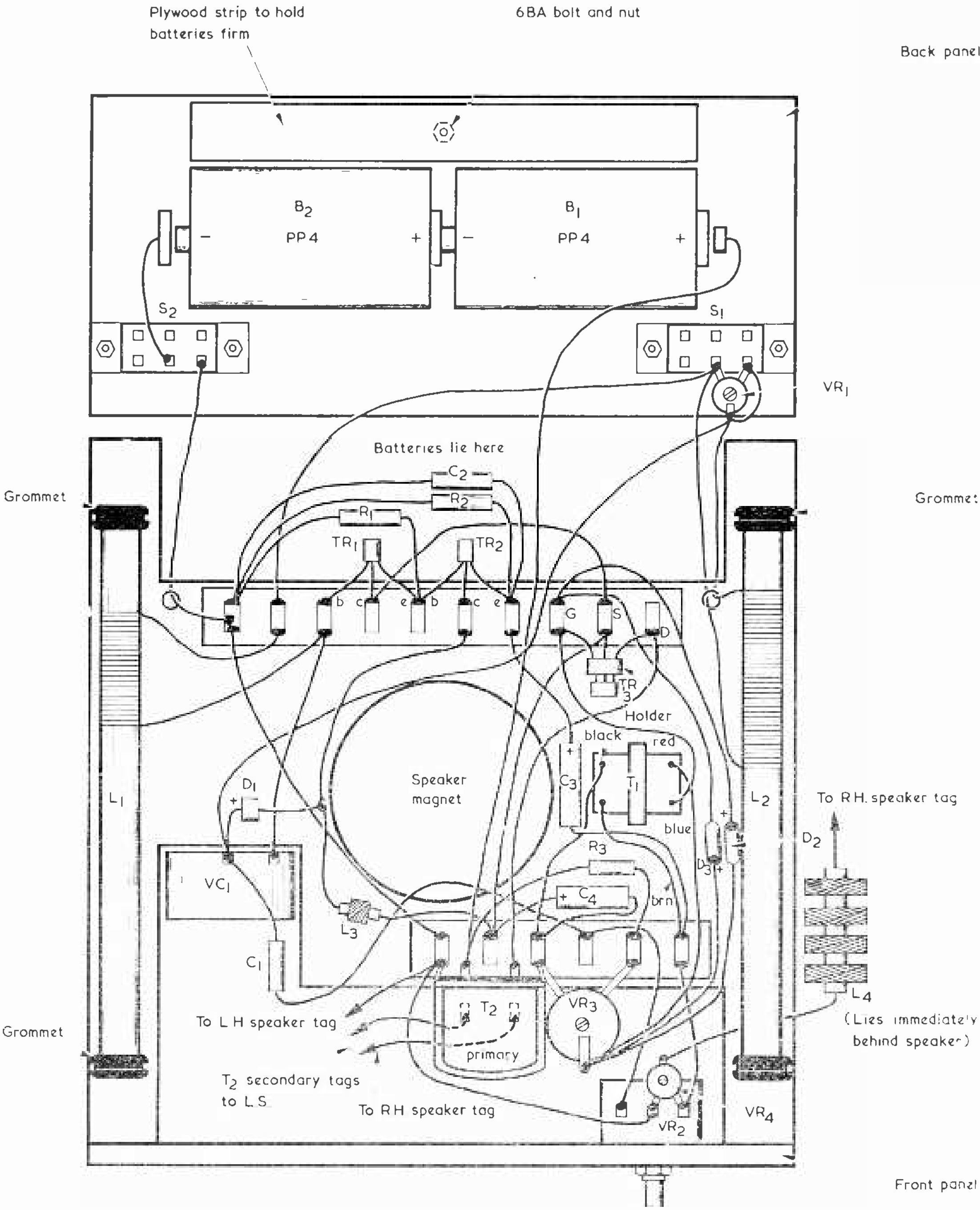


Fig. 3. The component and wiring layout. Check with the text on the positioning of components shown here in the battery space

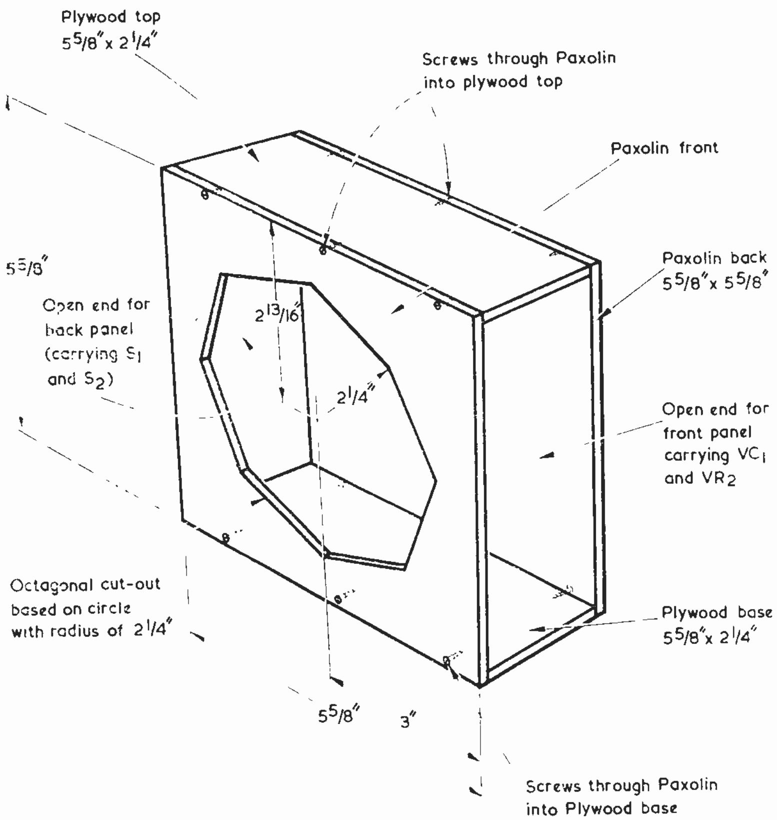


Fig. 4. A simple case may be built in the manner shown here

off, but may require re-adjustment of VR2 after a short interval.

Finally, VR4 should be adjusted. First tune to a weak station and set VR2 so that the receiver is nearly oscillating. Turn VR4 clockwise, whereupon volume will increase until, first, there is distortion and, later, low frequency oscillation. Leave VR4 at a satisfactory setting. The extra gain will not be large, but it is useful.

CABINET

A simple case may be made along the lines shown in Fig. 4. The large sides are made of Paxolin and the small side pieces of ¼in. plywood. The receiver slides into the case, match-box fashion. Before cutting the pieces, make sure that the receiver will fit. Some dimensions may not be exactly as specified due to small mistakes in construction, whereupon the dimensions in Fig. 4 should be modified accordingly. Note that the octagonal hole for the speaker is slightly to the left of centre to leave room for the tuning scale and its Perspex cover. The Paxolin pieces are screwed to the plywood pieces and the whole is covered with Fablon or Contact. To make entirely certain that no errors appear, it is advisable to fit the tuning scale and its Perspex cover before cutting out the parts for the case.

Place a piece of white card over the front panel of the receiver and make two small wire pointers to be screwed to the flange of the epicyclic drive. Calibrate the dial – an easy task as many stations will be received after dark. Cut a piece of Perspex, 5in. by 2¼in., with appropriate holes for VC1, VR2 and the handle, and place it over the spindles. Using thick 6BA nuts as spacers, to leave clearance for the pointers, screw the Perspex to the panel. Cut a piece of expanded metal grille to cover the speaker and slip the receiver into the case from the left hand side. Make a stiff wire handle, as shown in Fig. 2(g), and spring its ends into the appropriate holes in the receiver, which will then be held firmly in the case.

COMPONENTS

A final word or two about components. The constructor must use the specified transistors, all available from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey, who also stock D2 and D3. The M3 diode is obtainable from Henry's Radio Ltd. T1 is generally available, and there is no easy alternative for this component. If VR2 is more than about ¾in. in diameter, it may be necessary to make the adjacent foot of the platform a little narrower. A suitable component is the Radiospares 250Ω wirewound semi-precision control, but this has to be ordered through a retailer. An alternative which can be used instead is the 220Ω linear type P20 carbon track potentiometer, less switch, available from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey. This has a body diameter of 0.79in. and should fit into the receiver comfortably. The speaker should be within the maximum limits of 1¾in. magnet diameter and 2¼in. overall depth.

If the Radiospares transformer cannot be obtained for T2, it may be replaced by two Repanco transformers, types TT49 and TT46, coupled together in tandem, as shown in Fig. 5. They are mounted on a small piece of Paxolin and, in the diagram, are behind the Paxolin, their spills passing through small holes in it. The spills are then bent round to secure the transformers, and the assembly is bolted to the front panel between VC1 and VR2.

With this assembly the wiring in Fig. 3 is modified slightly. R3 now connects to the TT49 transformer, as shown in Fig. 5, and its lead may require extending. Since the first and third tags of the six-way tagstrip are not now bridged by the mounting feet of the Radiospares trans-

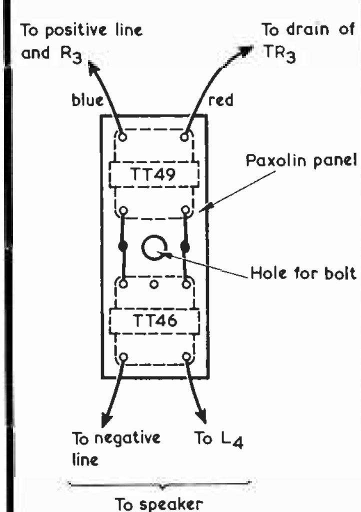


Fig. 5. Details of an alternative output transformer assembly

former, they need to be joined by a short length of insulated wire.

The primary of the TT49 transformer has a resistance of 150Ω, so that VR3 is adjusted to cause 0.45 volt to appear across it at the required current of 3mA. The two transformers offer an overall ratio of 36:1.

It will be apparent that if, for any reason, the coupling between the drain of TR3 and the connection to L4 is of opposite phase to that existing in the prototype, the feedback to T1 will be negative instead of positive, with a consequent reduction in gain as VR4 is advanced. It is unlikely that this will occur if either of the alternatives for T2 is connected as described, and it can, in any case, be corrected by transposing the primary connections in the drain circuit of TR3. ■

In your workshop

This month Dick and Smithy leave the realm of semiconductor devices and travel back in time to a subject which is of continual interest amongst readers: the repair and rejuvenation of old valve a.m. radios. Dick encounters a typical example of the receivers in this genre, whereupon Smithy is able to demonstrate the stock faults to which such receivers are prone, and to discuss their rectification

"For repair if economically justifiable."

Dick looked again at the ticket attached to the large mains radio on the 'For Repair' rack and scratched his head. To one of Dick's tender years the set appeared to be a very old receiver indeed. Its large wooden cabinet had collected a considerable amount of dust, and Dick blew some of this away so that he could peer at the tuning scale. So far as he could ascertain through the grime, the set was intended for long, medium and short waves.

Reluctantly, Dick picked up the set, carried it over to his bench and plugged it into one of the mains sockets at the rear of his bench. He tentatively tried the knobs on the front of the receiver and found the one which was coupled to the volume control and on-off switch. He turned this round. A weak pallid light behind the tuning scale gave witness of the electrical marvels of an earlier age.

After allowing a reasonable time for warm-up (since, as Dick correctly surmised, the receiver had been assembled before the junction transistor was even a gleam in W. Shockley's eye) Dick advanced the volume control to its fullest setting. There was no sound from the speaker. Dick turned back the volume control and experimented with the other knobs. The wavechange switch clicked mechanically in an encouraging manner, but there was no corresponding sound from the speaker. The tuning knob caused a cursor to move horizontally behind the tuning scale but it had, otherwise, no noticeable affect on receiver performance. A fourth control, which must obviously have been for tone, similarly failed to produce any audible results from the speaker. Dick switched the receiver off again.

A.M. VALVE RECEIVER

"Hey, Smithy!"

"What's up?"

"It's this weird radio I've got here," called out Dick. "I've never seen anything so old and grotty for ages."

Patiently, Smithy the Serviceman put down his test prods and turned round from the chassis he was working on. A gleam of recognition came into his eyes as he saw the receiver on Dick's bench.

"Well, well, well," he remarked. "Now, that's a model I've handled stacks of times in the past. It came out just after the war."

"The note tied to it," said Dick, looking at the ticket once more, "is something I've never seen in here before. It says the set's in for repair 'if economically justifiable'. All I've done up to now is to plug it in to the mains, and it seems to be completely dead."

"Economically justifiable, eh?" repeated Smithy. "Well then, the next thing you'd better do is to whip the back off and see what it looks like inside."

Smithy ambled over as Dick took the mains plug of the receiver out of the bench socket, turned the set round and then removed its back. Smithy looked inside interestedly.

"Ah yes," he remarked. "That chassis brings back a few memories to me. Almost all the radio sets in those days were four-plus-one jobs. This is one of them." (Fig. 1).

"Four-plus-one?"

"That's right. They were called four-plus-one sets because they all had four signal-handling valves and one h.t. rectifier valve. The signal-handling valves were a triode-hexode or triode-heptode frequency changer, a pentode i.f. amplifier, a double-diode-triode in which the diodes acted as signal and a.g.c. detectors and the triode as audio a.f. voltage amplifier, and an a.f. output pentode. This represented a stock receiver design and, to be frank, it used to work very well indeed. This set is a typical four-plus-one and, as you'll note, all the valves are on octal bases. It's also got a mains transformer, too."

"Will it be capable of being repaired without too much expense?"

"Oh, quite probably," said Smithy. "If there isn't anything excessively wrong with it, and it has been kept in a reasonably dry place, it may only need a few new components to get it working quite well once more. From the look of this particular set, I'd say it has been stored away in somebody's lumber room for years, and that that somebody has suddenly decided to see whether it's worth bringing it back to life again."

"Well," conceded Dick, "there's certainly enough dust, both on the cabinet and on the chassis, to support that last remark. It looks as though it hasn't been used for years."

"Fair enough," said Smithy. "Anyway, the first thing to do is to see whether anybody's been messing about in it and has started changing a lot of components around. The set will be too much trouble to bother about if we've got to first of all put right a lot of poor work carried out by some ham-handed Henry in the past."

"So far as I can see," said Dick,

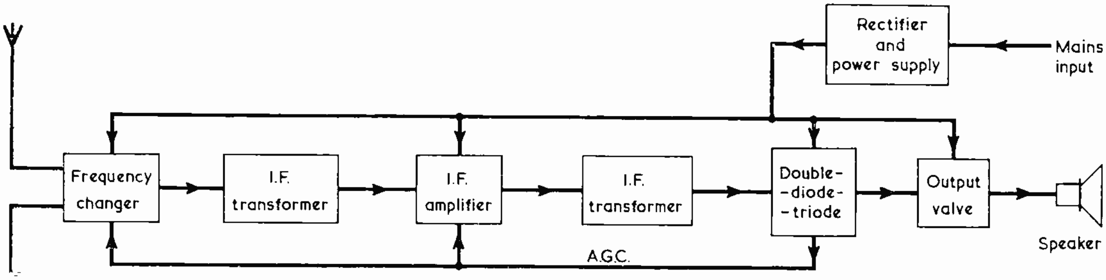


Fig. 1. Block diagram of a 'four-plus-one' a.m. valve receiver

taking a closer look inside the cabinet. "it looks all right above the chassis."

"Good." replied Smithy. "Let's next go through some other items which are likely to make the repair of sets of this nature uneconomical. To start off with, if the set has a push-button wave-change or station selection switch it would probably be best to forget about fixing it. These push-button switches tend to wear out more quickly than the rotary type and, to my mind, the replacement of what could well be a non-standard push-button switch would incur far too much trouble. See, also, that the tuning drive is in good condition. If a complicated mechanical drive is used and it's gone faulty, the set is again not really worth the bother of fixing."

"The tuning drive appears to be okay," remarked Dick. "And the wave-change switch on this set is a rotary one and it seems to have at least a good clicking action."

"That sounds promising," commented Smithy. "Well, you'd better get the chassis out and clean some of that dust off it."

Smithy returned to his bench, whilst Dick removed the chassis from the cabinet. He then took from its corner the Workshop's battered vacuum cleaner, in whose bag at some time had resided dust from most of the households in the locality, and proceeded to clean the top of the chassis. As a final act he coupled the hose of the cleaner to its blower end and blew away the final remaining traces of dust from odd crannies. On turning the chassis over, he was pleasantly surprised to find that the underside was quite clean, and bore only that particular patina which is peculiar to old radios. He examined the chassis underside carefully.

"This doesn't look too bad, Smithy," he called out. "I've taken a look at the wave-change switch, too, and it seems all right. Somebody in the past has changed one of the resistors, but he's made a nice neat job of it so *that* should be okay."

MAINS TRANSFORMER

"Fair enough," said Smithy, returning. "Now the set has got a mains transformer. If that proves to be all right then I think it might well be worthwhile getting this receiver to go again."

Smithy looked into the chassis, then picked up Dick's testmeter. He switched this to a resistance range and clipped one of the test leads to the chassis.

"We'll first check that the h.t. secondary is all right," he explained. "This set uses a standard full-wave rectifier circuit so there will be a centre-tapped h.t. winding to test."

The Serviceman applied the remaining test prod successively to two of the rectifier valve pins (Fig. 2) and looked at the meter needle.

"There's several hundred ohms in each half of the secondary," he said, "so that will be all right."

"The primary should be all right, too," put in Dick. "The tuning scale light lit up when I switched the set on."

"Did it?" said Smithy. "Then there's no point in carrying out any further tests, and we can say that the mains transformer is satisfactory."

"What," asked Dick, "is the next thing to do?"

"Make certain there are no shorts between h.t. positive and chassis," replied Smithy. "Seeing that you got no sound out of the set when you switched it on just now, it would seem reasonable to check that there are no broken-down h.t. smoothing electrolytics or anything like that. We don't have to actually locate the positive h.t. line because we can, of course, check directly at the tags of the h.t. electrolytics themselves. I see that this set has three electrolytics in a single can with smoothing resistors between them."

Smithy applied the test prods of Dick's meter to the tags of the electrolytic capacitors. (Fig. 3).

"This is quite encouraging," he remarked cheerfully. "I got a sizeable kick in the meter needle when I first put the prods on, which

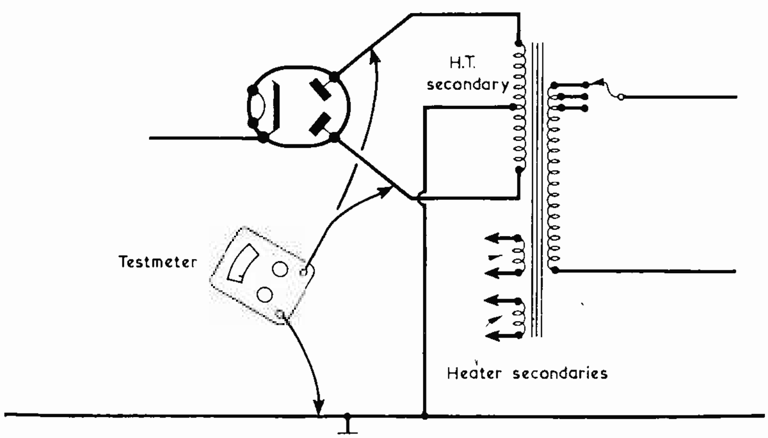


Fig. 2. Smithy checked the two halves of the mains transformer h.t. secondary by checking for continuity between chassis and first one anode and then the other anode of the full-wave valve h.t. rectifier

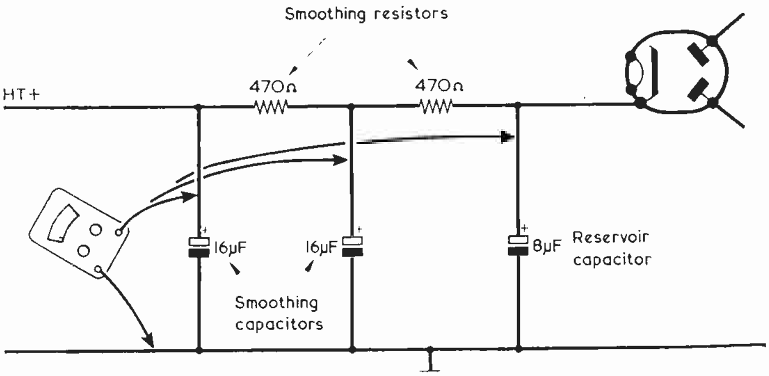


Fig. 3. Checking for h.t. short-circuits, Smithy tested between chassis and the positive tags of the h.t. electrolytic capacitors. This also enabled open-circuits in the smoothing resistors to be checked. The component values shown are typical

means that there's still a useful bit of capacitance in the smoothing circuit. And the final resistance to chassis at each of the positive tags was about 100kΩ. Sets of this nature don't usually have potential dividers in the receiver circuits, so that 100kΩ resistance is probably leakage resistance in the electrolytics. The fact that I got the same resistance reading on each of the tags also indicates that neither of the smoothing resistors is open-circuit. A figure of 100kΩ is a wee bit low for leakage resistance, but I think we can still switch the set on, nevertheless. Plug it in, Dick."

Smithy switched Dick's meter to a suitable voltage range, then reconnected it between chassis and the positive tag of the final electrolytic smoothing capacitor. At the same time, Dick put the receiver plug back in the socket at the rear of his bench. Smithy switched on the set. The tuning scale light, now relieved of its cocoon of dust, shone brightly. The heaters of the five valves in the receiver started to glow, shortly reaching full brilliance. The needle of Dick's meter suddenly shifted from its zero setting. As the seconds passed it ascended up its scale then slowed down to finish at a steady and triumphant 260 volts.

"There's plenty of h.t. there," remarked Dick. "Let's turn the volume up."

He reached over and turned the volume control spindle fully clockwise. As had occurred when the set was in its cabinet, there was still no sound from the speaker. Dick next attempted to adjust the wave-change switch, but it was too stiff to turn by means of its spindle only. Dick fitted its knob, then turned it experimentally from one position to the next.

There was a sharp crack, and a spark jumped between two pins of a valveholder on the other side of the chassis.

Dick turned the switch back to its previous position. Again there was a sharp crack, accompanied by the spark.

"Corluvaduk," exclaimed Dick, startled. "What have we got here?"

"We've got a symptom," replied Smithy, "which explains why this set is so silent. What you haven't realised is that the valveholder where that spark is occurring is the one that holds the output valve. Switch the set off, then trace for an open-circuit between the secondary of the speaker transformer and the speech coil of the speaker."

I.F. INSTABILITY

Impressed by this immediate diagnosis of the cause of the spark, Dick turned off the set, located the speaker transformer and traced through its secondary circuit to the speaker.

"Blimey, Smithy," he called out suddenly. "You must be a magician, mate! It's just as you said; what's happened is that a wire from the speaker has broken off at the transformer secondary tag. It was still positioned close to the tag and it wasn't till I waggled it that I found it wasn't actually connected."

Dick indicated to Smithy the break in the circuit (Fig. 4) then picked up his iron.

"We'll soon get this fixed," he called out jubilantly. "Incidentally, what made you so sure that the transformer secondary circuit *was* open?"

"It was almost certain to be," replied Smithy. "If, in a single-ended valve audio output stage, as we have here, the secondary of the output transformer isn't loaded by the speaker, the impedance presented to the output anode is the inductance of the transformer primary

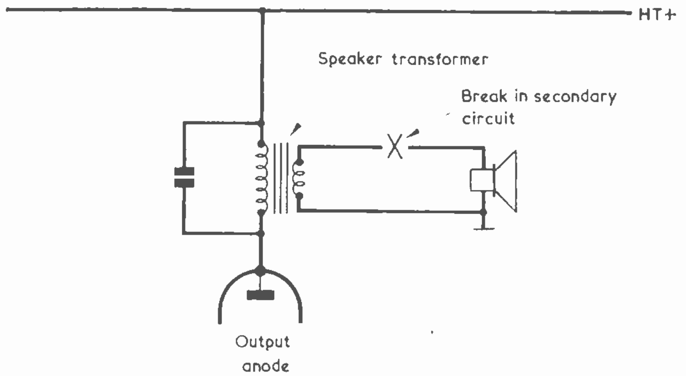


Fig. 4. The break in the speaker transformer secondary circuit. (The capacitor across the primary, normally around 0.1μF, is intended for 'tone-correction' and it reduces the shrill effect of third harmonic distortion in the output pentode.)

itself. This impedance is much higher than the normal anode load impedance, with the result that much higher a.f. voltages appear across it. If that secondary circuit hadn't been open just now there would have been a loud click from the speaker each time you moved the wave-change switch, this click being particularly loud since, as I noticed. you had the volume control at a full setting. With the speaker disconnected, though, that click became a large voltage pulse at the output anode instead, whereupon a spark jumped from the anode pin to the adjacent pin, which happens to be one of the heater connections. Incidentally. sparking at the output anode pin when the output transformer secondary circuit is open is quite a common occurrence. High level music or speech fed to the output valve can also cause it to happen."

"Well, that's something I didn't know before," said Dick. "Anyway, I've now repaired that secondary circuit connection, and I'm going to switch on again."

Dick turned the receiver on again. After a short wait, an h.t. voltage was once more indicated on the testmeter. Also, and much to the gratification of Dick's assistant, a hiss at comfortable level became audible from the speaker.

"We're really getting somewhere now," said Dick exhuberantly. "I'd better see if we can tune in a station."

He looked at the wave-change knob.

"We're switched to long waves," he continued. "Let's see if we can get Radio 2 on 1,500 metres."

"Plug an aerial in first," advised Smithy. "There were no such things as ferrite rods when this set was made. A few feet of wire will be enough for the time being."

Dick found an odd length of wire and inserted it in the aerial socket of the receiver. A comforting crackle was audible from the speaker at the instant of making the connection. Dick grinned. He then turned the tuning drive spindle between finger and thumb, whereupon a steady succession of further crackles was heard, these ceasing as he stopped turning. Dick's grin vanished abruptly and his expression changed to one of dismay.

"There's no point," he said gloomily, "in going any further with this set, Smithy."

"Why on earth not?"

"Didn't you hear those crackles when I turned the tuning drive spindle? The vanes in the tuning capacitor must have a shocking intermittent short-circuit between them somewhere."

"Nonesense," retorted Smithy. "Put the knob on that tuning drive spindle and try again."

Unwillingly, Dick fitted the knob to the spindle and turned it experimentally. Much to his amazement, he found that the crackles had disappeared completely.

"Stap me, Smithy, how do you do it?" he asked wonderingly. "And where did all those crackles go?"

"What was happening," said Smithy, "was that your body was acting as a counterpoise earth to that short aerial you fitted. The chassis of this set isn't earthed, and you were making an intermittent connection to it as you turned the spindle, the intermittent connection being given between the spindle and the holes in the chassis to which it's fixed."

Smithy indicated the points of contact. (Fig. 5).

"This intermittent connection," continued the Serviceman, "caused the effective counterpoise – you – to be coupled to the chassis by a

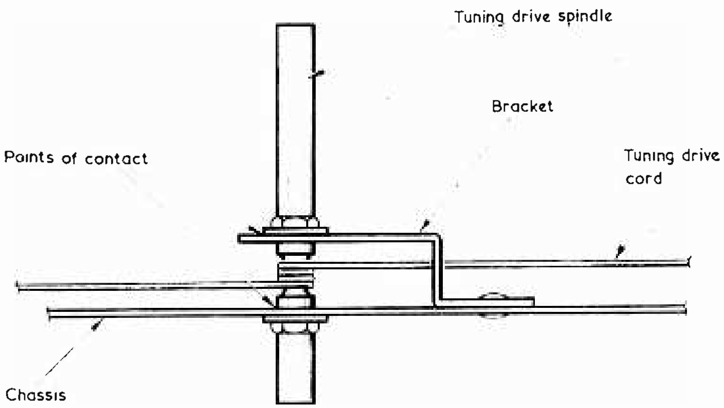


Fig. 5. In this typical tuning drive spindle mounting, the spindle simply revolves in holes in a mild steel chassis and support bracket. In consequence, the electrical contact between the spindle and the chassis, as the former is rotated, is of an intermittent character

'crackly' connection. After you'd put the knob on you were insulated from the spindle and so there were no more intermittent connections between you and the chassis, and hence no crackles. Okay?"

Dick looked at the receiver with a newly acquired respect.

"Servicing these old sets," he remarked, "involves a lot of tricks you don't encounter with modern receivers. Anyway, now that we've got the crackles out of the tuning, let's have another bash at picking up a station."

He turned the knob further and was rewarded by a high pitched whistle with a background of distorted music. The whistle descended in frequency as he turned the tuning drive and he was able to reach a position of zero-beat. The sound of heavily distorted music was loudly audible from the speaker.

"That's i.f. instability," remarked Smithy laconically. "The i.f. amplifier is oscillating at the intermediate frequency so that, when you tune in a signal, you get the same beat frequency effect as when you tune in a signal on a straight receiver in which the reaction has gone past oscillation point. Let's see if we can clear it up."

Smithy went to the spares cupboard and returned with a 0.5μF polyester capacitor. He applied this across the third electrolytic capacitor in the h.t. smoothing circuit. (Fig. 6). The beat frequency effect cleared immediately. With his free hand, Smithy turned the tuning drive of the receiver. The signal could now be tuned in and out in perfectly normal fashion, with no trace of the previous whistle. When tuned in correctly, the signal still exhibited a measure of distortion, but this was of a different nature and much less evident than that which had previously been present.

"You've done it again!" pronounced Dick incredulously. "That's the third snag you've cleared up first go. How on earth did adding that capacitor clear the instability?"

"To answer that question," replied Smithy, switching off the set again, "I must first tell you that quite a lot of these old valve sets have no anode decoupling for the individual stages at all. The frequency-changer anode load, the i.f. amplifier anode load, the a.f. voltage amplifier anode load and the output pentode anode load all go to the h.t. positive line direct. This is bypassed to chassis by the smoothing electrolytic capacitor which connects to the h.t. positive line, and there are no other anode bypass circuits whatsoever. It only requires the electrolytic capacitor to develop a little series impedance and the whole set takes off! The usual result is that oscillation takes place at the intermediate frequency because that's the frequency at which most amplification takes place."

NEW CAPACITOR

"Isn't it a bit naughty," queried Dick, "to expect an electrolytic capacitor to act as a bypass at intermediate frequencies?"

"It is rather, I suppose," said Smithy. "But the use of an electrolytic in this manner was an extreme-

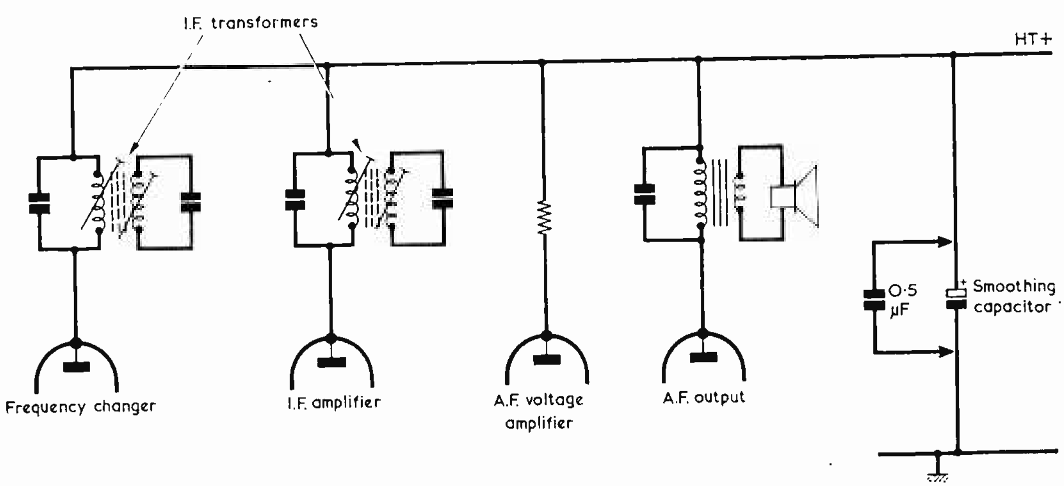


Fig. 6. In many a.m. valve receivers the final smoothing electrolytic capacitor bypasses the anode loads of all the stages. Smithy connected an 0.5μF capacitor across this capacitor to see whether it was causing i.f. instability

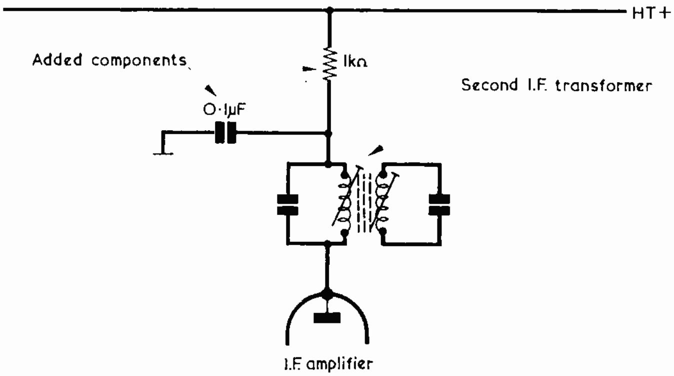


Fig. 7. An added h.t. decoupling circuit at the second i.f. transformer can, in some instances, cause an improved performance in valve a.m. receivers

ly common practice at the time. You'll have noticed, incidentally, that I only needed a 0.5μF capacitor to provide the bypassing that was required to clear the i.f. instability, so perhaps employing an electrolytic for the job isn't such bad practice after all. By the way, if you ever want to *improve* the i.f. response of one of these old sets, it's a good plan to add an h.t. decoupling circuit to the primary of the second i.f. transformer. A 1kΩ resistor and 0.1μF capacitor will be quite adequate." (Fig. 7).

"What does the decoupling circuit do?"

"It increases the isolation between the two i.f. transformer primaries," explained Smithy. "There is then less chance of regeneration from the anode circuit of the i.f. valve back to its grid circuit, and you can align the transformers to give really symmetrical responses. Adding the decoupling circuit doesn't *always* produce a significant improvement in receiver performance, but it's worth trying, just on spec."

"That's something I'll bear in mind for the future," said Dick. "At the time being, though, it looks as if I'd better fit a new electrolytic to this set."

"It does, rather," agreed Smithy. "As a matter of fact I would probably have suggested that you replaced the h.t. electrolytics in any case, even if they hadn't given rise to trouble or were allowing excessive hum to appear. Electrolytics as old as these ones are tend to fall into the category of components that are liable to give trouble at any time."

Dick walked over to the spares cupboard and selected a suitable triple electrolytic capacitor for replacement. Smithy watched him thoughtfully as he mounted it on the chassis and then soldered it into circuit.

"Whilst talking about i.f. instability," Smithy remarked, "another component which was likely to give rise to trouble on this score is the screen-grid bypass capacitor for the i.f. valve. This connects, of course, between the screen-grid and chassis."

"Why should it cause trouble?"

"Because the i.f. amplifier valve is expected to provide a very high level of amplification," explained Smithy. "With the result that, in many of these old sets, its screen-grid had to be tied down to chassis really good and tight. If you had a faulty screen-grid capacitor, or if the leads to it were too long, the set could similarly go unstable. Another cause of i.f. instability, in the *really* old sets, was the result of the metallising on the glass envelope of metallised valves becoming unstuck from its earth lead."

"Valve metallising? Blimey you're going back a bit, aren't you?"

"Perhaps I am," confessed Smithy, "but if we're going to talk about old sets, we might as well cover the subject completely. These valves were octal types with the control grid brought out to a top cap, and they were screened by a layer of metallising on the outside of the glass, this metallising connecting to a wire which went down to an earth pin. Very often the glass used to come adrift from the bakelite base of the valve and the connection to the earth pin would then break away. If the valve was an i.f. amplifier the set would probably go into i.f. oscillation as a result. The cure was to re-stick the glass of the valve to its base and then wrap a few turns of thin bare tinned copper wire round the metallising at the bottom. This wire was then run down the outside of the base to the earth pin and soldered to it at the point where its pin left the base." (Fig. 8).

"I had a go myself once," commented Dick thoughtfully, "at soldering to one of the pins of an octal valve. I had a dickens of a job getting the solder to take."

"You need to give the pin a touch with a file first," advised Smithy. "Just enough to remove the plating at one point and show the brass underneath. Have you got that new electrolytic in yet?"

A.F. DISTORTION

"Just finishing," said Dick.

Carefully, he completed the last connection, then he placed his soldering iron on its rest and switched on the receiver. Both of them listened critically to the music, without whistle, that the set now reproduced.

"The new electrolytic," remarked Dick, "has certainly cleared the i.f. instability. But the sound still seems a little distorted to me."

"Yes, it is a bit," agreed Smithy, picking up a screwdriver with an insulated handle. "Let's check the a.f. coupling capacitor to the output grid."

Smithy put the blade of the screwdriver on the chassis alongside the output pentode valveholder and touched its metal shaft to the control grid tag. With a crackle, the sound ceased. (Fig. 9). Smithy re-

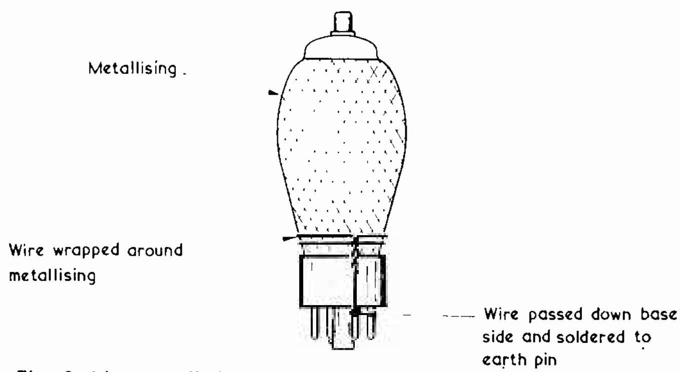


Fig. 8. The metallising of a valve may be connected to its earth pin externally

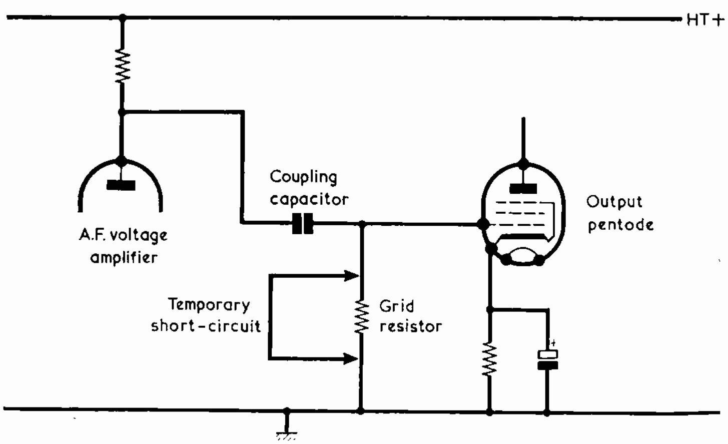


Fig. 9. Checking for a leaky a.f. coupling capacitor. If a crackle is heard when the grid resistor is short-circuited the coupling capacitor is leaky

moved the screwdriver whereupon, with a further crackle, the sound resumed.

"The coupling capacitor between the output grid and the previous anode has gone leaky," Smithy pronounced decisively. "New capacitor to be fitted, please!"

"Blow me," protested Dick, "you aren't half diagnosing faults in a hurry today. How the deuce can you be so sure that the coupling capacitor is leaky?"

"Because that output grid has got a standing direct voltage on it," replied Smith, "which is why I got a crackle when I short-circuited its grid resistor. If it hadn't had a direct voltage on it, the sound would simply have ceased without a crackle. This test is a reliable and quick one, but make certain you know which *is* the control grid pin if you carry it out. You can do a lot of damage if you accidentally short the wrong pin to chassis!"

Dick went to the spares cupboard and found a new replacement coupling capacitor. He switched off the set, soldered the capacitor in, then switched on again. The distortion was now completely cleared.

"Do you know, Smithy," remarked Dick after some moments, "this set sounds really *good*. The quality seems to be a darned sight better than what you get on many of the modern solid-state jobs we handle."

"When they're working properly," commented Smithy, "these old valve sets can sound very nice indeed. To start off with, they've got a straightforward Class A output stage with no complications, instead of the present-day transistor Class B circuits. Secondly, the sets were built in large wooden cabinets, which means that their speakers, which themselves are quite a big size, have a good effective baffle area to bring up the bass. I'll be the first to agree that the sound these sets give isn't high fidelity and that it isn't up to the high quality mark, even. And I'd agree also that the i.f. stages are usually sharply selective, so that you get an output which has a fair amount of top-cut to add to any bass thump that may be given by the large speaker and cabinet. Nevertheless, I still feel that these receivers can give quite a good performance. Try the other bands on the set."

Dick proceeded to put the set through its paces and found that it performed remarkably well. Long and medium wave reception was very good, and the set produced the usual staccato stream of signals as he swung over the short wave band. The more powerful short wave stations could be resolved with ease.

"Not bad at all," commented Smithy. "I think we can say that we have now achieved an acceptable repair at quite a reasonably low cost, both in components and in time. Admittedly, we were lucky to find that the set had the more usual stock faults on it. I tell you what: now that we've got it going, how about giving the cabinet a bit of a polish up?"

"Why not," replied Dick enthusiastically. "To tell you the truth, I'm beginning to fell quite a lot of affection for this old-stager, and I'd be only too happy to give its box more than the average amount of bull."

Dick found some rags and a tin of furniture polish, these being employed occasionally to give the more expensive receivers a final finishing. He polished away cheerfully to the accompaniment of mellow music from the old radio.

Smithy's assistant gave the cabinet of the receiver a final rub and then put the polishing cloth on one side. The receiver, its early post-war cellulose covering restored to its original splendour, gleamed in front of them. The tuning panel, now cleaned and fully illuminated, was radiant with a tuning scale pattern of many colours.

"The owner of this set," said Dick proudly, "can certainly be grateful to us for the work we've put in on it."

A thought suddenly occurred to him.

"Hang on a minute," he went on, frowning, "I've just remembered something. The ticket tied to that set didn't have any owner's name and address written down on it."

Smithy turned a guileless eye towards the ceiling.

"There's something fishy here," continued Dick, a tone of suspicion rising in his voice. "It's the rule that all the fault-tickets used here should have the set-owner's name and address on them. I must say it's funny that the first unusual job I've tackled for ages should also be accompanied by a label with no name and address on it."

The innocence exhibited in Smithy's face had now become so intensified as to approach the imbecile. Dick turned an accusing glance at him.

"Don't tell me," he intoned furiously, "that that set is yours!"

"I cannot," replied Smithy sweetly, assuming the mantle of the infant George Washington, "tell a lie. Yes, it is my set. As it happens, I found it when I was cleaning out the loft the other day."

"Why, you rotten old devil," spluttered Dick. "You *planted* that set on the rack. You snuck it in first thing this morning, before I got to work, and you darned well secreted it amongst all the other sets on the shelves."

Dick's sense of outrage grew even keener at the recollection of a further affront.

"Flaming heck," he fumed. "I've actually been vacuum-cleaning and polishing up that set, when it's *your* private job! No wonder there's a generation gap these days. It's because the people in the older generation are all like you – shysters and con-men!"

"You must at least admit," said Smithy soothingly, "that I've given you a chance to get in some experience in rejuvenating old sets."

"Well," conceded Dick grudgingly, "I suppose that that is true. But I still think you've been taking a liberty. However, I'll forget all about it on one condition."

"And what's that?"

"That you let me have a really good long gen-session with you during today's lunch-break."

And to that Smithy wearily agreed. ■

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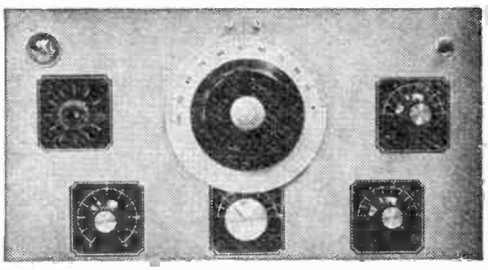

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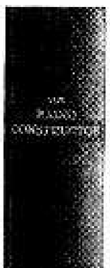

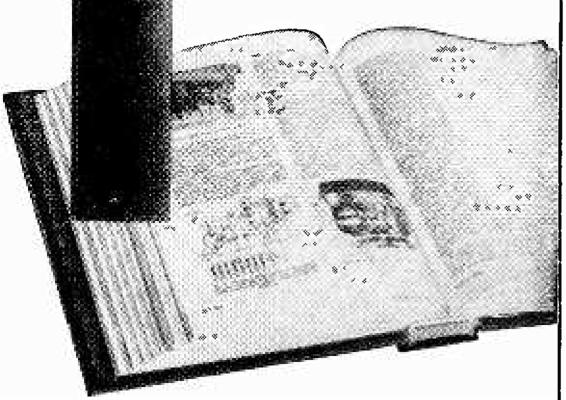

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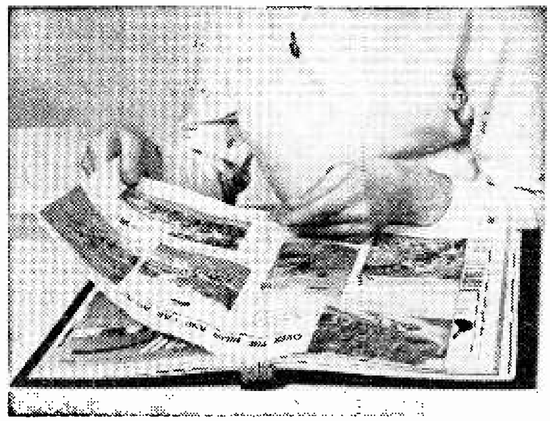

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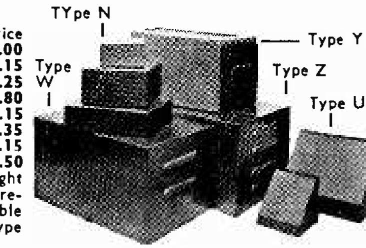

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Foreign Language Broadcasts

The Table lists B.B.C. transmissions in the languages shown. Two-figure numbers indicate Metre Bands and three-figure numbers indicate Metres. Where applicable, days are quoted in brackets. Time is in GMT. The list will be completed in Data Sheets 56 and 57

ARABIC
0345–0545 16, 19, 25, 31, 41, 49 and 198, 417, 428, 470m.
1300–2100 11, 13, 16, 19, 25, 31, 41 or 49 and 198, 417, 428 or 470m.

BENGALI
0130–0145 19, 25, 31, 41
0930–1000 13, 16 (W)
1415–1430 13, 16, 19, 25
1615–1645 25 (W)

BULGARIAN
0445–0500 16, 19, 25, 31, 41
1130–1145 13, 16, 19, 25
1400–1415 13, 16, 19
1645–1730 16, 19, 25, 31
1915–1930 41, 49 (Tu, Th, Sat)
2130–2200 19, 25, 31, 41, 49

BURMESE
0015–0030 19, 25, 31
1345–1415 13, 16, 25, 31
2330–2345 31, 49

CHINESE
Standard Chinese
1000–1030 13, 16, 19, 25, 31, 41
1200–1245 13, 16, 19, 25, 31, 41
2230–2245 19, 25, 31, 41, 49, 75

Cantonese
1245–1300 13, 16, 19, 25, 31, 41
2215–2230 19, 25, 31, 41, 49, 75

CZECH/SLOVAK
0515–0530 25, 31, 41, 49 and 232, 464m.
0615–0630 25, 31, 41, 49
1115–1130 16, 19, 25, 31 *(Slovak)*
1345–1400 19, 25, 31 (Su, Tu, Th, Sa)
1400–1430 19, 25, 31
1430–1445 19, 25, 31 (Su)
1600–1615 19, 25, 31 *(Slovak)*
1845–1900 19, 25, 31, 41, 49
1945–2015 19, 25, 31, 41, 49 and 232m.
2045–2115 19, 25, 31, 41, 49 and 232m. until 2100 *(Slovak)*
2145–2200 25, 31, 41, 49

FINNISH
1530–1600 19, 25, 31 (Su)
1545–1600 19, 25, 31 (M, W, Th, Sa)
1600–1645 19, 25
1930–1945 31, 41

FRENCH
Africa
0430–0445 19, 25, 31, 41
0515–0545 19, 25, 31, 41

(Africa ctd.)
0630–0700 19, 25, 31, 41
1200–1330 13, 16
1830–1930 13, 16, 19, 31
2115–2130 25, 31
2130–2145 16, 25, 31

Europe
0530–0545 232m.
0630–0645 31, 41, 49 and 232m., also 464m. (Sa, Su)
0715–0730 31, 41, 49 and 232m.
1115–1230 19, 25, 31, 49 and 371m.
1800–1900 31, 41, 49 and 232m.
2130–2145 41, 49, 75 and 232m.

GERMAN
0415–0500 31, 41, 49, 75 and 232, 464m.
0515–0600 25, 31, 41, 49 or 75
1145–1215 19, 25, 31, 41
1615–1630 371m. and 90.2MHz
1630–1700 25, 31, 49 and 232m.
1900–2100 31, 49, 75 and 232m. until 1945
2245–2300 41, 49, 75 and 232m.

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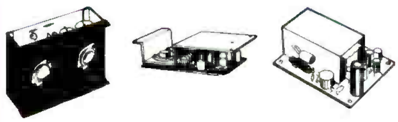

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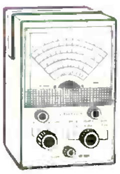

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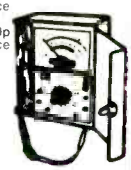

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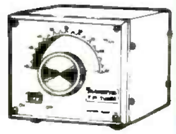

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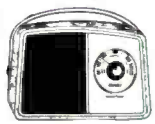

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