

Vol 20 No 2

THE Radio Constructor

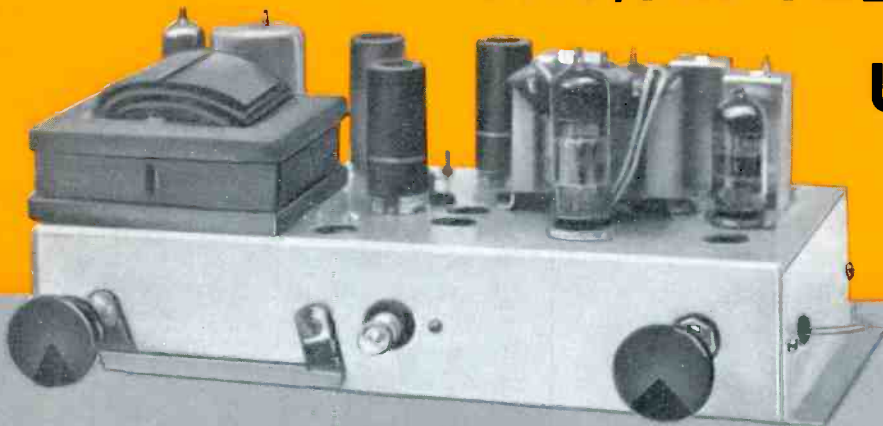
SEPTEMBER 1966

2/6

A DATA PUBLICATION

RADIO · TELEVISION
ELECTRONICS · AUDIO

VHF/FM FEEDER UNIT



6BW6 Power
Amplifier ★

12V Adding
Machine ★

Radio Control
Receiver ★

Pocket Voltage
Indicator

Scottish Insurance Corporation Ltd

38 EASTCHEAP · LONDON · EC3



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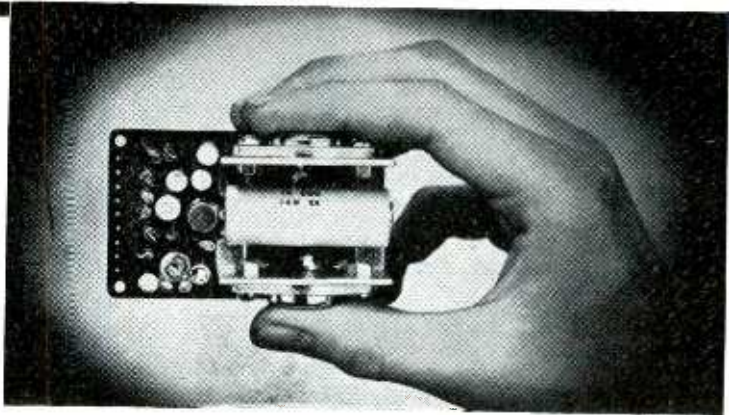
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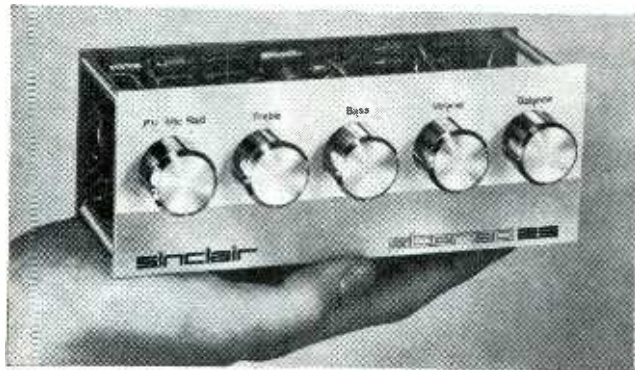
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**3+3W
STEREO
AMP.
S-33H**



**10W
POWER
AMP.
MA-12**



**GARRARD
PLAYER
AT-60**



**20+20W
STEREO
AMP.
AA-22U**

10W POWER AMPLIFIER. Model MA-12. 10W output, wide freq. range, low distortion. For use with control unit. Kit **£12.18.0** Assembled **£16.18.0**

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OS-2



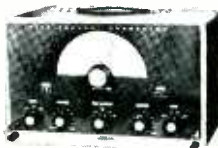
IM-13U



V-7A



RF-1U



IG-82U

Prices and specifications subject to change without notice

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Designed to match the AA-22U Amplifier. Available in separate units comprising Models TFMT-1 RF Tuning Unit **£5.16.0** incl. P.T. and TFA-1M (Mono) IF Amplifier, power supply, etc. **£15.3.0** kit or TFA-1S (Stereo) IF Amplifier, etc. **£19.2.0** kit. **TFM-1** 14 transistor circuit. Pre-assembled and aligned "front-end". 4 stage IF Amplifier. AFC. Printed circuit construction. Walnut veneered, finished cabinet available as optional extra. Can be built for:

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UXR-2



UXR-1



UJR-1

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**AM/FM
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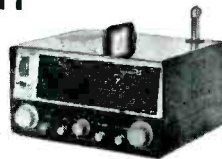
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GC-1U



RG-1



HM-11U

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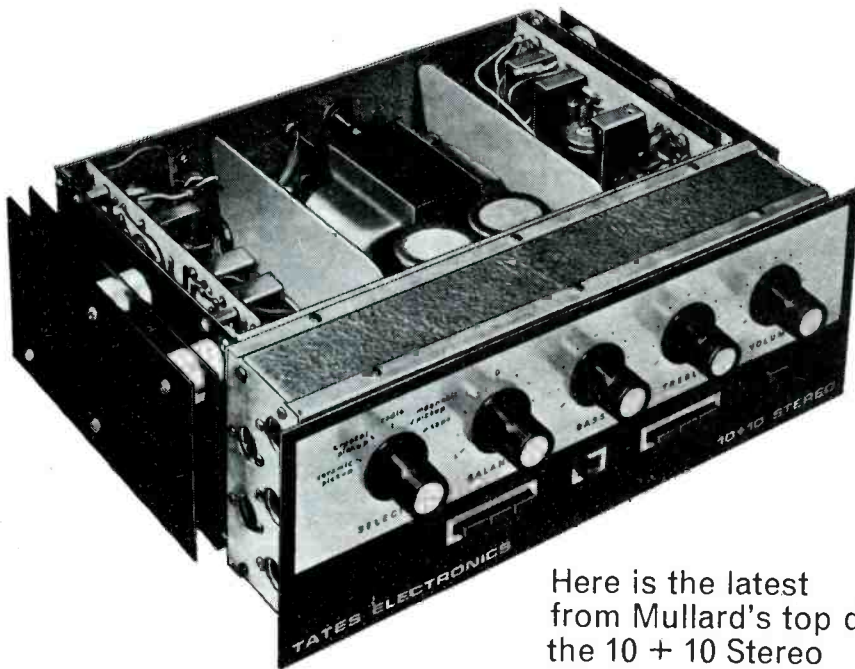
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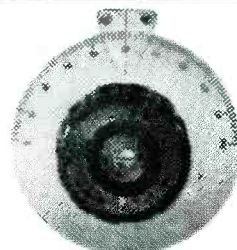
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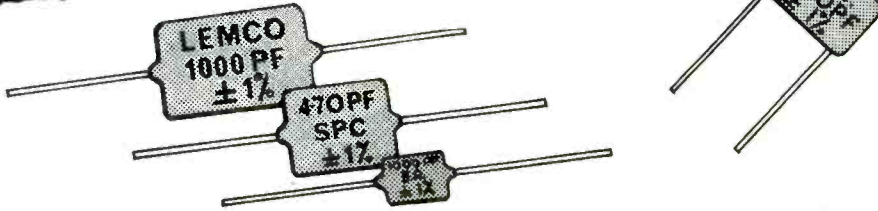
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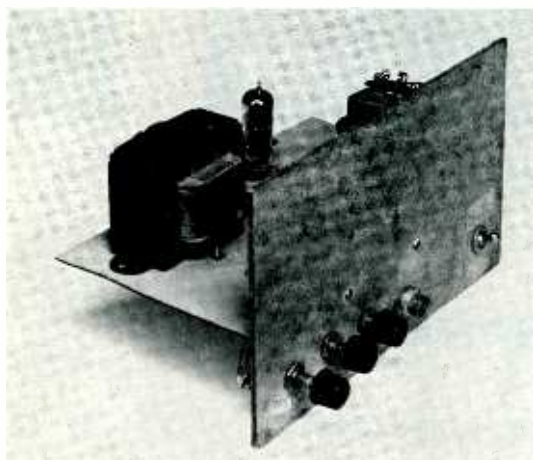
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1947

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6BW6 POWER AMPLIFIER

by Wilfred Smith

This simple amplifier incorporates a comprehensive tone control and provides an output that is more than adequate for normal domestic listening.

THE AMPLIFIER TO BE DESCRIBED EMPLOYS A 3 valve circuit, has bass and treble tone controls, and is capable of feeding some 2 to 3 watts of audio power to a 3Ω speaker. Negative feedback is used to improve the frequency response and to bring the amplifier into the good quality category. The three valves include the h.t. rectifier, and all remaining parts are kept to a minimum. When complete, the amplifier measures about 9in long, 5½in deep and 5½in high.

The familiar aluminium chassis is not employed, here, the bus-bar type of earth connection being used instead to obviate hum loops.

The Circuit

The input is applied directly to the grid of V_{1(a)} via a length of screened cable from the input socket. See Fig. 1. Screened cable is imperative here because of the close proximity of the mains transformer and the heater wiring. After amplification the

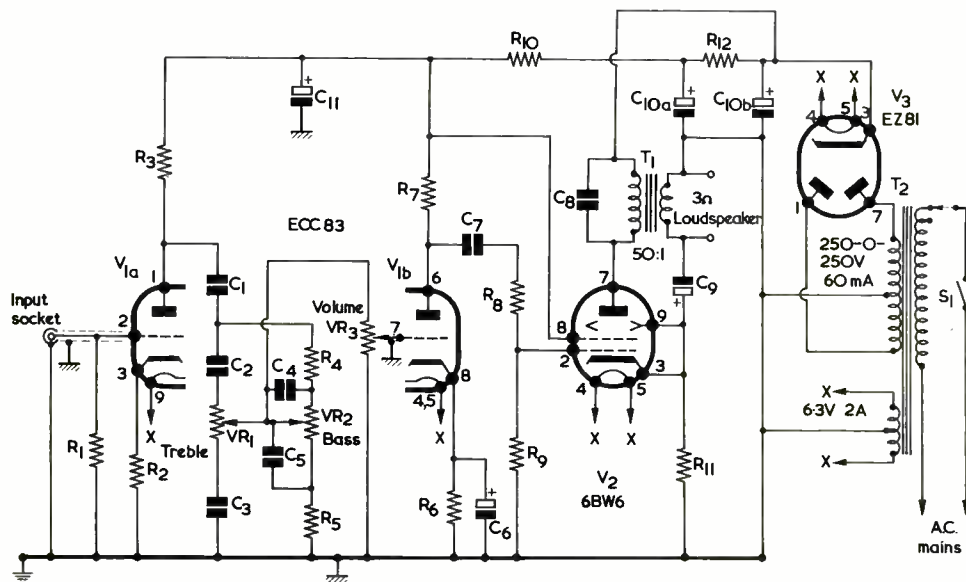


Fig. 1. The circuit of the 6BW6 Power Amplifier

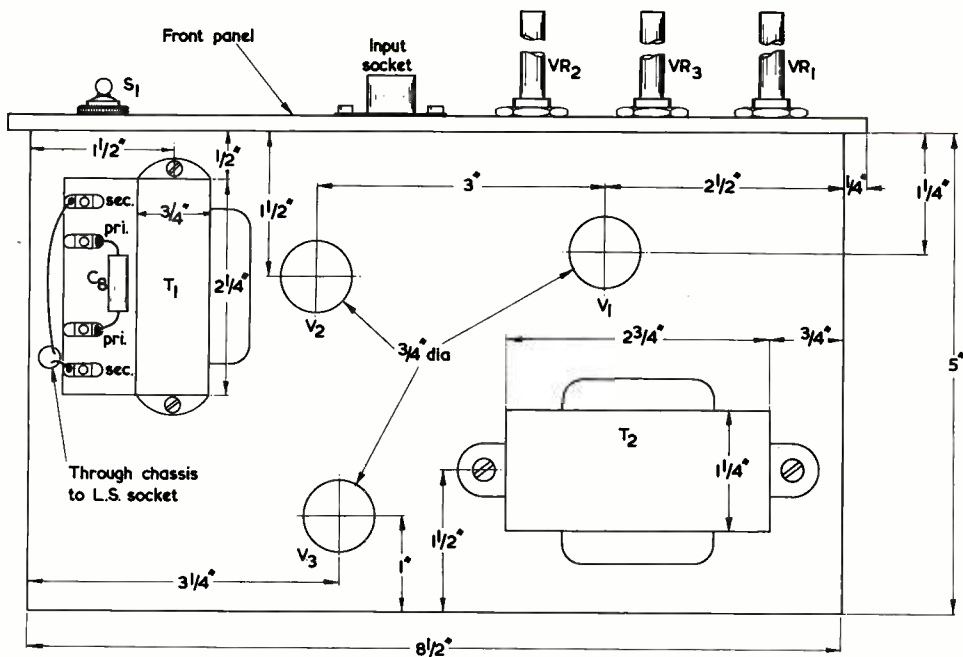


Fig. 2. Illustrating chassis dimensions, and the manner in which transformers T_1 and T_2 are mounted

Components List

Resistors

(All fixed values $\frac{1}{2}$ watt 10% unless otherwise stated)

R ₁	1M Ω
R ₂	2.4k Ω
R ₃	220k Ω
R ₄	1.5M Ω
R ₅	150k Ω
R ₆	2.7k Ω
R ₇	220k Ω
R ₈	10k Ω
R ₉	560k Ω
R ₁₀	4.7k Ω
R ₁₁	270 Ω
R ₁₂	4.7k Ω
VR ₁	1M Ω Lin. Potentiometer
VR ₂	1M Ω Lin. Potentiometer
VR ₃	1M Ω Log. Potentiometer

Capacitors

C ₁	0.01 μ F paper
C ₂	50pF silver mica
C ₃	500pF silver mica
C ₄	330pF silver mica
C ₅	0.003 μ F paper
C ₆	25 μ F electrolytic 6V wkg.
C ₇	0.01 μ F paper
C ₈	0.01 μ F paper
C ₉	25 μ F electrolytic 25V wkg.

C ₁₀	32+32 μ F electrolytic 350V wkg.
C ₁₁	8 μ F electrolytic 350V wkg.

Valves

V ₁	ECC83
V ₂	6BW6
V ₃	EZ81

Transformers

T ₁	Output transformer. Ratio 50:1, with tags.
T ₂	Mains transformer; Standard primary; Secondaries 250-0-250V at 60mA and 6.3V centre tapped at 2A. (R.S.C. Ltd. 54 Wellington Street, Leeds 1.)

Switch

S ₁	s.p.s.t., on-off switch
----------------	-------------------------

Sockets

Input coaxial socket
3-way output socket
3 B9G valveholders with centre spigots

Miscellaneous

3 control knobs
Clip for C₁₀
Paxolin for chassis, etc.

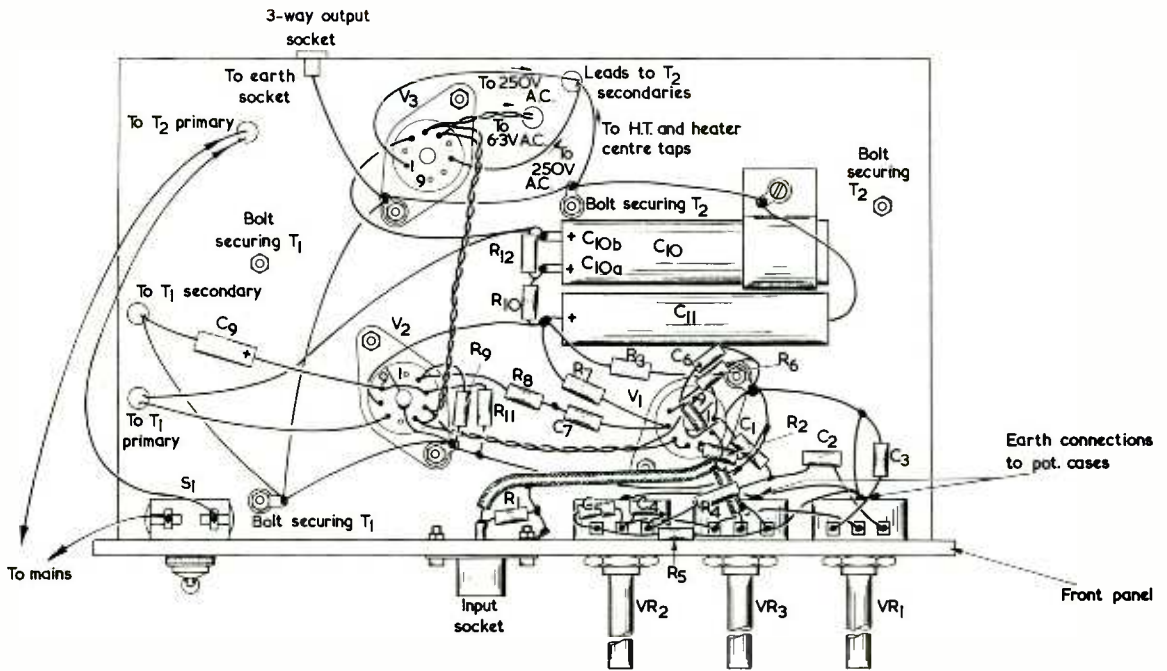


Fig. 3. Details of under-chassis wiring. The wire connecting the earth points together should be bare tinned copper of about 16 s.w.g.

signal is passed, via isolating capacitor C_1 , to the tone control circuit, R_3 being the anode load for $V_{1(a)}$. In the tone control circuit, VR_1 and VR_2 are the treble and bass controls respectively. The output from the tone control network is taken from the junction of the sliders of VR_1 and VR_2 to the track of the volume control VR_3 , the slider of which then connects to the grid of $V_{1(b)}$. Again, screened cable must be used for this connection. Resistor R_6 provides cathode bias for $V_{1(b)}$ and it is bypassed by C_6 . R_7 provides the anode load for $V_{1(b)}$, the output of which is taken via C_7 and grid-stopper R_8 to V_2 , the output stage.

The anode load of V_2 is the primary of the output transformer T_1 , this matching into a 3Ω speaker. Negative feedback is provided by C_9 .

The power supply stage is conventional, employing a double-wound mains transformer to obviate the use of a live chassis with its attendant shock risk.

Construction

The components are fitted on a stout Paxolin board, this being secured to a hardboard front panel and a hardboard rear panel by means of metal angle brackets. Assuming that the mains transformer and output transformer have the same, or closely similar dimensions to those used by the author, the Paxolin board dimensions should be $5 \times 8\frac{1}{2}$ in, as shown in Fig. 2. If larger transformers are employed, the board dimensions will have to be modified accordingly. As is illustrated in Fig. 2, the lamination clamp of T_1 measures $\frac{3}{4} \times 2\frac{1}{4}$ in, whilst that of T_2 measures $1\frac{1}{4} \times 2\frac{3}{4}$ in. The heights of these components are $1\frac{1}{2}$ in for T_1 and $2\frac{1}{2}$ in for T_2 . The transformers are positioned as in Fig. 2, mounting holes being marked out from the components themselves.

The three valveholder holes have next to be cut out, these taking up the positions shown in Fig. 2. When the valveholders are fitted they will take up the orientation shown in the under-chassis wiring diagram of Fig. 3, and so their mounting holes should be drilled accordingly.

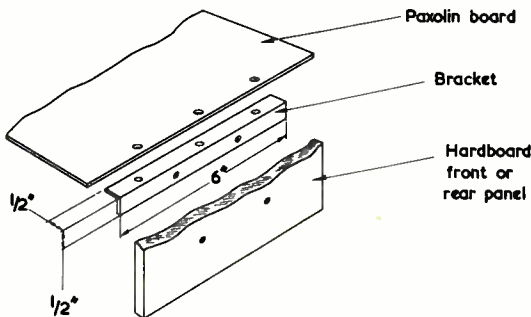


Fig. 4. How the Paxolin board is secured to the front and rear panels. Bracket material may be dural, aluminium or mild steel

A further hole is required in the Paxolin board for the bolt securing the mounting clip for C₁₀. The position of this hole is not critical and it is only necessary to ensure that it enables C₁₀ to take up the position shown in Fig. 3.

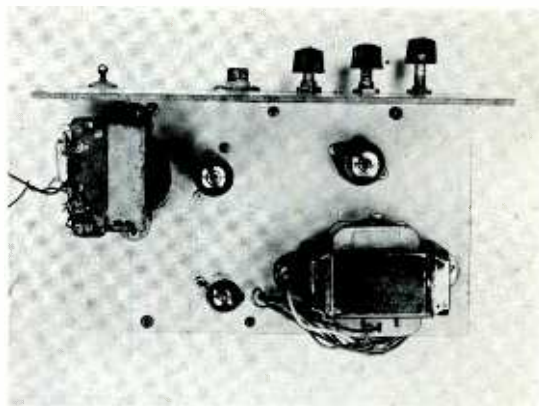
Also required are two holes to allow the passage of leads to T₁, and another three holes to allow the passage of leads to T₂. The positions of these holes may, again, be judged from Fig. 3.

It is next necessary to make the front and rear panels. These each measure 5½×9in and the Paxolin board is secured to them by means of angle brackets made of dural, aluminium or thin mild steel, as illustrated in Fig. 4. On the front panel are mounted the on/off switch S₁, the coaxial input socket and the three potentiometers. These take up the positions illustrated in Fig. 5. Fig. 5 also shows that the underside of the Paxolin board is 2¼in above the lower edge of the front panel.

The rear panel is shown in Fig. 6, and it will be seen that this mounts a 3-way socket providing connections for the speaker and for earth. The rear panel also has ventilation holes and these may be made in the manner illustrated, or in any other convenient form.

The Paxolin board and front and rear panels should first be bolted together. The method of assembly employed for these parts makes the provision of a suitable cabinet at a later date a relatively simple matter.

The components may next be fitted and wired up, following the wiring diagram of Fig. 3. Con-



Top view, showing the valves and transformers

nections to T₁, above the chassis, are illustrated in Fig. 2. Some output transformers will not have the same tag layout as that shown, and care should be taken to ensure that correct connections are made. At this stage, the negative lead of C₉ is not connected to T₁ secondary. Also, the earth connection to T₁ secondary is made in temporary fashion only, as it requires changing during the testing procedure. Either secondary tag may be used for the temporary earth connection.

The connections to the mains transformer primary depend upon the local mains voltage. The primary leads corresponding to this voltage

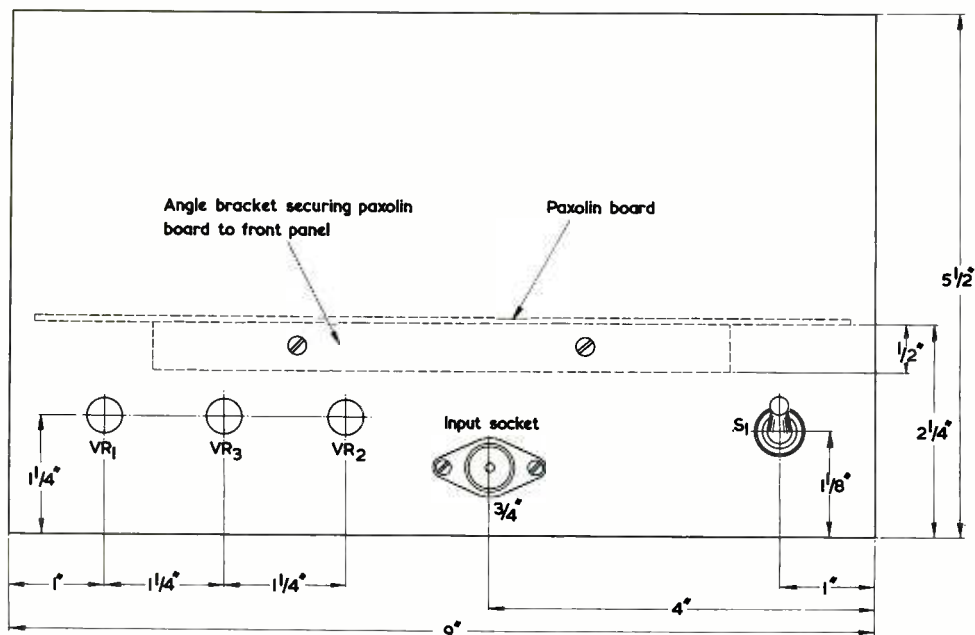


Fig. 5. The dimensions of the front panel

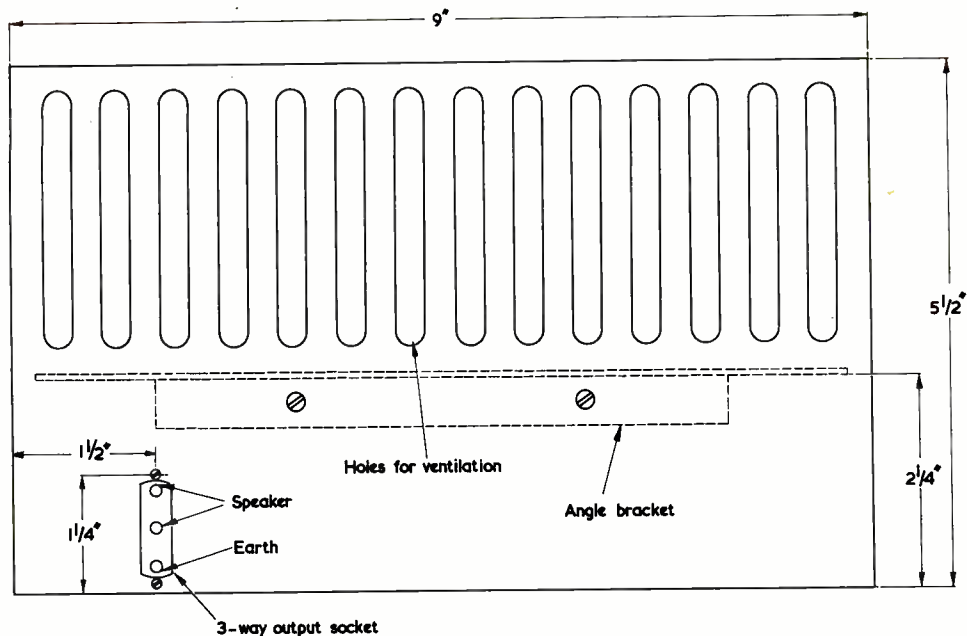


Fig. 6. The rear panel. An alternative style may be employed for the ventilation holes, if desired

are connected to the mains circuit, the unused lead (or leads) being carefully taped up so that there is no risk of accidental contact to any component or terminal.

Operation

After wiring is completed, carefully check all connections for errors and dry joints. Next, connect an ohmmeter between the earth bus-bar and the junction of R_{10} , R_{12} and $C_{10(a)}$. A very high resistance should be present after the electrolytic capacitors have charged up. Should there be a low resistance, recheck all the wiring. If all is well, connect a loudspeaker to the output socket, apply the mains and switch on. After about 20 seconds a slight hiss should be heard from the speaker, and all valve heaters should be alight.

Next, connect a suitable signal source such as a crystal pick-up or a radio tuner to the input socket, check that this is reproduced over the loudspeaker and that the three potentiometers are functioning correctly.

At this stage, maintain a watch on the under-

side of the chassis to ensure that there is no overheating in any of the components. All components should run satisfactorily within their ratings. With the prototype, it was found that T_2 became only slightly warm after several hours of continual use.

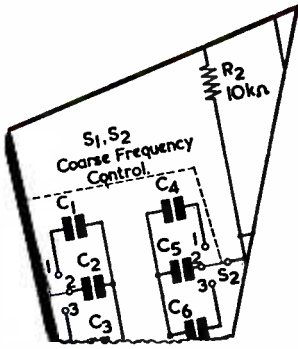
The final step consists of connecting the negative lead-out wire of C_9 . Connect this to the secondary tag of T_1 which does not have the earth connection, and observe results whilst reproducing a signal. Then, reverse the C_9 and earth connections to T_1 secondary and check again. Whichever method of connection offers lower volume level is the correct one for negative feedback, and C_9 and the earth lead should then be soldered permanently into circuit.

It will be found that the amplifier offers adequate gain and output with good quality. One precaution which needs to be observed is that it should not be operated unless a loudspeaker is connected to the output terminals. If the loudspeaker is not connected, high a.f. voltages may appear across the primary of T_1 and there may be a risk of damage in consequence.

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FLASHING FUSE FAILURE INDICATOR

SUGGESTED CIRCUIT No. 190

By G. A. FRENCH

IT IS CUSTOMARY TO EMPLOY ONE or more fuses in the power supply circuits of electronic equipment. Quite often, however, such fuses can blow without the user of the equipment being immediately made aware of the fact. This point is especially true with equipment having, say, a number of fused h.t. supply lines, since the blowing of a fuse in one of these lines may put a small section only of the equipment out of use and will not affect the remainder. The failure of the fuse might not then be immediately apparent, and time may be wasted before its condition is later realised.

This state of affairs can be eradicated by circuits which give *positive* indication of fuse failure, and two suitable methods are described in this article. The first method is not new or original, but it is included because of its general interest and because it provides a useful introduction to the method which follows. The latter has been specially devised by the author for this article in the "Suggested Circuit" series.

Positive Failure Indication

Fig. 1 (a) illustrates a typical power supply circuit in which a source of h.t. potential is applied to a load (i.e. one or more stages in a piece of electronic equipment) by way of a fuse. The presence of h.t. is shown by a neon bulb which is connected, via its series resistor, to the h.t. line after the fuse. If h.t. is present the neon bulb glows. If, then, the fuse blows, the neon bulb extinguishes.

The author feels that the extinguishing of the neon bulb provides only a *negative* indication of fuse failure. The attention of the equipment user is less liable to be caught

by the extinguishing of a neon bulb than it would be if the failure caused a second bulb to glow. A circuit capable of providing this added facility is shown in Fig. 1 (b). If, in this diagram, the fuse blows, the voltage across indicator NE₁ drops to zero and it becomes extinguished. At the same time the supply voltage is now applied, via the load, to NE₂, which commences to glow. A positive indication of fuse failure has therefore been achieved since a second bulb now becomes illuminated. If the two neon bulbs are mounted behind "lenses" of different colours the change in operating conditions is at once obvious. Where a number of fuses, each provided with the circuit of Fig. 1 (b) are employed, an alternative scheme to using

differently coloured "lenses" consists of mounting all the neon bulbs which carry out the function of NE₁ in one row, and all those which carry out the function of NE₂ in a second row. Fig. 2 (a) shows the bulbs fitted in this manner to a front panel. The transference of illumination in one circuit from the first row to the second then offers a striking indication of fuse failure, as may be seen from Fig. 2 (b).

In cases where it is desired to be advised *only* of the blowing of a fuse, the NE₂ circuit can be employed on its own in each fuse, as is shown in Fig. 3 (a). The failure of any fuse is then at once indicated by the illumination of a neon bulb which normally remains extinguished.

The circuits of Fig. 1 (b) and Fig.

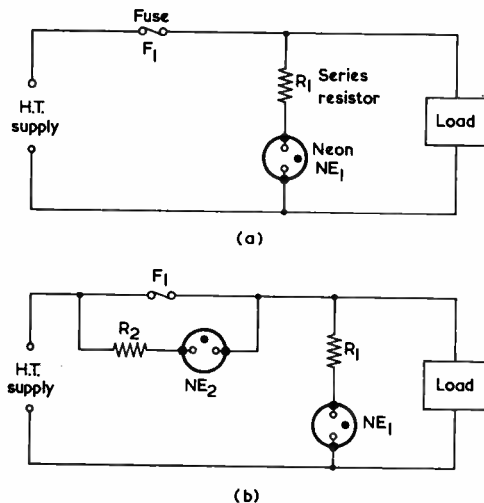


Fig. 1 (a). A conventional fuse and neon bulb indicator circuit. The neon bulb extinguishes if the fuse blows
(b). In this circuit, neon NE₂ glows when the fuse blows

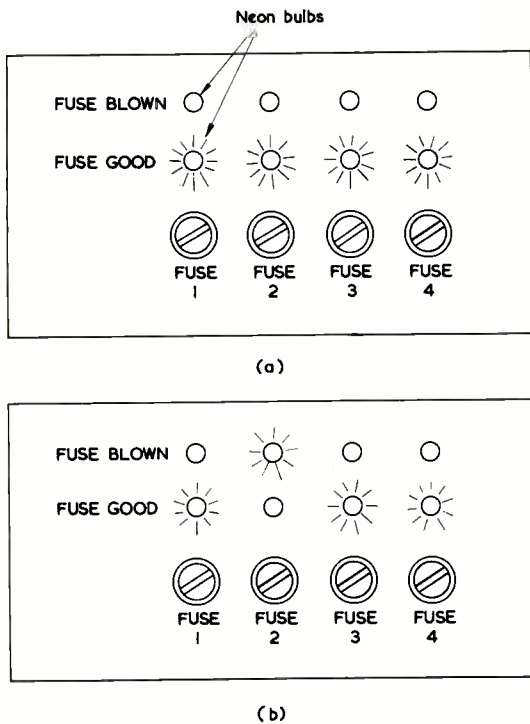


Fig. 2(a). A panel layout in which bulbs in the NE_1 circuit position (see Fig. 1(b)) are in the "Fuse Good" row, whilst bulbs in the NE_2 position are in the "Fuse Blown" row
 (b). The fact that Fuse No. 2 has blown is readily apparent here

3 (a) are suitable for supply voltages between some 100 and 500 volts, the neon series resistors being given values applicable to the voltage. Although operation has just been described in terms of direct voltage, the circuits will function equally well with an alternating voltage supply. An important point is to ensure that the effective resistance offered by the load is sufficiently low when the fuse has blown to enable a neon bulb in the NE_2 position to become illuminated with adequate brilliance. If, for instance, the fuse were in an h.t. supply line and the load consisted of a single valve stage with no resistive potentiometers across the supply rails for screen-grid supplies and the like, the effective resistance offered after fuse failure (due, say, to an intermittent fault) could be comparatively high. In such instances, it may be helpful to add an additional resistor across the load, as shown in Fig. 3 (b), to reduce the effective resistance in series with NE_2 . This resistor will usually need a value which causes it to pass about 1mA when the fuse is intact,

and so the extra loading it causes is negligible. However, neon bulb energising currents are relatively so low that it should be found, in practice, that the addition of such a resistor is rarely required.

Flashing Indicator

The method of fuse failure indication illustrated in Figs. 1 (b) and 3 (a) is simple and reliable, but the writer decided to investigate a more sophisticated method using a single neon bulb to cover both the fuse-intact and fuse-blown conditions. It was intended that the neon bulb would be steadily illuminated whilst the fuse was intact, but would flash on and off continually when the fuse blew. A flashing light would, of course, be much more capable of catching the attention of the user than would the steady illumination of neon NE_2 offered by the method just discussed.

A neon bulb may be made to flash on and off continually by connecting it in the circuit of Fig. 4, in which a capacitor is connected across the bulb, a resistor of fairly high value is connected in series, and a direct supply voltage is applied. With correct component values the circuit then functions as a relaxation oscillator in the following manner. On application of the supply voltage the capacitor commences to charge via the series resistor until the voltage across its plates reaches the striking voltage of the neon bulb. This then ignites, drawing current from the capacitor until the voltage across its plates falls below the

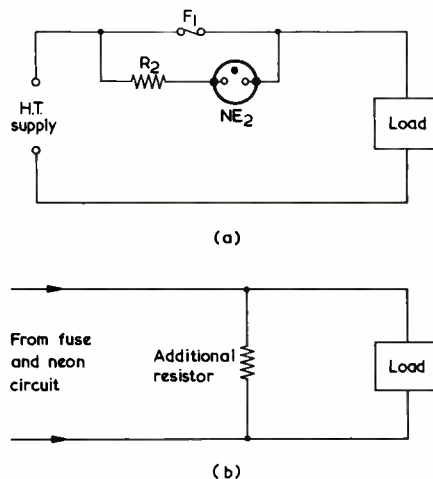


Fig. 3(a). If visual indication of fuse failure only is required, the NE_2 circuit may be used on its own
 (b). In cases where the load can offer a very high effective resistance after fuse failure an additional resistor may be connected across it.

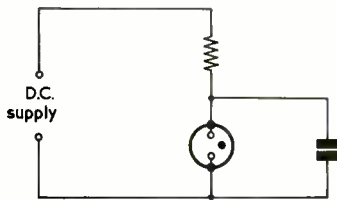


Fig. 4. When the requisite component values are employed, this circuit enables a neon bulb to operate as a relaxation oscillator

burning voltage. The neon bulb then extinguishes and the capacitor commences to recharge until the voltage across its plates once more reaches the striking voltage. Again the neon bulb ignites, and another cycle commences. The only further comment that need be made here about the operation of this circuit is that the value needed in the series resistor for relaxation oscillation to occur is normally much larger than that recommended for optimum brilliance in the bulb.

A number of possible circuit configurations capable of changing a neon bulb from steady illumination to the flashing mode on fuse failure were checked by the author, these leading up to the final circuit which is shown in Fig. 5 (a). In this diagram a d.c. supply of 200 to 250 volts is applied to fuse F_1 , and, thence, to the load. When the fuse is intact current flows to the neon bulb via R_1 and R_2 , diode D_1 passing current in the forward direction. Diode D_1 inserts negligible resistance and the neon bulb is steadily illuminated at good brilliance level since R_2 offers a low series resistance. When the fuse blows the upper supply rail to the load falls to the same potential as the lower supply rail, whereupon diode D_1 becomes reverse-biased. The neon bulb is now supplied via the relatively high value resistor R_1 , and the component values become such that the neon bulb flashes at a regular frequency, thereby indicating that the fuse has blown.

The neon bulb specified in the circuit is the Hivac 16L (available from Henry's Radio Ltd.). This is a small wire-ended type, and was employed in the prototype circuit. The particular bulb used by the writer had a striking voltage of 76 and a burning voltage of 60. At voltages of 200 to 250 the specified series resistance for the 16L is 220k Ω , and R_1 and R_2 in parallel approximate to this value. Thus,

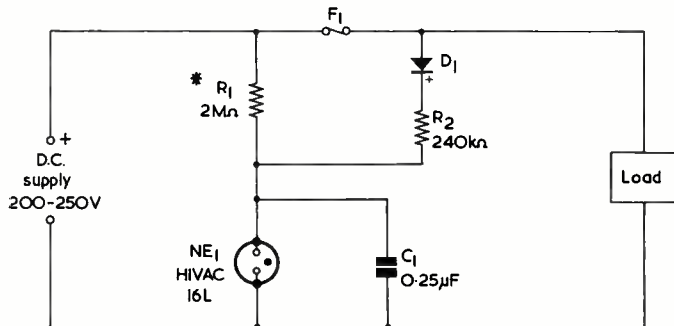
when the fuse is intact the neon bulb runs at correct brilliance level. When the fuse blows, the flashes given by the bulb are similarly at good brilliance level due to the initial discharge current from C_1 . The frequency of flashing may vary with different neon bulbs and different values (within its tolerance) in C_1 , whereupon it may be necessary to slightly adjust R_1 to obtain the flashing speed required. The value of 2M Ω shown in the diagram gave a flash rate of approximately 2 per second with the prototype circuit, the range of values in R_1 over which flashing occurred being from about 1.5 to 2.5M Ω . Diode D_1 should be a silicon rectifier having a peak inverse voltage higher than the applied direct voltage. An OA210 (p.i.v.=400 volts) would be more than adequate here.

The two resistors R_1 and R_2 can be $\frac{1}{4}$ watt 10% components. C_1 may be a paper or plastic-foil

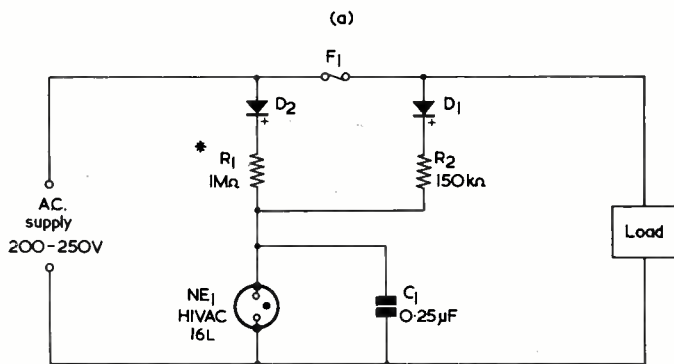
component having a working voltage greater than the striking voltage of the neon bulb.

It should be possible to employ neon bulbs other than the 16L in the circuit of Fig. 5 (a), but it will probably be necessary to find alternative values for R_1 and R_2 and, perhaps, C_1 . Different supply voltages may also be catered for, provided that these are greater than some 20 volts above the striking voltage of the neon bulb. Obviously, the values of R_1 and R_2 will then have to be changed accordingly. Also, the p.i.v. requirement in D_1 may alter. A useful feature of the circuit is that its operation is independent of the effective resistance offered by the load after the fuse has blown. The neon bulb will flash reliably, irrespective of whether the load presents an open-circuit or a short-circuit.

By the addition of a second diode the circuit may be made to operate



* Adjust for required flashing speed



* Adjust for required flashing speed (b)

Fig. 5(a). With this circuit a single neon bulb is steadily illuminated when the fuse is intact and flashes at a regular rate when the fuse blows (b). The same circuit principle may be used for fuses in a.c. mains circuits, but it is necessary to add a second rectifier

with a fuse in a 200 to 250 volt a.c. mains supply circuit. The appropriate circuit is shown in Fig. 5 (b), in which the additional diode is D₂. Operation is the same as for Fig. 5 (a) except that current in the R₁ and R₂ circuits only flows during the half-cycles where the upper supply terminal is positive.

In consequence, the values of R₁ and R₂ are proportionately reduced. As with Fig. 5 (a) it may be necessary to adjust the value of R₁ to obtain the desired flashing rate in the neon bulb. Both diodes are silicon rectifiers. Since C₁ can become charged to the striking voltage of the neon bulb, the diodes should

have a peak inverse voltage rating equal to the peak voltage of the applied a.c. plus this striking voltage.

A minimum p.i.v. figure offering a small safety margin would be 450. In the prototype circuit the author employed two silicon rectifiers type BY100 in the D₁ and D₂ positions.

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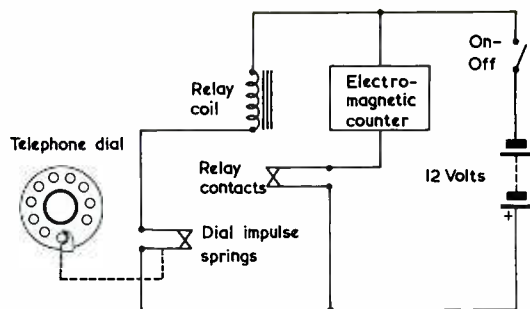
NAME

ADDRESS



Adding Machine for 12-Volt Operation

by **P. D. Somerville**



The circuit of the simple adding machine

This simple adding machine employs a telephone dial and runs from a 12-volt car battery. It is assumed that the reader is familiar with simple relay and electro-magnetic counter operation.

SOME TIME AGO A FRIEND REQUESTED THE WRITER to make an electronic adding machine capable of working from a 12-volt car battery. This was to be used for motor car rallies, so that the number of miles to be covered could be totalised.

The writer used an ex-G.P.O. telephone dial, a 12-volt relay and an electro-magnetic counter.

The electro-magnetic counter had to be rewound as it was of the 48 volt variety. This process consisted of stripping off the existing winding and rewinding the former with the contents of a 4 oz. reel of 22 s.w.g. enamelled copper wire. It is possible, however, to obtain 12-volt counters. If one of these is used there is, of course, no necessity for rewinding.

Relay Operation

The relay has to be capable of operating with 12 volts. Practically any relay will do provided it is sufficiently quick-acting and that the contacts will carry the current needed to operate the electro-magnetic counter. The relay requires one break contact set only.

The telephone dial impulse springs may be readily identified by operating the dial. These remain closed until the dial is released after selecting a number, whereupon they open the same number of times as the number selected. Thus, on selecting number 5 and releasing the dial, the impulse springs

open 5 times then revert to their normally closed condition. It is because the impulse springs indicate the number dialled by opening, instead of closing, that it is necessary to interpose a relay between them and the counter. Another reason for including the relay is that the counter current, at 12 volts, may be too heavy for the impulse springs.

The circuit of the adding machine appears in the accompanying diagram. When the on-off switch is closed, the relay operates by way of the dial impulse springs. There is also a momentary current through the coil of the counter before the relay contacts break, but the counter is too slow in operation to indicate a number.

On dialling a number the impulse springs open the appropriate number of times, the relay de-energises a similar number of times, and the counter indicates the number selected. When successive numbers are dialled the counter totalises them. Thus: $2+4+8=14$.

When numbers greater than 10 are desired, the 0 on the dial has to be selected for the number of tens; e.g. 34 is three 0's and a 4.

One can also multiply using the adding process. Thus: 3×4 is 3 dialled 4 times. Division and subtracting are beyond the scope of this instrument.

The best type of counter is the resettable type, but the others can sometimes be modified to reset.

Editor's Note

Counters, relays and dials may be obtained from a number of suppliers, including Henry's Radio, Ltd.; L. Wilkinson (Croydon) Ltd., Longley House, Longley Rd., Croydon, Surrey; Samson's (Electronics) Ltd., 9 and 10 Chapel St., London, N.W.1.; and Service Trading Company, 47-49 High Street, Kingston-on-Thames.

It may be found necessary to slow the dial slightly (or to speed counter operation) if dial impulse spring circuit interruptions are too fast for the counter to follow. Information on the adjustments which can be made here was given in "In Your Workshop" in the June 1963 issue.

NEWS . . . AND .



Beta-ray backscatter apparatus being used by ultra Electronics (Components) Limited to measure the thickness of precious metal plating in production processes

UP-TO-DATE!

A Beta-ray backscatter apparatus to measure non-destructively, on a production basis, the thickness of precious metal plating is being used by Ultra Electronics (Components) Limited.

Long and careful investigation has shown the apparatus to be capable of extremely rapid and highly accurate thickness measurement. By using this technique rather than the micro-sectioning method, many more components can be checked in a much shorter time to a much higher degree of accuracy.

The component is placed on an aluminium plate above a radioactive source. Beta-rays are then emitted, and pass through a slot in the aluminium plate, through the electro-deposited coating, and, on striking the base material, are reflected back into a detector. From this, the thickness of the plating is read off from a direct reading meter. Calibrations are carried out by taking readings on known standards.

REGULAR STEREO TRANSMISSIONS AT LAST

These notes are being written just before the commencement of the BBC stereo transmissions therefore most readers with the necessary equipment will have already sampled these broadcasts.

The beginning of these transmissions is greatly to be welcomed and will delight those who have been actively campaigning for them for so long.

One of our advertisers, Daystrom Ltd., have shown their usual energy and resource by anticipating the BBC decision. They have designed a new British Transistorised FM Stereo Decoder. The decoder will be available in November and is suitable for use with Heathkit Tuners, models FM-4U and AFM-1, and, because it is self-powered, it may also be used with most other makes of FM Tuner.

The kit will be priced at £8 10s. 0d. and will also be available already assembled for £12 5s. 0d. Further information may be obtained direct from Daystrom Ltd., Gloucester.

The transmissions will be on the pilot-tone system which has been extensively tested in the Music Programme and the system is a fully compatible one.

The stereo transmissions will be available at first only to listeners within the service area of the Third Network VHF transmitters at Wrotham and Dover (South-East England) but it is planned to extend them to the Sutton Coldfield VHF transmitter (Midlands) in approximately twelve months and to the Holme Moss VHF transmitter (North of England) in approximately fifteen months.

Further extensions of the service, both in relation

to coverage and to the number and character of the stereo programmes transmitted, will be considered in the light of public reaction and of the economic resources available.

WORKED ALL ZONES AWARD

One of our readers, Mr. Allan Herridge, G3IDG, has recently been investigating the origins of the Worked All Zones (WAZ) Award and he has kindly written to us as follows:

"I have discovered that the WAZ idea did not originate with Radio Magazines Inc. of N.Y., and not even in the year 1938.

It was, in fact, first suggested in R/9 magazine dated November, 1934. The same break-down of the world into 40 Zones applied then and, apart from some call-area changes (the introduction of VE6, 7 & 8 and WØ, and the re-allocating of some American States after the war), the whole thing appears to be as it exists today.

The idea does not seem to have caught on at that time, though, and neither did it when *Radio* magazine tried it again in their February, 1936 issue. In fact, it was not until it was once again suggested by them in the January, 1937 issue, that WAZ finally found favour. From then, until it was decided to suspend it for the duration in February, 1941, *Radio* ran a WAZ Honor Roll, and it is interesting to note that in the four years of its pre-war existence only three amateurs (ON4AU, and the late G2ZQ & J5CC) managed to work All Zones.

After the war *CQ* magazine, as successor to *Radio*, announced the resumption of WAZ in their January, 1947 issue, and the latest figures (*CQ*, June 1966) show 2892 WAZ Certificates issued in just over 19 years."

COMMENT

THE JBL MINUET

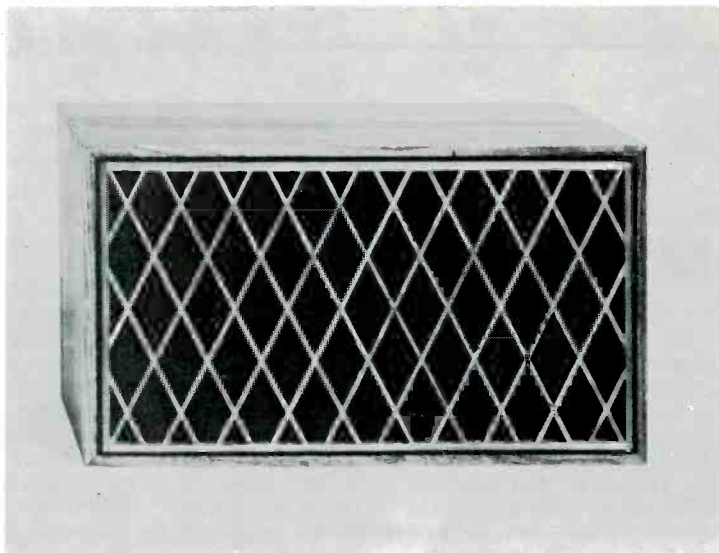
It is always of interest to learn of developments in aspects of our hobby which have emanated from the U.S.A.

There has recently been introduced the James B. Lansing "Minuet", a remarkably small enclosure for the quality and volume of sound which it offers.

JBL's smallest system uses the LE8T passive radiator for bass performance which is truly exciting for an enclosure of such limited dimensions (it is only $16\frac{1}{2} \times 9 \times 8$ in).

The LE8T is a full-range loudspeaker which achieves smooth, extended response probably never before realized in a unit only 20cm in diameter. The LE8T delivers full bass by employing a cone especially mounted to permit very long linear travel. The mid-range and highs are transparently pure. Pure silver impedance controlling ring extends treble range. The performance of the LE8T in an enclosure of this size is excellent.

Details of availability and other information can be obtained from Ad. Auriema Ltd., 125 Gunnersbury Lane, London W.3.



The James B. Lansing "Minuet"

NORTHERN RADIO SOCIETIES ASSOCIATION CONVENTION

The above Association was formed in January 1965 for the purpose of promoting a Convention devoted to Amateur Radio at Belle Vue, Manchester.

This Convention was duly held in October 1965 and was a great success. Accordingly it was decided to hold a second Convention on the 3rd and 4th September 1966, again at Belle Vue, Manchester.

Many aspects of Amateur Radio will be covered. The main feature will be an Exhibition in the Lancaster Hall at Belle Vue. Amateur stands will form a major part of the Exhibition and it is hoped that many Societies will be represented.

Further information may be obtained from the Chairman, I. D. MacArthur, G3NUQ, of 55 Langdale Road, Bramhall, Cheshire, or the Secretary, C. J. Fox, G3HII, of 21 Egerton Road South, Chorltoncum-Hardy, Manchester, 21.

We wish the Convention every success. As we have stated on a previous occasion, we wish it were possible for the annual R.S.G.B. exhibition to move around.

NEW CROWN PORTABLE TAPE RECORDER

The Heddon-Smith Group Ltd., have recently introduced two new Crown portable tape recorders one of which, Model CTR 5450 is shown below. It operates from four U2 batteries or a.c. mains, is twin track, two speed $1\frac{7}{8}$ and $3\frac{3}{4}$ i.p.s. Incorporating 5 transistors it takes up to 5 in spools and has an output of 700mW. Features are fast forward wind facility, record level indicator, tone control, and a safety button device is provided to prevent accidental erasure of tape.

It weighs 7.9lb. and measures $11\frac{1}{4} \times 8\frac{7}{8} \times 4\frac{3}{16}$ in.

Price complete with remote control dynamic microphone and magnetic earphone is 29½ gns.



Measuring Current with a Voltmeter

by John Black

How to find the current consumption and power requirements of mains or d.c. operated equipment with a low-cost testmeter.

MANY CONSTRUCTORS POSSESS MULTI-TEST-meters, but the majority of these, whilst having a.c. voltage ranges, do not have a.c. current ranges.

Despite the lack of a.c. current ranges, these simple meters may still be employed to find the current consumption and power requirements of mains operated equipment, the measurements being made by means of the simple approach described in this article. As is explained later, the technique may also be used for measuring direct currents with the aid of testmeters having voltage ranges only, or whose current ranges are too low for the current to be measured.

Mains Current Measurements

For mains current measurements, the only additional item of "test gear" needed is a 10Ω resistor of 10 watt rating. The method used is shown in the accompanying diagram, in which it may be seen that the 10Ω resistor is in series with one of the mains supply leads to the equipment being checked. The current consumed by the equipment is found by measuring the a.c. voltage dropped across the resistor, and evaluating from

the Ohm's Law equation, $I = \frac{E}{R}$.

If, for instance, it is found that 2.4 volts is dropped across the resistor, then

$$I = \frac{2.4}{10} \\ = 0.24 \text{ amps.}$$

For a mains voltage of 240 this will correspond to a power consumption in the equipment of 0.24×240 , which is approximately equal to 60 watts.

The use of a 10Ω resistor has the advantage of

simplifying the arithmetic. One has only to move the decimal point.

A slight discrepancy in the current measurement is caused by the fact that the voltage applied to the equipment is the mains supply voltage minus the voltage dropped across the resistor. In the example just given, the drop across the resistor was only 2.4 volts, whereupon there should be little alteration in the current consumption of the equipment. Nevertheless, if it is felt that the reduction in voltage might shift the working characteristics of the equipment, a 1Ω resistor should be used in place of the 10Ω component. The current, in amps, is then equal to the volts appearing across the resistor.¹

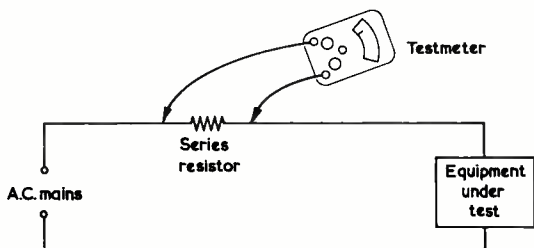
A 10 watt rating for the 10Ω resistor is suggested, this catering for currents up to 1 amp. If it is intended to measure higher currents the wattage rating may be increased or, preferably, the 1Ω resistor may be used.

Care should be taken to avoid shock when measuring mains currents with the aid of the resistor. Where practicable, it should be inserted in the neutral line.

Direct Current Measurements

Direct current measurements may similarly be made by using the resistor in series with the d.c. supply. Normally, these measurements will be at low voltages, whereupon it will be desirable to employ the 1Ω resistor to avoid excessive voltage drop.

For accurate measurements on a.c. or d.c., the series resistor should have a tolerance of 1% and suitable types may be bought, although they may not be generally available through home-constructor retail channels. If necessary, the resistor could be assembled from a number of lower wattage types, having suitable values and tolerances, connected in parallel. Alternatively, suitable resistors may be made up from resistance wire.² 80/20 nickel-chrome wire of 20 s.w.g. has, for instance, a nominal resistance of 1.52Ω per yard, whereupon a resistance of 1Ω is given by approximately 2ft. of this wire.



¹ With equipment employing half-wave h.t. rectifiers and in which a heavy h.t. current flows, as in a television receiver, it would probably be better to use the 1Ω resistor. It should be remembered, also, that accurate readings cannot be obtained with such equipment, since a non-sinusoidal voltage is applied to the testmeter.—Editor.

² A wide range of resistance wires is available from Post Radio Supplies, 33 Bourne Gardens, London, E.4.—Editor.

Understanding By W. G. Morley

Radio

LINKING THEORY WITH PRACTICE

A PRACTICAL PROJECT

GENERAL-PURPOSE POWER SUPPLY UNIT

This is the first of several practical projects which our author will be using to provide the many readers following this series with an opportunity to put into practice the theory they are learning

IN LAST MONTH'S ARTICLE IN THIS SERIES WE CONCLUDED our discussion on the factors which can affect oscillator frequency stability, then carried on to basic oscillator circuits of the type employed in amateur transmitting equipment. We next dealt with the effect known as "squegging" and concluded by seeing how positive feedback, as is employed in an oscillator, may be used to provide regeneration in a grid leak detector circuit, with a consequent improvement in performance.

In this month's article we shall introduce an interesting innovation to this series, this consisting of constructional details for easily assembled practical equipment based on the theoretical matters which have been previously discussed.

Practical Units

We have covered a considerable amount of ground since this series of articles commenced, and it now becomes possible to think in terms of practical assemblies to provide working illustrations of the theoretical points which have been covered in earlier articles. Some considerable thought has been given to this departure, and it was finally decided to develop a number of assemblies which not only showed a typical approach to practical circuit design but which also enabled the reader to make equipment capable of further use apart from that of merely demonstrating points of theory.

It was also decided that the assemblies to be described should involve the very minimum of metal-working. To this end, the assemblies will be built up on chassis made from prefabricated Lektrokit chassis construction parts. Many readers will already be aware of the Lektrokit chassis construction system, in which a number of different chassis plates, provided with holes suitable for the easy mounting of components and valveholders, etc., may be bolted to standard chassis rails. The Lektrokit system is primarily intended for laboratory development work, but it may also be employed for the construction of permanent equipment and it lends itself ideally to our present requirements. The use of a prefabricated chassis system tends to result in some assemblies being larger in overall size than would occur if they were constructed on conventional chassis specifically made for them, but this is a small disadvantage when weighed against the fact that no drilling or chassis bending is required, and that the tedious task of cutting out valveholder holes and the like is avoided.

The immediate programme for future articles in the "Understanding Radio" series consists of the description of a simple mains power unit capable of offering sufficient power for receivers and amplifiers, whose construction will then be covered in later articles. Immediately following the power unit will be a description of the construction of a

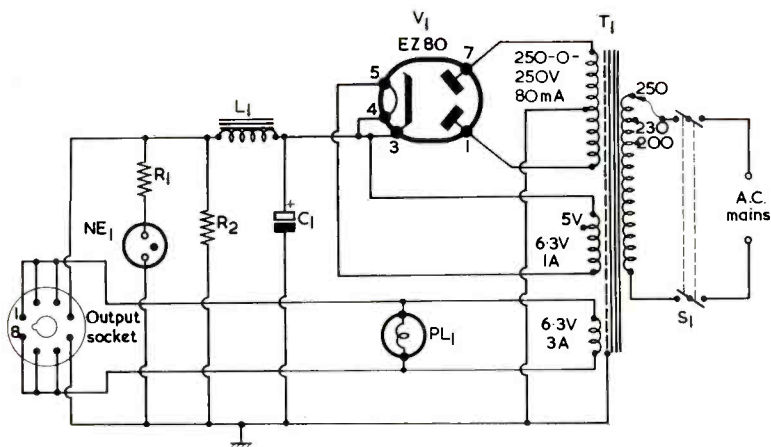


Fig. 1. The circuit of the power supply unit. This will be employed later with practical equipment to demonstrate the theoretical points discussed in previous articles

Components List

Resistors

- R₁ Part of neon bulb assembly, see NE₁
- R₂ 27kΩ 5 watts

Capacitor

- C₁ 32μF 350V Wkg. electrolytic. Cat No. EC44 (Home Radio (Mitcham) Ltd.)

Inductors

- L₁ 10 Henry, 90mA, smoothing choke. "Hygrade" (Radiospares)
- T₁ Mains transformer type MT1AT, Douglas. Secondaries: 250-0-250V at 80mA; 6.3V at 3A; 6.3V at 1A (tap, 5V at 2A). (Henry's Radio Ltd.)

Valve

- V₁ EZ80

Lamps

- NE₁ Signal lamp, List No. D.841-250V, water-clear "lens" (Bulgin)
- PL₁ Pilot lamp, m.e.s., 6.5V 0.15A (Radiospares)

Switch

- S₁ Rotary toggle switch, d.p.s.t., List No. S.256 (Bulgin)

Plug and Sockets

- 1 Octal plug. List No. P.112 (Bulgin)
- 1 B9A valvholder
- 1 International Octal Valvholder
- 1 M.E.S. bulb holder (See Note 2 below)

receiver using triode valves, this also being built up on Lektrokit parts. The articles will then revert to theoretical matters for several months, after which the points learned in these will be applied to further receiver and amplifier designs.

Screws, Nuts

- 33 6BA cheese- or binder-head screws, ¼in.
- 2 6BA cheese- or binder-head screws, 1¼in.
- 35 6BA nuts
- 6 6BA washers

Miscellaneous

- 1 ¼in pointer knob
- 2 6BA solder tags
- 2 4BA solder tags
- 1 ½in grommet
- 2-core flexible mains lead
- Connecting wire, solder, etc.

Lektrokit Chassis Parts

- All Lektrokit parts are available from Home Radio (Mitcham) Ltd. Those marked with an asterisk (*) are available in quantities of 10 or 12.
- 2 Side Plates No. 1. Part No. LK-301
 - 1 Chassis Plate No. 1 Part No. LK-111
 - 1 Chassis Plate No. 2 Part No. LK-121
 - 1 Chassis Plate No. 3. Part No. LK-131
 - 2 Chassis Rails. Part No. LK-201
 - *1 Tagstrip 5-way. Part No. LK-2231
 - *4 Spacers No. 2. ⅜in. Part No. LK-2521
 - *1 Plastic Clip No. 3. Part No. LK-2831 (or suitable alternative for securing mains lead to chassis)
 - *10 Insulators, Lead-Through, No. 1. Part No. LK-2021

Note 1. Radiospares components may be obtained through retailers only.

Note 2. The m.e.s. bulb holder is available at Woolworth's stores, and is discussed in next month's issue.

In this month's article we introduce the power supply unit. With one small exception, all that is required for the construction of this unit are screw-driver, pliers, side-cutters and soldering iron. The exception is given by the necessity to modify two

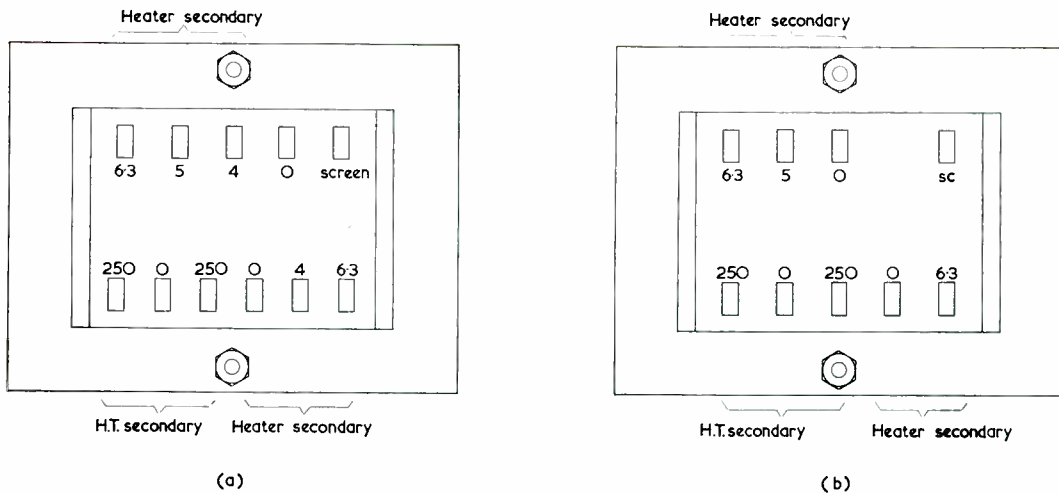


Fig. 2. Earlier versions of the mains transformer specified had 4 volt taps in the heater windings, as in (a). Currently manufactured transformers have the tag identification shown in (b)

of the Lektrokit chassis rails used in the assembly, this being a process that can be carried out with the aid of a small hacksaw and vice. A small hacksaw and vice of the type available in Woolworth's stores at low cost will prove to be quite adequate for this task, which only takes a minute or two to carry out.

The Power Unit

In the design of the power unit which forms the first of our constructional projects a number of factors have been taken into account. It was decided that the power unit should be capable of providing an adequately smoothed h.t. supply of the order of 250 volts with currents up to 65mA.

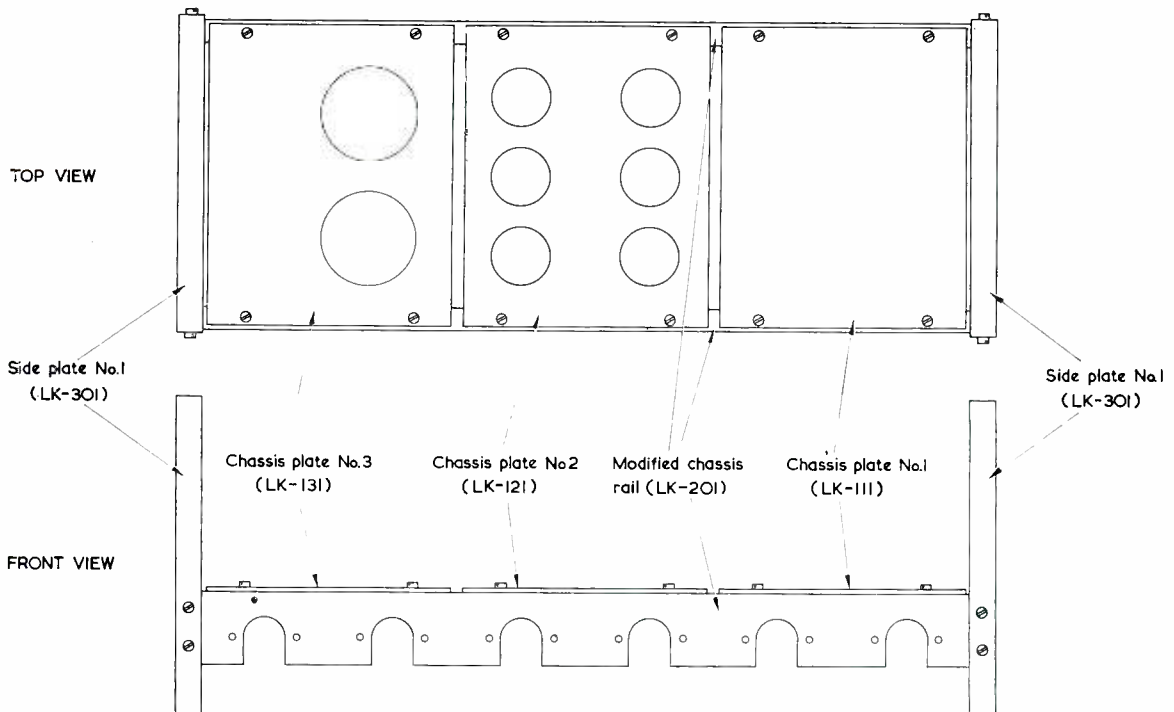
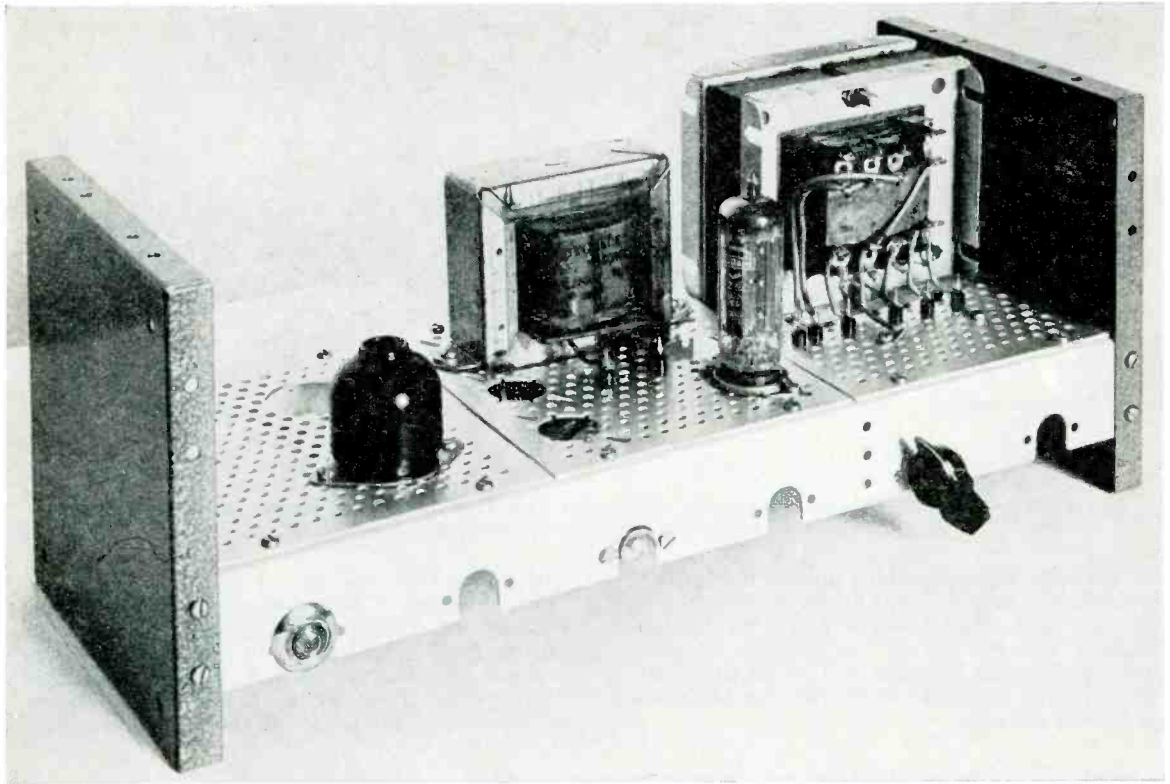


Fig. 3. How the Lektrokit parts are assembled to form the chassis. The two Chassis Rails are modified before assembly



The ease of assembly with Lektrokkit parts is well demonstrated by this view of the completed power unit.

A 6.3 volt heater supply was also required, this offering currents up to some 3 amps. Although the primary purpose of the power unit is to supply subsequent constructional projects in the "Understanding Radio" series of articles, it was intended that it should also be suitable for any other equipment of the same nature which the reader might wish to construct. In consequence, the h.t. and heater outputs are brought out to an octal socket, so that any suitable equipment can be plugged in.

The circuit of the power supply unit is shown in Fig. 1. For the receivers and amplifiers envisaged, a high level of h.t. voltage regulation is not considered necessary, whereupon a simple full-wave rectifier circuit with reservoir capacitor becomes quite acceptable. The mains transformer specified has an h.t. secondary of 250-0-250 volts at 80mA, whilst the maximum limiting output current for the EZ80 rectifier employed is 90mA. The h.t. current requirement for the power unit is, in consequence, comfortably met. The mains transformer also has a 6.3 volt secondary winding rated at 3 amps which, again, meets requirements adequately. A 6.3 volt pilot lamp connected across the heater supply indicates that the unit is switched on and operative, whilst a neon bulb indicates the presence of h.t. voltage.

The output of the power supply unit is coupled to an octal valveholder, into which an octal plug may be inserted. It will be noted that one side of the 6.3 volt output connects to pins 1, 2 and 3, whilst the other side connects to pins 6, 7 and 8. The reason for using three pins for each connection is that the Bulgin octal plug specified for use with the socket is rated at 1 amp per pin. If the consumption, at 6.3 volts, of equipment connected to the unit is in excess of 1 amp, then connection may be made by way of two or three of the plug pins in parallel, according to the current required. The 6.3 volt output is not connected to chassis at any point in the power unit. All chassis connections to the heater supply will be made in the equipment which couples to the power unit.

In any rectifier circuit incorporating a reservoir capacitor it is important to ensure that the series limiting resistance per rectifier anode does not fall below the minimum figure specified by the manufacturers of the rectifier.¹ For the EZ80, the minimum limiting resistance figure (quoted by Mullard) is 125Ω for 250 volts r.m.s. a.c. input per anode. In our power unit the rectifier is supplied by a mains transformer, whereupon we have first to check the resistance of the secondary and primary windings to see what limiting resistance these provide. The resistance offered per rectifier anode by the transformer is the resistance of half the h.t. secondary

¹ See "Understanding Radio" for March 1965.

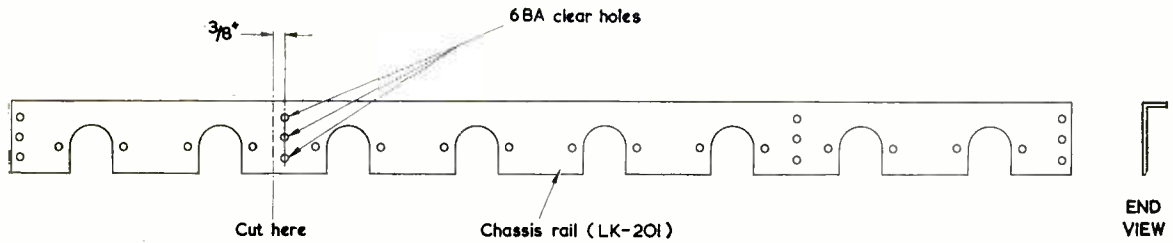


Fig. 4. Cutting the Chassis Rails to enable them to take three Chassis Plates

(i.e. from the zero centre-tap to either 250 volt terminal) plus the "reflected" resistance from the primary.² This is equal to $R_s + N^2 R_p$ where R_s is the secondary resistance in the rectifier anode circuit, R_p is the primary resistance and N is the secondary-to-primary turns ratio (which is equivalent to the voltage ratio). N is expressed as a fraction and with, for example, a 2:1 step-down transformer would appear as $\frac{1}{2}$. With a mains transformer having voltage taps in the primary, the primary resistance to the highest tap offers the worst case and is that which should be used in the calculation. The resistance of the two halves of the h.t. secondary of the transformer specified for the present power supply unit was measured and it was found that one half had a resistance of 200Ω and the other half a resistance of 210Ω .³ The primary winding, between the zero and 250 volt terminals, had a resistance of 33Ω . Since the ratio between the 0 to 250 volt primary and one half of the h.t. secondary is 1:1, the N^2 expression becomes 1. The lowest resistance offered, per anode, by the transformer to the rectifier is, therefore,

200Ω plus 33Ω , or 233Ω . This is well in excess of the minimum limiting resistance figure quoted by the rectifier manufacturer and so no physical series limiting resistors are required. In our power unit, the internal resistance in the transformer windings provides all the limiting required.

It may be added that in practice it is frequently unnecessary, in exercises of the type just described, to measure the primary resistance of the mains transformer. The secondary resistance per anode should first be checked. If this is in excess of the minimum limiting figure quoted for the rectifier there is no need to proceed further, since the rectifier manufacturer's requirements are already met by this resistance on its own. In the present case the calculation was, however, carried out in full for purposes of demonstration.

The reservoir capacitor should be capable of passing the ripple current in the rectifier circuit. For home-constructor applications, a simple "rule-of-thumb" is to assume that reservoir capacitor ripple current for a full-wave rectifier at 50c/s is of the order of 1.4 times the d.c. load current. As will be seen, we shall be drawing an overall maximum d.c. load current approaching 80mA, which corresponds to a ripple current of 1.4 times 80, or 112mA. (The direct current in excess of

² See "Understanding Radio" for July 1963.

³ The half of the h.t. secondary which is wound on the inside will have a slightly lower resistance than the half wound on the outside because it employs less wire.

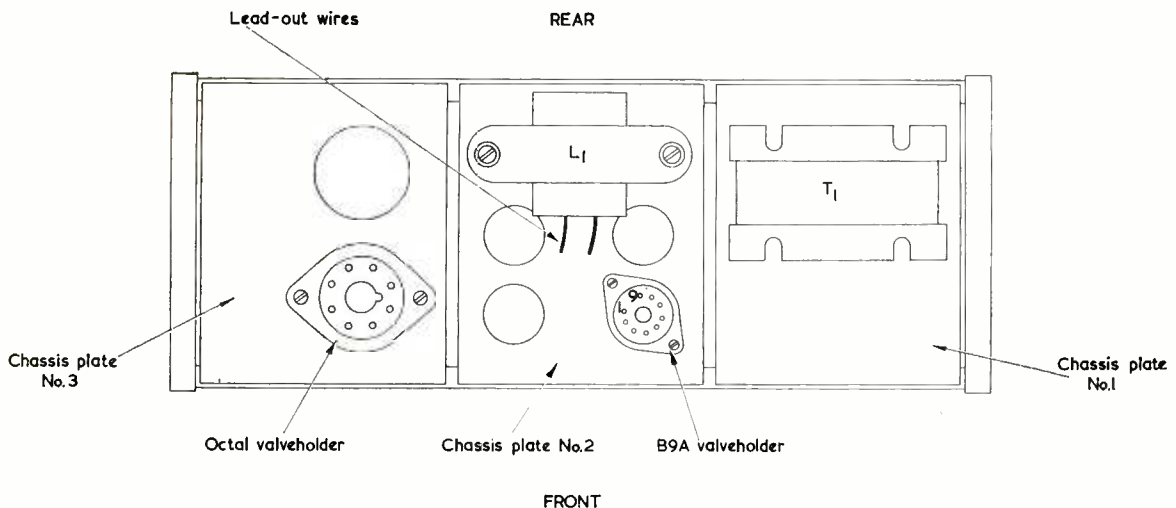


Fig. 5. Fitting the main components above the chassis

65mA is drawn by R_2 and NE_1). The capacitor specified for the C_1 position is quoted in the Home Radio catalogue as having a maximum ripple current of 200mA, which gives a reasonable safety margin. The capacitor specified also has a working voltage of 350, which will allow for the tendency of the rectified voltage in the circuit to rise to the peak value of the applied alternating voltage under low-load conditions.

The insulation between the cathode and heater of the EZ80 rectifier is sufficient to withstand 500 volts maximum. The heater could, in consequence, be connected to the same 6.3 volt supply as is used for other valves in the associated equipment and which would normally be at chassis potential (e.g. one side of the 6.3 volt supply could be connected to chassis). In the present case, a separate heater winding offering 6.3 volt at 1 amp is available in the mains transformers and this can be used to supply the rectifier heater on its own. To prevent the risk of high static voltages appearing in this separate heater circuit, one side of the heater winding may be connected either to chassis or to the cathode of the rectifier. It is marginally preferable to connect it to the rectifier cathode, since it may be assumed that the cathode-heater insulation is slightly more vulnerable to breakdown than the insulation between the 6.3 volt winding and other windings on the transformer.

The transformer specified has an electrostatic screen between primary and secondary.⁴ This screen is connected to chassis.

There is no smoothing capacitor after the smoothing choke. In some of the equipment which will later be connected to the power unit, the smoothing capacitor will also provide a low source impedance for a.f. and r.f. currents. To avoid long connecting leads to this low source impedance, the necessary smoothing capacitor will in consequence be fitted in the chassis of the supplied equipment.

The neon bulb, NE_1 , offers a convenient indication of the presence of h.t. voltage. It is supplied in a self-contained assembly which includes the series resistor needed to keep neon current at a safe level. The neon draws a current of approximately 1.5mA.

After some thought, the writer decided not to include a fuse in the h.t. positive line. The absence of a fuse does, however, make it necessary for the constructor to take especial care to avoid accidental h.t. short-circuits in equipment connected to the power unit.

Finally, a bleeder resistor, R_2 , is connected across the h.t. output. This component is included for two reasons. First of all, it is possible to switch on the power unit without an external load connected whereupon the reservoir capacitor may, in the absence of R_2 , remain charged after switching off again. Unexpected and unpleasant shocks may be received from the capacitor in this condition. (The neon bulb and its series resistor cannot be

⁴ The screen in a mains transformer may consist of a thin shim of brass or copper fitted around the primary but with its ends insulated from each other to prevent the appearance of a "short-circuited turn", or it may be a layer of winding wire to which connection is made at one end only.

relied upon to ensure quick and complete discharge of the capacitor after switching off the mains supply). Secondly, under very low load current conditions, the voltage output from the power unit, without R_2 , could rise to a somewhat undesirably high level. The bleeder resistor, which draws some 10mA, prevents the appearance of such high voltages. This resistor dissipates some 2.7 watts. Since the wattage ratings ascribed to resistors available through home-constructor channels are frequently the maximum limiting ratings, R_2 is specified in the Components List as 5 watts.

The output voltage of the prototype, at zero external load current, was 290 volts. At an external load current of 65mA, this dropped to 230 volts.

The Mains Transformer

Before proceeding further, it is necessary to give a brief note concerning the mains transformer. This is the type MT1AT, manufactured by Douglas Electronic Industries, Ltd., and it is a robust component which may be readily mounted on the Lektrokit metal-work. The MT1AT transformer has, however, recently undergone a small change in design, and since earlier versions of the transformer may still be held in retailers' stocks, this change will be briefly noted here.

The original version of the transformer had the secondary tag layout shown in Fig. 2(a). It will be seen that both heater windings offer 6.3 volts, and that one is tapped at 4 volts, whilst the other is tapped at 4 and 5 volts. The taps enabled the transformer to cater for a wide range of heater voltages in home-constructor and similar equipment. However, since the war the use of valves with 4 volt heaters has virtually completely declined. The 4 volt taps in the transformer have now therefore been discontinued, and currently produced transformers have the secondary tag layout shown in Fig. 2(b). Some interim transformers were manufactured with the same general tag layout as in Fig. 2(b), but the identifying label alongside the two bottom right-hand tags (0 and 6.3) may bear the figures 0, 4 and 6.3. If such a transformer is obtained, the figure 4 on the label should be ignored.

The Chassis

We may now proceed to constructional matters.

The chassis of the power unit is made up from the following Lektrokit parts: two Side Plates No. 1; two shortened Chassis Rails; one Chassis Plate No. 1; one Chassis Plate No. 2; and one Chassis Plate No. 3. These parts are assembled together as shown in Fig. 3.

The three Chassis Plates just mentioned are manufactured from 18 s.w.g. half-hard aluminium alloy sheet, and all are punched with a uniform pattern of $\frac{1}{8}$ in. diameter holes. (These holes are not shown in Fig. 3). Chassis Plate No. 2 also has six holes for B7G or B9A valveholders, and Chassis Plate No. 3 has two holes for octal valveholders.

Two Chassis Rails are available in the Lektrokit system, one having a length corresponding to two

Chassis Plates, and one having a length corresponding to four Chassis Plates. The most convenient layout for the power supply unit is given on three Chassis Plates and it was decided, for the sake of the appearance of the completed power unit, to modify two of the longer Chassis Rails so that they could take three plates. All that is required is to cut away the end section of each Chassis Rail as shown in Fig. 4, whereupon a group of 6BA clear holes becomes available, at the cut end, for bolting to the Side Plate. As was mentioned earlier in this article, the Chassis Rails can be cut very quickly with the aid of an inexpensive hacksaw. After the Chassis Rails have been shortened the assembly of Fig. 3 is then made up, the parts being secured together with $\frac{1}{4}$ in 6BA screws and nuts.

No other metal-working processes whatsoever are involved, and the chassis is now complete!

Mounting The Main Components

The first component to be mounted is the mains transformer, and it is fitted to the Chassis Plate No. 1. The transformer should be mounted as shown in Fig. 5, with the primary tags (0, 200, 230, 250) at the rear, and the tags for the h.t. and heater secondaries at the front. Looking at the transformer from the front of the chassis, the 250-0-250 h.t. secondary tags are at the bottom left, as in Fig. 6. The transformer should be positioned so that two rows of $\frac{3}{16}$ in. holes in the Chassis Plate are visible behind its frame. It may be secured with four $\frac{3}{16}$ in. 6BA screws, with washers under the heads to accommodate the wide mounting slots in the transformer frame.

The smoothing choke has next to be fitted, and this is mounted on the Chassis Plate No. 2. The choke is secured with two $\frac{3}{16}$ in. 6BA screws having washers under the heads, and is positioned such that two rows of $\frac{3}{16}$ in. diameter holes are visible behind its clamp and laminations. The lead-out

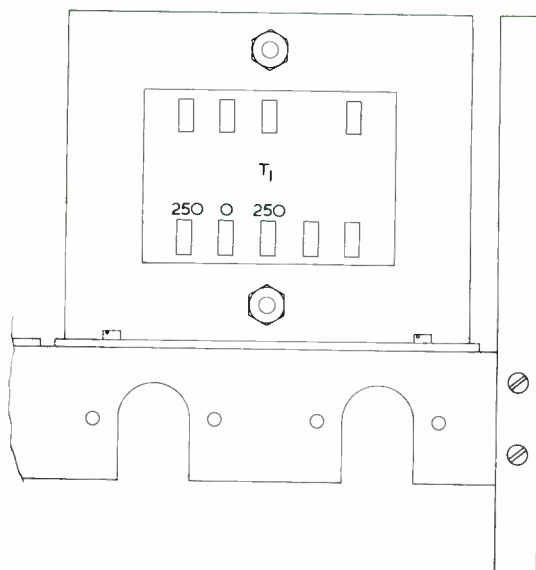


Fig. 6. Front view, showing the manner in which the mains transformer should be mounted

wires from the choke should protrude at the front.

The B9A valveholder is next fitted, and it takes up the orientation shown in Fig. 5.

The last of the main components to be fitted is the octal output socket. This is mounted on the Chassis Plate No. 3. The octal valveholder should have the same orientation as is shown in Fig. 5. A 6BA solder tag should be fitted below the chassis under the mounting nut adjacent to pins 4 and 5.

Next Month

In next month's issue we shall give further assembly and wiring details for the power unit.

Recent Publication . . .

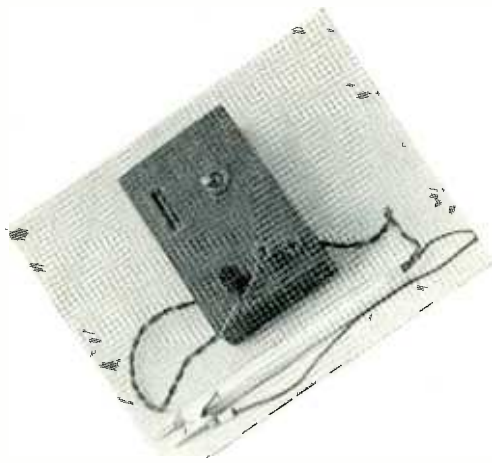
MICROWAVE PRIMER. By Albert Camps and Joseph A. Markum. 198 pages, $5\frac{1}{2} \times 8\frac{1}{2}$ in. Published by W. Foulsham & Co. Ltd. Price 30s.

"Microwave Primer" is another title in the Foulsham-Sams Technical Books series, and its American origin offers no hazards to the English reader because the subject-matter is universally applicable. The book is primarily aimed at the person wishing to enter the field of microwave technology or who wants a broader comprehension of the subject. The authors have employed the slightly unusual device of presenting the text in question and answer form. This approach pays off dividends in the present volume since it enables each question to be dealt with in its entirety and with proper emphasis.

The book is based on extensive laboratory experience and deals very adequately with an exceptionally wide range of topics in the microwave category. Mathematics are employed where necessary but, in general, the treatment is non-mathematical.

Instead of chapters, "Microwave Primer" is divided into four sections, these being headed "Introduction To Microwaves", "Transmission Lines", "R.F. Components" and "Measurement Techniques". It is impossible, in this short review to list the exceptionally large numbers of subject covered. Apart from material on microwaves, Section 1 includes details on engineering drawing and on all the mathematics needed in the later parts of the book. Section 2 offers comprehensive information on, amongst many other subjects, wave propagation, transmission lines, waveguides and matching. The third section includes details on masers, lasers, parametric amplifiers and cavity resonators, whilst Section 4 includes V.S.W.R. measurements, the use of the Smith Chart, and noise factor measurement. So far as the reviewer can ascertain, there is not a basic question on microwave technology at its present state that is not dealt with at sufficient depth to enable fundamental operation to be understood. Each answer is, of necessity, brief, but a commendable economy of words enables the maximum amount of information to be given in the space.

"Microwave Primer" is warmly recommended for the newcomer to microwaves and for anyone whose work necessitates occasional ventures into this field.



Pocket Voltage Indicator and Oscillator

by P. J. LeRiche

Based on a device featured in the "Suggested Circuit" series, this instrument offers approximate measurements of voltage and has a very high input impedance. The only power supply required is a 3 volt battery.

SOME TIME AGO, G. A. FRENCH DESCRIBED A POCKET valve voltmeter using the sub-miniature tuning indicator type DM70.¹ Although the idea

¹ G. A. French, "Pocket Valve Voltmeter", Suggested Circuit No. 147, *The Radio Constructor*, February 1963. This article described a simple unit incorporating a DM70 tuning indicator powered by a 1.5 volt cell and a 90 volt h.t. battery. The voltage to be measured was applied between grid and filament of the DM70, whereupon an approximate indication of its value was given by the length of the fluorescent column displayed. The device had a very high input impedance and could also be used with an a.c. probe.—Editor.

appealed to the writer, the h.t. battery it employed did not, and in consequence the circuit described in this article was evolved.

The present circuit lacks, to some extent, the simplicity of that described by G. A. French, but offsetting this is the fact that only a 3 volt supply, obtainable from two U16 cells, is required. Furthermore, the unit can also be used as a small and convenient audio generator.

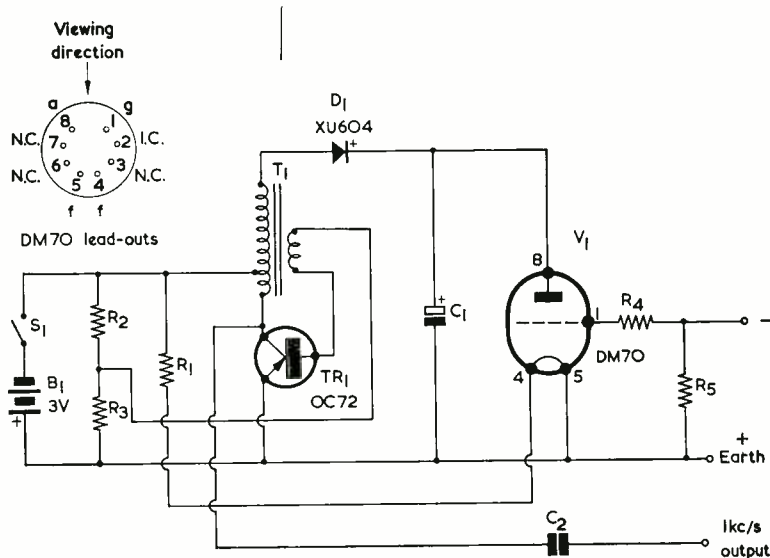


Fig. 1. The circuit of the unit. The DM70 is a small tuning indicator having a fluorescent column whose length varies with the applied grid voltage. It has wire lead-outs which connect directly into circuit. The voltage to be measured is applied to the "+" and "-" terminals

Components List (Figs. 1 and 2)

(Note: As is explained in the text, some components may need to be adjusted in value).

Resistors

(All $\frac{1}{8}$ or $\frac{1}{10}$ watt 20% unless otherwise stated)

- R₁ 62Ω 5%
- R₂ 47kΩ
- R₃ 10kΩ
- R₄ 6.8MΩ
- R₅ 10MΩ
- R₆ 10MΩ
- R₇ 2.2MΩ

Valve

V₁ DM70

Switch

S₁ s.p.s.t. toggle

Battery

B₁ 3 volts (two U16 cells in series)

Capacitors

- C₁ 1μF, electrolytic, 250V wkg
- C₂ 0.01μF ceramic, disc or tubular
- C_{3,4} 0.01μF ceramic, tubular

Transformer

T₁ Step-up (see text)

Semiconductors

- TR₁ OC72
- D₁ XU604
- D₂ OA81

The Circuit

The circuit is shown in Fig. 1 and it can be seen that it consists basically of a transistorised audio oscillator, employing an OC72 transistor, which feeds a step-up transformer to obtain the h.t.

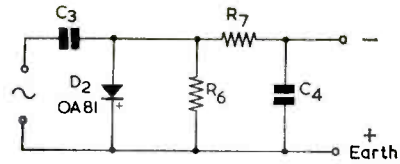


Fig. 2. The circuit of the a.c. probe

voltage. Rectification is achieved by means of the silicon diode D₁ and the resultant h.t. voltage is smoothed by C₁. An audio output at about 1kc/s is obtained from the collector of TR₁ via the 0.01μF capacitor C₂. The output is, however, a long way from a pure sine wave, and it varies from a pulse to a rather poor square wave as the current drawn by V₁ is altered. The filament of the DM70 is rated at 1.4 volts, and to save an extra pole on S₁, the full 3 volts of the battery is applied via the dropping resistor R₁. This component has a tolerance of 5% to avoid any risk of damaging the valve.

The rectifier employed in the prototype was an XU604, but any silicon type with a p.i.v. rating of at least 500V should be suitable. It is possible that a small contact-cooled selenium component, (such as the Siemens E250C50, which would require no heat sink) might be better, as this could more readily withstand transients. However, the component used in the prototype functions perfectly well, quite possibly because it receives a certain amount of protection from the high internal impedance of the high voltage supply, this being in the order of 1MΩ.² The smoothing capacitor, C₁, is probably larger than is necessary, but the component specified was used as it was to hand.

² The XU604 is a 140 volt r.m.s. (500 p.i.v.) silicon rectifier rated at 500mA, whilst the E250C50 is a 250 volt (max input) component rated at 50mA. Since the current drawn by the DM70 is of the order of 100μA only, these rectifiers are employed considerably below their normal ratings. However, their relatively low cost justifies their choice here.—Editor.

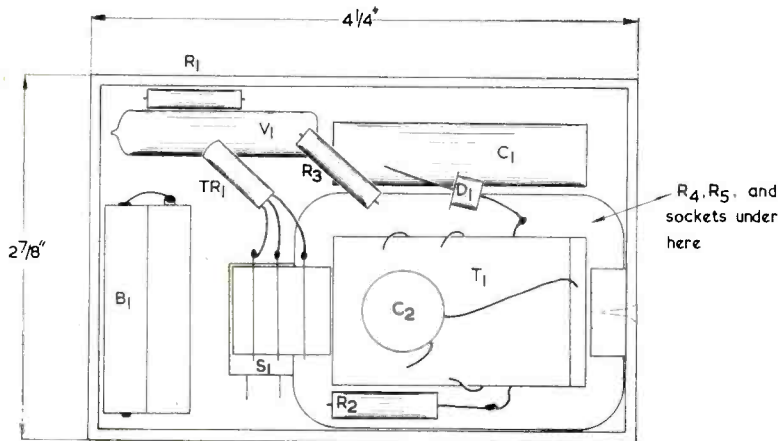


Fig. 3. General layout of components in the case. The depth of the latter is 1 1/2 in

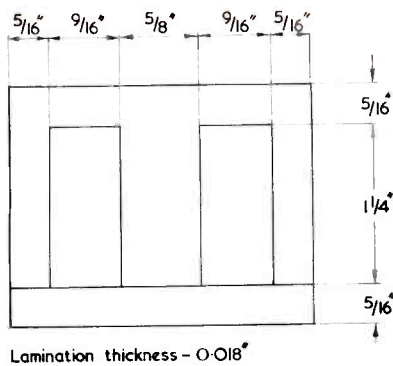


Fig. 4. Dimensions of transformer laminations used in the prototype

A smaller value would be permissible and would reduce the slight delay of the fluorescent column in reaching its final length.

Almost any small power transistor could be used in the TR₁ position, but one with a lower power rating than the OC72 is not recommended as it may be incapable of supplying sufficient h.t.

Voltages to be measured by the unit are applied to the "+" and "-" test terminals, and an indication of their value is given by the length of the fluorescent column in the DM70.

The grid resistor R₅ should not be omitted or increased in value as otherwise the unit can be affected considerably by electrostatic charges.

The circuit of the a.c. probe is shown in Fig. 2, and is quite straightforward and conventional in design; it is, in fact, very similar to that described by G. A. French. Its d.c. output connects to the "+" and "-" terminals in Fig. 1.

Construction

The prototype was housed in a small hardboard box measuring approximately $4\frac{1}{4} \times 2\frac{7}{8} \times 1\frac{1}{2}$ in, the layout being shown in Fig. 3. There is, of course, nothing to stop the constructor altering these dimensions over quite wide limits. Unless somewhat smaller components are used, however, it will not be found possible to reduce the size by any large amount.

The transformer is held in position between S₁ and the end of the box by means of small pieces of wood attached to these parts. The piece attached to the box is held by a screw so that the transformer can be removed if necessary. The other piece of wood is glued in position to the back of S₁, and it also holds three pieces of 16 s.w.g. wire to which the OC72 is soldered, this providing a convenient mounting for the transistor. A transistor holder could equally well be employed. The DM70 is held in place by passing pieces of sleeving over its leads and glueing these to the case. The battery is soldered directly into the circuit, it being found unnecessary to mount or connect it in any other way.

The transformer is wound especially for the unit and uses a $\frac{1}{4}$ in stack of E and I laminations

Table I

Transformer Winding Details

Collector Winding:—3,700 turns 40 s.w.g. enamelled copper wire tapped at 370 turns.

Base Winding:—230 turns 28 s.w.g. enamelled copper wire (Base winding put on first)

Core:— $\frac{1}{4}$ in stack, see text and Fig. 4.

having the dimensions shown in Fig. 4. These laminations were taken from an old transformer. Similar results will be given with laminations having approximately the same dimensions, and the main point to observe is that the cross-sectional area of the centre is about $\frac{3}{8}$ sq in, as in the author's transformer. U and T laminations may also be used, instead of E's and I's. The laminations are interleaved (i.e. alternate E's and I's), and winding details are given in Table I. The constructor should not be discouraged by the number of turns in the collector winding as these can be wound on quite quickly once construction has started.

After the transformer has been finished, a mock-up of the circuit should be made, omitting the valve. When any mistakes have been found and corrected, the battery may be connected and the unit switched on. The h.t. voltage across C₁ must now be checked, this being done with either a 10,000Ω/volt meter on the 100 volt range, a 2,000Ω/volt meter on the 500 volt range, or a 1,000Ω/volt meter on the 1,000 volt range. Whichever of these is used, a reading of about 85 to 90 volts should be obtained. If a valve voltmeter with a resistance of at least 10MΩ is used, a reading in the range of 155 to 175 volts can be expected. Small changes in h.t. voltage may be effected by altering R₂, but this resistor should not be reduced in value below about 15 to 20kΩ. Larger changes may be made by modifying the h.t. winding on the transformer. If the unit oscillates at far too high a frequency and only gives about 20 to 30 volts, or does not oscillate at all, the connections to the base windings should be reversed.

The a.c. probe was housed in a 5 in length of $\frac{1}{2}$ in dural rod with a $\frac{1}{8}$ in hole bored down the centre. The layout of the components is shown in Fig. 5, these being insulated from the case by a length of 6mm sleeving. There is no reason why a case made of insulating material should not be used instead of the dural tube.

Sensitivity

As can be seen from Fig. 6, the sensitivity of the

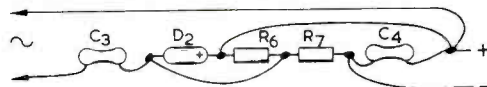


Fig. 5. How the a.c. probe components are wired together inside the probe housing

Table II

Measurements made on the Prototype

3V consumption, no input	33mA
H.T. consumption, no input	90 μ A
H.T. voltage, no input	85V*
H.T. voltage, DM70 cut-off	165V*
Internal resistance of h.t. supply (approx)	1M Ω

unit is not constant, but varies considerably below about -8 volts. This is not a disadvantage, as it enables small voltages of the order of a volt or less to be easily detected, whilst still enabling the unit to be used up to 20 to 30V.

Increased sensitivity is not easily obtained. It could be achieved by reducing the h.t. voltage, but this would be at the expense of brightness. Reducing the source impedance of the h.t. supply would also improve the situation and without this disadvantage. A reduced source impedance would probably be given by using thicker wire in the h.t. winding of the transformer, replacing TR₁ by a more powerful transistor and reducing the value of R₂. These measures would also modify the h.t. voltage, and in consequence the h.t. winding of the transformer would need to be tapped at several points so that this can easily be remedied. It should be pointed out that these schemes for reducing the h.t. source impedance are suggestions only, and they have not been tried by the writer in practice.

Uses

The unit has a large number of uses. In addition to such applications as alignment of superhets, testing of audio equipment and null indication with bridges, it can be used for less obvious purposes. Typical examples are given by the testing of insulation or capacitors. In the latter case, connect the

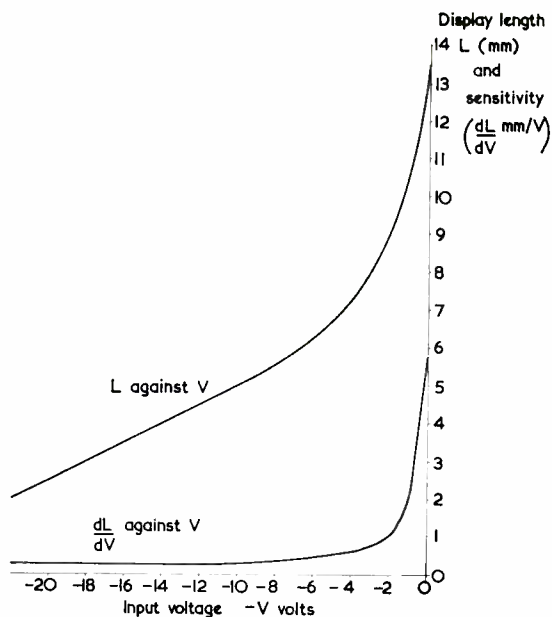


Fig. 6. Curves showing display lengths in mm and sensitivity ($\frac{dL}{dV}$ mm/V) against input voltage

capacitor under test across the input in series with a 9 volt battery; the initial jump of the display gives a rough indication of the capacitance if it lies between about 100pF and 1 μ F, and the length of the column indicates the state of the insulation.

The writer feels sure that these, and the many other uses to which the unit can be put, will make it an almost invaluable tool in every workshop.

CAN ANYONE HELP?

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

Ekco Transmitter/Receiver Type CE40/12.—Fg.Off. T. D. Marsden, Officers Mess, RAF Binbrook, Lincolnshire,—this equipment is 11-14 volt operated and bears the serial number WR476. Circuit, service sheet or manual, loan or purchase.

* * *

“The Radio Constructor”.—K. V. Williams, House 3, Fire Station, College Road, Birmingham, 22C,—requires copy of the July 1959 issue—now out of print. Gladly pay 5/- and refund postage.

* * *

Bush TUG26.—N. Miller, 29 Chadacre Road,

Stoneleigh, Surrey,—borrow or purchase circuit or service sheet.

* * *

Jason Argus A. M. Tuner.—J. R. Ault, 17 Hollyhedge Road, West Bromwich, Staffs,—constructional and alignment details.

* * *

Recording C.W. Signals.—C. W. Waite, 55 Woodhouse Drive, Keighley, Yorks,—has a high speed tape recorder 10G/36 Type UG6A No: 3744Z, maker Marconi. Circuit diagram and use of same to record amateur band c.w. signals.



VHF/FM Feeder Unit

by V. E. Holley

This versatile unit may be employed as a v.h.f./f.m. tuner with its own monitor a.f. output stage, as a tuner unit with a cathode follower output, or as a complete receiver. Readily available components are employed and a special feature is the crystal controlled oscillator which provides switched station selection with absolute freedom from drift.

THIS unit was designed to feed the Light and Home Service v.h.f. programmes into a public address system. In its original form, it may have rather limited general application but, by minor modification, it can serve as a high quality tuner or receiver for domestic use. Construction does not present any real difficulties but it is desirable that the constructor shall have had some previous experience of broad-band high frequency circuits, where the physical form often has quite a lot to do with the performance. The cost has been kept low by using cheap and easily obtainable valves and a minimum of other components.

R.F. Stage

Referring to the circuit of Fig. 1, it will be seen that the signal from the dipole aerial is applied to the coil L_1 and thence to the grid of the first valve, a high gain pentode type EF91. The coil and the input capacitance of the valve form a circuit of favourable L/C ratio which is slug tuned broadly to the band of frequencies to be received. The coil

L_2 which loads the anode circuit of V_1 , is similarly tuned and the amplified signal is passed via capacitor C_5 to the grid of the mixer valve, V_3 . It will be noticed that all decoupling is to the valve cathode and thence to chassis, and that the anode circuit of V_1 is also decoupled to the cathode of V_3 . This is an arrangement which permits high gain without loss of stability. As well as making a useful contribution to the overall sensitivity, the V_1 stage serves to isolate the aerial from the local oscillator, the second harmonic of which falls in television Band III.

Oscillator

Frequency stability is always a problem with oscillators. Valves and their bases, and most other components, have positive temperature coefficients and so, as the temperature rises in the chassis, the effective capacitance across tuned circuits tends to increase, with the result that the operating frequency of the oscillator drifts low. This effect is most marked at high frequencies and with f.m. reception it has quite a distressing effect on the quality of reproduction. Of the several solutions available to the designer, that of controlling the oscillator by means of a quartz crystal is probably the most accurate and reliable, and it has been adopted in this tuner.

The crystals are cut to operate on the fifth mechanical overtone so that they work directly at oscillator frequency. They are resonated in a grounded grid oscillator formed by the valve V_2 , the coil L_3 and associated capacitors, an arrangement which has the merit of simplicity and which needs few components. Switch $S_{1(a)}$ selects the crystal appropriate to the transmission to be received, while $S_{1(b)}$ introduces the capacitance required to resonate it. Crystal XTAL₁ in Fig. 1 is that for the highest



Front view of the receiver. The mechanical linkage to switch S_1 can be readily seen here

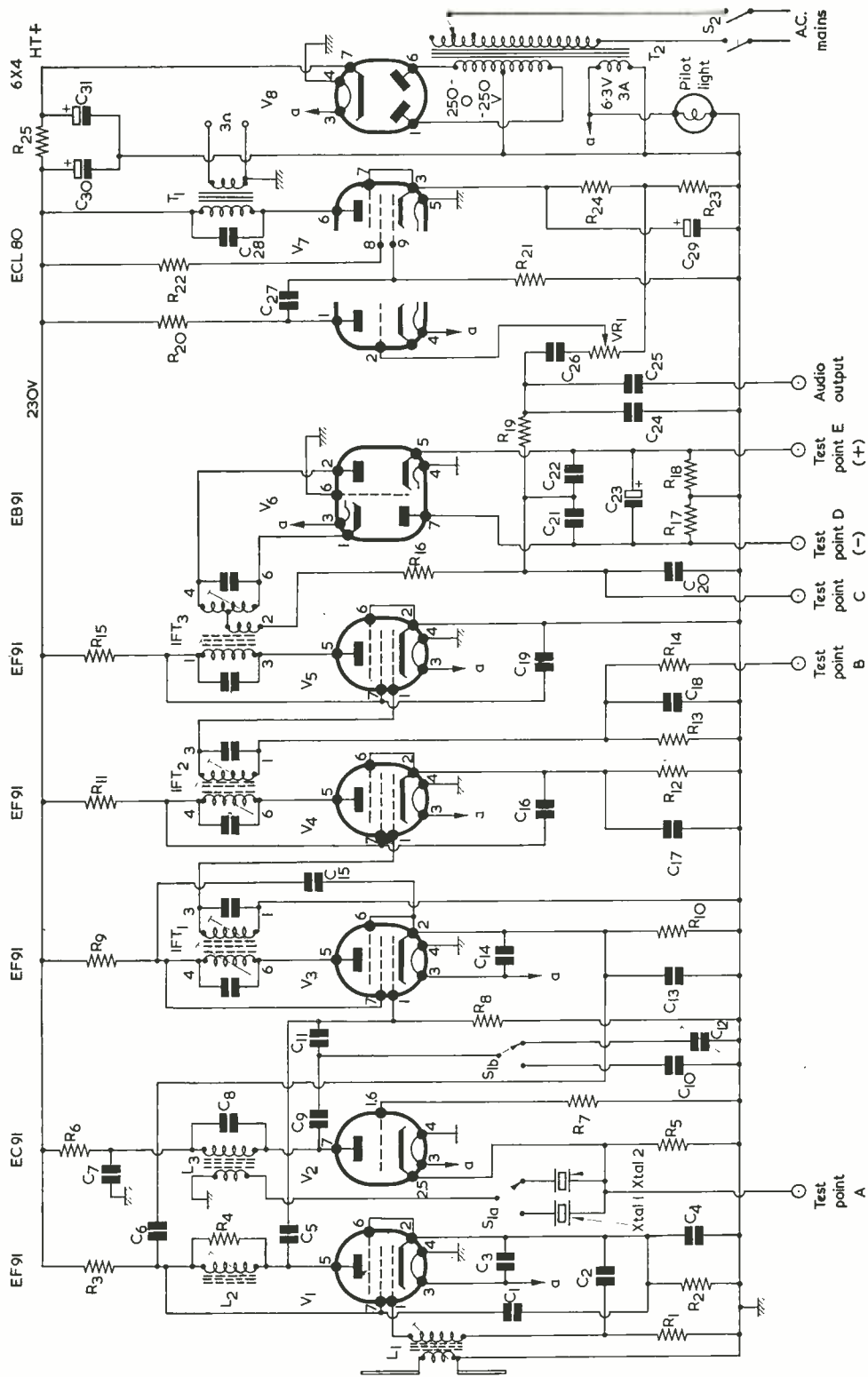


Fig. 1. The circuit of the complete receiver. A third programme is available if another crystal is included and a third way added to S₁ (a) (b). The a.f. stages may be modified, as described in the text. If the receiver is to be employed in badly ventilated locations, V₈ may be replaced by two silicon diodes, such as the BY100

Components List

N.B. Components marked with an asterisk (*) may not be required if the a.f. sections of Figs. 2 or 3 are employed.

Resistors

(All fixed values $\frac{1}{2}$ watt 10% unless otherwise stated)

R ₁	47k Ω
R ₂	150 Ω
R ₃	4.7k Ω
R ₄	4.7k Ω
R ₅	150 Ω
R ₆	10k Ω
R ₇	22 Ω
R ₈	1.2M Ω
R ₉	4.7k Ω
R ₁₀	470 Ω
R ₁₁	4.7k Ω
R ₁₂	150 Ω
R ₁₃	47k Ω
R ₁₄	100k Ω 20%
R ₁₅	47k Ω , 1 watt
R ₁₆	47 Ω
R ₁₇	6.8k Ω } matched 4% or better
R ₁₈	6.8k Ω }
R ₁₉	27k Ω
*R ₂₀	220k Ω
*R ₂₁	470k Ω
*R ₂₂	2.7k Ω
*R ₂₃	220 Ω
*R ₂₄	220 Ω
R ₂₅	1k Ω , 5 watt
*VR ₁	1M Ω , potentiometer, log track with d.p.s.t. switch

Capacitors

(All 350V wkg. unless otherwise stated)

C ₁	0.002 μ F disc ceramic
C ₂	0.002 μ F disc ceramic
C ₃	0.002 μ F disc ceramic
C ₄	0.002 μ F disc ceramic
C ₅	39pF tubular ceramic
C ₆	0.001 μ F tubular ceramic
C ₇	470pF disc ceramic
C ₈	15pF silver-mica
C ₉	15pF silver-mica
C ₁₀	5pF silver-mica
C ₁₁	2pF ceramic
C ₁₂	2-8pF concentric trimmer (Mullard)
C ₁₃	0.002 μ F disc ceramic
C ₁₄	0.002 μ F disc ceramic
C ₁₅	0.01 μ F disc ceramic
C ₁₆	0.01 μ F disc ceramic
C ₁₇	0.01 μ F disc ceramic
C ₁₈	47pF ceramic
C ₁₉	0.01 μ F disc ceramic
C ₂₀	270pF ceramic
C ₂₁	270pF disc ceramic
C ₂₂	270pF disc ceramic
C ₂₃	8 μ F electrolytic, 25V wkg.
C ₂₄	1,500pF tubular ceramic

C ₂₅	0.1 μ F paper
*C ₂₆	0.01 μ F paper
*C ₂₇	0.01 μ F paper
*C ₂₈	0.001 μ F paper
*C ₂₉	500 μ F electrolytic, 25V wkg.
C ₃₀	32 μ F electrolytic
C ₃₁	16 μ F electrolytic

Inductors

L _{1,2,3}	Wound on three 0.276 in dia. formers type 351/8BA with v.h.f. cores (Denco). See text and Fig. 8.
IFT _{1,2}	10.7 Mc/s i.f. transformers type IFT. 11/10.7 (Denco)
IFT ₃	10.7 Mc/s ratio discriminator transformer type RDT.1 (Denco)
*T ₁	Speaker transformer, 70:1
T ₂	Mains transformer. Secondaries (see text) 250-0-250V at 80mA; 6.3V at 3A. Drop-through, maximum outside chassis dimensions $3\frac{1}{2} \times 3$ ins

Valves

V ₁	EF91
V ₂	EC91
V ₃	EF91
V ₄	EF91
V ₅	EF91
V ₆	EB91
*V ₇	ECL80
V ₈	6X4

Switches

S _{1(a)(b)}	d.p.d.t. wafer switch. (See text and Fig. 9)
S ₂	On-off. Ganged with VR ₁

Sockets

(Valveholders are ceramic or nylon loaded, and fitted with centre spigot)

- 3—B7G with screen (for V₁, V₂ and V₃)
- 4—B7G without screen (for V₄, V₅, V₆ and V₈)
- *1—B7G without screen (for V₇)
- 1—pilot lamp holder
- 1—coaxial aerial input socket (with plug)
- 1—coaxial or phono output socket (with plug)

Crystals

As required. Type 2MM, state frequencies (see text). (Cathodeon Crystals Ltd., Linton, Cambridge)

Miscellaneous

*1	—3 Ω speaker
1	—6.3V 0.3A pilot lamp
2	—knobs
16	s.w.g. aluminium for chassis
	Hardware for switch S ₁ linkage
	Connecting wire, screened lead, etc.

frequency transmission and is resonated by the fixed capacitor C_{10} ; crystal $XTAL_2$ and the air-spaced trimmer C_{12} are for the next lower frequency. A third channel can be added by introducing a third crystal and another trimmer and fitting a 2-pole, 3-way switch in place of the 2-way component of Fig. 1.

The method by which the oscillator voltage is introduced to the mixer valve must not impose too great a load on the oscillator or it will cease to function. This requirement is met by assigning values of 2pF to the coupling capacitor, C_{11} and $1.2M\Omega$ to the mixer grid resistor, R_8 .

Mixer and I.F. Stages

The valve V_3 is arranged as an additive mixer. Signal and oscillator frequencies are applied to grid No. 1 and the resultant intermediate frequency of 10.7 Mc/s is extracted from the anode circuit by the transformer, IFT_1 . Resistor R_9 and capacitor C_{15} provide decoupling which, as with V_1 , is to the valve cathode. The conversion conductance is high and the stage contributes its full quota to the overall gain.

The i.f. signal is passed on for further amplification by the valve V_4 in a conventional i.f. stage which needs no explanation, and thence by way of transformer IFT_2 to the following stage.

Limiter

A second i.f. stage is formed around the valve V_5 , which is operated as a limiter. The anode current, reduced by resistor R_{15} to a low value, is further restricted by the negative bias generated at the grid by resistor R_{13} and capacitor C_{18} , and as a result the valve is able to amplify incoming signals up to a predetermined limit only. Thus, interference

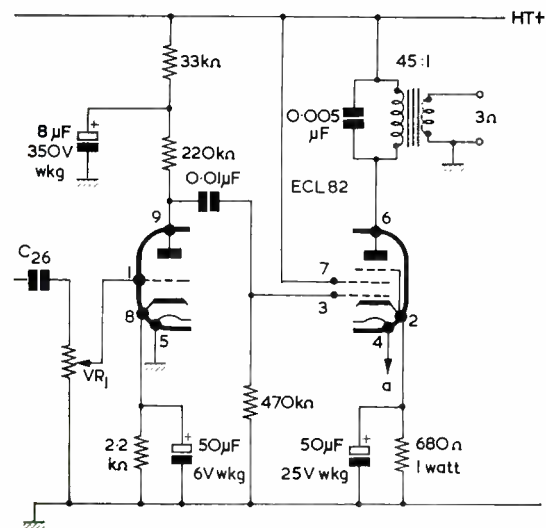


Fig. 2. A suggested alternative a.f. section which offers a greater output than does the ECL80 in Fig. 1

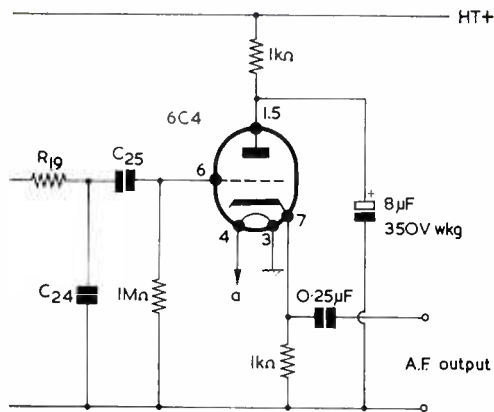


Fig. 3. If the receiver is employed as a tuner unit, a 6C4 cathode-follower may be fitted instead of a triode-pentode

from car ignition systems and other man-made and natural static, are not reproduced in the limiter output.

If the receiver is to be used in an area of high field strength, the limiter stage will not be necessary and can be omitted entirely, the anode of V_4 being connected directly to the ratio detector transformer, IFT_3 .

Detector

From the anode of V_5 , the signal is passed through the transformer, IFT_3 , to a simple symmetrical ratio detector formed by the double diode valve, V_6 , and its associated R/C network. The audio output appears at the junction of capacitors C_{21} and C_{22} and, after passing through the de-emphasis network R_{19}/C_{24} , is available through capacitor C_{25} for delivery to an audio amplifier. A pair of crystal diodes of the GEX34 type could be used instead of the valve V_6 , but the valve is cheaper and avoids the need to find a matched pair of crystal diodes.

Modifications

Beyond the detector, the circuit meets the special requirement of the prototype for pilot a.f. and output stages, using a triode-pentode valve type ECL80. This serves merely to monitor the output and does not, of course, do justice to the quality of the transmission being received; most domestic users will want something better. If a complete receiver is required, a triode-pentode type ECL82, in the circuit of Fig. 2, may be substituted for V_7 with acceptable results. If, on the other hand, the audio signal is to be fed to a separate amplifier, it may be taken direct from C_{25} ; but a better arrangement would be to fit in place of V_7 , a cathode follower stage as in Fig. 3, so that the signal can be carried at low impedance to any desired distance without high frequency loss.

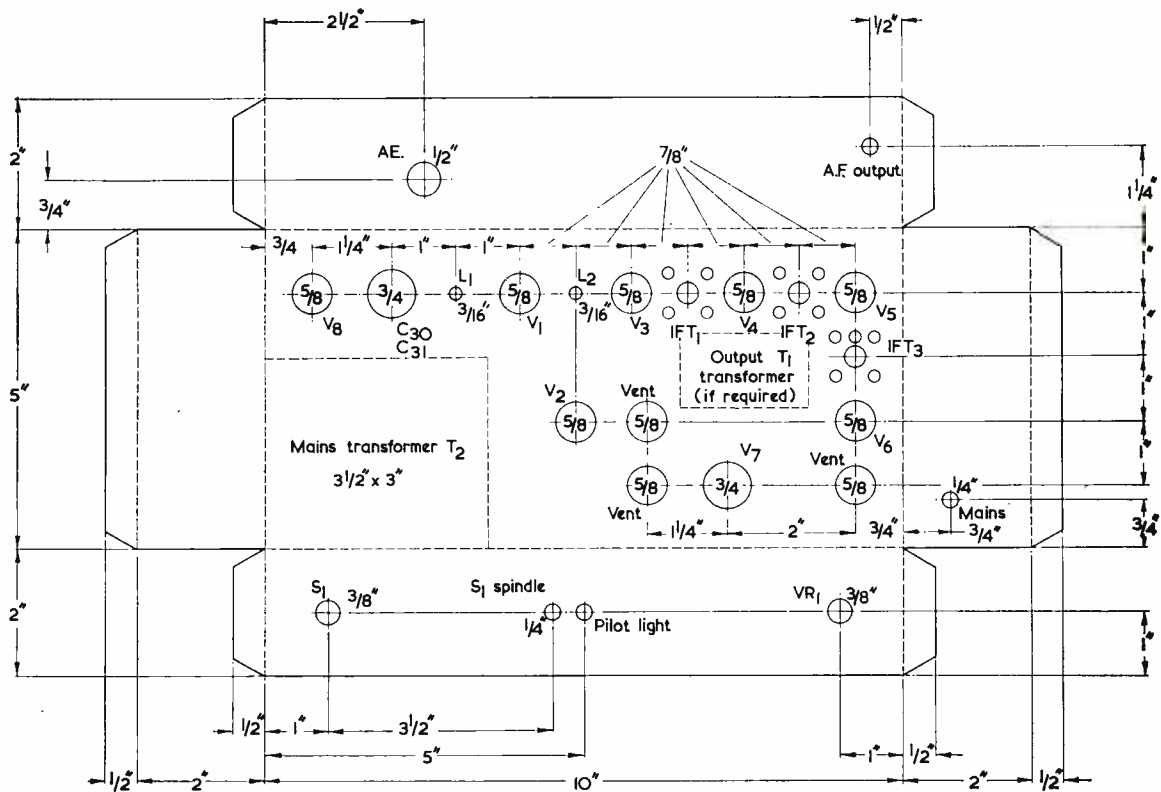


Fig. 4. Plan view of the chassis showing the location of the principal components, the positions of the mains and output transformers being indicated by the dashed outlines. The location of L₃ is shown in Fig. 9. Also shown in Fig. 9 is the orientation of the valveholders. The diameter of the hole for the pilot lamp may be made to suit the particular lamp assembly employed, it being remembered that clearance for S₁ spindle is needed. In the prototype, the lamp passes through a rubber grommet

Power Supply

The mains transformer in the prototype is rated at 250V 80 mA and 6.3V 3A. These ratings will be suitable (so far as h.t. is concerned) for a complete receiver using the ECL82 output valve, but if a tuner only is being constructed, a 60 mA transformer will suffice. Full-wave rectification is by valve, 6X4, and it will be seen that its heater is connected in parallel with those of the other valves.¹ If the transformer has a separate rectifier heater winding, it is better to use it and so avoid the large difference of potential between heater and cathode. Smoothing is by resistor R₂₅ in conjunction with electrolytic capacitors C₃₀ and C₃₁. The value of R₂₅ will of course, require adjustment according to the load current, taking into account the constructor's modifications to the a.f. circuits. Mains switching is incorporated with VR₁.

¹ The 6X4 requires a minimum supply resistance per anode, at 250 volts r.m.s., of 330Ω, and this resistance should normally be present in the windings of the mains transformer. Constructors should measure the d.c. resistance of either half of the h.t. secondary and add to this the d.c. resistance of the primary. If the resultant sum is less than 330Ω, additional resistors should be inserted in series with each anode of the 6X4 to bring the supply resistance up to this figure.

Construction

The unit is constructed on a chassis of 16 s.w.g. aluminium sheet, 10×5×2ins, details of which are given in Fig. 4. Good ventilation is important and it will be seen that a number of vents are provided in the deck of the chassis for this purpose. The programme selector switch must, for electronic reasons, be sited close to V₂ and in order that the external controls may be presented symmetrically to the user, the switch control is transferred 3 1/2in to the left by a mechanical linkage made from strips of 18 s.w.g. brass. Details of this are given in Fig. 5, while Fig. 7 shows the aluminium bracket on which the switch itself is mounted.

Screens are required across the bases of V₁ and V₃ to separate the input circuits from the output. These are made from one piece of sheet aluminium as shown in Fig. 6 and secured by a single bolt to the rear chassis runner. Correct orientation of the valve bases is of course, essential, and the necessary information is given in Fig. 9.

Coils

Coils L₁, L₂, and L₃ are wound anti-clockwise

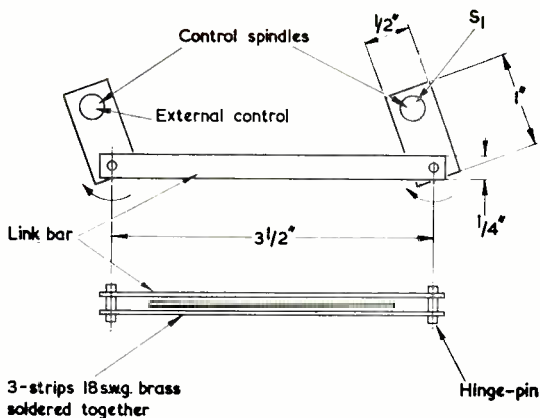


Fig. 5. The switch control linkage

on formers of 0.276in diameter. The number of turns for each winding and the wire to be used are given in Fig. 8. The wire should first be straightened by stretching and then close-wound on to a piece of 1/4in rod, putting on an extra turn. Remove the rod and slip the coil on to the former, where it will be a tight spring fit. The turns should then be adjusted for number and spaced out by one wire diameter, after which a coat of clear cellulose or cellulose cement will ensure that they do not move. It is a good idea to make the secondary of L_3 $1\frac{1}{2}$ turns so that half a turn is available for adjustment when the testing stage is reached; it is easier to subtract than to add!

Crystals

The crystals, type 2MM, are supplied to order in small hermetically-sealed cans with wire ends for soldering directly into circuit. They are manufactured to a tolerance of $\pm .015\%$ of the nominal frequency and a much closer tolerance on the difference between any two of a set. The number required should therefore be ordered as a set, stating the transmissions to be received and the intermediate frequency required, i.e. 10.7 Mc/s below the transmission.

Other components

The wattage and voltage ratings for resistors and capacitors are given in the components list

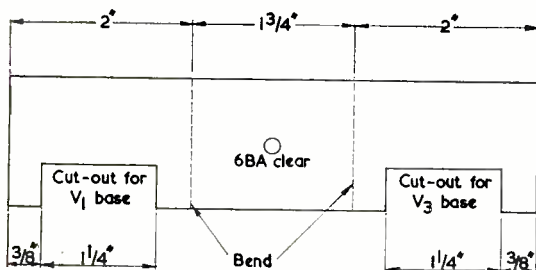


Fig. 6. The under-chassis screen

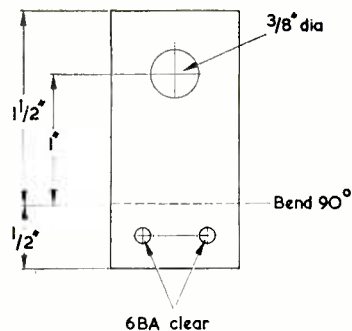


Fig. 7. The bracket on which switch S_1 is mounted

and the type of capacitor to be used in each case. It is important to adhere to this specification. Resistors R_{17} and R_{18} in the detector circuit should be matched as closely as possible. Valve bases should be ceramic or nylon loaded so as to reduce the positive temperature co-efficient to a minimum.

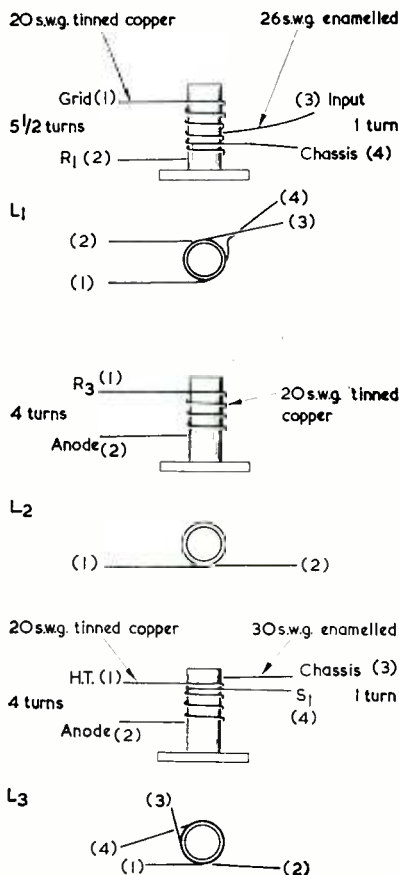


Fig. 8. Details of coil construction

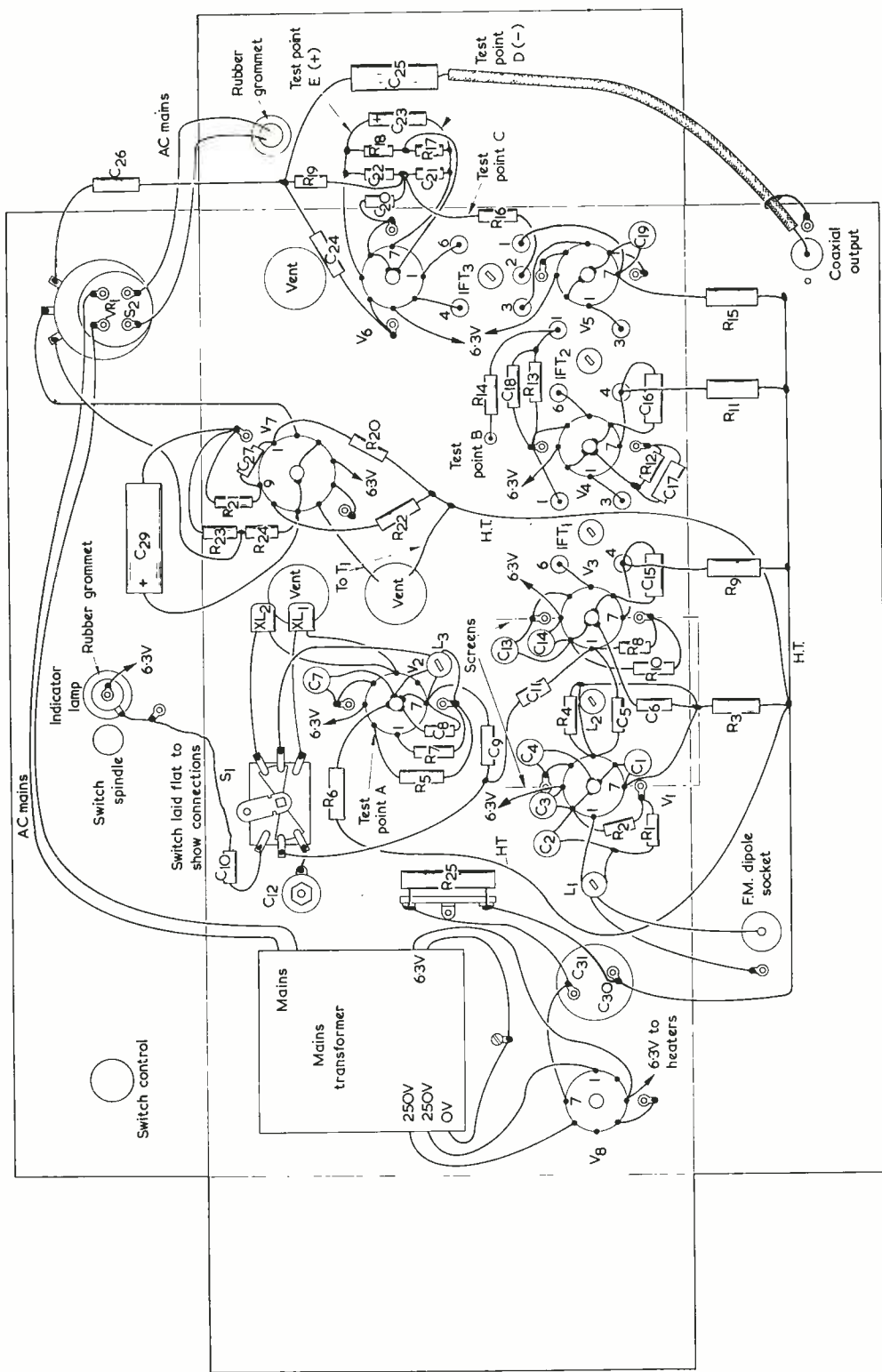


Fig. 9. Underchassis wiring diagram. The a.f. section corresponds to the ECL80 circuit of Fig. 1. C₂₈ is mounted on the output transformer tags, above the chassis. Before wiring to S₂, identify the correct switch tags with an ohmmeter. It should be noted that the centre spigots of some of the volholders are not connected direct to chassis (although they are at chassis potential for r.f. or a.f.) and are used as anchor tags

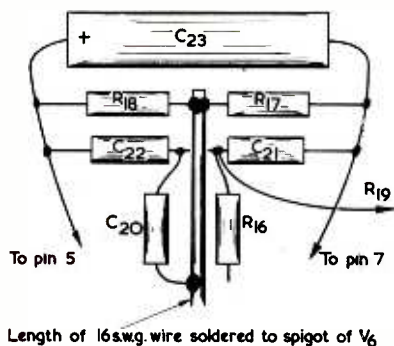


Fig. 10. Detail showing the construction of the detector component sub-assembly at V_6

Wiring

Tinned copper wire of 22 s.w.g., covered with Systoflex, is suitable for all the wiring, which can be completed in any desired order. The connections to be made and the approximate positions of the components are shown in Fig. 9. Here, the wiring has been "opened out" for clarity; in construction it is important to follow v.h.f. technique and reduce all connections to absolute minimum length. This is particularly important in the early stages and it will be found that few wires, other than the h.t. and heater lines, need be longer than $\frac{1}{8}$ in if the specified components are used. Decoupling resistors should be mounted vertically so that, when all else is complete, the h.t. line can be run round to each in turn, well away from the "hot" parts of the circuit where it will not be likely to introduce unwanted coupling between stages. Fig. 10 shows in elevation how the detector sub-assembly is mounted on the base of V_6 .

Testing

When the wiring is complete, the usual check should be made with a meter applied between C_{31} and chassis to see that there are no short-circuits in the h.t. wiring. After this, power can be applied and further checks made to verify that voltage is present at the appropriate valve electrodes.

I.F. Alignment

If a signal generator is available, it is best to commence by aligning the i.f. and detector transformers to 10.7 Mc/s as follows. Remove V_2 and connect a high resistance d.c. voltmeter (20,000 ohms per volt or better) positive to chassis and negative to test point B (Figs. 1 and 9). Set the generator to 10.7 Mc/s and inject an unmodulated signal at the grid of V_4 . Adjust the cores of IFT_2 for maximum reading on the meter, reducing the input as the circuits come into line. Transfer the generator to the grid of V_3 and adjust the cores of IFT_1 similarly. To align the ratio detector transformer, IFT_3 , connect the meter to test points D and E, observing polarity, inject a signal at the grid of V_5 and adjust the top core of the trans-

former for maximum indication. Then connect the meter between test point C and chassis and adjust the bottom core for zero output. As this core is traversed through the former, the meter reading will be observed to rise to a maximum, then fall through zero to a reverse maximum, then back to zero. The correct position for the core is the zero between the two maxima. These adjustments need not be made with very great accuracy because the final alignment must be carried out on the i.f. produced by the crystals.

Oscillator Alignment

To set up the oscillator, replace V_2 , connect a dipole aerial (and an a.f. amplifier if a tuner only is being constructed) and set the programme switch to the highest frequency transmission. Commence with the core of L_3 halfway out of the former and enter it slowly until the required programme is received. Do not be alarmed if there is a little distortion, as the final i.f. alignment will correct this. Further movement of the core will increase the volume very slightly until the point is reached where the crystal loses control and reception ceases. Adjust the core to a position just before that at which control is lost. Set the programme switch to the next lower frequency transmission and, commencing with trimmer C_{12} at minimum, increase its capacitance slowly till the programme is received and lost. Adjust as before to a point just short of loss of control. Adjust any further channels similarly.

The behaviour of crystal controlled oscillators can be a little puzzling to those not familiar with them. The crystal must be supplied with just the right amount of drive from the tuned circuit. If there is not enough, there will be no oscillation; if too much, the tuned circuit will itself take charge and will behave as if the crystal were absent. In the former condition, there will be no reception; the latter condition will be recognised by the fact that several different transmissions can be received

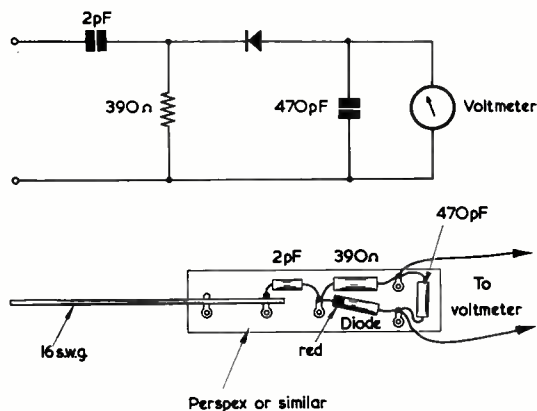
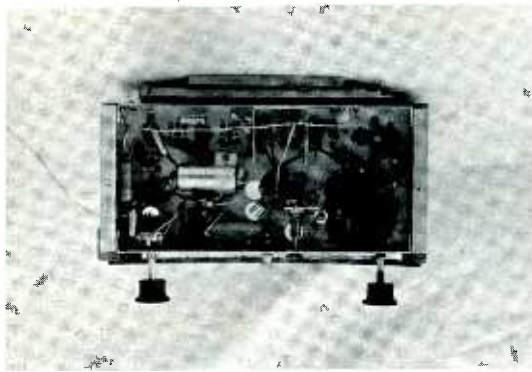


Fig. 11. The circuit and construction of a suitable v.h.f. probe. This may be required if a 10.7 Mc/s signal generator is not available



An under-chassis view of the receiver, showing the neat layout employed

by manipulation of the core of L_3 . If the secondary of L_3 has been given $1\frac{1}{2}$ turns, it is likely that there will be a little too much drive. In this case the extra half turn can be removed, a little at a time, by pulling the wire carefully away from the former until the right condition is found.

Final I.F. adjustment

Though the error will be small, the i.f. produced by the crystals with a broadcast signal will probably not be exactly that to which the i.f. circuits have been aligned with the generator. When the oscillator has been set satisfactorily, therefore, the i.f. and detector transformers must be finally adjusted with the aid of the meter as already described, using the crystal i.f. in place of the generator signal.

R.F. Alignment

With the negative meter lead connected to test point B, and positive to chassis, adjust the core of L_1 for maximum reading on the lowest frequency transmission and the core of L_2 for maximum on the highest.

Alignment without a generator

Alignment can be carried out quite satisfactorily

without a signal generator if one of the crystals is first brought to resonance. With a dipole aerial connected, apply the v.h.f. probe of a high resistance voltmeter to test point A and enter the core of L_3 slowly into the former. As resonance is approached, the meter reading will be observed to rise slowly to a maximum, after which it will fall abruptly to zero as control is lost. Adjust the core to a position just before that at which control is lost. The circuit and method of construction of a simple probe which can be used in conjunction with a 20,000 ohms per volt meter is given in Fig. 11.

Having successfully resonated one of the crystals, the i.f. and detector transformers can be adjusted as already described.

Operation

The prototype was fitted in a polished plywood cabinet $12 \times 8 \times 6$ ins, together with a small pilot speaker. Entirely satisfactory results were obtained at 40 miles from the transmitter, using a simple indoor dipole. Provided with a normal outdoor dipole and reflector, the unit would no doubt perform well in a fringe reception area. One minor fault appeared in service when it was found that, despite generous under-chassis ventilation through holes in the bottom of the cabinet, the temperature rise after six hours continuous operation in a high ambient temperature was such that the crystals were unable to retain control. The temperature rise was reduced by moving resistor R_{25} to a position above the chassis and replacing V_8 by a pair of silicon diodes.² No further trouble has been experienced in two years' service.

In the less arduous conditions of domestic use, the trouble just mentioned is unlikely to appear but, if the unit is to be used under conditions of limited ventilation, it would be prudent to re-position resistor R_{25} .

² The silicon diodes could be type BY100. Care should be taken, when using these diodes, to ensure that the nominal h.t. secondary voltage does not exceed 250 volts (as would occur if the mains tapping to the primary were set too low).—EDITOR.

Sudbury BBC-2 Station

The BBC has placed a contract with Bailey & Goates Ltd., of Sudbury, Suffolk, for the construction of the building for the UHF transmitting station which is to be built some three miles south-east of the town.

The Sudbury station is one of the first group of high-power stations for BBC-2, which it will transmit on Channel 44 with horizontal polarisation. It is expected that the service from Sudbury will start during the autumn of 1967. The area served will extend over the southern part of Suffolk, including Sudbury, Hadleigh, Ipswich and Felixstowe, and most of northern and eastern Essex including Braintree, Colchester, Harwich, Clacton-on-Sea, Frinton, Walton-on-the-Naze, Witham and a large part of Chelmsford.

In Your Workshop

This month Smyth the Serviceman, aided as always by his able assistant, Dick, embarks on a discussion of the ingenious circuits which appear in the sound channels of current 405-625 line TV receivers

FOR THE TENTH TIME THAT morning, Dick switched the dual/standard TV chassis on his bench to 625 lines and, for the tenth time that morning, the Workshop was inundated with the raucous sound of a 50 c/s field buzz. Smyth gritted his teeth.

Dick switched back to 405, and the air became full of melody as the music which accompanies Test Card D was reproduced by the loudspeaker. Dick scratched his head uncertainly, then returned to 625 lines, turning the volume control to full as he did so.

Again, the Workshop was flooded with the harsh nerve-rending buzz.

Stabilising Capacitor

It was too much for Smyth. Furiously, the Serviceman crashed his iron down on its rest, stood up and stalked over to his unsuspecting assistant. He lowered his head until his mouth was some three inches from Dick's right ear.

"For the love of Mike," he roared, over the noise, "turn that racket down!"

Even Smyth was mildly surprised at the reaction to this request. The completely engrossed Dick, shattered out of his preoccupation by the unexpected Stentorian bellow, swung his head wildly to the right to find a baleful eye poised several millimetres away from his own. Had *The Radio Constructor* been quite a different type of journal and our readers Eskimos the fact that the noses of Dick and Smyth then rubbed together for a fleeting instant could well have heralded a passage which, in the days when authors made a living the easy way, ended in a neat row of asterisks printed across the page. But the present circumstances were not at all conducive to that sort of malarky, and the only asterisks which could

enter a description of subsequent events would be ascribed to the comments of Dick as, under the unexpected stimuli of sound, sight and touch, he shot up from his stool, tripped over his soldering iron lead and fell heavily to the floor.

Smyth looked down at him meditatively, then reached over and turned off the chassis on Dick's bench. Relative silence returned to the Workshop, broken only by the mutterings of Smyth's assistant as he lay prone on the floor. Eventually, Dick picked himself up, and began a lengthy and involved examination for broken bones.

"You must," he said bitterly at length, "be stark staring bonkers. Goodness knows what damage I've done to myself."

"If I *am* bonkers," replied Smyth equably, "it's because you've made me that way. All you've done this morning is pump out 50 cycle buzz at full blast, with the result that it's only my innate self-control which has prevented me from going completely up the wall."

"At any rate," retorted Dick accusingly, "I don't go around shouting down peoples' lug-holes like you do. Blimey, I reckon I must be stone-deaf on the right hand side after what you did just then."

He applied a finger tip to his left ear and listened intently as he experimentally tapped a screwdriver on his bench.

"Well," he remarked reluctantly, "my right ear doesn't seem to have *completely* broken down. No thanks to you, though!"

Smyth decided to steer the subject to a safer channel.

"Why," he asked, "were you kicking up that din, anyway?"

"I," pronounced Dick, "have got a fault."

"You have," replied Smyth without hesitation, "many."

"The fault," continued Dick acrimoniously, "is in this TV here. Every time I switch it to 625 lines and tune in the local BBC-2 station I get a dirty great buzz on sound."

"Have you," asked Smyth, "checked the stabilising capacitor in the discriminator circuit?"

An expression of doubt passed over Dick's face.

"Well," he said, a little uncertainly, "I haven't exactly done *that*."

"Also," went on Smyth, "have you checked the resistors in series with that stabilising capacitor? Usually, one of these is a pre-set skeleton pot and you could find an open-circuit there."



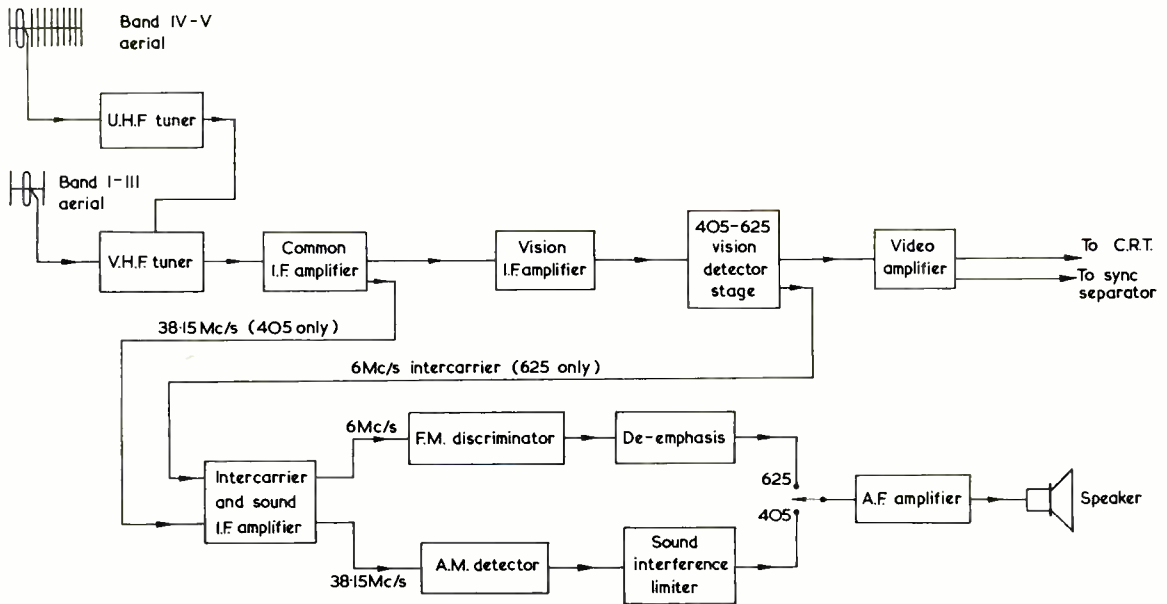


Fig. 1. Block schematic diagram showing the signal-handling sections of a 405-625 television receiver. Circuit operation, including i.f. response switching, is discussed by Smyth

Dick looked uncomfortable.

"I must admit," he said unhappily, "that I haven't got quite as far as doing that yet."

"Then what in blazes," asked Smyth irritably, "have you done?" "Nothing very much in particular," replied Dick miserably.

There was silence for a moment. "To tell you the honest truth," confessed Dick suddenly, "I'm not altogether certain where I should even begin with this particular snag. These 405-625 sets aren't anything near as easy as the old 405-only jobs were, and I haven't got entirely used to the things that go on inside them. I did get the service sheet out, but the only thing they've forgotten to include in the circuit diagram is the new Victoria Line!"

"Some of the 405-625 TV circuits," admitted Smyth, "are a wee bit complicated at first sight. But it's only because of the 405-625 switching. I suppose I'd better give you some background on the circuit of this receiver so that I can get you started off in the right direction. Otherwise, you'll be messing around with it for ages."

Forgetting his recent injuries, Dick leaned forward eagerly and pulled the service manual, open at the circuit diagram, to the front of the bench. Smyth cast an experienced eye over it.

"Well, this," he said, "represents

quite a standard set-up so far as the line-up of the individual sections in the receiver are concerned. (Fig. 1). You've got separate u.h.f. and v.h.f. tuners, with the output of the u.h.f. tuner going into the v.h.f. tuner. The u.h.f. i.f. output is applied to the mixer in the v.h.f. tuner when the channel selector in the latter is set to the appropriate position. This setting also stops the v.h.f. oscillator from running, whereupon the v.h.f. mixer acts as an i.f. amplifier, giving you an extra stage of i.f. amplification when you're receiving u.h.f. signals."

405-625 I.F. Layout

"That," commented Dick, "is fair enough. What happens after the tuners?"

"You then," said Smyth, "enter the i.f. section of the receiver. Which, I will agree, has a lot more gubbins in it than you'll encounter in a 405-only i.f. strip. The first thing to remember is that, on 405 lines, the standard vision carrier i.f. is 34.65 Mc/s and the standard sound carrier i.f. is 38.15 Mc/s. On 625 lines the standard vision carrier i.f. is 39.5 Mc/s and the standard sound carrier i.f. is 33.5 Mc/s."

"On 405 lines," interjected Dick, "the sound carrier i.f. is above the vision carrier i.f. On 625 lines it's below the vision carrier i.f."

"That's right," agreed Smyth. "And the consequence is that some pretty crafty switching of tuned circuits is fitted in the vision i.f. strip of a 405-625 set since it has to accommodate these two quite different sets of frequencies for the two standards. It's impossible to generalise on the switching circuits used here because they vary considerably from make to make, but most sets follow the same overall pattern. This consists of applying the i.f. output from the v.h.f. tuner to a common i.f. amplifier employing a single valve. On 405 lines this amplifies both 34.65 and 38.15 Mc/s signals and on 625 lines it amplifies both 39.5 and 33.5 Mc/s signals."

"That's the same basic idea," interjected Dick, "as you get in 405-only sets. You usually have a common i.f. amplifier in these sets, and this handles both the 34.65 and the 38.15 Mc/s i.f. signals."

"Exactly," agreed Smyth. "A further similarity is that, in the 405-625 set, a sound i.f. output is taken off at 38.15 Mc/s after the common i.f. amplifier when you're switched to 405 lines, and is passed to the sound i.f. amplifier. The remainder of the signal is then fed to the vision i.f. amplifier."

"What about the 33.5 Mc/s sound i.f. on 625 lines?" asked Dick. "Isn't that taken off after the common i.f. amplifier?"

"No," stated Smithy, "and this is for a very good reason which I'll explain to you in a minute. The vision i.f. amplifier in these 405-625 sets usually employs a single valve and, when you're switched to 405 lines, it amplifies the 34.65 Mc/s vision carrier i.f. and its modulation sidebands in the same way as in a 405-only set. When the 405-625 receiver is switched to 625 lines the second vision i.f. amplifier handles the 39.5 Mc/s vision carrier i.f. and the 33.5 Mc/s sound carrier i.f., and it feeds *both* of these to the vision detector. I should add that, on 625 lines, the overall i.f. amplification given to the 33.5 Mc/s sound carrier i.f. is by no means as great as that given to the vision carrier i.f. and its sidebands. Nevertheless, the 33.5 Mc/s signal is fed to the vision detector at quite an appreciable level."

"Well, I'm dashed," said Dick suddenly. "Of course it is! That's so that you can get your 6 Mc/s intercarrier sound signal. Why, I'd almost forgotten about the fact that you use intercarrier sound on 625 lines."

Smithy cast a despairing glance at the ceiling.

"I must confess," he remarked eventually, "to a *slight* raising of the spirit at the thought that, after all the 405-625 sets that have passed through your hands in the last year or two, you've actually remembered that they use intercarrier sound."

"I also remember," said Dick proudly, "how the intercarrier system works, too. If you apply two frequencies to an a.m. detector, you get a beat frequency equal to the difference between them. It's the same effect as you have with the b.f.o. in a short-wave superhet. If you tune in a short-wave signal so that its carrier passes into the receiver i.f. at, say, 460 kc/s, then set the b.f.o. to run at 459 kc/s, you get a 1 kc/s beat note with the received carrier. In the 625 line case you feed a 39.5 Mc/s and a 33.5 Mc/s signal to the vision detector, whereupon you get a 6 Mc/s beat in the detected output. And that 6 Mc/s is the intercarrier signal."

"Well, you've got that off pat enough," said Smithy, a note of reluctant approval entering his voice. "The 6 Mc/s beat is, of course, heavily amplitude modulated by the vision signal as well as being frequency modulated by the sound signal. So you've got to remove the amplitude modulation if you're to reclaim the frequency modulation and reproduce it over the receiver loudspeaker. With the set you've

been tormenting me with this morning, it's obvious that the amplitude modulation was not being removed, and that it was sailing right through to the audio amplifier stages."

Intercarrier Advantages

But Dick was more interested in Smithy's explanations than in the receiver on his bench.

"What," he asked, "is the point of using this intercarrier system, anyway? As I suggested just now, why not simply take off the 33.5 Mc/s sound i.f. after the common i.f. amplifier and pass it on to a 33.5 Mc/s i.f. amplifier?"

"The intercarrier system," replied Smithy, "has several advantages over the alternative system you've just suggested, and which make it more attractive for the set-maker. To start off with, the intercarrier signal obtained at the vision detector

is at a high level, this being achieved without using any more amplifying stages than are needed for the vision i.f. in the first place. Also, it's possible to get quite a bit more amplification at negligible extra cost by passing the intercarrier signal through the video amplifier as well. A second advantage is that the intercarrier frequency is fixed by the broadcast carriers put out at the transmitter. No matter how much the tuner unit oscillator drifts off frequency, and provided that both vision and sound carrier i.f.'s arrive at the vision detector, that intercarrier beat stays rock-steady at 6 Mc/s. Apart from the frequency modulation that's on it, of course."

"Doesn't tuner drift," asked Dick incredulously, "have any effect on the intercarrier frequency at all?"

"Nary," replied Smithy, "a sausage. The tuner unit u.h.f.

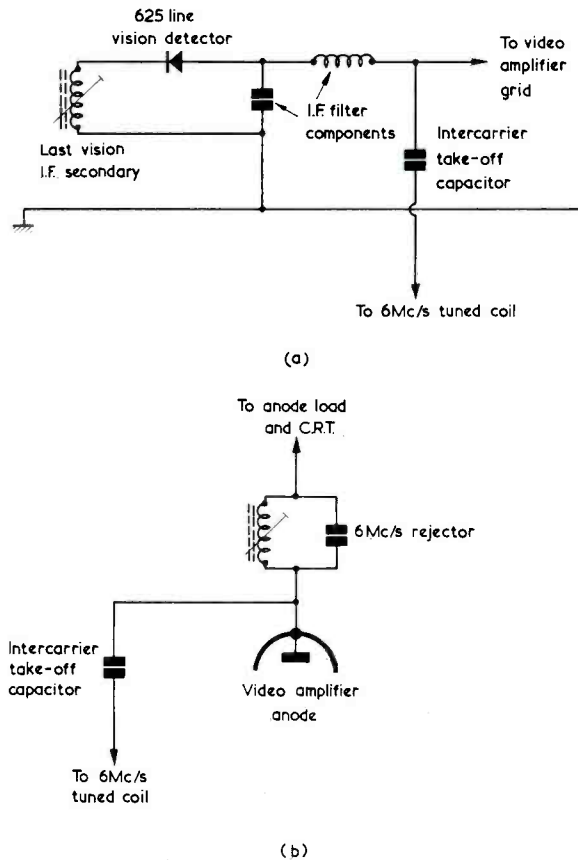


Fig. 2 (a). Simplified circuit (with 405-625 switching omitted) showing how the 6 Mc/s intercarrier signal is taken off after the 625 line vision detector (b). The intercarrier signal may, alternatively, be taken off at the video amplifier anode

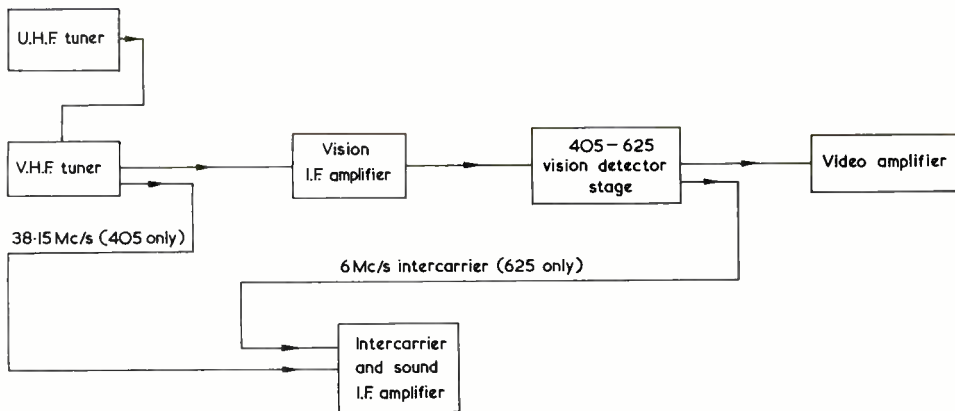


Fig. 3. Some 405-625 receivers do not have a common i.f. amplifier, whereupon the interconnection between sections takes the form shown here. The remainder of the line-up is the same as in Fig. 1

oscillator runs higher than signal frequency, so let's assume that it drifts half a megacycle high. The difference frequencies will then similarly increase by half a meg, so that the vision carrier will come out at 40 Mc/s and the sound carrier at 34 Mc/s."

"Blow me," said Dick, impressed. "I see what you mean now. Whatever happens to the oscillator frequency, the intercarrier frequency always appears exactly at 6 Mc/s."

"Provided," repeated Smithy, "that both the vision and sound carrier i.f.'s appear at the vision detector. Which brings in the further advantage that, since the intercarrier frequency is fixed, the circuits which amplify it and recover its modulation can be designed to give optimum performance at that particular frequency."

"How do you take off the inter-carrier signal?"

"There are several methods," replied Smithy. "But the most usual one these days seems to consist of taking it off by way of a low puffage capacitor. This capacitor can appear after the vision detector (Fig. 2(a)) or after the video amplifier (Fig. 2(b)), the capacitor normally having a value between 3 and 5pF. There'll be a 6 Mc/s rejector circuit after the take-off point to prevent the 6 Mc/s beat appearing on the screen. When the take-off point is at the anode of the video amplifier, the rejector circuit usually follows immediately afterwards."

Sound I.F. Amplifier

"I seem," said Dick happily, "to be picking up quite a good bit of gen this morning. I like these general theory seshes."

"I'm afraid," commented Smithy, "that the present general theory sesh is now about to come to an abrupt close. The only further thing I want to say is that, in some 405-625 receivers, you don't have a common i.f. amplifier immediately following the v.h.f. tuner. The 38.15 Mc/s 405 line sound i.f. is, instead, taken off immediately after the v.h.f. tuner, whereupon it is applied to the sound amplifier. (Fig. 3). However, everything else remains the same and you still have intercarrier working and a sound amplifier handling both the 38.15 Mc/s i.f. and the 6 Mc/s intercarrier signals. In this case the sound amplifier normally has two valves. In the previous case, where we had the common i.f. amplifier, the sound amplifier normally has one valve. And that, me old mate, is the end of general theory for this morning."

"Well, that's a nice approach, I must say," complained Dick bitterly. "After first of all scaring the wits out of me by bellowing down my earhole and then getting me all geed-up on 405-625 sets, you next proceed to drop the subject flat. What's more, you do so just when we're getting to the really interesting bit."

"To wit?"

"To what?"

"To wit?"

"Gosh, Smithy," said Dick, daunted, "I think you really are going doolally!"

"All I said," remarked Smithy irritably, "was 'to wit'."

"To whoo!"

"There are times," Smithy sighed, "when an impenetrable barrier seems to rise up between you and me,

rendering it completely impossible to communicate by way of speech. If you think I'm trying to do Percy Edwards out of a job by saying 'to wit', let me try a different approach. What is the burden of your complaint?"

Dick gathered his thoughts.

"I was complaining," he replied, "at your ending our natter on 405-625 general theory just as we'd got to the bit that's of greatest interest to me."

"And what is that?"

"The fault in this set on my bench," said Dick promptly. "You've already told me that the 6 Mc/s intercarrier signal is heavily amplitude modulated by the vision carrier when it's applied to the inter-carrier amplifier section. And I now see that, with this set, that vision carrier is not being removed in the intercarrier amplifier as it should be."

"Neither is it," confirmed Smithy. "Now, when I said just now that I was going to call it a day on general theory, I meant that I was about to get down to something a bit more practical, instead. In other words, I'm going to help you clear the snag on this set."

"Ding-dong," said Dick, pleased. "Just the job! Where do we start?"

"The first thing to do," replied Smithy, "is to have a shufti at the circuit of the sound i.f. and intercarrier amplifier of the receiver."

He pulled the service sheet towards him and examined the circuit section in question. (Fig. 4).

"Excellent, excellent," he remarked cheerfully, "you couldn't have anything simpler than this."

Dick's jaw dropped open.

"Simpler?" he repeated unbelievably. "You call *that* simple?"

"Of course it's simple," said Smithy, "as you'll soon see if we trace it through. I'll start off with the two switches set to the '405' position. The 38.15 Mc/s sound carrier i.f. is fed to L₂₂ and C₈₅, which are tuned to that frequency, and thence to the grid of the pentode. This amplifies in the usual way and the signal on its anode is applied to the primary of the 38.15 Mc/s transformer and to the primary of the 6 Mc/s transformer. Having the two windings in series is just the same idea as having 465 kc/s and 10.7 Mc/s i.f. windings in series in an a.m./f.m. sound receiver. In this instance only the 38.15 Mc/s winding responds to the signal at the pentode anode, and this frequency is applied to the a.m. detector, D₁. An a.g.c. voltage is fed back to the grid of the pentode via R₇₈, and you'll note that this a.g.c. circuit applies to 405 line reception only. The detected a.f. is next passed to a standard sound interference limiter given by R₈₈, D₄, R₈₉ and C₉₉. Normally, D₄ is held conductive by R₈₈ and R₈₉, whereupon it

simply passes on the detected a.f. to the following volume control. At the same time, the detector, D₁, is connected into circuit with a polarity which causes detected interference pulses to be negative-going. If a strong interference pulse is received, therefore, the upper terminal of diode D₄ goes highly negative. The lower terminal of D₄ also tries to go negative but is restrained from doing so at the same speed as the upper terminal because C₉₉ is relatively slow to discharge. The pulse will have come to an end before the lower terminal of D₄ has made any large negative excursion, with the result that D₄ is cut-off during most of the pulse. In consequence, only a very small amount of the pulse is passed to the subsequent a.f. amplifier and its audible effect is considerably reduced. Is that little bit O.K.?"

"Sure," said Dick. "That interference limiter circuit has been used for years now; in 405-only sets as well as in 405-625 ones."

"Good," commented Smithy briskly. "All that remains to be

said is that the detected a.m. signal, after passing through the interference limiter, is then fed to the volume control and the usual triode-cum-pentode a.f. amplifier you find in TV receivers. Let's now see what happens when we switch to '625'."

Smithy picked up a screwdriver and indicated the two switch sections concerned.

"The first thing," he continued, "is that the 6 Mc/s intercarrier signal is applied to coil L₂₃. This, in company with the series capacitance to the take-off point and stray capacitances, resonates at 6 Mc/s. There is no a.g.c. now, and the 6 Mc/s signal is passed to the pentode grid via C₈₇ and R₇₇. The signal amplitude will be greater than the cathode bias of the pentode, whereupon the pentode acts as an a.m. limiter, R₇₇ and C₈₇ being the associated grid leak and capacitor. You'll find a grid leak and capacitor at this point in other receivers, too, these similarly allowing the valve to function as a limiter. In some sets the screen-grid voltage is reduced on 625 lines,

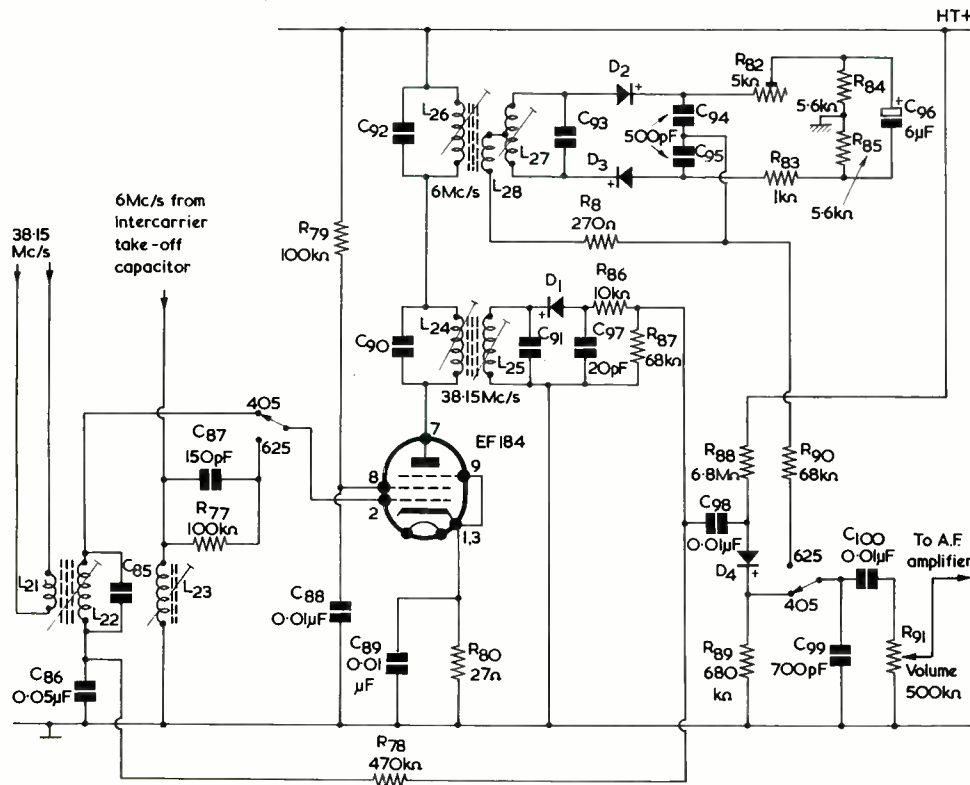


Fig. 4. A 405-625 sound i.f. and intercarrier amplifier, which is representative of current design and practice. (It is assumed that component suffix numbers below those shown here appear elsewhere in the receiver circuit)

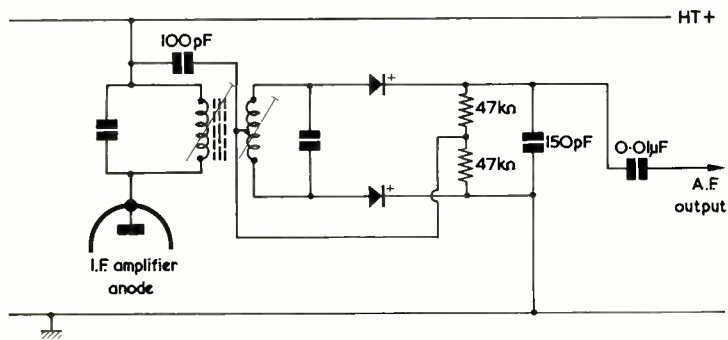


Fig. 5. The basic phase discriminator circuit with representative component values. The i.f. amplifier valve will normally be a limiter. The circuit may be readily differentiated from the ratio discriminator due to the diode polarity and the absence of a stabilising capacitor

thereby reducing the grid base of the pentode and making it more effective as a limiter. The limiting offered by the valve is not perfect, partly because of the heavy amplitude modulation on the intercarrier signal given by the vision signal, and further limiting has to be carried out by the discriminator circuit. The majority of 405-625 receivers use a ratio discriminator for the intercarrier signal, and that is what has been done here. The ratio discriminator diodes are D_2 and D_3 ."

"Hey," interrupted Dick. "Hang on a jiffy! How can you be so confident that it's a ratio discriminator? Why couldn't it be a phase discriminator? That's got two diodes, too."

Smithy chuckled.

"Apart from the point," he said, "that a phase discriminator doesn't give any amplitude limiting and so wouldn't be used in the present application in any case, there is the fact that either circuit possesses features that make it stand out a mile in circuit diagrams. The ratio detector has two diodes facing in opposite directions, as occurs in the circuit in our service manual, whereas the phase discriminator has two diodes facing the same way. (Fig. 5). Another feature is that the ratio discriminator has an electrolytic stabilising capacitor, the two diodes being connected with a polarity that causes signal voltage to charge it. The stabilising capacitor will normally have a value of some 4 to 10 μ F, and it's C_{96} in our service manual circuit. It's the stabilising capacitor which causes the ratio discriminator to have its limiting action, by the way."

"Is it?" asked Dick. "How does it do that, then?"

"It's a fairly simple process," replied Smithy. "If you look at the circuit diagram in the service manual you'll see that the 6 Mc/s intercarrier signal is applied to the primary of the discriminator transformer, L_{26} , which couples to the secondary, L_{27} . If, for the moment, we ignore R_{82} and R_{83} , we can see that the 6 Mc/s signal across the secondary feeds into the load resistance given by R_{84} and R_{85} in series, and into the stabilising capacitor, C_{96} . Now, if C_{96} were out of circuit the secondary would feed into the load resistance on its own and this, assuming constant forward resistance in the diodes, would provide a fixed measure of damping in the transformer circuit regardless of the input amplitude. When we add C_{96} , however, we get a different effect. When the input signal amplitude is constant C_{96} charges up to a steady voltage. If signal amplitude increases, however, an additional charging current flows into C_{96} , and this, so far as the transformer is concerned, is just the same as would occur if the load resistance were decreased in value. The transformer circuits suffer increased damping therefore, this counteracting the increase in signal amplitude. Similarly, if signal amplitude decreases, a discharge current flows from the capacitor, less current has to be provided by the discriminator transformer and it behaves as though it had an increased load resistance. It suffers less damping and this counteracts the decrease in signal amplitude. The time constant in the load resistance and stabilising capacitor circuit is normally of the order of 0.06 to 0.1 seconds, which means that the circuit soon settles down to an average input amplitude,

and limits amplitude modulation and impulsive interference above some 15 c/s or so."

"Why," queried Dick, "are R_{82} and R_{83} put into the circuit?"

"To get a really high level of a.m. limiting," explained Smithy in reply, "everything in the circuit has to be carefully balanced out. There are a lot of variables which can't be closely controlled, these including the coupling factor between the primary and secondary of the discriminator transformer, and tolerances on value in the load resistors and the stabilising capacitor. In consequence, the circuit is designed so that the effect of the stabilising capacitor and its load resistance is just right when a series resistance between, say, 2 and 5k Ω is inserted between the diodes and the stabilising and load circuit. The circuit is then finally set up for optimum limiting by adjusting this series resistance. In our own circuit the series resistance is given by R_{82} and R_{83} , and the final adjustment is given in R_{82} . If all is well, there should be enough range in R_{82} to take up all the variables and tolerances which appear elsewhere in the circuit and allow optimum limiting to be achieved. I should add that the optimum limiting only occurs at one frequency (Fig. 6), but this doesn't worry us in our present case because we are working with an intercarrier signal which is spot-on at 6 Mc/s. In practice, you normally adjust R_{82} for minimum field buzz on a broadcast TV signal."

Smithy paused for a moment.

"Well," he said, collecting his thoughts, "we've veered away a little from the immediate topic, which is the passage of the intercarrier signal through the sound amplifier. You'll recall that we applied the 6 Mc/s signal to the pentode grid whereupon, after the limiting this pentode gives on 625 lines, the signal appears across the primary of the 6 Mc/s discriminator transformer which, in company with its associated stabilising capacitor network, provides further limiting. The discriminated a.f. appears at the open end of the tertiary winding, L_{28} , and is passed to the volume control via filter resistor R_{81} , and series resistor R_{90} . R_{90} , in company with C_{99} , gives a 50 μ S de-emphasis circuit which bashes down the 50 μ S pre-emphasis which the B.B.C. boys stick onto the sound channel at the transmitting end."

Final Case

"Why, that's neat," exclaimed Dick appreciatively. "On 405 lines,

C_{99} is the time constant capacitor needed for the sound interference limiter."

"These 405-625 sets are full of cunning little tricks like that," replied Smyth. "Anyway, let's have a look at this one you've got here. Since one way of getting a ratio discriminator to detect a.m. is to take the stabilising capacitor out of circuit, let's examine that component first."

Smyth cast an expert eye over Dick's chassis, and located the ratio discriminator stabilising capacitor. He gave it a light exploratory prod with his finger.

Effortlessly, one end of the capacitor came adrift from the printed circuit board.

"Ye gods," snorted Smyth irately, "is *this* all that's wrong? Am I to understand that I've been wasting all this time just because you can't recognise a badly soldered electrolytic!"

Recognising the danger signs, Dick hurriedly rushed to the sink to fill the battered Workshop kettle and prepare the teapot, and as quickly rushed back to the receiver to re-solder the capacitor whose means of support was 50% below the norm. Thus it was that, later, the mollified Serviceman, smoothed in spirit by the sound of clear music from Dick's repaired receiver and

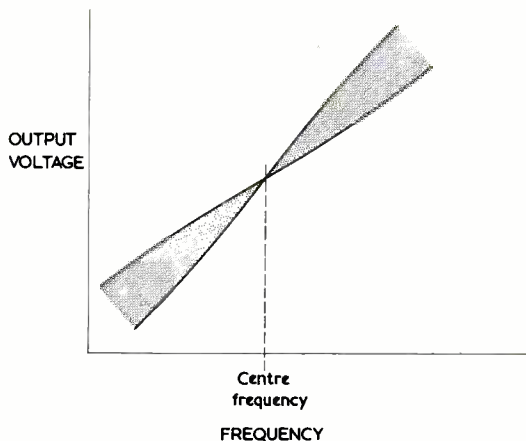


Fig. 6. If a signal which is simultaneously amplitude and frequency modulated is applied to a ratio discriminator, the discriminator output (as displayed on an oscilloscope running at the f.m. frequency) takes up the typical appearance shown here. The sloping line given by frequency discrimination widens on either side of the centre frequency due to the appearance of the amplitude modulation. In this case a.m. limiting is most efficient at the centre frequency

soothed in body by the life-giving properties of the precious fluid in the disgraceful mug at his side, gave vent to an expression of content with the world in general and with Workshop affairs in particular.

With a glance at the clock, Dick

decided that he'd give Smyth just another five minutes to ripen before he broached the subject of poor line linearity on 625 lines only. As occurred in the *other* 405-625 receiver he'd unsuccessfully attempted to repair that morning.

THE RHYTHM METHOD OF MORSE TUITION

We were very interested to be given the opportunity recently of trying out the Rhythm Method of Morse Tuition available from G3HSC, The Morse Centre, 45 Green Lane, Purley, Surrey.

G3HSC makes available to students wishing to learn the morse code, two specific courses:

The complete Course consists of three records, together with explanatory literature. There is a Beginners 12in L.P. record; and Advanced Students 12in L.P. record and a 7in E.P. Speed Check Record. All of these may be played at 33, 45 and 78 r.p.m., giving a great variety of morse speeds. This course, including postage (U.K.) costs £4 4s 0d.

The Beginner's Course consists of two records; a 12in Instruction record and one 7in E.P. recording simulating a G.P.O. amateur transmitting licence morse test. Together with instruction book, this course costs £3 0s 6d.

We found the teaching sequence logical and easy to grasp. As G3HSC states—"A book is read by eye; morse is read by the ear". "The interpretation of heard morse is entirely a matter of recognising rhythm".

The beginning of the Course provides the morse symbols clearly and definitely recorded and, by playing the early grooves over repeatedly, the student will rapidly memorise the sound of them. As one progresses through the records, new symbols are introduced and the speed is increased. Learning morse is, of course, a matter of constant practice but it is often difficult for the beginner to receive the signals which would cater for his needs. One cannot always easily find morse at the required speed on a radio receiver, nor can one always find a friend who is prepared to put in a lot of time giving practice on a morse buzzer.

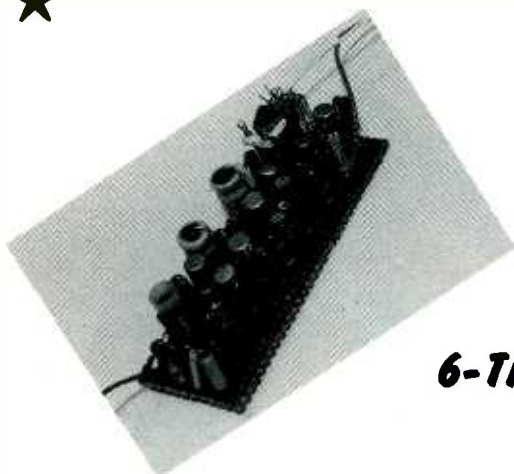
We felt that these records would be a great help to anyone wanting to learn the code and would also be much appreciated by the more experienced wishing to improve their speed of reception. They should be available in every radio club or school where morse is taught, for both class and individual tuition.



BASIC RADIO CONTROL

Part 3

By F. L. THURSTON



6-Transistor Receiver

This article, covering the construction of the super-regenerative receiver which is intended for use with the transmitter described last month, concludes this particular series of three articles. Further articles by the same author are planned and these will be appearing in the near future. They will continue the same theme by carrying on to the construction of more complex systems.

FOLLOWING LAST MONTH'S DESCRIPTION OF THE single channel "carrier" type transmitter, we now deal with a suitable receiver system. The receiver to be described has a six-transistor super-regenerative circuit, with a relay output.

The Receiver

The block diagram of the receiver is shown in Fig. 1. The signal from the aerial is fed into the super-regenerative detector stage, and the detected output is then passed on to the filter-amplifier circuit. In the absence of an input signal the output of the filter-amplifier consists of a great deal of noise, which falls to a very low level when a carrier signal is picked up by the aerial. The noise signal is rectified and smoothed, and the resulting d.c. is

used to bias a transistor "switch" in the Off position. In the absence of this noise, the bias voltage disappears and the switch turns On. The switch drives the output relay, which may then be used to operate an external circuit such as a motor or actuator, etc.

The full circuit diagram of the receiver is shown in Fig. 2. Dealing with the circuit in detail, the super-regenerative detector comprises TR₁, R₁, R₂, R₃, C₂, C₃, C₄, L₁ and L₂, with the aerial signal fed to the collector of TR₁ via C₁. Due to the feedback capacitor, C₃, from the collector to the emitter, the circuit is in a permanent state of oscillation, operating in the high a.f. or low r.f. range. In the absence of an input signal at the aerial this oscillator signal contains a great deal of noise while, if a signal is present at the aerial the oscillator signal is modulated

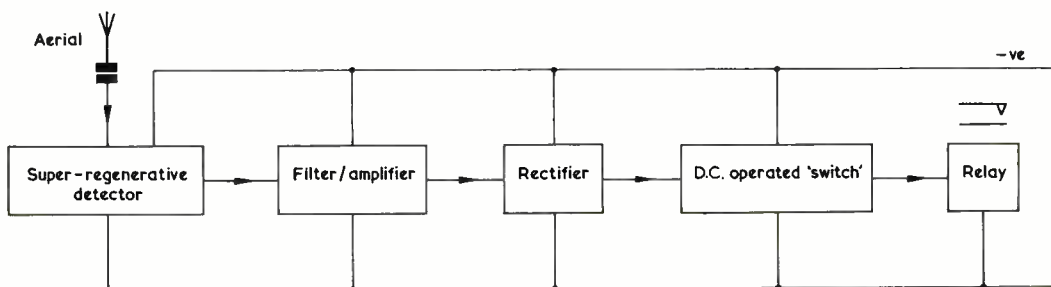


Fig. 1. Block diagram of the "carrier" type receiver

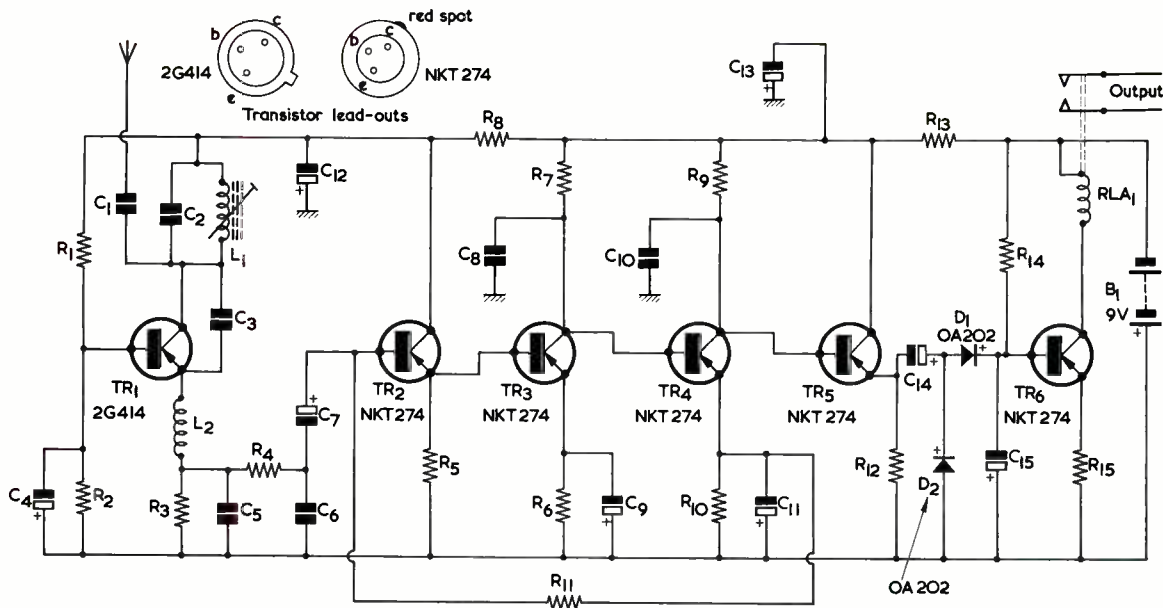


Fig. 2. The circuit of the super-regenerative receiver

Components List

Resistors

(All resistors $\frac{1}{4}$ watt carbon, 10%)

R ₁	22k Ω
R ₂	6.8k Ω
R ₃	6.8k Ω
R ₄	12k Ω
R ₅	4.7k Ω
R ₆	1k Ω
R ₇	4.7k Ω
R ₈	220 Ω
R ₉	4.7k Ω
R ₁₀	2.2k Ω
R ₁₁	47k Ω
R ₁₂	3.9k Ω
R ₁₃	1k Ω
R ₁₄	68k Ω
R ₁₅	22 Ω

Capacitors

(All capacitors sub-miniature, 9V wkg or greater. The prototype employed sub-miniature capacitors obtained from Newbury Radio (Forest Gate) Ltd., 274 Romford Rd., Forest Gate, London, E.7.)

C ₁	12pF
C ₂	12pF
C ₃	18pF
C ₄	2 μ F electrolytic
C ₅	0.002 μ F
C ₆	0.01 μ F
C ₇	8 μ F electrolytic
C ₈	0.01 μ F
C ₉	16 μ F electrolytic

C ₁₀	0.04 μ F
C ₁₁	16 μ F electrolytic
C ₁₂	50 μ F electrolytic
C ₁₃	50 μ F electrolytic
C ₁₄	2 μ F electrolytic
C ₁₅	1 μ F electrolytic

Inductors

- L₁ 11 $\frac{1}{2}$ turns of 24 s.w.g. enamelled wire, close-wound on Radiospares 0.27 in former, with iron-dust core.
- L₂ 100 turns of 36 s.w.g. enamelled silk-covered wire on 100k Ω $\frac{1}{4}$ watt 20% resistor (see text). Pile or scramble-wound.

Transistors

(Transistors are available from Newbury Radio, (Forest Gate) Ltd.)

- TR₁ 2G414 (Texas)
- TR₂ -TR₆ NKT274 (Newmarket)

Diodes

- D₁, D₂ OA202 (Mullard)

Relay

RLA₁ Grundig type G3693, 300 Ω coil (Home Radio (Mitcham) Ltd.)

Miscellaneous

Veroboard, 0.1 in hole matrix, dimensions as in Fig. 3(a). (Newbury Radio (Forest Gate) Ltd.)
9-volt battery
Wire, sleeving, etc.

by the modulation signal of the carrier; thus, if the carrier signal is *NOT* modulated, the oscillator signal will not be modulated either, and the noise disappears.

Thus, the output of the super-regenerative detector consists of an unwanted oscillator signal of fairly high frequency, either with or without the noise which is needed to operate the later stages of the circuit. This mixed signal is first passed through a filter network comprising C_5 , R_4 , and C_6 , which attenuates the unwanted oscillator signal by a considerable degree whilst attenuating the noise signal by only a small amount. To give the required filter characteristics with a minimum degree of attenuation of the wanted signal, it is necessary to terminate the output of the filter at a high impedance, and the emitter-follower, TR_2 , is used for this purpose.

The output of the filter appears at TR_2 base, and hence at TR_2 emitter. TR_2 emitter is direct-coupled to TR_3 base. TR_3 is wired as a common emitter amplifier, with its collector load bypassed for high frequency signals by C_8 ; thus, TR_3 amplifies the wanted noise or a.f. input signal by a considerable amount, but gives negligible amplification to the unwanted high frequency signal. Similarly, TR_4 is also wired as a common emitter amplifier with its collector load, R_9 , bypassed for high frequency signals by C_{10} , and again tends to amplify the wanted signal whilst rejecting the unwanted one. Thus, the final output of the filter-amplifier circuit, appearing at TR_4 collector, consists of the wanted a.f. signal only.

To minimise the number of components used in the TR_2 - TR_3 - TR_4 circuit direct coupling is used; whilst, to obtain good temperature stability, d.c. feedback is used between TR_4 emitter and TR_2 base.

A low impedance output (necessary for driving the rectifier and smoothing circuit) is obtained by feeding the signal from TR_4 collector to a second emitter-follower stage, TR_5 , which has an emitter load given by R_{12} .

The low impedance output signal is fed, via C_{14} , to the two rectifiers, D_1 and D_2 , and the resulting d.c. is smoothed by C_{15} and fed to the base of TR_6 . It should be noted that the output of the rectifier circuit is positive in polarity, so that, in the presence of a noise input, the emitter-base junction of TR_6 is reverse-biased and the transistor is cut off. In the absence of the noise signal and, thus, the positive bias, base current is allowed to flow via R_{14} , and TR_6 is biased hard on, operating the relay, RLA.

The circuit uses a 9 volt battery supply, with decoupling networks R_{13} - C_{13} and R_8 - C_{12} interposed between the major sections of the circuit to prevent instability.

Construction

No particular effort has been made to miniaturise this particular circuit as it is primarily intended for use in model boats, where space is not too restricted and a fairly high pay load is permissible. Nevertheless, the receiver only measures $3\frac{1}{4} \times 1\frac{1}{2} \times 1$ in, complete with relay. The writer feels that the

business of trying to obtain the ultimate in micro-miniaturisation in radio control receiver circuits is frequently a complete waste of effort, since it is usually found that the receiver is, in any case, the smallest part of the payload (both in weight and physical size) even in model aircraft. Batteries, servos, etc., are by far the largest components of the whole control system.

Construction of the unit is started by cutting the Veroboard panel to size, as shown in Fig. 3. Then, drill the two holes in the panel as indicated. Next, very carefully break the copper strips exactly as shown, using either a small drill or the special cutting tool that is available for this operation. Clean up the lands between the copper strips with the aid of a small modelling knife, making sure that no short-circuits are occurring.

The wiring up of the panel is a delicate and fairly complex operation, and is best carried out "by numbers", in the following manner.

(1). Secure the coil former in place. This can be accomplished either by cutting off the base of the former and pushing the body into the hole, securing it with glue or, as in the case of the prototype, by merely pushing the complete former into the hole from the copper side of the panel, relying on friction to hold it in place. Now wind the coil onto the former using 24 s.w.g. enamelled copper wire, start by soldering one end of the wire into hole 2J, then close-winding $11\frac{1}{2}$ turns clockwise, from the base upwards, finishing off by soldering the remaining end of the wire into hole 5G.

(2). Wire shorting links, using bare 32 s.w.g. tinned copper wire, as follows; 3J to 3H, 3F to 3E, and 18J to 18I.

(3). Wire shorting links, using *sleeved* 32 s.w.g. wire, as follows; 1J to 11J, 9H to 11F, 11G to 12E, 11H to 14C, and 14H to 16B. Finally, wire a link from 31J to 31C.

(4). Solder the following components in position, noting that all components fitted now and in later steps are mounted vertically; C_1 between 1G and 1I, C_2 between 4J and 4G, C_3 between 3G and 3D, R_1 between 2H and 2F, R_2 between 2E and 2B, R_3 between 3C and 3B, and C_4 between 1E and 1B (with polarity indicated).

(5). Solder one end of a length of 36 s.w.g. enamel and silk covered copper wire to the lead of a high value ($100k\Omega$) $\frac{1}{4}$ watt resistor, close up to the body, and tightly wind 100 turns on to the resistor body, finishing off by soldering the free end of the wire to the remaining resistor lead. Coat the resulting inductor, L_2 with a covering of polystyrene cement (as used in plastic modelling) to hold the windings in place. L_2 may be either pile-wound or scramble-wound. When dry, solder L_2 between 4C and 6D.*

(6). Solder TR_1 in place with its emitter to 8D, its base to 8F, and its collector to 8G. Solder the aerial, a 24 inch length of ordinary insulated

* The resistors available in the home-constructor market under the nominal description "quarter watt" vary somewhat in dimensions. The resistor used in the prototype for L_2 had a body length of $\frac{1}{4}$ in and a diameter of approximately $\frac{1}{8}$ in, and a resistor of similar dimensions should be employed by constructors.—Editor.

A - drill to clear relay securing bolt
 B - drill to clear coil former (approx. 1/4" dia)

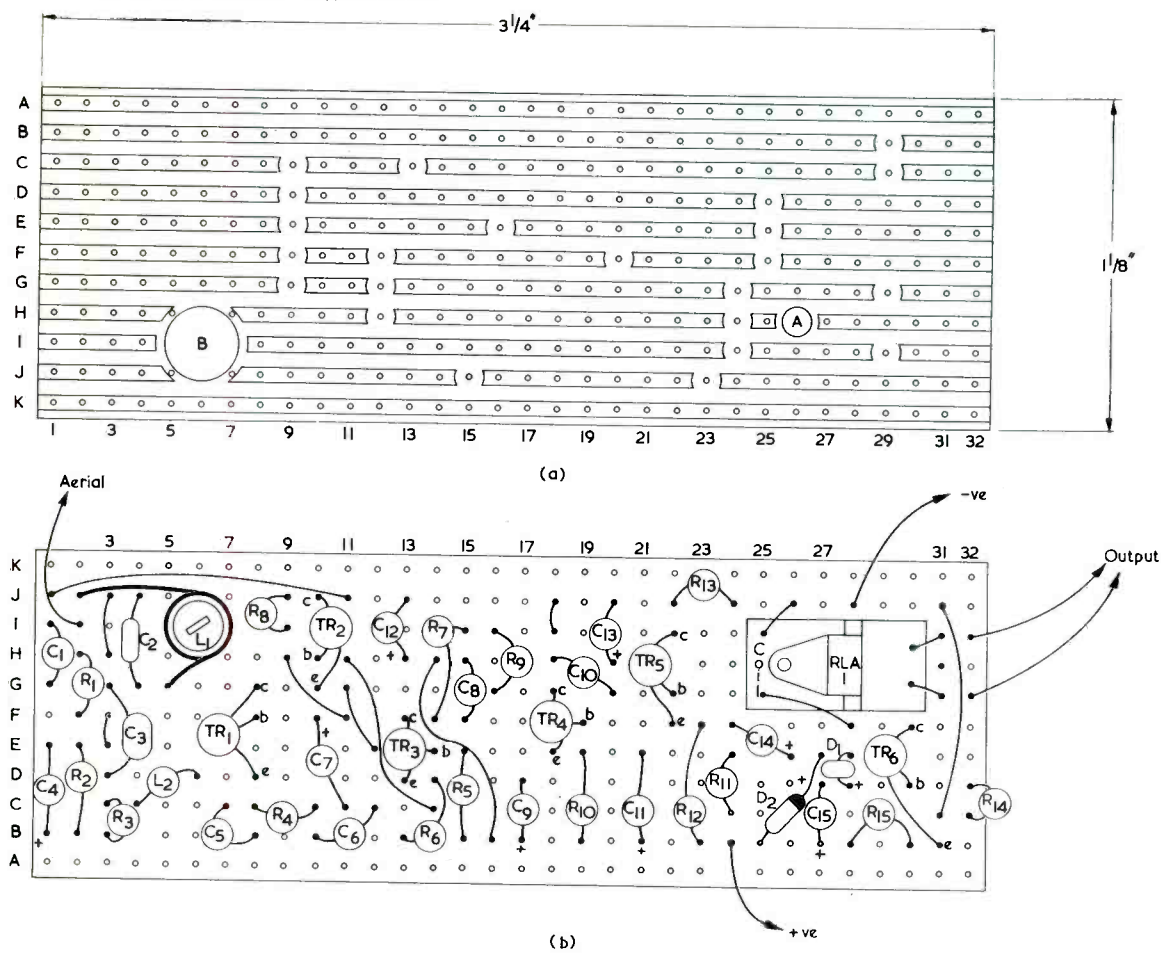


Fig. 3(a). Dimensions of the Veroboard, showing also the points where the strips are cut and the holes drilled
 (b). The components fitted to the Veroboard

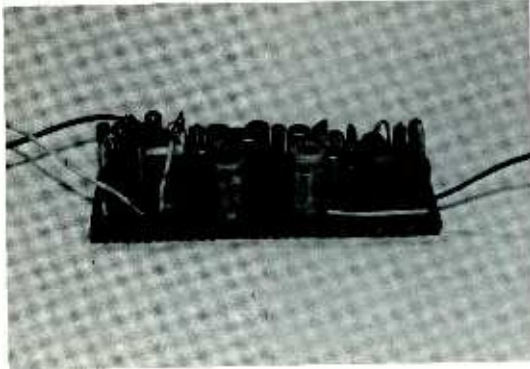
multi-strand wire, to 2I. This completes the actual super-regen detector circuit, and, if required, this part of the circuit can now be given a functional test. Temporarily connect a 9 volt supply with its positive to 4B and its negative to 12J, and connect a crystal ear piece across R₃, (alternatively, connect the output across R₃ to an audio amplifier via a blocking capacitor). If the circuit is working correctly a strong hissing or rushing noise should be heard. Now, press the "transmit" button on the transmitter (described last month); if the circuit is working correctly the noise should cease or fall to a very low level. It may be necessary to adjust the core of L₁ to get the circuit to operate correctly. If no rushing noise is heard initially, suspect a wiring fault or a faulty component. When this functional check has been completed,

remove the temporary battery and earphone connections.

(7). Solder C₅ between 7C and 8B, R₄ between 8C and 10C, C₆ between 10B and 12C, C₇ between 10F and 11C (note polarity), and R₈ between 9J and 9I. Solder TR₂ in place with emitter to 10G, base to 10H, and collector to 10J.

(8). Solder TR₃ in place, with its emitter to 13D, its base to 14E, and its collector to 13F. Solder R₆ between 13B and 14D, R₅ between 15B and 15E, R₇ between 15I and 14F, and C₁₂ between 13J and 13H (observe polarity).

(9). Solder C₈ between 15H and 15F, R₉ between 16G and 16I. Solder TR₄ in place with its emitter to 18E, its base to 19F, and its collector to 18G; solder C₉ between 17B and 17D, (observe polarity) R₁₀ between 19B and 19E, and C₁₁



Side view, showing the position taken up by the relay

between 21B and 21E (observe polarity).

(10). Solder C_{10} between 18H and 20G; solder TR_5 in place with its emitter to 22F, its base to 22G, and its collector to 22I. Solder C_{13} between 20H and 20J (observe polarity), R_{13} between 22J and 24J, R_{12} between 23B and 23F, and R_{11} between 24C and 24E. Now solder a positive battery lead to 24B, and solder a negative battery lead to 28J. This completes the wiring of the major part of the circuit, less the rectifiers, relay, and "switch". The circuit can, at this stage, be given a further simple functional check, if required, in the following manner.

Inspect the reverse (copper) side of the Veroboard and check that no short circuits are occurring across the lands; if satisfactory, connect a 9 volt battery to the unit, taking care to ensure that the correct polarity is observed. Connect a crystal or high impedance earpiece across R_{12} via a small blocking capacitor, whereupon a strong rushing or hissing noise should be heard. Now press the "transmit" button on the transmitter; if the circuit is working correctly the noise should cease or fall to a very low value. If the circuit functions correctly at this stage, remove the battery and complete the rest of the circuit wiring, as follows:—

(11). Mount the small 300 ohm relay in position on the Veroboard panel (see photographs); solder a lead from 28F to one of the relay coil terminals, and another lead from 26J to the other relay coil terminal. Now solder one lead from one of the relay contact pins to 31I, and a second lead from the other relay contact pin to 31G.

(12). Solder C_{14} between 24F and 26E (observe polarity), D_2 between 25B and 27E (observe polarity), D_1 between 28E and 28D (observe polarity), C_{15} between 27B and 27D (observe polarity). Solder TR_6 in position with its emitter to 31B, its base to 30D, and its collector to 30F; solder R_{15} between 28B and 30B, and R_{14} between 32C and

Test Voltages

	TR_1 5.6v*	TR_2 6.2v	TR_3 1.2v	TR_4 3.5v	TR_5 6.4v	TR_6 9v
Collector						
Base	1.5V	1.1V	1.1V	1.2V	3.5V	0V
Emitter	1.6V	1.1V	1.0V	1.1V	3.6V	0V

32D. Finally, solder one output lead to 32G and a second output lead to 32I.

Testing

This completes the assembly of the receiver circuit, and the unit is now ready for testing. Check the reverse side of the Veroboard panel and make sure that no short circuits are occurring across the lands. If satisfactory, wire a small bulb in series with a suitable battery and connect the combination across the receiver output leads; now connect the receiver to its own 9 volt supply and check the operation of the unit. At the moment that the receiver supply is connected the relay should operate and the bulb should light up, but after a second or so the relay should turn off again of its own accord, and the bulb should extinguish.

Now press the "transmit" button on the transmitter. The relay on the receiver should energise and the bulb should light up. If the relay does not operate, try adjusting the core of L_1 .

If the circuit operates correctly, carry out a range check. Two people are needed to carry out this test, one holding the transmitter in the normal way, keying the "transmit" button on for (say) 1 second in every five while the other person walks away from the transmitter with the receiver held in his hand, preferably with the aerial fixed in the vertical position. The core of L_1 should be adjusted by trial and error to give the best possible range, which should be approx. 150–200 yards.

The receiver can be installed in the model either by simply packing it between foam rubber or cotton wool, or by bolting it down with rubber-faced clamps; the former method, although very crude, is to be preferred, as it gives greater protection to the circuit in the event of a crash. The receiver must be powered by its own batteries, separate from any that are used to drive the actual model or servos, and the aerial must be kept as far away as possible from electric motors or moving metal surfaces.

The accompanying Table shows test voltages obtained with the prototype using an Avomator on the 10 volt range and with a new 9-volt battery fitted to the receiver. Overall current consumption is 3.3mA under no-signal conditions.

DESIGN AND CONSTRUCTION OF MEASURING BRIDGES

Part 3 (conclusion) of this series will appear next month.

RADIO TOPICS . . .

by Recorder

IT IS INTERESTING TO SEE THE manner in which valve heater circuits for television receivers have developed over the years. This point was brought home to me a week or so ago when I had a quick look at an acquaintance's somewhat elderly receiver. I was rather surprised to find that it included a hefty mains transformer and that this transformer supplied all the valve heaters in parallel.

The a.c./d.c. TV receiver, in which all the valve heaters are in series, made its debut in the U.K. before 1950, by which year most manufacturers had changed over to this system. One or two set-makers still continued with a mains transformer and parallel heaters for a number of years after 1950, and it was one of these models which I encountered. And which was still, I should add, giving quite an acceptable picture.

Series Chains

Until the last few years, the use of a series heater chain with a dropping resistor sitting at the top presented an extremely familiar background to the TV servicing scene. So much so, indeed, that I had almost forgotten that television sets ever had mains transformers and parallel heaters.

It seems now, however, that the TV heater dropper is also beginning to go into retirement. This is a perfectly understandable step, particularly when one considers the amount of heat the series dropper adds to that already dissipated in the signal and scanning stages. The voltages in a TV heater chain, plus thermistor, can add up, typically, to about 160 volts. This means that, for the commonly encountered 240 volt mains, the series dropper has to dispose of the remaining 80 volts. At the normal heater chain current of 0.3 amps, this corresponds to a dissipation of 24 watts.

In recent years we have seen the appearance of silicon rectifiers as heater "droppers". These only pass alternate half-cycles and, since

their forward resistance is negligibly low, the amount of heat they dissipate is similarly negligible. Incidentally, if you aren't too certain about how, in terms of voltage, the silicon rectifier functions in a heater chain, the following facts should be of interest.

The accompanying Fig. 1(a) shows a silicon rectifier in series with a heater chain and a resistor. The silicon rectifier passes half-cycles only with the result that, following simple half-wave rectifier theory, the "effective" (r.m.s.) voltage across the heater chain and resistor in series is 0.5 times the peak value of the applied a.c. Since peak value is 1.414 times r.m.s. value, the "effective" voltage after the rectifier

is 0.5 times 1.414, i.e. 0.707, times the r.m.s. value of the applied alternating voltage. To take an example, let us assume that the applied alternating voltage has an r.m.s. value of 100, as in Fig. 1(b). The valve heaters and resistor will then heat up to exactly the same temperature as if an alternating voltage with an r.m.s. value of 100×0.707 , or 70.7, volts were applied direct to them, as in Fig. 1(c). The heat dissipated in Fig. 1(c) is exactly the same as the heat dissipated in Fig. 1(b). If, in Fig. 1(b), the applied alternating voltage had the more familiar mains r.m.s. value of 240, the "effective" voltage appearing across the heater chain and series resistor would be 240 times 0.707, or 170 volts. It should be noted that this 0.707 voltage relationship holds good regardless of the current which flows, and it is only necessary to work in terms of voltage.

Should the a.c. mains in your shack be 240 volts and you want to use a silicon rectifier in a heater chain circuit, you use the following procedure. First of all, add up all the heater voltages in the proposed chain, then subtract this figure from

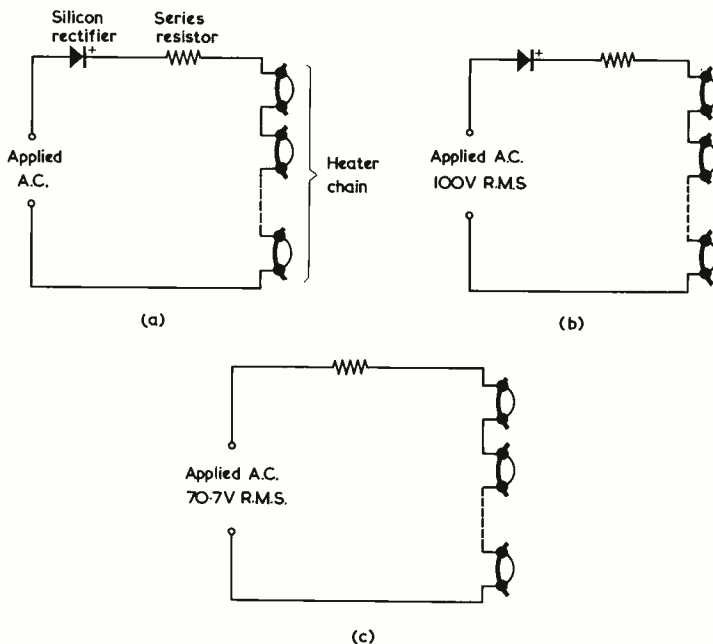


Fig. 1(a). A silicon rectifier employed with a television heater chain. The heat dissipated in the chain and series resistor is the same irrespective of which way round the rectifier is connected

(b). The rectifier and heater chain with an applied a.c. of 100 volts r.m.s.

(c). Exactly the same heat is dissipated in the resistor and heater chain of (b) if a supply of 70.7 volts r.m.s. is applied directly

170 volts. Next, insert a series resistor to drop the voltage figure thus obtained. Let us assume that you are using a chain of 0.3 amp heaters and that their total voltage comes to 140. This means that there are still 30 volts at 0.3 amps to get rid of, whereupon you top the chain with a resistor of 100Ω. See Fig. 2(a).

The resistance in the circuit needn't all appear after the rectifier. Some of it could appear before the rectifier, as in Fig. 2(b), whereupon mains voltage tappings can be provided. In the example we just worked out, the 100Ω series resistance could appear, in Fig. 2(b), as 50Ω in the R₁ position and 50Ω in the R₂ position, whereupon the mains tapping corresponds to 220 volts, as shown. When the 240 volt mains tapping is selected, we have 100Ω series resistance as before. When the 220 volt mains tapping is selected, the "effective" voltage due to the rectifier is 0.707 times 220, or 155 volts. This means that 15 volts at 0.3 amps has to be dissipated by the series resistor, and hence the use of a 50Ω resistor in the R₂ position.

Practical Circuit

In practice, it would be helpful to insert a thermistor in the heater circuit, to reduce the switch-on current surge. The hot resistance of this thermistor is then part of the series resistance.

The fact that the silicon rectifier causes rectified a.c. to appear across the heater chain has resulted in some interesting commercial design techniques. In the Thorn 980 Series 12-inch portable, for instance, the series silicon rectifier is connected such that the top end of the heater chain is negative of chassis. A tap is then taken half-way down the heater chain to provide a negative bias voltage (after smoothing) for the vertical output valve. Another neat approach is evident in the Pye 19-inch model 40F. A resistor is inserted in the bottom end of the silicon-diode-fed chain, and a half-wave rectified voltage of about 14 appears across it. After smoothing, this is used to power the transistors used in the i.f. stages and the tuner.

Silicon rectifiers aren't the only devices which replace the heater dropper in present-day TV receivers. Two years ago, the Thorn group introduced a mains autotransformer with a tap at 150 volts for the heater chain in order to obtain cool running. A set has also appeared in which a series capacitor is used for most of the valve heaters, the

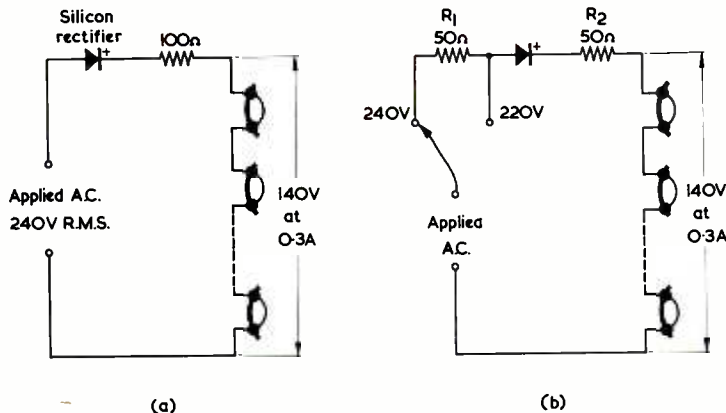


Fig. 2(a). A worked example in which the mains voltage is 240 volts r.m.s., and the total heater chain voltage is 140 at 0.3 amp
 (b). Some of the series resistance may appear on the mains side of the rectifier

remainder appearing in the h.t. power supply circuit where they also function as a smoothing resistor.

As a final word concerning heater chains which are fed via silicon rectifiers, it should be pointed out that inaccurate voltage readings will be given if voltage measurements are made into the chain with normal multi-testmeters switched to an a.c. range. This is because bridge rectifier moving-coil meters are only accurate with a true sinusoidal waveform. However, you can obtain a useful measure of the heater voltage by using the testmeter switched to a *direct voltage* range. A moving-coil meter reads average voltage and will, for a half-wave rectified voltage, give a direct voltage reading which is 0.64 times the "effective" r.m.s. voltage. So, if you apply a testmeter switched to a d.c. range across a 6.3 volt heater in a chain fed by a silicon rectifier, you should get a direct voltage reading of 6.3 times 0.64, or 4 volts.

On the other hand, accurate readings, both of voltage and current, will be given by an r.m.s.-reading instrument such as a moving-iron meter.

Gymnarchus Niloticus

Turning to another matter, the rather startling name of *Gymnarchus Niloticus* does not apply to a recent electronic invention, but to the African Nile fish. This fish lives in water which is so murky that it is impossible to see more than a very short distance indeed through it. The Nile fish has developed an

electrical direction finding system for ascertaining its bearings and detecting the presence of its prey.

The fish "transmits" about 300 electric pulses per second of an amplitude between about 2 and 6 volts. Like many other fish the Nile fish can detect very small changes in the direction of the electric field in its vicinity. Indeed, it can detect changes of less than 50 microvolts per cm. Any neighbouring objects cause small changes in the electric field pattern and are thus detected. The detecting system in the fish has a sensitivity quite comparable with that of a small radio receiver, although it is admittedly very different from the latter. Thus even in the field of sensitive electrical detection, Nature appears to have beaten us!

New Adhesive

If you're keen on making your own cabinets, a new adhesive is announced which may prove to be just the thing you've been waiting for.

This is Timbabond 606 Woodwork Adhesive, and it is intended for all joinery and cabinet-making work. The manufacturers are Tretobond Ltd., Tretol House, The Hyde, London, N.W.9.

The adhesive is based on a very high quality synthetic resin dispersed in an aqueous medium. It is applied to one surface only and, upon drying, deposits a translucent non-staining glue line. It is claimed that the resultant bond is always stronger than the wood itself.

Timbabond 606 has an open assembly time of from 4 to 8 minutes, depending on the porosity of the wood, the ambient temperature, the humidity and the thickness of the applied coating. It is available in quantities of 1 gallon, 2 lb and 1 lb, and may also be obtained in 5 oz tubes.

B.B.C. Colour Cameras

I note that the Marconi Company is now in process of making the

new colour cameras ordered by the B.B.C. for the anticipated colour TV service starting next year.

Thirteen Marconi Mark VII cameras, introduced in December of last year, are currently on order. A major feature of the Mark VII is that four tubes are incorporated, three for red, green and blue, and one for luminance (i.e. black-and-white picture). The luminance signal is at high bandwidth in a colour television system and the colour signals are at low band-

width, and the new camera enables luminance detail to be resolved on a single tube. This reduces the registration errors which are inevitable if the luminance signal is obtained from the output of three separate colour tubes. It is stated that the four tube system gives better colour pictures than any other camera tube configuration known at present, and that it also ensures that excellent black-and-white pictures will be produced on existing monochrome receivers.

Professional Panel Finish for Prototype Instruments

by **Nicholas J. Murrell, F.B.H.I.**

How to give your home-built equipment that "factory-fresh" look

IT WAS FOUND NECESSARY BY THE WRITER TO develop a simple, quick and reliable system of lettering and various colour finishes for application to instrument panels in prototype work and small batches of instruments. The system described in this article has proved very satisfactory and hard wearing in use.

The Panel

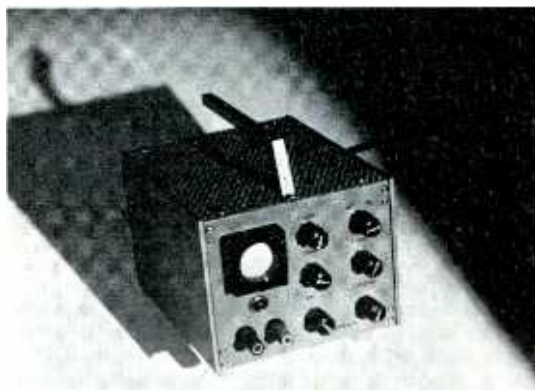
Aluminium or dural is preferred for the panel blank, although very good results can be obtained with steel. The method adopted by the writer is to place the various controls, sockets, etc., in their approximate positions on the blank panel, ensuring that such things as meters, cathode ray tubes and indicators are not covered by the hand when operating the switches or controls. Careful selection of components for appearance in the completed equipment is very desirable. For example, a square meter looks smartest in a square case. Control knobs should be large enough to be turned easily and should not be spaced too closely together. It is surprising what a difference a little thought at this stage will make, both in the appearance of an instrument and in the pleasure given when using it.

Drilling The Panel

The next stage after marking out the panel is to drill the necessary holes. To ensure that the drill does not run off centre, centre-punch the point to be drilled and use a small drill as a pilot. Drill No. 43 is very suitable and is also the tapping size for 6BA. The author tries to keep all fixing screws to 6BA or 4BA, as this results in the

use of only three drills: No. 43 for 6BA tapping, No. 34 for 6BA clearance and 4BA tapping, and No. 27 for 4BA clearance.

The small workshop or laboratory seldom has a large power drill for cutting holes having a diameter greater than $\frac{1}{2}$ in, but good results can be obtained using Enox or similar circular hole cutters held in an ordinary wood brace. For the small workshop with a vertical power drill the Dormer "Rotor Bore" circular hole cutters are very efficient, and are worth obtaining when a large number of holes are to be drilled.



This oscilloscope, built by the author to a Radio Constructor design, clearly demonstrates the very attractive appearance which results from the panel finish system described in this article

Square holes are always difficult to produce, but good results can be obtained quite quickly by first removing most of the metal with an Abrasive saw, then placing a straight edge of steel in the vice, clamped along the scribe line, and filing down to the straight edge of this block. It is important, when holding the panel in the vice, that cardboard packing pieces are inserted between the panel and the vice jaws so that the panel surface is not scratched.

Preparation For Spraying

Having drilled the panel, ensure that it is free from burrs, and check that the controls and other panel-mounted components fit correctly. If the panel is highly polished it will be found that, by using a very fine emery cloth to roughen the surface, a better bond is obtained between paint and panel.

It cannot be stressed too much that the panel must be completely clean and free from grease or oil before spraying. This can be achieved by wiping with turpentine, washing in hot soapy water, rinsing, and drying thoroughly.

Aerosol Sprays

The most suitable spray lacquer found so far is made by the American firm of Plasti-Kote, Inc. This is available in aerosol cans in a wide range of colours. Also available are air drying hammer enamels in five colours. A little difficulty in supplies in this country seems, at present, to be experienced, but every effort is being made to improve the position.

Holt's spray enamels supplied by Halfords, Ltd., have also proved very good indeed. They are available in a wide range of car colours, being intended for touch-up purposes. Recently introduced are Dupli-Colour and "U" sprays, both giving very good results. These are similarly available from Halfords.

The following tips apply to all aerosol spray paints and lacquers. *Always read the instructions on the can.* Use only in a well ventilated room. Hold the spray nozzle about 18ins from the work. To insure that there are no blotches aim just off the work, then bring the nozzle slowly over the panel. Two thin coats are much better than one thick one. When the Aerosol can is empty, on no account pierce it or place it on a fire as the results can be very dangerous.

Lettering

After spraying the panel with the basic colour (or, incidentally, if using a standard case which has already been sprayed) the next stage is panel lettering. Data Publications Panel-Sign Transfers produce a really "professional" finish. Panel-Sign Transfers are obtainable from Data Publications, Ltd., 57 Maida Vale, London, W.9. They are very simple to use and the fixing instructions on the packet are clear and easy to follow.

There are four basic sets, each costing only 4s. 6d. plus 4d. postage, and they represent excellent value.

The sets are as follows:

Set 3, which gives wording in white for Receivers, Transmitters, Amplifiers and Test Equipment, etc. Letter size is $\frac{3}{16}$ in high and is on six handy-size sheets measuring 8 x 4 $\frac{1}{2}$ in and containing over 1,000 words. There are also two safety panels with white letters on a red background measuring approximately 4 x 3in; the wording is "Danger High Voltage" and "Main Control Switch".

Set 4 is the same as Set 3, but with the lettering in black. The safety notices have black lettering on a red background.

Set 5 covers dials and scales, and includes one rectangular panel, 6 $\frac{1}{2}$ x 3in, suitable for a tuning scale, etc., one large half-round dial in a rectangular frame of 6 x 4in, two medium half-round scales in rectangular frames of 4 x 2 $\frac{1}{2}$ in, and 18 small scales of 1 $\frac{1}{2}$ in diameter. The scale colour is white markings on a clear background.

The fourth set, Set 6, is the same as Set 5 except that the markings are white on a black background.

When lettering the panel, it is well worth checking that the words and symbols, etc., are in the correct place and position (e.g. ON/OFF are the correct way round).

Final Stage

To hold and protect the letters the panel is sprayed with clear lacquer, such as Plasti-Kote 270 or T.5 if a Plasti-Kote product has been used. The writer has been informed that the "U" Clear Spray also gives good results. Ensure that the panel is really dry before assembling. It is well worth that little extra patience at this stage.

A Trial Run

Before starting on a panel, the writer would suggest a trial run on, say, a piece of dural or steel to get the feel of the system and, also, to try out any particular designs and colour combinations which are desired. If different spray lacquers and enamels or other combinations are to be used, a check should be made to see that they do not set up chemical reactions. Some attractive results can be obtained with suitable combinations. For example, spraying Plasti-Kote hammer enamel with Plasti-Kote Lacquer results in a crackle hammer finish.

Oscilloscope

The accompanying photograph shows an oscilloscope made up by the writer using the system just described. The oscilloscope panel is up to the standard found on commercial instruments. The oscilloscope measures only 4 $\frac{1}{2}$ x 5 x 6in deep, being finished with black lettering and green panels at top, back and front. The side panels are dark grey. The "Get up and go" handle is the writer's own design and is comfortable to hold. The circuit is based on the "Miniature Economical Oscilloscope" described by M. J. Darby in *The Radio Constructor* for May, 1962. The 1in tube gives a very clear trace. The unit being fully portable with a built-in mains power pack, is an ideal service instrument which is also very attractive in presentation.

Club Events

Basildon and District Amateur Radio Society

Hon. Sec.: J. Barker, G3IJB, Milestone Cottage, London Road, Wickford, Essex.

September 6th—Social

September 27th—Annual General Meeting—Mayflower Restaurant (adjacent to the Van Gogh, Paycocke Road, Basildon)

British Amateur Television Club

The British Amateur Television Club will be holding its bi-ennial convention this year on Saturday, October 8th in the Conference Suite of the Independent Television Authority at 70 Brompton Road, S.W.3, from 10 a.m. to 6 p.m. During the Convention, an exhibition of equipment built by members including two colour picture sources, and a short symposium of papers of general television interest will be held.

Anyone interested will be very welcome and further details concerning the Convention and the work of the Club can be had from M. Cox, at 135 Lower Mortlake Road, Richmond, Surrey.

Derby and District Amateur Radio Society

Hon. Sec.: F. C. Ward, G2CVV, 5 Uplands Avenue, Littleover, Derby.

September 7th—Surplus Sale.

September 10th—Exhibition Station (G2DJ and G3ERD) at Scout Headquarters, Browning Street, Derby.

September 14th—Film Show.

September 21st—D.F. Practice Night—talk in the Club Room for non-participants.

September 28th—Social Evening (ladies are invited) at the Electricity Board Social Centre, West Hallam.

Northern Radio Societies

September 3rd-4th—Convention, Manchester. (See News & Comment)

Harlow and District Amateur Radio Society

Hon. Sec.: G. O'Donald, G3TLJ, "Great East", Harlow Road, Roydon, Harlow, Essex.

September 25th Annual Mobile Rally.

Radio Society of Great Britain

September 11th—National Mobile Rally, Woburn Abbey, Bedfordshire.

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Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Contributions on constructional matters are invited, especially when they describe the building of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate sheets. Typewritten articles should have maximum spacing between lines. In handwritten articles, lines should be double-spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will re-draw in most cases, but all relevant information should be included. Sharp and clear photographs are helpful, where applicable. If negatives are sent, we usually work from these rather than from prints. Colour transparencies normally reproduce badly—black and white photographs are very much better. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for return, if necessary, and should bear the sender's name and address. Payment is made for all material published.

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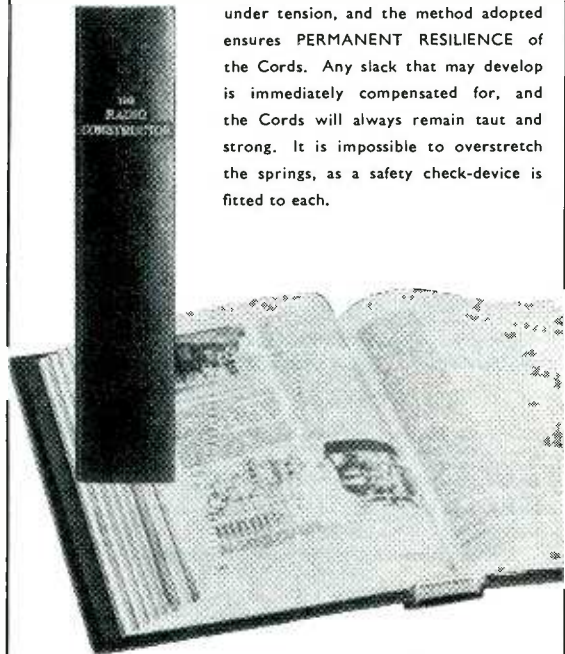
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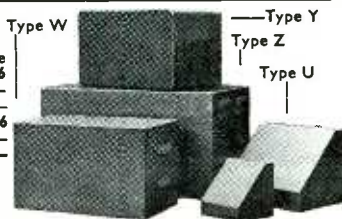
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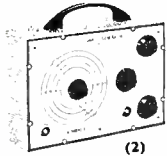
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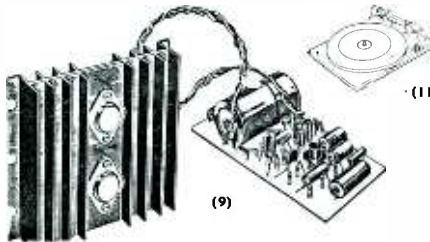
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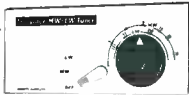
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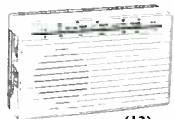
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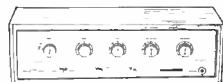
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