Vol 20 No 3

THE Radio Constructor

OCTOBER 1966
2/6
A DATA PUBLICATION

RADIO · TELEVISION
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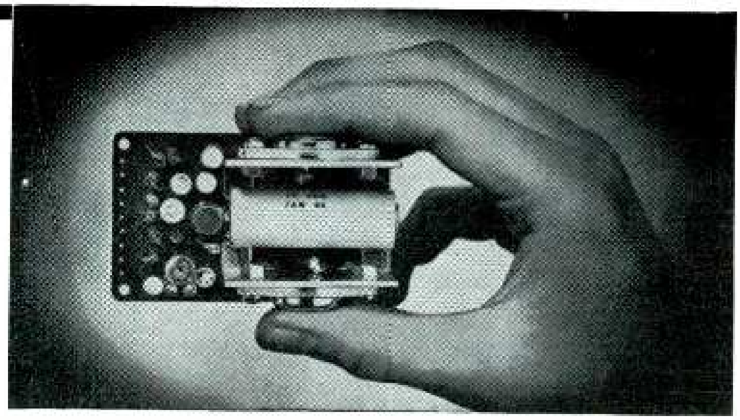

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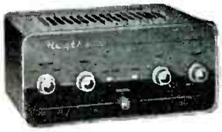

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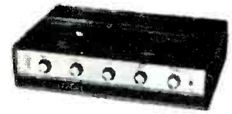

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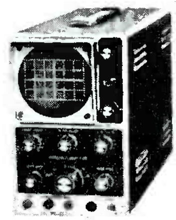

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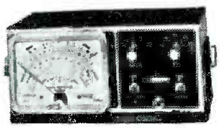

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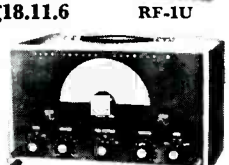

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Cabinet £2.5.0 extra. Send for full details.

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★

Versatile Test Oscillator

by

H. T. KITCHEN

In addition to its r.f. output, this comprehensive test oscillator incorporates an a.f. output, a crystal calibrator output, internal or external modulation and a meter for coupling to the output transformers of receivers under alignment. Particular attention has been paid to screening, and external radiation is negligibly low. Coverage can be long, medium, short waves and intermediate frequencies or, with two extra coils, continous from 16 to 2,000 metres

Although many amateurs seem to manage without a test oscillator, there is little doubt that, for any serious work, such an instrument is indispensable. Although the circuit to be described is by no means complicated or difficult it is rather more versatile and refined than some that the author has seen. This should not be taken to mean that the author decries simple designs, only that he considers the serious amateur should possess an instrument capable of fulfilling any tasks he may require of it.

In the author's opinion coil winding is a tedious and usually unnecessary chore except for those who enjoy it. Consequently, the present design employs commercial coils which, depending on the number incorporated, can cover from 16 to 2,000 metres; whilst those who enjoy coil winding may care to try their hand at extending the range.

The unit offers quite wide facilities. Apart from the variable r.f. oscillator, there is an accurate and stable 100 kc/s crystal oscillator which can be used to check the frequency calibration. Either internal modulation at 1,000 c/s or external modulation can be employed. The internal modulating signal is also available for external use, the output being variable. A separate cathode follower output stage effectively isolates the r.f. oscillator from the effects of external loads. Since there is not much point in providing a signal if its effect cannot be observed, a small 0–1mA meter is also fitted, into which the output of the receiver under alignment can be fed. The ear rapidly becomes accustomed to the modulation note, which can be very boring anyway, and this output meter will be found a most useful accessory.

Power requirements are quite modest, being 250V at 30mA and 6.3V at 1.2A, so that a "converter" type mains transformer will prove suitable. A contact cooled rectifier is used instead of a valve rectifier which, because it runs hot, could adversely affect the frequency stability of the r.f. oscillator.

Some test oscillators handled by the author have had, in his opinion, a number of serious faults. The r.f. output has been unstable, and merely touching the case, altering the attenuator, or reconnecting the output lead to another test point has been enough to cause the frequency to shift by several kc/s. In others the output lead has been superfluous, the r.f. being picked up by a receiver some distance away, and the so-called "attenuator" making an excellent fine tuning control! In the circuit to be described these faults have been either eliminated or reduced to negligible proportions by simple precautions. It should be added that, with the design under discussion, unwanted radiation is non-existent due mainly to a good metal cabinet which provides adequate screening and to a thoroughly filtered mains input circuit. It is not always appreciated that a mains lead can act as an aerial, causing any measurements which are made to be useless.

The Circuit

Fig. 1 shows the complete circuit, from which it it will be seen that four valves are used, these all being Z77's. The Z77 is the direct replacement of the EF91 and 6AM6 and CV138 and is available quite cheaply. It is also a very efficient and reliable little valve, and well suited to its present use.

The circuit will now be described in detail, commencing with V_1 the variable oscillator. The V_1 stage is the outcome of several experiments, all aimed at producing an oscillator that was reliable and had a clean waveform. The coils were first tried in the anode and grid circuits, but this resulted in fierce oscillations which could not be damped down sufficiently to give good and reliable results. The relatively high anode voltage was an incentive to try the cathode-grid arrangement shown and this proved to be completely satisfactory. VC_1 is the main tuning capacitor with a value of 500pF. This should be as good a component as possible. In

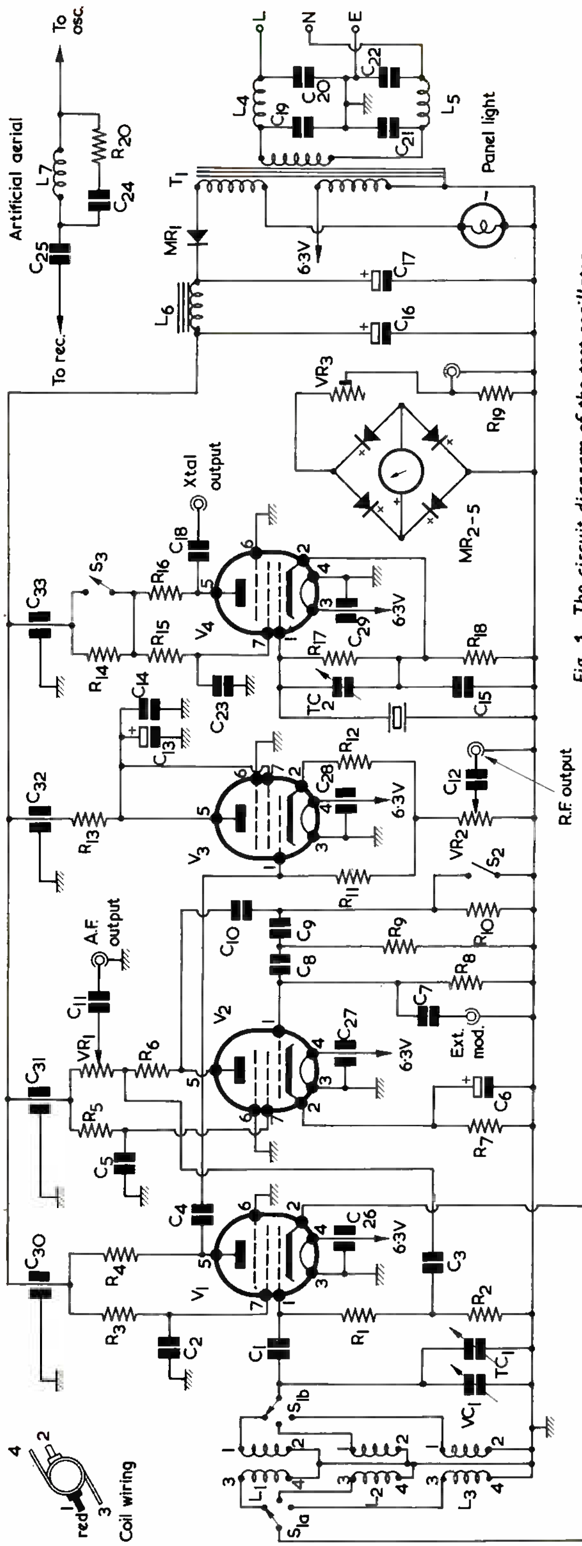


Fig. 1. The circuit diagram of the test oscillator

COMPONENTS

Capacitors

C_1	100pF Silver mica
C_2	5,000pF Ceramic
C_3	1,000pF Ceramic
C_4	100pF Silver mica
C_5	0.05µF Paper
C_6	50µF Electrolytic 6V wkg.
C_7	0.05µF Paper
$C_{8, 9, 10}$	500pF Silver mica
C_{11}	0.05µF Paper
C_{12}	1,000pF Ceramic
C_{13}	8µF Electrolytic 350V wkg.
C_{14}	5,000pF Ceramic
C_{15}	1,000pF Paper
C_{16}	32µF Electrolytic 350V wkg.
C_{17}	16µF Electrolytic 350V wkg.
C_{18}	500pF Silver mica
C_{19-22}	1,000pF Paper or ceramic 300V a.c.
C_{23}	5,000pF Ceramic
C_{24}	400pF Silver mica
C_{25}	200pF Silver mica
C_{26-33}	1,500pF (nominal) Feedthrough (see text)
VC_1	500pF Air-spaced variable
TC_1	25pF Air-spaced variable
TC_2	100pF Mica, trimmer

Inductors

L_1	Coil type PHF3 (Wearite)
L_2	Coil type PHF7 (Wearite)
L_3	Coil type PHF1 (Wearite)
L_4	See text
L_5	See text
L_6	15H 50mA Choke
L_7	See text
T_1	Mains transformer; Input 240V; Output 250V (35mA min) 6.3V (1.2A min).

Resistors

(All ½W 10% except where stated)

R_1	68kΩ
R_2	470Ω
R_3	22kΩ
R_4	100kΩ
R_5	1kΩ
R_6	10kΩ
R_7	1kΩ
R_8	100kΩ
R_9	100kΩ
R_{10}	100kΩ
R_{11}	1MΩ
R_{12}	220Ω
R_{13}	10kΩ
R_{14}	1MΩ
R_{15}	100kΩ
R_{16}	33kΩ
R_{17}	470kΩ
R_{18}	10kΩ
R_{19}	3Ω or 15Ω 5W (See text)
R_{20}	390Ω
VR_1	15kΩ Potentiometer, linear. Carbon
VR_2	5kΩ Potentiometer, linear. Carbon
VR_3	15kΩ Potentiometer, linear. Carbon, pre-set

Valves
V_{1-4} Z77, EF91, 6AM6 or CV138

Rectifiers
MR_1 250V, 35mA contact cooled rectifier
MR_{2-5} GEX34

Switches
S_1 2-pole 3-way, or 2-pole 5-way (see text)
S_2 1-pole on-off rotary
S_3 1-pole on-off rotary

Crystal
100 kc/s crystal

Lamp
0.1 or 0.15A bulb and holder (see text)

Meter
Moving-coil, 0-1mA

Dial
Full Vision (Eddystone) or type 4489 (Jackson Bros.)

Sockets, etc.
4 B7G valveholders with centre spigot
4 coaxial sockets
1 holder for crystal
2 terminals

Cabinet
Metal cabinet type Y, 12×7×7ins (H. L. Smith & Co.)

parallel with VC_1 is TC_1, which has a capacitance of 25pF and is used to reset the oscillator should it drift, thereby enabling the main tuning control to be accurately set at all times. TC_1 could also, if desired, be used as an incremental tuning control covering some particular band of frequencies, as for example, the i.f. range. The coils are switched by means of $S_{1(a)}$ $S_{1(b)}$. Three Wearite r.f. coupling coils were used in the prototype, these covering 16—47 metres (PHF3) 250—750 metres (PHF7) and 700–2,000 metres (PHF1) but as there is room to spare in the r.f. compartment two further coils could also be used, these extending the range to 34–100 metres (PHF5) and 91–261 metres(PHF6).[1] If these coils are added, the wavechange switch will need to be a 2-pole 5-way component. C_1, R_1, R_2 and R_3, R_4 were chosen to provide a signal with a good waveform. Failure of the valve to oscillate over either whole or part of a band can be cured by increasing C_1 or decreasing R_4. Squegging can be cured by increasing R_4 or decreasing C_1. Squegging is easily recognised because it consists of a rough hissing carrier extending over a band of frequencies instead of a single sharply tuned signal. Stubborn refusal of a valve to oscillate is an almost sure sign of a wrong component or incorrect wiring. Oscillations can be checked in the absence of a receiver by placing a milliammeter in series with R_4 and short-circuiting the grid to chassis, whereupon the anode current should increase.

V_2 is the audio oscillator used to modulate V_1. It is of the conventional and well tried phase shift type modified to enable external modulation to be used if so desired. The latter function is provided quite simply by short-circuiting R_{10} by means of S_2, and thus preventing the valve from oscillating. A signal fed into the Ext. Mod. socket is passed to the grid of V_1 via C_7, R_8 being the grid leak. The valve then functions as a normal pentode amplifier, C_8, C_9 and C_{10} only serving to bypass the higher frequencies. If complete isolation is required when external modulation is selected, a 2-pole switch could be used, one pole being connected between anode and C_{10} and the other pole between grid and C_8. The valve will then cease oscillating when the switch is open.

The modulating signal, whether internal or external, is available in amplified form at the A.F. Output socket by way of VR_1 and C_{11}. C_3 couples the signal at V_2 anode to V_1 grid via R_1 and R_2, and modulates V_1 a depth of approximately 30%, this being the level usually accepted for test oscillator work.

The signal from the anode of V_1 is fed to the grid of the cathode follower V_3 via C_4. R_{13}, C_{13} and C_{14} decouple the anode of the cathode follower. Electrolytic capacitors have appreciable self-inductance at radio frequencies and C_{14} provides a low reactance at these frequencies. R_{11} is the grid leak for V_3 and R_{12} the cathode bias resistor. VR_2 is the r.f. output control. To be really effective the earthy end of the track and metal casing of VR_2 should be securely bonded to the chassis, preferably at several points.

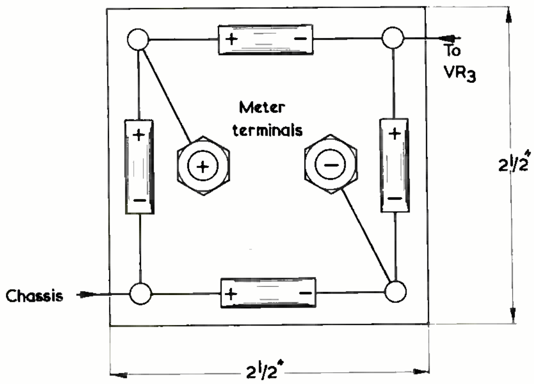


Fig. 2. How rectifiers MR_2–MR_5 may be fitted at the back of the meter

[1] The five coils will, of course, give complete coverage from 16 to 2,000 metres. With three coils, the choice of a PHF7 coil instead of a medium wave PHF2 coil (200–557 metres) enables an output to be obtained over the intermediate frequencies around 465kc/s, although no output is then available over the higher frequency end of the medium wave band. In practice, however, it will probably be found that the absence of a parallel trimmer (of the type which would be employed were the PHF7 coil used in a normal receiver circuit) will allow this coil to tune to wavelengths lower than the nominal limit of 250 metres.—Editor.

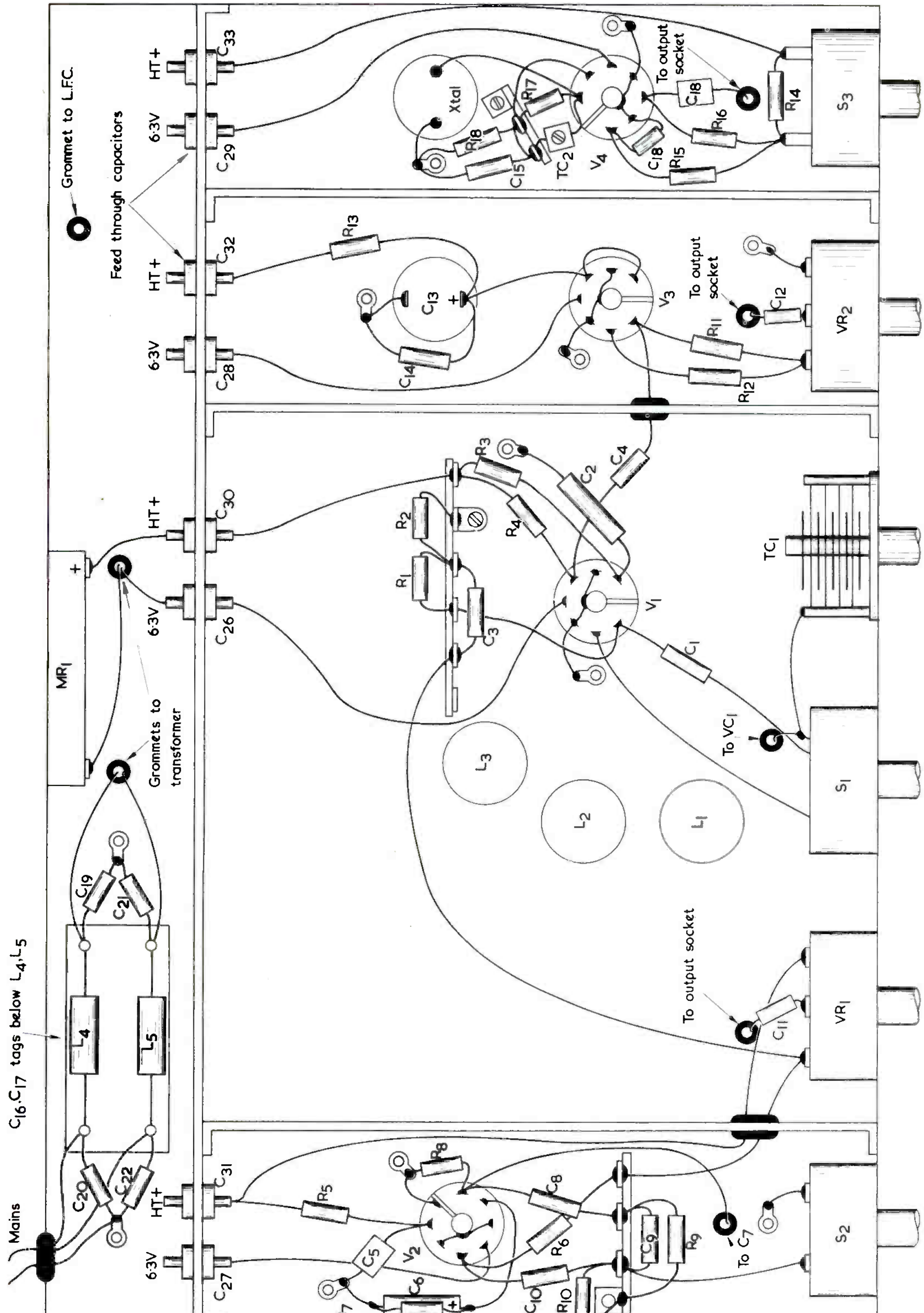


Fig. 3. Under-chassis layout and wiring diagram. For clarity, the wiring between S_1 and the coils, and some of the power supply wiring in the rear compartment, have been omitted

V_4 is the crystal calibrator and this again uses conventional and well tried circuitry. In the original a 100 kc/s crystal was used not only because it was handy but because it represents a convenient figure. Other crystals can no doubt be used but it should be borne in mind that the higher the fundamental frequency of the crystal the less useful it will be towards the low frequency end of the r.f. coverage. TC_2 is used to beat the output of the crystal against the Light Programme at 200 kc/s. Once set, TC_2 should not require further adjustment unless, perhaps, V_4 has to be changed. The heater voltage is applied continuously to V_4 keeping it at working temperature, and on-off switching is provided by S_3. R_{14} allows sufficient anode current to flow to prevent cathode poisoning but not enough to allow the valve to oscillate. The crystal used in the prototype was mounted in a B7G envelope which was completely evacuated. However, ordinary 2 pin crystals are available quite cheaply and could be used with no modifications to the oscillator circuit apart from the obvious mechanical changes.

Power Output Meter

The power output circuit is very simple, consisting of the meter, four germanium diodes, and one fixed and one variable resistor. R_{19} is the load resistor and should be chosen to match the output impedance of the receivers it will be used with. Normally, it will be 3Ω, since this is a common value with domestic receivers (except for some transistor portables which vary from 3Ω to some 40Ω). VR_3 is the series multiplier and is set during initial calibration to give a full scale deflection at some suitable input. Although an arbitrary figure could be used it is much preferable, and not too difficult to arrange for f.s.d. to correspond to some known value so that a check can be made on the efficiency of the output stage of the receiver undergoing test. Since domestic receivers rarely exceed power outputs of 5 watts, this could well be chosen as the f.s.d. If the load resistor is made 3Ω, an output of 3.87 volts r.m.s. will give f.s.d. whilst a 15Ω load will require 8.67 volts r.m.s. for f.s.d. Table 1 gives the various voltages required across 3Ω and 15Ω for power inputs ranging from 500mW to 5W, and from this it will be seen that, though the scale is somewhat cramped towards the bottom end, accuracy of readings can still be sufficient for most servicing requirements.

The meter rectifier consists of four germanium diodes. GEX34's were used in the original but there is no reason why other diodes with approximately similar ratings should not be used instead. These diodes are mounted on the back of the meter in the following fashion. A thin piece of Paxolin some 2½in square has four turret tags (or failing these four 6BA solder tags) mounted in each corner, and the diodes are soldered to these, taking note of polarity. See Fig. 2. Two holes to take the meter terminals are then drilled in the Paxolin, which is next attached to the back of the meter using the meter terminal nuts. If a miniature potentiometer is used for VR_3 this could, perhaps, also be mounted on to the Paxolin, necessitating a slight re-arrangement of tag and meter hole positioning. The load resistor R_{19} is soldered from the appropriate meter input socket to a convenient earth tag on the chassis or front panel.

Power Supply

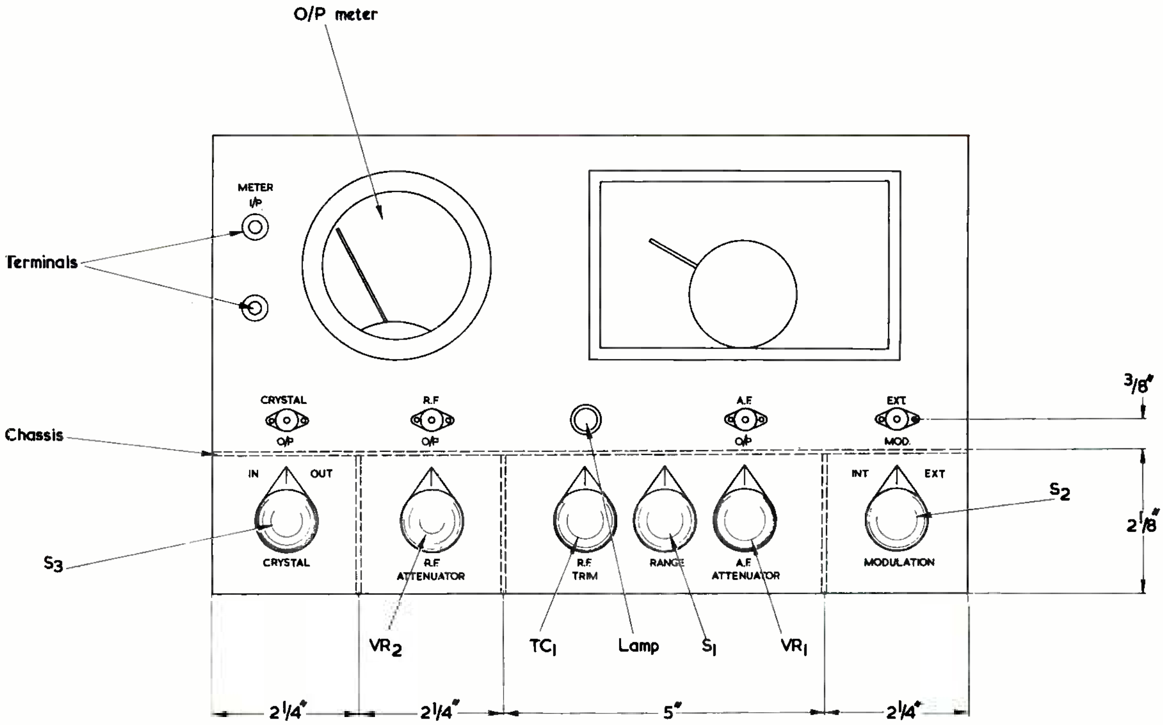
Simple though it is, the power supply will be described in some detail since it possesses a number of features that may not be familiar to the beginner. MR_1 is the rectifier, whilst C_{16}, C_{17} and the l.f. choke comprises the smoothing components. MR_1 is a contact cooled rectifier, and is bolted direct to the rear wall of the chassis, as shown in Fig. 3. Due to voltage surges before the valves have warmed up, C_{16} and C_{17} should have a working voltage of 350, thereby providing a margin of safety. The dial light is connected at the bottom end of the secondary of the mains transformer where it not only shows the presence of h.t. but, by acting as a fuse in the event of short-circuits, provides a measure of protection to the power supply components.[2] The mains transformer is only lightly loaded to the extent of 35mA h.t. and 1.2A heater, consequently it need not be a large and expensive component. The capacitors C_{19} to C_{22} form, with L_4 and L_5, the r.f. filter in the mains input circuit, and effectively prevent any radiation by way of the mains lead. It is most important that the voltage rating of these capacitors should be 300 volts a.c. L_4 and L_5 are each close-wound in a single layer with 28 s.w.g. enamelled wire on a ¼in diameter former, 2in long, the length of the coil being slightly shorter than the length of the former. They are then mounted on a piece of Paxolin measuring 3 by 1in with a turret tag in each corner. See Fig. 3. Although this Paxolin panel was mounted in the original as shown, it, may perhaps, be preferable to fit it to the rear wall of the chassis so as to allow free access to the tags of C_{16} and C_{17}.

No on-off switch is shown in the circuit and layout diagrams, but this can easily be added, if desired. All that is required is a 2-pole toggle switch in series with the Live and Neutral leads from the mains. It may be mounted on the rear wall of the chassis.

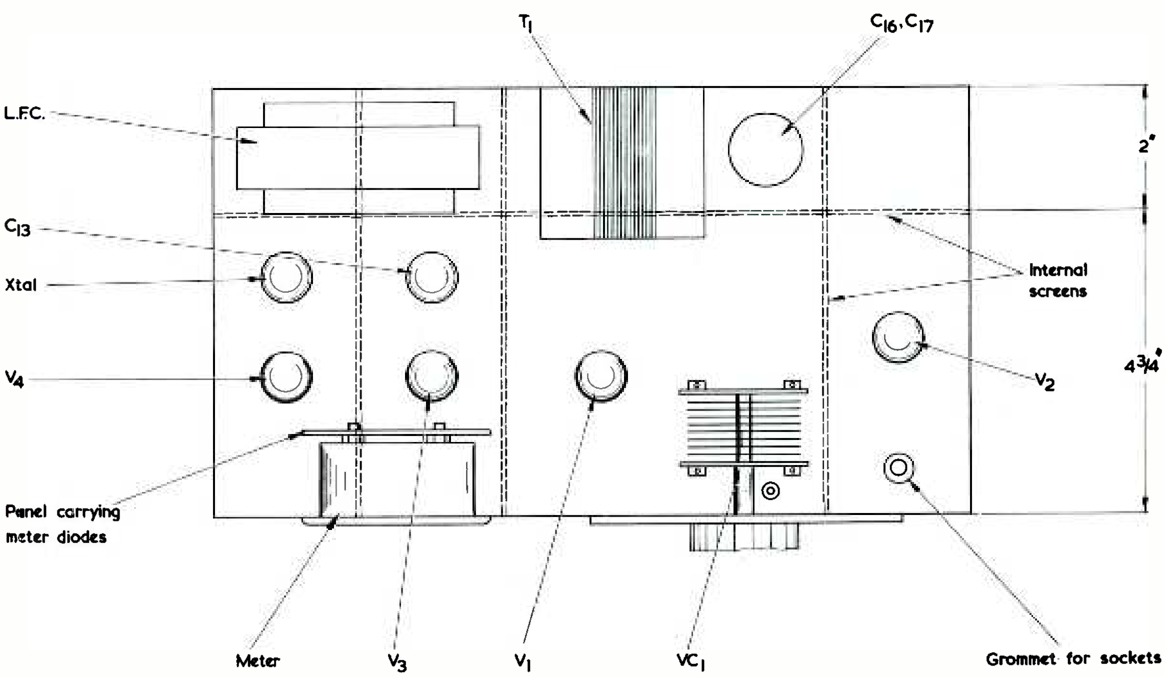
Mechanical Details

Mechanically, the instrument is reasonably compact whilst still allowing adequate room for all the components fitted. It is entirely self-contained in an attractive metal cabinet 12 by 7 by 7in obtainable from H. L. Smith & Co., the cabinet actually used being the type "Y". An aluminium chassis 11¾ by 6¾ by 2¼in high is employed, upon or inside which most of the components are mounted. The Eddystone Full Vision dial and drive is recommended for VC_1 since it allows the oscillator frequencies

[2] The panel light passes the ripple current in the reservoir capacitor circuit, and this will vary according to the resistance of the mains transformer secondary and the forward resistance of MR_1. The panel lamp may also be subject to surges on switching on. Because of these points, it would probably be preferable to initially check the circuit with, say a 0.3A bulb, changing to a lower current bulb if results with the 0.3A bulb indicate that this may be safely done.—Editor.



FRONT PANEL LAYOUT



ABOVE CHASSIS LAYOUT

Fig. 4. The front panel and above-chassis layout

to be drawn directly on the scale, which is a great convenience during use. However, if there are no objections to graphs, the Jackson Bros. dial and drive type 4489 is also suitable.

The chassis is divided underneath by a number of screens which serve to isolate the various sections and help to minimise mutual interference. Heater and h.t. supplies are fed into the various compartments by way of feedthrough capacitors C_{26} to C_{33}, these having a nominal capacitance of 1,500 pF.[3]

Fig. 4 shows the front panel and top chassis layout. Exact dimensions are not given since they are not critical and will in any case depend on the components actually used. If the Eddystone Full Vision dial is used, there will not be much room to spare between the edge of the dial on the outside and the top of the chassis on the inside. Consequently, the coaxial sockets employed for Ext. Mod. and A.F. Output will need to be accurately positioned, as also will the lamp. The lamp could, however, be mounted elsewhere where panel space is less at a premium, should this be desired. The switches and potentiometers protruding through the panel should be positioned equidistant from one another and an inch above the edge of the panel, the latter being secured to the chassis by the fixing nuts of these components. Coaxial sockets should be used at the Crystal Output, R.F. Output, A.F. Output and Ext. Mod. positions, but a pair of terminals would be more suitable for the Meter Input.

Construction And Testing

Construction can commence when all the components are at hand. The major items such as the mains transformer should be laid on the chassis using Fig. 4 as a guide and the position of the fixing and grommet holes marked out. The valveholders are mounted with the orientation shown in Fig. 3. The coils should be fitted as near S_1 as is practicable, as, also, should the valveholder for V_1. The coil associated with the highest frequencies should be nearest the switch with the long wave coil furthest away. Tinned copper wire of 22 s.w.g., suitably sleeved, should be used for wiring the coils to the switch and the switch to the valveholder. Wiring should be direct and point to point.

The internal dividing screens are only required during actual operation and can be left out during initial wiring, though it is advisable to mark the positions on the chassis so that components can be arranged to clear them. It is also advisable to allow sufficient wire to reach from the various heater pins to the respective feedthrough capacitors.

Wiring, as always, should be a methodical affair with plenty of time for thought and, if necessary, reconsideration. Valve by valve, stage by stage is the ideal approach. Care taken during wiring is very much worthwhile, and can often save many hours of fault finding afterwards. A test oscillator is, or should be, a precision piece of equipment and the standard to which the user has to work. It is therefore deserving of extra care and attention at all stages of construction and of the best components that can be afforded.

When wiring is completed it should be checked not only for incorrect connections or components but for the tiny bits of wire and solder that can be relied upon to provide a pyrotechnical display when the mains supply is plugged in! A number of preliminary tests can be carried out after the mains has been applied for several minutes. The h.t. voltage should be in the region of 250V. A pair of phones connected to the A.F. Output socket will prove the presence or lack of audio oscillations, the amplitude of which should vary as VR_1 is rotated. S_2 should, of course, be open for this test, i.e. at the Int. Mod. position. With S_2 closed, in the Ext. Mod. position, the note should cease since V_2 can no longer oscillate. With S_2 at Ext. Mod. a signal may be fed into the Ext. Mod. socket, and this should be heard in the phones. Care should be taken not to overload the V_2 stage with a strong signal.

To check the r.f. oscillator a receiver is necessary. Connect the lead from the R.F. Output socket to the aerial socket of the receiver and, with S_2 set to Int. Mod., check that the oscillator is working by tuning in the signal on the receiver. The various ranges should be swept, keeping the oscillator and receiver in tune. Squegging or lack of oscillations can be cured by appropriate alterations to C_1 and R_4 as previously described.

The crystal calibrator can be checked by connecting its output socket to the receiver and tuning in the Light Programme on 200 kc/s (1,500 metres), whereupon a beat should be observed, this being tuned to zero by means of TC_2.

The power output meter does not really require checking at this stage an can be left till final calibration.

Calibration

Test oscillators seem to have acquired a reputation, not really deserved, of being difficult to calibrate. A careless approach can certainly lead to chaos and confusion but, in the author's opinion, a thorough understanding of the principles involved together with a careful and methodical approach should make calibration both easy and straightforward. It is well worthwhile going to a good deal of trouble to get the initial calibration really accurate, since it will affect the ultimate usefulness of the instrument.

There are several ways of calibrating the oscillator. The calibration can be carried out against a standard signal generator or against broadcast signals of known frequency using, in both cases, a wide range receiver as an indicator. For final

[3] If the section of the chassis to which the feedthrough capacitors are mounted is aluminium, these capacitors will have to be of the type which is secured by a nut instead of the type which is soldered in position. Should difficulty be experienced in obtaining suitable feedthrough capacitors (whose value could, in practice, lie between 1,000 and 2,000pF) it will be almost equally satisfactory in the present application to use lead-through connectors, with a disc ceramic capacitor of 1,000 to 2,000pF coupling the spill inside the compartment to chassis via very short leads—Editor.

calibration the oscillator should be fitted into its case and, together with the standard signal generator and receiver, allowed at least half an hour for warming up. The spacing of the calibration frequencies is a matter for personal preference, though it is suggested that 10 kc/s, 25 kc/s and 50 or 100 kc/s for the long, medium and short wave bands respectively be used. The section of the PHF7 band covering the intermediate frequencies could, however, be calibrated more closely if the standard signal generator will allow it. Points could thus be plotted at 450, 455, 460, 465, 470 and 475 kc/s, these catering for the most commonly used intermediate frequencies. 315 kc/s (equals 952 metres on the PHF1 range) could also be plotted as an i.f. since some of the older transistor radios used this frequency.

If the signal generator to be used as the standard is a borrowed one or one the constructor is not familiar with, it is well worth checking the accuracy of its calibration either against the crystal calibrator or against broadcast stations. All but the very best oscillators drift to some extent, hence the inclusion of TC_1 in the present design. This control should be set to its mid-point during calibration and not touched again until, at some later date, it is perhaps found necessary to correct for oscillator drift.

For calibration the outputs of the standard signal generator and the test oscillator should be very loosely coupled to the receiver being used for calibration. Tight coupling must be avoided for it may result in frequency pulling and the generation of spurious and misleading harmonics. A few feet of wire from the two outputs laid near to each other and near the receiver's aerial terminal should prove satisfactory in most cases. The long waveband (PHF1 coil) should be calibrated first since it is probably the easiest, and the practice gained will prove invaluable when the higher frequencies are attempted. The standard signal generator is adjusted to 150 kc/s with the modulation off, and its signal is tuned in on the receiver. (If any difficulty is experienced in tuning in this signal on the receiver it may prove useful to switch on the modulation, switching it off again when the receiver is accurately tuned). The test oscillator frequency is then adjusted, again with modulation switched off, until its r.f. output signal is heard to beat against that of the standard. The test oscillator is adjusted to bring the beat note to zero, and the setting of VC_1 noted as the 150 kc/s point. The standard is then tuned to the next chosen frequency, which can be 160 kc/s or whatever frequency the constructor fancies or the standard permits, and the receiver again accurately tuned in. The test oscillator is then tuned as before and the new dial setting noted as 160 kc/s. The remainder of the long waveband can be calibrated in this fashion, the crystal being used to check the 200 kc/s point.

The medium waveband, as offered by the PHF7 coil, comes next. This requires rather more care and a somewhat different approach, because part of the band covers the i.f. range and the receiver will not tune directly over the intermediate frequencies. Harmonics will therefore have to be used, requiring greater care if mistakes are to be avoided. An example may make explanations easier and clearer. Assume that the 465 kc/s point has to be calibrated and the standard is already tuned to this frequency. The receiver will not tune to 465 kc/s so the second harmonic will have to be used, this being $2 \times 465 = 930$ kc/s. If the receiver is now tuned to 930 kc/s the signal generator harmonic should be heard. If the standard signal generator and test oscillator are kept carefully in step up to the frequency at which the change over to working on the harmonic occurs, there can be no chance of tuning to an incorrect harmonic.

The medium waveband can, in consequence, be calibrated as follows. The standard signal generator is tuned to 1,200 kc/s, again without modulation, and this signal tuned in on the receiver. The test oscillator is carefully tuned until the two frequencies are identical, and give zero beat, whereupon the VC_1 dial setting is noted as the 1,200 kc/s point. The next chosen frequency is then tuned on the standard signal generator, this could well be 1,225 kc/s, and the receiver tuned in and then the test oscillator tuned for zero beat again. The medium waveband should be calibrated at intervals of 25 kc/s in this manner until the low frequency limit of the receiver tuning range is reached, this being in the region of, say, 545 kc/s or 550 metres. It is at the limit of receiver tuning range that the change over to the second harmonic is made. If the two oscillators have been kept in step all the way, the chances of making mistakes at this point will be negligible. Assuming that 545 kc/s has been successfully calibrated, leave the test oscillator and standard signal generator alone, and retune to the second harmonic of their signals on the receiver at $2 \times 545 = 1{,}090$ kc/s, or 275 metres. Calibration then continues as before, taking care to keep the signal generator and test oscillator in step all the time. At frequencies between 450 and 475 kc/s, it will be desirable to use 5 kc/s separation between calibration points. Summarised, the process consists of calibrating on medium waves in the same way as on long waves until the low frequency end of the receiver's tuning range is reached. Then change to the second harmonic on the receiver only, calibrating on the fundamental frequency of the standard signal generator. Every 100 kc/s, or, at worst, every 200 kc/s, the crystal calibrator should be used to check the accuracy of calibration.

If a receiver with the requisite coverage is available, the short wave ranges do not require the use of harmonics, and calibration is therefore fairly straightforward. On the 90–260 metre band, a separation frequency of 50 kc/s will prove suitable but 100 kc/s will be easier over the 16–47 metre and 34–100 metre bands. The procedure is exactly the same as for the high frequency end of the medium wave range, each range being calibrated

TABLE 1
Output Meter Calibration

15Ω		3Ω	
5W	8.67V	5W	3.87V
4.5	8.20	4.5	3.67
4	7.75	4	3.46
3.5	7.25	3.5	3.24
3	6.70	3	3.00
2.5	6.10	2.5	2.74
2	5.47	2	2.45
1.5	4.74	1.5	2.12
1	3.87	1	1.74
500mW	2.74	500mW	1.23

from the high frequency end to the low frequency end. Extensive use should be made of the crystal calibrator to ensure good accuracy.

The power output meter should next be checked and, if possible, calibrated against Table 1. The figures in this Table are to two places of decimals, but little accuracy will be lost in practice if calibration is made to the first decimal place only. The calibration should be carried out with a sine wave signal monitored by an a.c. voltmeter. If the constructor does not have the equipment to carry out this calibration it is still possible for the meter to provide very useful comparative output level readings. VR_3 is then adjusted to give full-scale deflection for the greatest output anticipated from receivers with which the test oscillator is to be used.

Artificial Aerial

If the best possible use is to be made of the test oscillator an artificial aerial is a very desirable accessory. From the inset in Fig. 1 it will be seen that the artificial aerial consists of two capacitors, C_{24} and C_{25}, one resistor, R_{20}, and a coil, L_7. The coil consists of 60 turns of 28 s.w.g. enamelled wire wound on a former of ¼in diameter. All the components can be mounted in a small tin, which serves to protect and screen them. Constructional notes are not given since almost any tin at hand can be pressed into service. Although he has not himself tried the idea, the author feels that greater operational convenience would result if the artificial aerial were built into the oscillator cabinet itself. Space could readily be made available for it by a slight rearrangement of components in the V_3 compartment.

Editor's Note

Wearite coils, as used in this design, may be obtained from Home Radio Ltd., 187 London Road, Mitcham, Surrey—see page 32 of their latest catalogue (Reprint No. 12).

RECENT PUBLICATIONS

TRANSISTORS FOR TECHNICAL COLLEGES. By L. Barnes, M.Sc.Tech., A.M.I.E.E. 194 pages, 5¼ x 8¾in. Published by Iliffe Books Ltd. Price: 42s. casebound (by post, 43s.) or 24s. limp covers (by post, 25s. 10d.).

Transistors For Technical Colleges is aimed at the student of electronic engineering at Technical College, but it should also provide a very useful textbook for the design engineer. The intention of the book is to introduce the student to practical transistor circuit design, and the seven chapter headings give a good idea of the manner in which this is done. These headings are: Fundamentals of Crystal Diode and Transistor Action; The Transistor in Practice; Approximate Design of Linear Circuits; Parameters and Equivalent Circuits for Low Frequencies; Frequency Effects; Switching Circuits; Experiments.

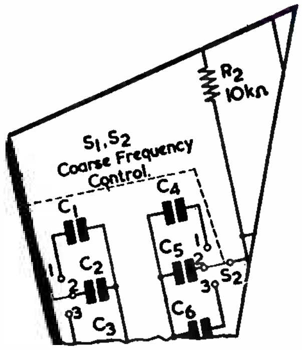
Approximately the last third of the book is taken up with nine appendices, these covering essential points which, if introduced into the earlier text, would impede the flow of explanation. Also dealt with are zener diodes and thyristors.

This book is an attractive proposition for the student, and the availability of a low cost edition will be particularly welcomed by those with shallower pockets.

TRANSISTORS IN LOGICAL CIRCUITS. By J. Ph. Korthals Altes. 125 pages, 5½ x 8¾in. Philips Paperback published by Iliffe Books Ltd. Price 16s.

After a short introductory chapter explaining the development from relay switching to semiconductor switching, this book proceeds straight into Boolean algebra as exemplified by switch and lamp circuits. The binary system is next briefly dealt with, whilst the following chapter discusses the transistor as a switch element, particular attention being paid to the component values involved. The next chapter covers diode circuits, after which AND-, OR- and NOR-gates are introduced. Subjects subsequently dealt with include bistables, multivibrators, simple counting circuits and arithmetical operations. The book concludes with some typical applications for transistor logic circuits, together with a chapter giving hints on using digital circuits in practice.

The approach is down-to-earth, and many of the circuits given in the book could well be assembled by the home-constructor. The translation from the Dutch has been carried out most ably, and the book offers an introduction to transistor logic which will have especial appeal for the practical man.



Automatic Mains-Battery Supply Circuits

SUGGESTED CIRCUIT No. 191

By G. A. FRENCH

ONE OF THE MOST ATTRACTIVE features of transistorised items of equipment is their low power supply requirements, which can often be met by a relatively inexpensive dry battery. When transistorised equipment is permanently installed a mains power supply is often preferable and, here again, the low power supply requirements can result in the provision of a very simple and low-cost mains power unit.

In some cases, it is desirable to provide transistorised equipment with a supply which enables it to run either from the mains or from a battery, this facility being of particular value if the changeover from one to the other can be carried out automatically. A power supply circuit with automatic changeover from mains to battery can also guard against cessation of the mains supply. A baby alarm amplifier could, for example, be run normally from the mains, but would immediately revert to battery operation in the event of mains failure. Other applications in which continual operation of transistorised equipment is required, regardless of whether a mains supply is available or not, will also occur to the reader.

In this month's Suggested Circuit article, the writer discusses two practical circuits which enable switching from mains to battery operation, and *vice versa*, to occur automatically, there being no cessation of the supply whilst switching over takes place. If the item of equipment is, for instance, a radio receiver, the act of coupling it to a mains supply causes no noticeable change in operation, but it results in the receiver supply current being diverted from the battery to a mains power unit. There need similarly be no noticeable change in operation when the mains supply is disconnected, and the receiver will then automatically draw its current from the battery once more.

A Relay Circuit

The first of the two practical circuits to be discussed is that shown in Fig. 1. This involves no new principle of operation, and is included to give an example of automatic switching employing a relay.

In Fig. 1 the relay coil is energised from the rectified output of the mains power supply unit, with the result that its contacts move to the energised position whenever a mains input is present. If switch $S_{1(a)(b)}$ is closed without a mains input, supply current flows from the battery via the relay contacts in the de-energised position. If, now, a mains input is applied, the relay energises and its contacts disconnect the battery and apply the output of the mains power unit to the equipment. The relay returns to the de-engergised position when the mains supply is removed, whereupon the battery provides the supply current once more.

Should the relay be fitted with normal changeover contacts there will be a very short interruption of supply current as it changes from one supply to the other. If, however, the equipment has (as will usually be the case) a high value bypass capacitor across its supply rails this short cessation of supply current will not be noticeable.

The circuit of Fig. 1 has the considerable advantage of simplicity, and its only main disadvantage is that reliance has to be placed on an electro-mechanical component—the relay. The writer decided, in consequence, to investigate automatic supply switching circuits incorporating semiconductor devices to carry out the switching operation.

Semiconductor Circuits

The idea first checked by the writer is based on the circuit shown in Fig. 2, in which it is assumed that the equipment requires a nominal supply voltage of 9. In Fig. 2 the output of the mains supply unit is applied via a series resistor to a zener diode, D_1, which stabilises at a voltage slightly higher than battery voltage. Thus, when the mains supply is present, silicon diode D_2 is reverse-biased and no current flows from the battery. At the same time current flows from the zener diode circuit to supply the

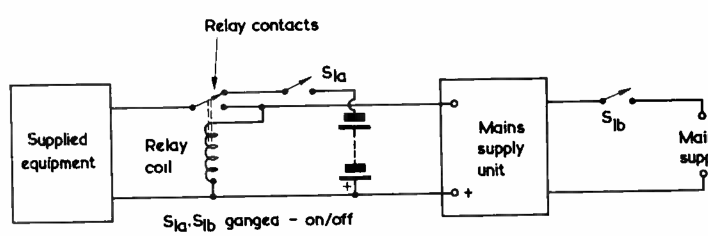


Fig. 1. An automatic power supply switching circuit incorporating a relay

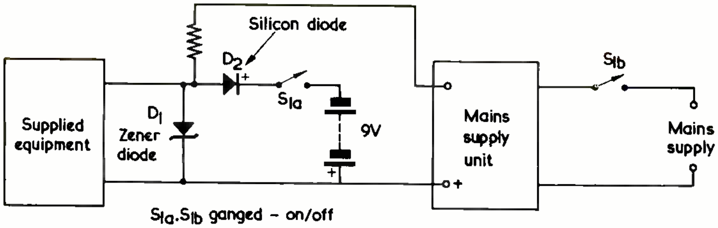


Fig. 2. An experimental switching circuit for use with a zener diode stabilised supply

equipment. When the mains supply is disconnected the voltage across the zener diode drops, diode D_2 becomes forward-biased and current flows from the battery to the equipment. Thus, the requirements of an automatic switching circuit are theoretically achieved. No current is drawn from the battery during mains operation, and the battery automatically powers the equipment when the mains supply is disconnected.

In practice, this approach did not work out as well as had been expected, this being due to two factors. The first of these is that zener voltage is not constant but decreases slightly as zener current decreases (due, for instance, to increasing current drawn by the equipment). The second factor is that about 0.4 volts is dropped across silicon diode D_2 when passing current in the forward direction. When the circuit was set up to obtain completely positive switching from one supply to the other (so that no current flowed from the battery during mains operation, and no leakage current from the battery flowed in the zener diode during battery operation) it was found necessary to have a zener voltage during mains operation which was at least 0.2 volts greater than battery voltage, with the result that the supply voltage dropped by at least 0.6 volts when changing over to the battery.

It must also be appreciated that to obtain a zener voltage which is only slightly higher than battery voltage it is necessary to select the zener diode, since these components normally have a tolerance of 5% or more.

The basic circuit of Fig. 2 is capable of switching reliably, provided that a relatively high voltage drop is acceptable when changing over to battery operation. But the circuit is rather fiddling to set up and necessitates the selection of a suitable zener diode. Interested readers may care to experiment further with the basic idea, and the writer has included the circuit for this reason.

Transistor Switching Circuit

The writer then investigated an alternative approach employing a transistor, and the result, which forms the second practical circuit to be described, is shown in Fig. 3. Whilst this circuit does not provide an exact parallel with the relay circuit of Fig. 1 so far as switching is concerned, it is much more effective than that of Fig. 2. The most interesting feature of the circuit of Fig. 3 is that the battery affects operation when the mains supply is connected and affords a considerable economy in components together with a high level of performance. As shown, the circuit provides a nominal output of 9 volts at currents up to 100mA.

When the mains supply is applied, a rectified negative voltage appears on the upper plate of the reservoir capacitor, C_1, and is applied to the collector of the transistor. Connected to the base of the transistor is the negative terminal of the battery. The transistor then functions as an emitter-follower, allowing a voltage slightly lower than battery voltage to be applied to the output terminals. When the mains supply is removed, the base-emitter junction of the transistor functions as a forward-biased diode, whereupon current from the battery flows into the output load. It should be noted that, due to the collector-base junction, the negative battery voltage also appears at the collector when the mains supply is absent. However, the polarity of rectifiers D_1 to D_4 prevents the flow of direct current into the mains transformer secondary and so the only wasted battery current in the mains supply section is given by leakage current in the reservoir capacitor.

In the author's prototype, the rectifiers D_1 to D_4 were Lucas silicon diodes type DD000 (with a maximum forward current of 500mA and a p.i.v. of 50 volts). The mains transformer secondary offered a voltage of 12.6 (given by two 6.3 volt windings in series) whilst the 9-volt battery was a type PP9. The transistor was an OC26. The accompanying Table shows voltages applied to the output terminals, for currents up to 100mA for both mains and battery operation. Bearing in mind that the internal resistance of the PP9 battery was such that its terminal voltage dropped by about 0.5 volts at a load current of 100mA, it may be seen that there is only a relatively small drop in supply voltage for each current when changing from mains to battery operation. Most of the drop is that inevitably caused by battery internal resistance.

What may not be apparent at first sight of Fig. 3 is that, on mains operation, the battery functions as a constant voltage reference source having a low internal impedance, whereupon a well-regulated voltage with a low ripple content becomes available at the transistor emitter. The transistor takes the place of a smoothing resistor, thereby affording a simple circuit with considerable

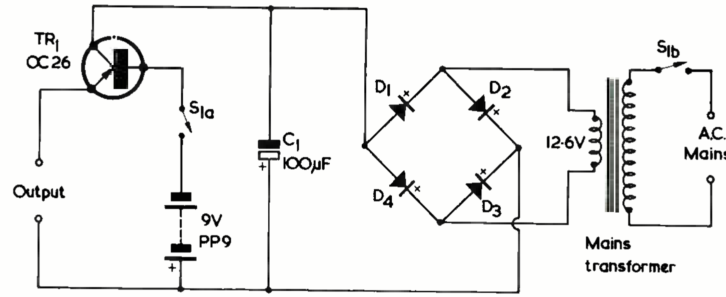


Fig. 3. A power supply switching circuit in which the battery functions as a reference voltage source on mains operation

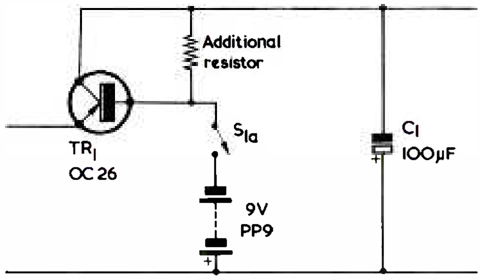


Fig. 4. Battery discharge during mains operation may be reduced by the addition of the resistor shown here

filter components being the transistor itself. On the debit side is the fact that a small current flows from the battery when the mains supply is applied, although this may, by the choice of a suitable transistor, be as low as 0.5mA for 100mA load current. If the resistor of Fig. 4 is added, the current drawn from the battery during mains operation can be even further reduced. The use of a high gain transistor and, if desired, the addition of the resistor of Fig. 4, should result in a battery life during continual mains operation which is only slightly less than shelf life.

economy of components. The maximum dissipation in the transistor is equal to the maximum current drawn by the supplied equipment multiplied by the voltage which appears between collector and emitter when maximum current flows. In the prototype circuit, the voltage appearing across the transistor at 100mA output was 6 volts, resulting in a maximum dissipation of 600mW. The maximum current drawn by the equipment should not exceed the maximum base current specified for the transistor. With the author's set-up, the OC26 employed is entirely satisfactory in these requirements at load currents up to 100mA, and the use of a heat sink is hardly justified.

Output Current (Mains Operation)	Output Voltage (Mains Operation)	Output Voltage given with mains supply disconnected
1mA	9.1V	8.95V
10mA	9.05V	8.9V
30mA	9.0V	8.7V
100mA	8.95V	8.35V

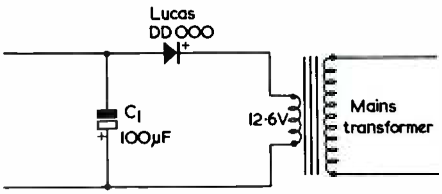


Fig. 5. A half-wave rectifier is sufficient for output currents up to 50mA

Whilst the switching circuit of Fig. 3 gives an extremely good performance it suffers from the disadvantage that a small current is drawn from the battery by the transistor base when the mains supply is applied. In the prototype, a current of some 3mA was drawn from the battery when the load current was 100mA, this indicating a gain in the transistor chosen of about 30. Proportionately lower battery currents were drawn at lower load currents. If a higher gain transistor were employed, such as the OC22 with an average gain of 200 at 100mA, the battery current which flows during mains operation would be proportionately lowered.

Battery consumption during mains operation can be reduced to an even lower level by adding a resistor, as shown in Fig. 4. This resistor should have a value which allows the flow of slightly less than the average current drawn from the battery during mains operation.

Summing up, the circuit of Fig. 3 allows immediate and efficient changeover from mains to battery operation, and *vice versa*, with the use of a single power transistor whose heat sink requirements, at the voltages and currents discussed, are minimal. The circuit offers the incidental advantage of giving extremely good regulation and suppression of ripple when operating from the mains, one of the main

Readers employing the basic circuit of Fig. 3 may prefer to use an alternative mains transformer and rectifier circuit. This is quite in order, of course, but it is desirable to ensure that the rectifier circuit output is sufficient to allow several volts to appear across the transistor at maximum load current. The writer found that the half-wave circuit of Fig. 5 was adequate for load currents up to some 50mA, the bridge circuit of Fig. 3 being preferable for higher currents.

As has already been stated, the prototype employed a PP9 9-volt battery. The circuit principle may be similarly applied for any other battery voltage in the range applicable to transistorised equipment.

EMI Equipment in Community TV Network

When their current installation programmes have been completed the neighbouring Hertfordshire towns of Hatfield, Stevenage, Letchworth and Welwyn Garden City will contain the biggest concentration of v.h.f. wired television networks, serving at least 28,000 houses, in the United Kingdom.

The system used is the Community Television System developed by EMI Electronics Ltd. and supplied to the main contractors, Rediffusion, who are installing and operating the network as v.h.f. Community Service Schemes. Four television and four sound programmes; B.B.C. 1 and B.B.C. 2, I.T.A. London and I.T.A. Anglia, B.B.C. Home, Light and Third Programmes and Radio Luxembourg will be supplied initially but the system is capable of carrying additional television programmes as they become available.

The use of master aerials at carefully selected sites ensures the distribution of adequate interference-free signals over the distribution network so that the viewer is assured of better reception than by any other means.

NEWS . . . AND .

Speech Microscope

Accurate reconstruction of the original complex of sounds is very necessary for the quality reproduction of musical recordings. By contrast, intelligibility of speech is not necessarily dependent on the maintenance of exact replicas of the input signals throughout any system of recording or transmission.

Some components of speech are undoubtedly essential, others, particularly parts of certain vowel sounds, appear to be redundant. It may, therefore, be neither economical nor necessary to transmit the whole of the information contained in a speech waveform in order to retain intelligibility.

Speech studies have been made by Standard Telecommunications Laboratories Limited to determine where there is redundancy in the speech signal, the effect of different types of distortion on intelligibility, and the effect of modifying the signal to suit different forms of transmission media. For this purpose there has been developed by STL a speech microscope, a device for, in effect, dissecting speech—enabling portions of each separate word on a

The rotating head system of the Speech Microscope, which replays repetitively the portion of stationary tape which is wrapped around part of the periphery of the rotating disc. The equipment can be used to study the duration of sounds necessary for correct speech recognition

tape-recording to be isolated so that it can be both heard and seen with its waveform displayed on an oscilloscope.

This experimental equipment provides for timed portions of sounds to be removed during the replay of a recording. By using several adjustable time delay switches which are operated from a reference point on the tape-recording, the equipment can be used to study the duration of sounds necessary for correct speech recognition.

The effect of removing part of the duration of a vowel sound has been examined and it is found that up to one half of the duration of the vowel can be removed from some sounds without the listener being at all aware that there has been any change in the signal. The point transition from consonant to vowel sound is very important, however, changes here are found to materially effect the perception of speech.

The Speech Microscope was one of the items shown by STL at this year's Physics Exhibition (organised by the Institute of Physics and the Physical Society) at Alexandra Palace, London.

Australian Amateur Radio Satellite

The Melbourne University Radio Club have announced that they are well on the way to completing an OSCAR, which will be launched for them by the Americans from California.

Of particular interest is that this OSCAR will transmit a signal in the 10 metre amateur band, on 29.450 Mc/s to be exact; which will enable far more radio amateurs to listen to it than has been the case with the previous OSCARS which radiated principally in the v.h.f. regions. This OSCAR will also radiate in the more usual 2 metre amateur band on 144.050 Mc/s. The identification signal will be "VK" in morse code.

An interesting feature of the satellite is that it will be fitted with bar magnets, the purpose of which is to endeavour to stabilise it in the earth's magnetic field, thus reducing the tumbling effect and the consequent variation in signal strength, due to a constant changing of aerial pattern.

With the opening up of the 10 metre band now taking place with the ionospheric cycle improvements, some interesting results can be expected. The satellite will be known as AUSTRALIS 1.

International Radio Communications Exhibition

The exhibition will again be held in the Seymour Hall, Seymour Place, London, W.1., from Wednesday October 26th, to Saturday October 29th, 1966 and will be open from 10.00 a.m. to 9.00 p.m. daily, admission 3s.

The stage presentation will be a display by the Royal Signals who are taking part for the first time.

The RSGB will occupy a longer stand with a book and information service, live transmitting stations on several frequencies including v.h.f.

The Exhibition Awards for home construction and manufacturers equipment will again take place and silver plaques presented to the winners. Many new ideas on developments of home and overseas transmitters, transreceivers and receivers particularly on s.s.b. and v.h.f. will be seen and the latest technical books will be available for inspection or purchase.

. . . COMMENT

NEW BSR TAPE DECK

The TD20 is a completely new BSR tape deck with mechanical, direct action push button controls. The advanced design of the push button linkage is such that fingertip pressure alone is sufficient to engage the direct action keys—a feature not often associated with mechanisms of this type.

The deck will accommodate reel sizes up to $5\frac{3}{4}$in diameter and records at speeds of $1\frac{7}{8}$in, $3\frac{3}{4}$in or $7\frac{1}{2}$in per second. The rotary speed change control is located at the back of the deck between the tape reels.

A "pause" control key allows the tape to be held stationary for brief periods when pauses occur during recording; the tape is stopped only while this control is held depressed.

The unit can be supplied with any of the wide range of BSR tape heads either two track or four track for stereo operation and, if required, a three digit counter with either wheel or push button reset can be fitted.

Particular attention has been given to the appearance of the TD20, it is styled and engineered to enhance the appearance and performance of the most modern tape recording equipment.

The TD20 measures approximately $12\frac{1}{4}$in long x 10in wide (front to back) x $4\frac{5}{16}$in deep overall.

The other tape decks in the BSR range, the TD2 and the TD10, will continue to be produced.

Pye Telemetry Equipment for Grafham Water

The telemetry equipment for the Grafham Water Scheme of the Great Ouse Water Authority, Huntingdonshire which has been supplied and installed by Pye Telecommunications Ltd., fulfils two main purposes.

One is the transmission of measurements from each outstation in the scheme to the central control room and the control command signals from the control room to the outstations.

The other is the logging of this data so that a permanent record is obtained of the working of the entire installation.

Three Telescan equipments, situated at the intake pumping station, the dam pumping station and at Flitton booster station, send measurement information continuously in digital form to the control room.

Typical measurements are water pressures, rates of flow and levels. A monitoring system is incorporated which transmits continuously the state of all plant and provides warning if any faults occur.

A telephone circuit is also included with connections at each outstation. The telemetry signals are transmitted over cables buried alongside the pipelines.

The main telemetry equipment in the control room at the treatment works routes and processes all incoming information for display on the control panel and for recording. Signals can be transmitted from the control room to operate remote pumping plant as required.

These signals are coded and transmitted automatically when the appropriate switches on the control panel are operated. The controls include the starting and stopping of pumps, control of pump speeds and the operation of valves on the pipelines.

The data logging system which is supplied with information from the telemetry equipment and local instruments has two sections: the operations logger and the statistical logger.

The operations logger records major changes in the state of plant, such as the starting or stopping pumps, the opening of valves or the occurrence of alarms.

The statistical logger records selected data at pre-set time intervals of from half-an-hour to two hours, or on demand.

Each logger is completely independent, with automatic print-out on an associated electric printer.

The telemetry equipment in this installation deals with some 200 separate measurements and can operate more than 50 controls on command.

New Development in Headset Manufacture by Amplivox

The Jetlite Headset, shown below, with an integral micro-miniature pre-amplifier as part of the boom arm assembly. This means that users of "carbon" radio systems will now be able to benefit from the high quality of e.m. microphones without having to modify their equipment. The headset when plugged into a carbon system will be compatible and will automatically provide carbon level.

The micro-miniature pre-amplifier fitted on a Jetlite Headset

THE DESIGN AND CONSTRUCTION OF MEASURING BRIDGES Part 3

by W. KEMP

In the preceding two articles in this series, our contributor has discussed general attributes of measuring bridges and has paid particular attention to the components and circuit of a precision Wheatstone bridge for measuring resistance. This concluding article deals with voltage sources for a.c. bridges and suitable indicator devices. Also given are circuits for two simple a.c. bridges which may be constructed at home

A.C. Bridge Source

The energising source of the bridges now under consideration is a.c. Generally speaking, the choice of frequency is a matter of compromise. The minimum frequency is dictated by the sensitivity of the detector or balance indicator.

In any practical circuit certain unwanted stray capacitances and inductances exist, and at high frequencies these tend to become troublesome. While measures can be taken to allow for these unwanted quantities it is generally found that the best way to deal with them is to use a frequency of not much above 1 kc/s, at which frequency these strays have a reasonably small effect.

Several alternative means of obtaining the desired a.c. signal are available, but the final choice will depend on the type of detector to be used in the final bridge, whether the bridge is to be portable or not, and on the financial situation of the individual reader. Some of these alternatives are now listed.

50 c/s mains. The bridge can be driven from the mains via a suitable step-down transformer. This has the advantage of low cost and, also, that any desired voltage can be easily selected. The disadvantages are that the bridge is tied to a mains socket and is therefore not really portable, and that a visual balance indicator must be used as the ear is not very sensitive at this low frequency. While 50 c/s is excellent for measuring large values of capacitance and inductance, it is not very good for small values of these quantities.

Buzzers. These have the advantage that they can be battery operated so that the equipment can be made portable. On the debit side, they are not very reliable, need to be sound insulated if used with earphones, and require a certain amount of maintainance. They are not particularly cheap to buy and are not recommended.

Valve Oscillators. These are fairly expensive, are generally mains-driven and therefore not portable. A certain amount of warming up time is required and the oscillator unit will take up a fair amount of space. On the credit side, they are very reliable and their operating frequency can be altered easily. Any desired amplitude can be obtained

Transistor Oscillators. These have the advantage of extreme compactness, low power consumption, and their operating frequency can be altered as desired. They require no warm up time and are ideal for portable instruments. They are reasonably cheap to build and their only disadvantage seems to be their limited output.

Neon Oscillators. Neon oscillators are fairly cheap but will normally have to be driven from the mains via a rectified and smoothed supply. Their only real advantage is that the neon can also be used as a leakage indicator when testing capacitors.

Detectors

Most bridge measuring instruments of the more advanced type will combine a.c. and d.c. bridges so that the indicator will have to be able to deal with both types of voltage. Some of the cheaper bridge measuring instruments, on the other hand, measure only resistance and capacitance and use a.c. for both, so that almost any a.c. indicator can be used. Once again several alternative types of detector can be used and some of these alternatives will now be listed.

Earphones. Earphones are cheap and need not be fixed to the bridge, so that they are available for other uses. They can only be used with a.c. and are almost useless at 50 c/s. They are not particularly sensitive and the balance point may sometimes be lost in external noise. They are not generally recommended except on cheap instruments in which a high standard of accuracy is not needed.

Magic eye. This is tied to a mains supply and requires a certain amount of warming up time. It is useful in cheap mains-driven bridges where a.c. only is used for both resistance and capacitance tests.

Oscilloscope. If available, an oscilloscope is by far the most accurate means of observing the balance point, as phase can also be checked. It will incur a certain amount of setting up, however, and is rather liable to waste time. The oscilloscope would not, of course, be built into the bridge, on account of the expense involved. Reading of resistance ranges will also entail d.c. coupling of the oscilloscope.

Built-in valve voltmeter. This works out rather expensive, but is the method used on the better class of commercial universal bridges.

Sensitive moving coil indicator. If of the type described in Fig. 5, (published in Part 1) where a 50μA meter is fed from a bridge rectifier, and where a limiting diode is placed across the meter and a series resistance, this will probably be found the most useful of the alternative indicators. It is fairly cheap

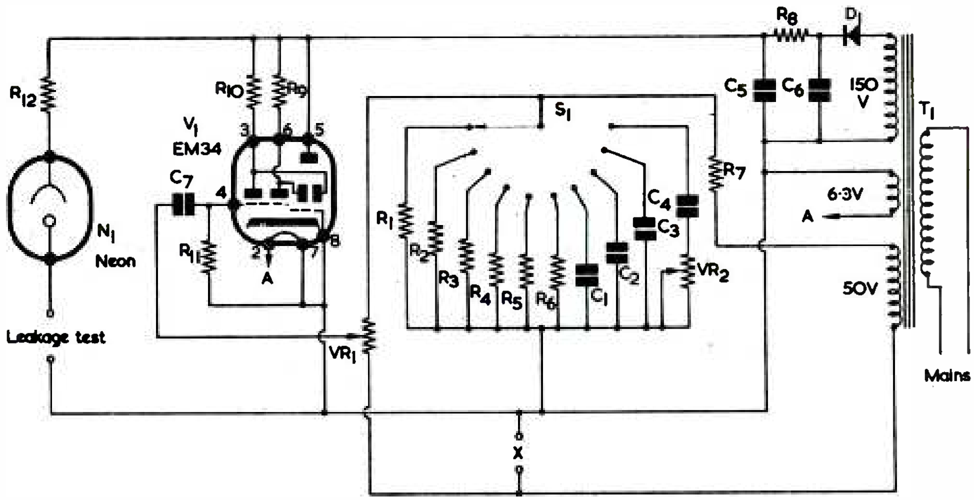


Fig. 16. A simple mains operated bridge capable of measuring resistance and capacitance

Components List (Fig. 16)

Resistors
- R_1 1MΩ 1% ¼ watt
- R_2 100kΩ 1% ¼ watt
- R_3 10kΩ 1% ¼ watt
- R_4 1kΩ 1% ¼ watt
- R_5 100Ω 1% ¼ watt
- R_6 10Ω 1% ¼ watt
- R_7 10kΩ 20% ½ watt
- R_8 10kΩ 20% ½ watt
- R_9 1MΩ 10% ¼ watt
- R_{10} 1MΩ 10% ¼ watt
- R_{11} 2.2MΩ 10% ¼ watt
- R_{12} 100kΩ 10% ¼ watt
- VR_1 5kΩ wirewound linear
- VR_2 5kΩ carbon linear

Capacitors
- C_1 0.001μF 1% silver mica or paper
- C_2 0.01μF 1% silver mica or paper
- C_3 0.1μF 1% paper
- C_4 1μF 1% paper
- $C_{5,6}$ 1μF or larger (may be electrolytic)
- C_7 0.1μF paper

Valve
- V_1 EM34

Rectifier
- D_1 Any rectifier able to withstand 450 p.i.v. and pass 5mA

Neon
- N_1 Small panel mounting neon (Bulgin type D.815 or similar)

Switch
- S_1 single pole, 10-way

Transformer
- T_1 Primary, to suit local mains voltage. Secondaries, 150V at 5mA, 50V at 5mA, 6.3V at 0.2A (Currents quoted are minimum requirements)

and sensitive, is not subject to overload problems and does not need a variable sensitivity control, and it will read a.c. and d.c. equally well.

Transistorised voltmeter. If d.c. coupled and used in conjunction with the above moving coil indicator, this will offer an improved performance at the cost of greater expense.

General Considerations

It is recommended that the two simple bridges described in this concluding article be built up as complete units if possible and not as a set of "boxes". This is because the bridge will probably be in frequent use and the box method of construction will be excessively time wasting.

The variable arm of the bridge will normally consist of a wirewound potentiometer.

As mentioned when discussing the Wheatstone bridge, the final accuracy of the equipment will be dictated by the standards used init. All resistor standards should be wirewound or high stability types, and the capacitors must be either silver-mica or paper types. Electrolytics must not be used as they are very unstable in maintaining their specified capacitance.

A Mains-driven A.C. Bridge for C and R.

Fig. 16 shows the circuit diagram for this instrument, which covers the range 1Ω to 10MΩ and 10pF to 10μF in 11 ranges.[1] Power factors can be measured on the larger value capacitors.

The bridge is energised from the 50 c/s mains via a transformer, and a "magic eye" is used as the balance indicator.

The variable resistor VR_1 forms the two ratio arms of the bridge, the other two arms being formed by the unknown component under test and the standard. It can be seen that the bridge is built around the Wheatstone and the De Sauty circuits.

[1] A capacitance of 10pF offers a reactance of around 300MΩ at 50 c/s and would necessitate great care being taken with respect to insulation. Also, self-capacitances in the bridge, particularly between the 50 volt and 150 volt secondaries of T_1, may result in inaccuracies. Mainly because of these points, we would suggest that the lowest reliable readings are liable to be at 100pF but that, if due attention is paid to insulation, etc., readings for capacitances considerably lower than this are quite feasible. The standards go up in multiples of 10 and this will result in an overlap between ranges. However, there is the advantage that most readings can then be taken at a more central position of VR_1. It would, of course, be possible to use fewer standards than is shown in the diagram. —Editor.

The neon may be used for leakage and insulation tests. When checking capacitors for leakage they should be connected across the correct terminals and the action of the neon observed. If the neon flashes once and then goes out and stays out, the capacitor may be considered "good", the first flash indicating that it has charged up and the subsequent continued extinction of the neon indicating that leakage is low. A rapid succession of flashes indicates that leakage is high, while a continuous glow indicates a short circuit. If the neon does not flash initially the capacitor is open circuit. It should be added that the initial flash may not occur with good capacitors below a certain value, this value being found experimentally with the particular neon employed.

The power factor of a capacitor is a measure of its "goodness" and is in fact the cosine of the phase angle between its current and voltage. In a perfect capacitor the voltage and current will be 90° out of phase and the cosine or power factor will be zero.

In this instrument the power factor control is in use on one range only. When balancing the bridge on this range it will probably be found that the null point is not very clearly defined. Adjustment of the power factor control in conjunction with the main control will enable sharper definition to be obtained and at one point sharpness will be at a maximum. At this point the power factor of the capacitor under test is balanced.

The power factor control may be calibrated directly if desired, using the following formula:

$$\text{P.F.} = \text{Resistance}/\sqrt{\text{Resistance}^2 + (\text{Reactance of C})^2}$$

It can be seen that the power factor depends on frequency. The required calibration points may be worked out on paper assuming values of resistance within the range of the power factor control, and these can then be transferred direct to the control at the correct resistance points.

It is unlikely, however that this calibration facility will be required by many amateurs.

Calibration is carried out by connecting known values of resistance and capacitance across the test terminals and marking the scale accordingly. If close tolerance components are used as standards in the bridge it will be necessary to carry out the calibration procedure on one range of resistance and capacitance only, the remaining ranges being multiples of the calibrated ranges.

A Transistorised, Portable A.C. Bridge for C and R

The circuit for this instrument is shown in Fig. 17. It uses the same basic bridge as the mains powered bridge described above and all information concerning range and calibration already mentioned for the mains version therefore apply to the transistorised circuit.

The primary difference between the two circuits lies in the type of detector and energising source used, and the fact that the transistor version has no facility for checking leakage of capacitors.

The transistor used for the prototype oscillator was a Red Spot surplus type, but any other transistor with a satisfactory voltage rating may be used, although this may require a certain amount of "fiddling" with the component values shown. In the circuit in Fig. 17 a small inter-stage transformer with a ratio of about 3:1 is used to provide a feedback voltage to cause the transistor to oscillate, and the voltage used to feed the bridge is taken from the collector of the transistor. The amplitude of this voltage is not very great and when reading high values of resistance or low values of capacitance difficulty may be experienced in observing the null point if 'phones are used.[2]

It would therefore be better, if a suitable component is available, to use a transformer with three windings, two of them forming the 3:1

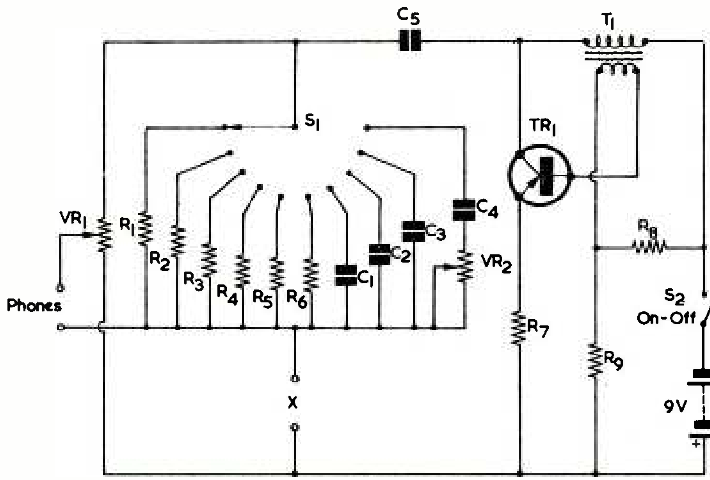


Fig. 17. A portable transistorised bridge. T_1 is a transistor interstage transformer having a ratio of around 3:1

Components List (Fig. 17)

Resistors
- R_1 1MΩ 1% ¼ watt
- R_2 100kΩ 1% ¼ watt
- R_3 10kΩ 1% ¼ watt
- R_4 1kΩ 1% ¼ watt
- R_5 100Ω 1% ¼ watt
- R_6 10Ω 1% ¼ watt
- R_7 1kΩ 10% ¼ watt
- R_8 22kΩ 10% ¼ watt
- R_9 4.7kΩ 10% ¼ watt
- VR_1 5kΩ wirewound linear
- VR_2 5kΩ carbon linear

Capacitors
- C_1 0.001μF 1% silver mica or paper
- C_2 0.01μF 1% silver mica or paper
- C_3 0.1μF 1% paper
- C_4 1μF 1% paper
- C_5 0.1μF paper

Transistor
- TR_1 Red Spot, OC71, etc.

Transformer
- T_1 transistor interstage transformer (see text)

Switches
- S_1 single pole, 10-way
- S_2 single pole, single way

Phones
High resistance phones

Battery
9-volt battery

windings to drive the oscillator, and the third being a step up winding to feed a reasonably high voltage to the bridge. In this case a transistor such as the OC72 would probably be best and a limiting resistor should be fitted in the supply line to the bridge to limit the current, as mentioned when discussing energising sources for the Wheatstone bridge.

The phones used for the detector should be of the high resistance type. If the readers pocket is deep enough it is recommended that the 50μA meter circuit shown in Fig. 5 (published in Part 1 of this series) be used in place of phones as the meter will be found to be by far the more sensitive instrument.

(CONCLUSION)

[2] The frequency of oscillation may be varied, if necessary, by connecting a capacitor across either winding of T_1, the value of capacitance being found experimentally. It should be noted that a high audio frequency will offer greater sensitivity with low value test capacitors.—Editor.

Varactor Diodes

By **M. J. DARBY**

IN THE FIELD OF MODERN COMMUNICATIONS THE trend to use still higher frequencies continues, but the efficient generation of power becomes more difficult with increasing frequency. In the past the generation of moderately large amounts of power at high frequencies (over 100 Mc/s) has been accomplished almost exclusively by the use of thermionic valves. Nevertheless, the use of semiconductor devices is obviously very attractive for mobile transmitters.

During the past few years power transistors have been developed which can operate at frequencies of up to about 200 Mc/s and supply some tens of watts. The output power from one or more of these transistors can be multiplied in frequency by a factor of up to about seven by means of a varactor diode circuit in order to produce an output in a suitable frequency channel. Some loss of power will occur in the multiplication process, but no power supply (other than the r.f. input) is required.

The use of a high power varactor diode enables very simple frequency multiplying to be constructed. Such diodes are basically semiconductor variable capacitors[1], the capacitance across the junction varying with the applied potential in a non-linear way. Readers familiar with Fourier analysis will understand that it is this non-linear effect which gives rise to the production of harmonics.

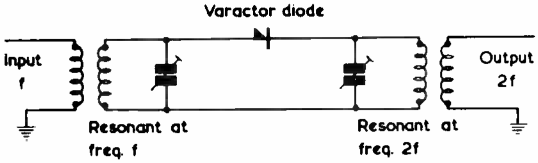
The basic circuit of a typical series frequency doubler is shown in the diagram. Somewhat similar circuits in which the diode is used as a shunt can also be designed.

Performance

Varactor diodes may be usefully employed for frequency multiplication over quite a wide range of frequencies. For example, the silicon diode BAY96 may be employed in a frequency trebler circuit for converting an r.f. input of 30 watts at a frequency of about 150 Mc/s into an output of 24 watts in the region of 450 Mc/s[2]. This efficiency of 75% is quite remarkable and the circuit should be of interest to radio amateurs who wish to convert a 144 Mc/s signal (2 metres) into an output of 432 Mc/s (70 cm.).

At much higher frequencies the power levels must be reduced. For example, a Sylvania D5047C varactor diode will convert 200 mW of power at 11,620 Mc/s into an output of 108 mW at 34,860 Mc/s[3]. If a higher harmonic is required, the efficiency is reduced. For example, a Sylvania D4957 diode will convert a 150 mW signal at 10,000 Mc/s into an output of 50,000 Mc/s at 0.45 mW.

In general the efficiency of a varactor diode frequency multiplier falls with increasing frequency and with increasing power levels.



A frequency doubler employing a varactor

Other Uses

Varactor diodes can be used in parametric amplifiers (a form of very low noise amplifier) and as switches in addition to their uses as frequency multipliers.

It is interesting to note that the Mullard CAY10 varactor diode (which has a cut-off frequency of 250,000 Mc/s and a maximum power dissipation of 100 mW) employs gallium arsenide as the semiconductor material. The first letter, C, in the coding of this device signifies that it is this particular semiconductor material which is used. The CAY10 can be used as a parametric amplifier down to liquid nitrogen temperatures and can be usefully used to produce harmonics up to about 18,000 Mc/s.

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[2] R. J. Bosselaers. "Design of a High Power U.H.F. Trebler", Amperex Tech. News, Vol. 6, No. 1, March 1965. (Reprinted in Mullard Technical Communications, Vol. 8, No. 78, p. 256, November 1965).

[3] "Sylvania Varactors for Harmonic Generator Applications". (A Sylvania publication.)

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Novel Square Wave Generator

by **M. HARDING**

OBSERVING A SQUARE WAVE BY MEANS OF AN oscilloscope at the output of an audio amplifier is a wellknown and simple way of evaluating the latter's performance.

Methods of generating square waves using transistors are many and varied, but one of the simplest and cheapest is the collector coupled astable multivibrator. A typical circuit of such a device is shown in Fig. 1, together with the waveform one would expect to find at each collector. As can be seen, one of the drawbacks of the circuit in its simplest form, as shown, is the drooping trailing edge of the output waveform. This is caused by the long recovery of the "off' collector as its load resistor recharges the associated timing capacitor. Remedies for this involve diodes to isolate the "off" collector from its associated capacitor during the recharging time, or the use of an additional transistor as a clipper.

Series Connected Multivibrator

However, the series connected multivibrator shown in Fig. 2 does not suffer from the characteristic defect just described in its output waveform, and uses only two extra resistors compared with the original circuit. The waveform at either collector is the same as that shown in Fig. 1, but the output waveform at the junction of R_3 and R_4 is an excellent square wave.[1] This arises since the potential at this point always follows the switching on of each transistor in turn. Since the transistors are turned on in a matter of just a few microseconds, both rise and fall times are equally fast, giving an excellent waveform for minimum cost in components. The operation of the circuit is very similar to that of the conventional circuit except that the timing waveforms on each base have different aiming and cut on potentials, thereby slightly complicating the calculation for the frequency of oscillation of the circuit. The bias resistors must be chosen in the seemingly strange ratio of 4:1 in order to satisfy the different saturation needs of the respective "on" transistor from the voltage available to produce this condition. However to obtain a 50:50 mark-space ratio (m.s.r.) for the output waveform, the timing capacitors are chosen in a 3:1 ratio as is explained in the appendix.

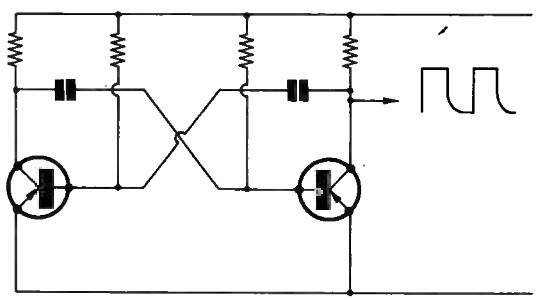


Fig. 1. A conventional astable multivibrator

Practical Circuit

Now for the bits and pieces. The circuit as shown in Fig. 2 covers four frequencies, these being approximately 100 c/s, 1 kc/s, 5 kc/s and 10 kc/s. These frequencies were chosen as the most useful for assessing the performance of audio gear. For different frequencies new values of C_1 and C_2 will be required, and assuming all the other component values remain the same, the new values may be found using the formulae

$$\left.\begin{aligned} C_1 &= \frac{0.084}{f}\mu F \\ C_2 &= \frac{C_1}{3}\mu F \end{aligned}\right\} \text{See appendix}$$

where f is the frequency in kc/s.

Example:—

The required frequency is 5 kc/s,

$$\therefore\ C_1 = \frac{0.084}{5} = 0.016\mu F$$

$$C_2 = \frac{0.016}{3} = 0.0053\mu F$$

Values of $0.02\mu F$ and $0.005\mu F$ for C_1 and C_2 are perfectly satisfactory in practice.

If other component values are changed a different formulae must be applied, as is discussed in the appendix.

The function of VR_1 is to trim the m.s.r. to an exact 50:50. It also affects the frequency slightly, but to a negligible extent compared to the m.s.r. The output amplitude is some 5 volts peak-to-peak when supplied by a 9V battery for a current consumption of 3mA. The construction of the circuit is in no way critical and is best left to the individual constructor.

Finally it should be noted that some of the frequency determining capacitors are made up from two standard capacitors connected in parallel. This was done for the sake of good frequency accuracy.

[1] In the subsequent theoretical discussions of the circuit of Fig. 2, it is assumed that the resistance in VR_1 above the slider is included in R_3, and that the resistance in VR_1 below the slider is included in R_4.—Editor.

COMPONENTS

Resistors
(All fixed values 10% ¼ watt. Note that two R_c resistors are required)

R_1	22kΩ
R_2	82kΩ
R_3	2.2kΩ
R_4	2.2kΩ
R_c	1kΩ
VR_1	250Ω wirewound

Capacitors

$C_{1(a)}$	1μF
$C_{1(b)}$	0.1μF
$C_{1(c)}$	0.02μF
$C_{1(d)}$	0.01μF
$C_{2(a)}$	0.3μF (0.25+0.05μF)
$C_{2(b)}$	0.03μF (0.02+0.01μF)
$C_{2(c)}$	0.005μF
$C_{2(d)}$	0.003μF
C_3	8μF, electrolytic, 15V wkg.

Transistors
TR_1, TR_2 OC45

Switch
$S_{1(a)\ (b)}$ 2-pole, 4-way

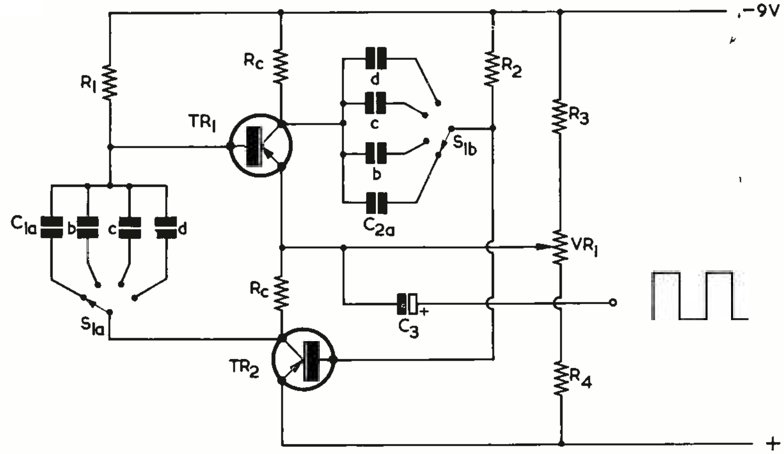


Fig. 2. A practical series-connected multivibrator. Component values are given in the Components List

This little circuit has proved a reliable oscillator and is very easy to get going.

APPENDIX

Take a deep breath, and look at Fig. 2. By examining the exponential shape of the waveform appearing at the bases of the two transistors, it is possible to derive expressions for the "off" times of each transistor thus:—

$$t_1 = R_1C_1 \log_e A$$

$$t_2 = R_2C_2 \log_e \left(2 - \frac{1}{B}\right).$$

where t_1 and t_2 are the respective "off" times of transistors TR_1 and TR_2.

$$A = 1 + \frac{N R_c}{R_4 + R_c} \qquad B = 1 + \frac{R_c}{N(R_3 + R_c)} \qquad N = \frac{R_4}{R_3}$$

The logs, of course, are of the Naperian variety to the base 'e'.[2]

The position of N in the expression for A and B gives a clue to the way in which VR_1 in the practical circuit varies the m.s.r. Varying VR_1 varies the ratio $\frac{R_4}{R_3}$ hence N, and this has a "differential" effect on t_1 and t_2, i.e. one goes up and the other comes down. This of course changes the m.s.r. However the effect is a little uneven, affecting one time interval more than the other and hence there is a slight shift in frequency. If the ratio $\frac{R_4}{R_3}$ is kept close to unity, as in the circuit shown, this latter effect is very small indeed.

Frequency being the reciprocal of the sum of the two "off" times, it is given by

$$f = \frac{1}{R_1C_1 \log_e A + R_2C_2 \log_e \left(2 - \frac{1}{B}\right)}$$

This is the formula that must be used for finding C_1 and C_2 if different values are used for R_1, R_2, R_3, R_4, or R_c. (Best of luck!).

Looking now at the practical circuit, for which the "donkey work" has been done, N=1, i.e. $R_3 = R_4 = 2.2k\Omega$. $R_c = 1k\Omega$.

Therefore $t_1 = R_1C_1\ 0.27$ and $t_2 = R_2C_2\ 0.21$. For the required m.s.r. of 50:50 t_1 must equal t_2.

$$\therefore \frac{t_1}{t_2} = 1 = \frac{R_1C_1\ 0.27}{R_2C_2\ 0.21}$$

However, since we know the ratio $\frac{R_1}{R_2} = \frac{1}{4}$, as discussed in the text, we can find from this equation the ratio of $\frac{C_1}{C_2}$.

$$\frac{C_1}{C_2} = \frac{4.\ 0.21}{0.27} \sim 3$$

$$\therefore \quad C_1 = 3C_2.$$

Hence the 3:1 ratio of the frequency determining capacitors.

Since the ratio of all the timing components is now known, a simplified frequency expression may

(continued on page 165)

[2] These equations have been derived from Ohms Law, the two transistors being considered as ideal switches. When TR_1 is off its base voltage ranges from zero volts to the voltage at the junction of R_3 and the parallel combination of R_4 and R_c the period being controlled, by R_1 and C_1. When TR_1 switches on, the charged C_2 takes the base of TR_2 positive of zero volts by the voltage across the parallel combination of R_3 and R_c in the potential divider given by this parallel combination in series with R_4. This results in TR_2 being switched off. TR_2 comes on again when its base reaches zero potential, the period being controlled by R_2 and C_2.

★

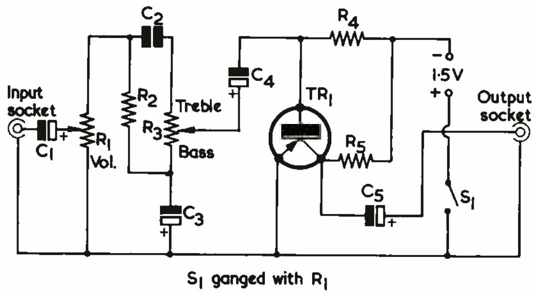


Fig. 1. The circuit of the pre-amplifier

Simple Pre-Amplifier

By

G. MAYNARD

A simple low-level a.f. pre-amplifier incorporating bass and treble tone control

THIS LITTLE PRE-AMPLIFIER IS INTENDED FOR USE with transistor equipment only, and it may for instance be inserted between a transistor tuner and a transistor a.f. amplifier. It gives a very comfortable degree of treble or bass boost, as required.

The Circuit

The circuit appears in Fig. 1. In this, the volume and tone controls which precede the transistor have values which were found after a considerable amount of trial and error, and the circuit finally evolved is most effective. The transistor amplifier makes up for the signal level lost in the tone control network.

The pre-amplifier may be made up in a very small case, and only a 1.5 volt cell is needed for supply. Checking the circuit experimentally with a 3 volt supply gave no useful increase in gain, so the 1.5 volt cell was retained. This is an Ever Ready cell type D23 which, in the prototype, was soldered direct into circuit.

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)
R_1 5kΩ potentiometer, log track
R_2 1kΩ
R_3 5kΩ potentiometer, linear track
R_4 220kΩ
R_5 100Ω

Capacitors
C_1 25μF electrolytic, 6V wkg.
C_2 0.04μF, paper
C_3 2μF electrolytic, 6V wkg.
C_2 25μF electrolytic, 6V wkg.
C_5 25μF electrolytic, 6V wkg.

Transistor
TR_1 OC44

Switch
S_1 on-off, ganged with R_1

Cell
1.5 volt cell type D23 (Ever Ready)

Sockets
Input and output sockets

Construction

Using small components, the author's version was fitted in a case measuring 3x2x¾in only, but it may be found more convenient to use a slightly larger case to avoid crowding. The constructor should judge the size of case required after obtaining the components. The layout is not critical and that employed in the prototype is shown in Fig. 2 (*a*), with the panel layout in Fig. 2 (*b*).

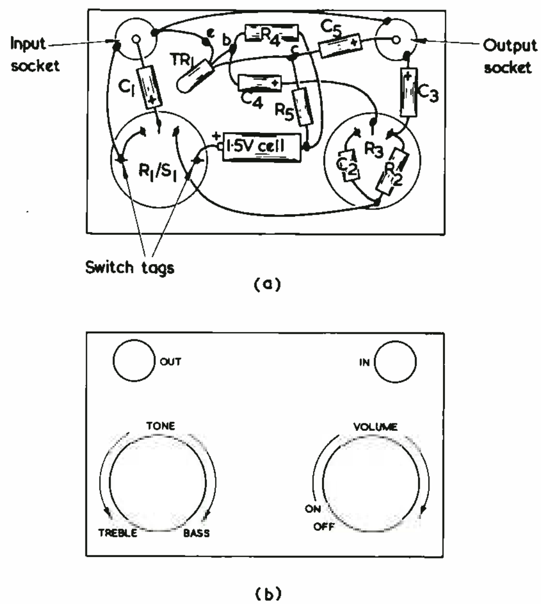


Fig. 2 (a). A suitable layout for the components
(b). Front panel view, showing control layout

It would, perhaps, be preferable to fit the components in a flat tin or metal housing. However, since the unit operates at low impedance, screening is not essential, and it will in most cases be adequate to use a plastic or wooden box if this is desired. If a metal case is used, an internal lining of insulating material is desirable, to prevent connections short-circuiting to the inside surface.

The input and output sockets may be phono or TV coaxial types. It will be noted, in Fig. 2 (*a*), that connections along the positive supply line are carried by the mounting lugs of these sockets.

Sinclair "Microvision" POCKET TV

Sinclair Radionics Limited of Cambridge announces details of its remarkable pocket-sized transistor television receiver. The mini TV has been christened "Microvision" —a name which the company claims will rapidly become a household term.

"Microvision", a prototype of which was demonstrated throughout the Radio and Television Show, will go into production at an initial rate of 1,000 per month in January 1967. It will have a retail price on the home market of 49 gns. (including purchase tax).

With a screen size of 2in (5cms), and overall dimensions 4 x 2½ x 2in (10 x 6.4 x 5cm), it can be held in the palm of the hand and becomes *the world's first commercial pocket TV set.* Its closest equivalent, Japan's Model SR-TV3A, manufactured by the Standard Radio Corporation—with a screen of 3in—is eight times as large and five times as heavy.

Sinclair's tiny TV, weighing a mere 10½oz (297 grammes), with batteries, is a marvel of miniature electronics. Its 30 transistors are powered by six penlight cells, which are priced at 3s. 6d. a set and have an estimated normal life-span of two to four weeks.

British Lead

The technical characteristic which distinguishes "Microvision" from any other TV is its entirely new type of circuitry. This brand new integratable system invented by Sinclair has reduced the cost of production to the point where the company knows it can under-cut competitor prices anywhere in the world. The circuit —which will be of considerable interest to manufacturers of standard TV sets—can be applied to any size of set and readily adapted to colour.

This novel circuitry has enabled the miniature TV to be equipped with a loudspeaker system and to receive all 13 channels in Bands I to III. "Microvision" can be tuned to both B.B.C. 1 and I.T.V. in any part of the United Kingdom, and with the simplest of production adjustments, can be adapted for use throughout the world.

"Microvision", which has been developed at a cost of £10,000, will be proof to buyers at home and abroad that young British engineers and designers can lead the way in ingenuity and craftsmanship.

Technical Details

The Sinclair Microvision, the World's first complete pocket television set, is a new design in every aspect from the tuner to the tube. The cathode ray tube has a rectangular face plate with an aspect ratio of 3 : 4 and a diagonal measurement of 2 inches. The angle of deflection is 70° and the overall length is only just over 3 inches. The shortness has been achieved by using a ½in neck which is far smaller than has ever been used before. The tube uses magnetic deflection and focus and, perhaps most remarkable of all, the heater consumes less than 100mW. The c.r.t. was, of course, developed for the receiver.

The circuit of the Microvision uses 30 transistors including silicon epitaxial planar and germanium epitaxial planar types. The major problem in the design was reducing the consumption since it was felt that the set should have a reasonably long battery life using cheap, readily available batteries. In fact, the consumption is only 450mW, which is less than the power taken by the tube heater in existing transistor televisions.

The receiver is powered by six ordinary penlight cells. A highly efficient d.c. to d.c. converter reduces the battery voltage to a stabilised 4 volts used by the set. This arrangement ensures that the performance does not vary during the life of the battery and that the maximum possible life is obtained from the batteries.

The tuner is a very much miniaturised permeability type employing two germanium expitaxial planar transistors and covering channels 1 to 13. The vision and sound receiver circuits are both very unusual as a result of the need to keep consumption to a minimum. The loudspeaker is a specially developed two inch piezo-electric type with an overall depth of less than ½in. The advantages of this arrangement, apart from the reduced size and weight, are the very high efficiency of the speaker and the absence of magnetic fields.

The speaker is driven by a transformerless push-pull stage using two silicon transistors operating from an 80 volt rail. The quiescent consumption of this stage is only 80 microamps.

The frame timebase also uses a class B push-pull output stage as this eliminates the usual frame output transformer and halves the power consumption. A multivibrator type of oscillator is used to avoid the need for a blocking oscillator transformer. A similar arrangement is used for the line timebase which is of the boosted h.t. variety. E.H.T. is taken from the line flyback in the usual way.

In Your Workshop

In this month's episode, Smithy the Serviceman, aided as always by his able assistant Dick, sacrifices part of his lunch-break to discuss vertical timebase topics and, in particular, the vertical timebase switching circuits used in 405–625 line receivers

"VERTICAL, SHMERTICAL," snorted Dick. "Oh, my life!"

Smithy diverted his attention from the crossword puzzle with which he was passing the last twenty minutes of his lunch-break, and cast a quizzical glance at his assistant.

"And what," he enquired, "is the reason for that little outburst?"

"It's these vertical oscillator circuits," replied Dick, with a disparaging gesture at a pile of television service sheets on his bench. "Sometimes these sheets refer to vertical oscillator circuits, sometimes they refer to frame oscillator circuits, and sometimes they refer to field oscillator circuits. Why can't they just choose one word and stick to it? After all, 'vertical', 'frame' and 'field' all mean the same thing!"

Smithy looked suitably shocked.

"They jolly well don't you know," he declared firmly. "Those three words have all got meanings of their own. Expecially 'frame' and 'field'."

"How *can* they have?" protested Dick. "A vertical oscillator is the same as a frame oscillator and it's the same as a field oscillator. So how *can* the words have different meanings?"

Smithy picked up the disreputable tin mug at his side and drained its contents with one prodigious swallow. Smacking his lips he held up the mug, whereupon Dick, following time-honoured tradition, rose without a word and took it over to the Workshop sink.

Fields And Frames

As the homely sound of clattering crockery (if, in a context where the meaning of words is obviously to be discussed, such a term can be applied to the dubious array of cracked and chipped utensils which formed the entire culinary effects of the Workshop) reached his ears, Smithy sighed contentedly and returned to his crossword. One of the clues incorporated a tricky little anagram which he had very nearly sorted out . . . . .

"Well, what *is* the difference between them?"

Startled, Smithy looked up, to see his assistant standing in front of him.

"Difference? Between what?"

"Between 'vertical', 'frame' and 'field'."

Resignedly, Smithy put his newspaper on one side. Long experience had taught him that when Dick was athirst for information the only way to obtain any peace was to satisfy that thirst as soon as possible.

"The ordinary television picture," Smithy commenced, "consists of two sets of lines interlaced. Doesn't it?"

"That's right," replied Dick promptly, as he returned to the stool at his bench. "You first of all cause one set of lines to appear on the screen and you then go back and cause a second set of lines to appear between them." (Fig. 1).

"Exactly," confirmed Smithy. "Now, each single set of lines is known as a 'field'. After two interlaced fields have been scanned, you then get a 'picture'. With the U.K. standards, both on 405 and 625 lines, the field frequency is 50 c/s and the picture frequency is 25 c/s."

"Where," asked Dick, "does the word 'frame' come in?"

"The words 'picture' and 'frame' mean the same thing," explained Smithy. "So you can say that the two interlaced fields also make up a frame. But there's a little snag here."

"Oh yes?" queried Dick. "What's that?"

"In the earlier days of TV in this country," replied Smithy, "we used to refer to 'fields' as 'frames' so that we looked upon two *'frames'* as making up a picture. In general, the industry changed over to the present usage of the word some six or seven years ago, the matter being clinched by a British standard which came out in 1960 and which deprecated the use of the word 'frame' with its older meaning. But for quite a while after that British Standard came out people were still associating the word 'frame' with its old meaning, and it's only now that this practice has just about finally died out. It's important to bear this little bit of history in mind because you will almost certainly bump into the word 'frame' with its previous meaning in books, magazines and service sheets which were published before 1960, and the alternative meaning of the word is liable to confuse you a little."

"That's an interesting piece of information," remarked Dick. "It looks as though there's quite a lot of difference between the words 'field' and 'frame', after all."

"There is," confirmed Smithy, "and particularly nowadays."

"What," continued Dick, "about the 'vertical' bit?"

" 'Vertical'," replied Smithy, "is merely an adjective to describe the circuits which cause the tube to be scanned in the vertical direction. In consequence, you get expressions like 'vertical oscillator' and 'vertical output'. As opposed to the line timebase stages which may be correspondingly referred to as the 'horizontal oscillator' and 'horizontal output' stages. Everything's dead easy there, with no complications or mix-ups from earlier days."

405—625 Vertical Oscillators

Smithy picked up his mug and took a copious draught of its contents.

"Ah-ha," he remarked appreciatively. "That's just what I needed to revive the old tissues. Anyway, why the sudden interest in vertical oscillators and things like that?"

"I'm just catching up," explained Dick, "on some of the finer points in the 405–625 line sets that are coming in to us these days. You may remember that we had a session last month on 405–625 sound circuits, and that whetted my appetite. I thought I'd spend a bit of spare time having a look at other parts of 405–625 receivers, and the vertical timebase stages seemed to be as good a place to start off as any."

"You certainly," chuckled Smithy, "chose an easy bit! With 625 lines having the same field frequency as 405 lines, the vertical timebase sections of 405–625 receivers are almost exactly the same as the ones we had in the old 405-only sets. Also, there's no complicated switching as you go from one standard to the other."

"There is *some* switching, though," objected Dick. "Some of these circuits include a section of the 405–625 switch which puts different values of resistance in series between the height control and the boosted h.t. line. At the moment the reason for such switching has got me completely mystified."

"I shouldn't worry about it," said Smithy carelessly. "Those switching circuits are fitted merely to counteract changes in boosted h.t. voltage as you go from one standard to the other."

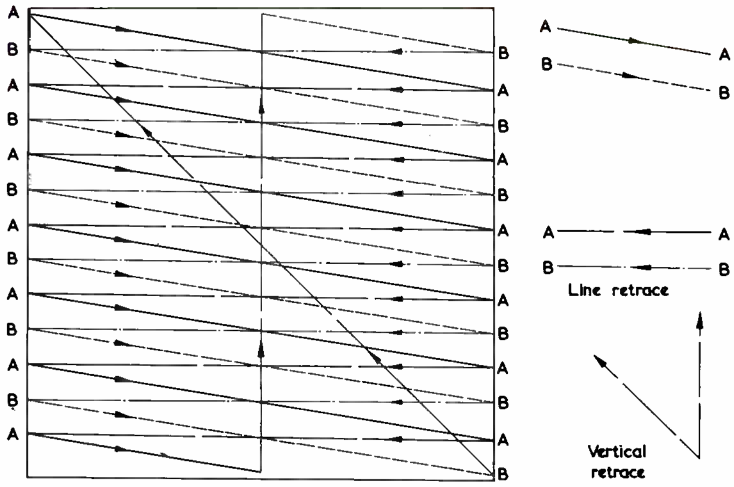


Fig. 1. A simplified diagram illustrating the make-up of an interlaced television picture. The solid lines (AA) constitute one field whilst the dashed lines (BB) constitute the second field. Two fields make a picture, or frame

Convinced that he had completely enlightened Dick on the subject of the switching circuits in question, Smithy returned happily to his crossword puzzle. Dick looked at him irritably.

"Why," he asked firmly, "does the height control have to go to the boosted h.t. line in the first place?"

"Either," replied Smithy absently, "to give a more linear sawtooth drive to the vertical output valve or to compensate for changes in e.h.t. voltage. Or, again, to do both of these things."

"Well, that's a lot of help, I must say," complained Dick disgustedly. "I ask you a question and all I get are statements which leave me more baffled than when I started!"

Still absorbed in his puzzle, Smithy suddenly picked up his pen and, with a grunt of satisfaction, filled in a word. He had run that anagram to earth at last.

"What," he asked conversationally, "are you beefing about?"

"These 405–625 switching circuits in the vertical timebase," replied Dick, "the ones that are in series with the height control."

Height Control And Linearity

Irritably, Smithy threw his newspaper onto his bench.

"A fine lunch-break this has turned out to be," he grumbled. "Just like Elephant's Child you are."

"Like *what* child?"

"Like Elephant's Child. You're full of 'satiable curtiosity'."

An uncertain expression spread over Dick's face.

"Would that," he said dubiously, "have anything to do with the owl impersonations you were giving last month?"

"Nothing at all," replied Smithy, "Elephant's Child lived on the banks of the Limpopo River and had his nose pulled by a crocodile. And that," concluded the Serviceman cheerfully, "is how the elephant got its trunk."

There was silence for a moment.

"I've been wondering recently," said Dick unhappily, "whether you haven't been working a bit too hard lately, Smithy. Are you sure you couldn't do with a few days off?"

"Nonsense," said Smithy briskly. "Anyway, if I'm going to answer your questions I'd better get down to them right away and get them all cleared up. It also looks as though I'll have to give you some basic information. Bring your stool up."

Dismissing the misgivings which had risen in his mind, Dick stood up and brought his stool over to Smithy's bench. The Serviceman quaffed deeply from his disgraceful tin mug, and pulled his notepad towards him.

"A representative vertical oscillator," said Smithy, scribbling out a circuit in his notepad (Fig. 2), "can employ a multivibrator driving a vertical output valve. The important thing to note is that the circuit will include a shaping capacitor across which a sawtooth is developed for application to the output valve

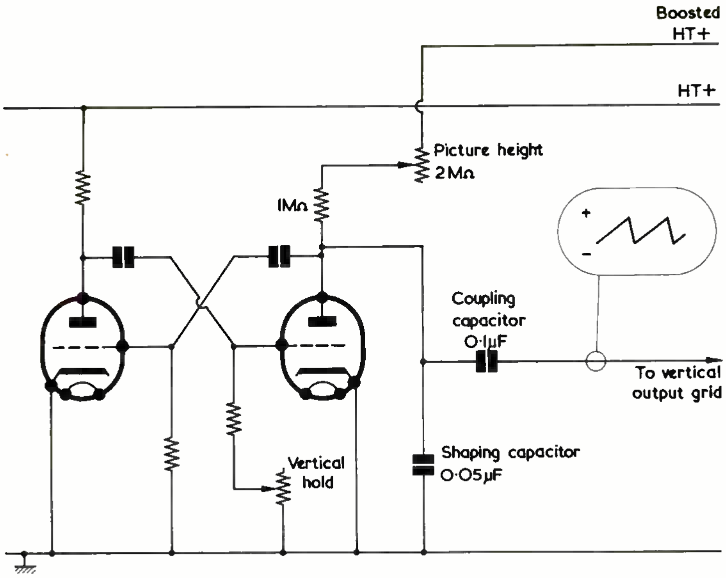


Fig. 2. A basic vertical timebase oscillator and sawtooth-forming circuit. The right hand triode is cut-off during the scan period. Representative values are given to components in the sawtooth-forming circuit, which may run from the boosted h.t. positive line. Frequently, the lower plate of the shaping capacitor connects to the cathode of the vertical output valve instead of to chassis, but its basic function remains the same

grid. The multivib can have two triodes in it, one of these being cut-off during the vertical flyback period and the other being cut-off during the vertical scan period. The triode which is cut-off during the scan period is, obviously, conductive during the flyback period. The anode of this triode is coupled to the shaping capacitor, which also connects to an h.t. positive supply via a high value of resistance and the height control."

"I know," offered Dick, "how *that* little lot works. During the flyback period the triode discharges the capacitor. When the scan period commences, the capacitor charges via the resistance in series with the h.t. positive point."

"Fair enough," said Smithy, picking up his pen once more. "Now, let's take things a little further, and sketch out the sawtooth waveform that results. (Fig. 3(*a*)). As you can see, the slow-rising part which occurs during the scan period is positive-going, which is just what you want for application to the grid of a vertical output valve. The output valve will then draw increased anode current as the vertical scan proceeds down the screen of the tube. If we were to draw the complete charging curve for the capacitor and series resistance on their own, and without any other circuitry, we would get the familiar exponential curve I'm sketching here. (Fig. 3(*b*)). But this is not at all a linear curve, and so it becomes necessary to arrange component values so that only the first part of it is used in the sawtooth waveform, with the result that we work with a reasonably straight part of the exponential waveform. We do this by choosing capacitor and resistance values which ensure that the shaping capacitor has become only partially charged when the multivib triode becomes conductive at vertical flyback. (Fig. 3(*c*)). The multivib triode then discharges the capacitor and only the first part of the exponential curve appears in the sawtooth."

Dick gazed at Smithy's sketches and scratched his head.

"Now, how," he queried thoughtfully, "does the height control affect the sawtooth?"

"It's obvious," said Smithy. "If the height control inserts a high series resistance the shaping capacitor will charge to a relatively low voltage before the flyback period comes along and discharges it again. And, if the height control inserts a low series resistance, the shaping capacitor will charge to a relatively high voltage before the flyback period causes it to discharge again. By reducing the series resistance inserted by the height control we're increasing the amplitude of the sawtooth waveform. Since this sawtooth is amplified by the vertical output valve and applied to the vertical deflector coils we're obviously increasing the height of the picture as well. And that is how the height control affects the actual height of the picture."

Dick frowned.

"Wait a minute," he said suddenly. "There's a snag here!"

"Is there? Where?"

"If," said Dick excitedly, "you increase the height by reducing the resistance inserted by the height control then you're reducing the time constant of the shaping capacitor and the series resistance."

"Well?"

"That means, then," Dick rushed on, "that more of the exponential curve appears in the sawtooth waveform before the capacitor discharges at flyback. In other words, the shaping capacitor will have gone further along an exponential charging curve before the flyback period comes along and takes it back to the start again."

"So?"

"What happens then," concluded Dick, "is that you're going to get a more non-linear scan section of the sawtooth when the height control inserts a low resistance than when it inserts a high resistance."

Dick leaned back and gazed triumphantly at the Serviceman.

"Is that," asked Smithy, "your snag?"

"It is," replied Dick proudly. "And I should imagine that I must be the very first person who's ever stumbled on this particular fact."

A curious change was taking place in Smithy's complexion. A colour television engineer might well refer to increasing saturation along the red axis.

"You know, Smithy," continued Dick condescendingly, "I must admit I'm pretty good at spotting little points like this one. I think I'll refer to it as Increasing Non-Linearity With Picture Height, or the Dick Effect."

At last, Smithy regained the power of speech.

"You roaring twit," he spluttered.

"Who, me?"

"Yes, you," rumbled the Serviceman. "It baffles me how you can even get that great head of yours through the Workshop door in the morning. What happens when you get a set with a worn-out vertical output valve?"

"Why, I replace it, of course."

"Anything else?"

"Well, the height of the picture will usually be too great with the new valve. And so I readjust the height control."

"Then what?"

"Now and again," said Dick innocently, "I have to alter the vertical linearity controls as well to get the picture properly proportioned at the new setting of the height control. Particularly if I've made a big adjustment to it."

"Exactly," snorted Smithy. "In other words what you're doing, at least in part, is readjusting the linearity circuits to take up the altered linearity in the sawtooth given by the new height control setting."

"Do you mean," asked Dick incredulously, "that this business of sawtooth linearity altering with different settings of the height control is common knowledge?"

"Common knowledge?" repeated Smithy, with an expression of disbelief almost equal to that displayed by Dick. "Common knowledge? Why, you great nit, it was the first thing they would have considered when they originally worked out TV timebases using capacitors and resistors."

"Well, blow me," said Dick, patently amazed at Smithy's statement. "I was beginning to think that this was something I'd discovered all on my own. At any rate, it shows that I'm on a par with the pioneers!"

Height Control Switching

Smithy cast a glance at the ceiling and decided to give up the unequal contest.

"Let us," he said doggedly, "return to this shaping capacitor circuit and the manner in which it works. We've just seen that we can obtain a reasonably linear sawtooth by using only the beginning of the exponential charging curve. If, therefore, we apply a high positive potential to the upper end of the resistance in series with the shaping capacitor we can obtain a shorter length of exponential curve for a given sawtooth amplitude than if we apply a low positive potential. This gives us better linearity, and is one reason why it is common practice to return this series resistance to the boosted h.t. line in a TV receiver instead of to the ordinary h.t. line."

"That statement," remarked Dick, "seems to ring a bell. Why, it's the answer to one of the questions I asked you originally!"

"It is," confirmed Smithy. "And it means that one of my answers has now been fully explained. The other thing I said at that time was that connecting the series resistance to the boosted h.t. line provided compensation for varying e.h.t. voltage."

"Ah yes," said Dick. "Now, how does that work?"

"It's quite simple really," replied Smithy. "As you know, e.h.t. current depends upon the overall brightness of the picture displayed on the screen of the tube. If the overall picture brightness increases, so does e.h.t. current. The consequence is that an increase in overall brightness can result in a decrease in e.h.t. voltage, the drop in voltage depending upon the regulation of the e.h.t. supply. If the drop is serious the picture is liable to open out, or 'bloom'."

"I know the effect," put in Dick. "It's the same as you get in sets where a fault in the e.h.t. circuit reduces the available e.h.t. current. As you turn up the brightness control the picture expands."

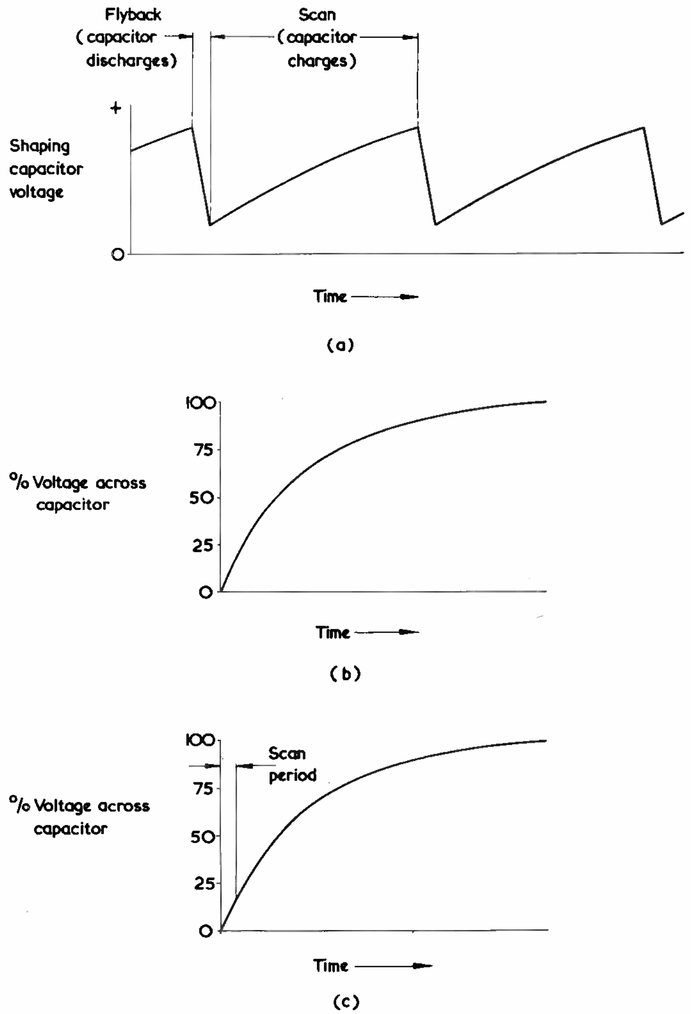


Fig. 3 (a). The sawtooth voltage, relative to chassis, appearing on the upper plate of the shaping capacitor of Fig. 2
(b). If the shaping capacitor were not discharged during the flyback period, the voltage across it would follow the familiar exponential curve shown here. In this diagram, the time scale is shorter than in (a)
(c). To obtain reasonable linearity, only a short part of the start of the exponential curve is used in the vertical sawtooth waveform

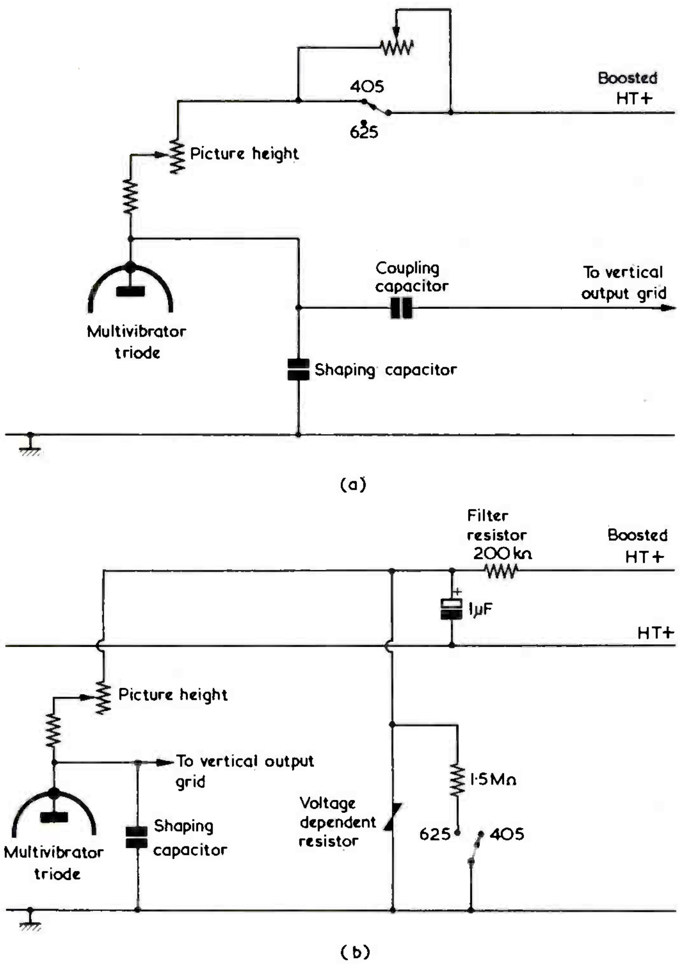


Fig. 4 (a). A simple circuit which compensates for differing boosted h.t. voltages on 405 and 625 lines. The variable resistor brought into circuit on 625 lines will have, typically, a value of 300kΩ
(b). An alternative switching arrangement, in which additional picture height stabilisation is given by a voltage dependent resistor

"Exactly," confirmed Smithy. "The opening out is due, incidentally, to the fact that a lower e.h.t. voltage reduces the velocity of the electrons passing through the deflector yoke on the neck of the tube, with the result that they are in the deflecting field for a longer period and undergo greater deflection. Now, the e.h.t. voltage is obtained from the line output stage and increased e.h.t. loading reduces the value of the boosted h.t. voltage. In consequence, there is a lower line deflection current in the deflector coils and the effect of a reduction in e.h.t. voltage is counteracted by a reduction in line deflection current."

"I see," commented Dick. "The line output circuit automatically offers less deflection, and so the drop in e.h.t. voltage causes no increase in line width."

"That's right," confirmed Smithy. "This holds good only for small drops in e.h.t. voltage, of course, but these are all that should be given by a reasonably well regulated e.h.t. supply in any case. At the same time, if the shaping capacitor network in the vertical timebase is run from a constant h.t. voltage no compensatory effect is given. The vertical timebase offers an output of constant amplitude, with the result that a reduction in e.h.t. voltage would cause an increase in picture height. When the vertical timebase shaping capacitor is run from the boosted h.t. supply, however, the picture height deflection will automatically decrease as boosted h.t. decreases, so that compensation for drops in e.h.t. voltage are obtained in the vertical sense as well."

"I'm dashed," exclaimed Dick. "And to think I've been looking at these vertical timebase circuits for ages without realising the little tricks that are hidden away in them!"

"Well, there we are then," said Smithy. "I should add that, if the e.h.t. supply in the TV receiver has good regulation, the main advantage offered by running the shaping capacitor circuit from the boosted h.t. line is that it enables you to obtain a more linear sawtooth, since the compensating effect for picture height is not so necessary. Anyway, let's get back to your original question. This, you will remember, is concerned with the 405–625 switching arrangements you encounter in the height control circuits of dual-standard receivers. Such switching arrangements are needed if the voltage on the boosted h.t. line changes when you switch the line output stage from a line frequency of 10,125 c/s for 405 lines to 15,625 c/s for 625 lines, or vice versa. Normally, the boosted h.t. voltage increases at the higher line frequency given by 625 line operation, with the result that, if precautions aren't taken, the picture height will increase also. The usual method of overcoming the change in boosted h.t. voltage is to insert a preset variable resistor in series with the height control, this being shorted out on 405 lines and brought into circuit on 625 lines. You adjust height as per usual on 405 lines, then switch to 625 lines and adjust the variable resistor for the same height." (Fig. 4(*a*)).

"We're back," said Dick suddenly, "to Dick Effect! Won't the bringing into circuit of this additional variable resistor affect vertical linearity?"

"There'll be a slight change in linearity," agreed Smithy. "But this should usually be too small to be of any great significance. Another approach consists of having a section of the 405–625 switch connect an additional resistor between the boosted h.t. line and chassis, the switching circuit appearing after a filter resistor and capacitor."

Smithy sketched out the circuit (Fig. 4(*b*)) and showed it to Dick.

"In this case," he remarked, "the height control circuit runs from the electrolytic capacitor which follows the filter resistor. When the switch section is set to 625 lines, the added resistance to chassis causes the voltage across the electrolytic to be reduced to about the same value as on 405 lines. An advantage with this circuit is that the electrolytic capacitor has a low impedance at vertical timebase frequency, and the shaping capacitor circuit is offered virtually the same operating voltage at the same impedance on both standards. This overcomes any tendency towards the Dick Effect you mentioned just now. Blimey, you've got *me* at it now!"

"I tell you," said Dick. "Pioneer-minded, that's me!"

"With this last type of circuit," continued Smithy, ignoring his assistant's comment, "you also get a voltage dependent resistor following the electrolytic capacitor. As you know, a voltage dependent resistor offers reduced resistance as the voltage across it increases, whereupon its voltage-current curve becomes rather similar to that for a zener diode or a valve stabiliser. (Fig. 5). In the present circuit, the v.d.r. offers an extra bit of picture height stabilisation when switching from one standard to the other. Since the v.d.r. does not stabilise over as narrow a range of voltages as does, for instance, a valve stabiliser, the circuit should still allow some compensation in picture height for changes in e.h.t. voltage to take place as well."

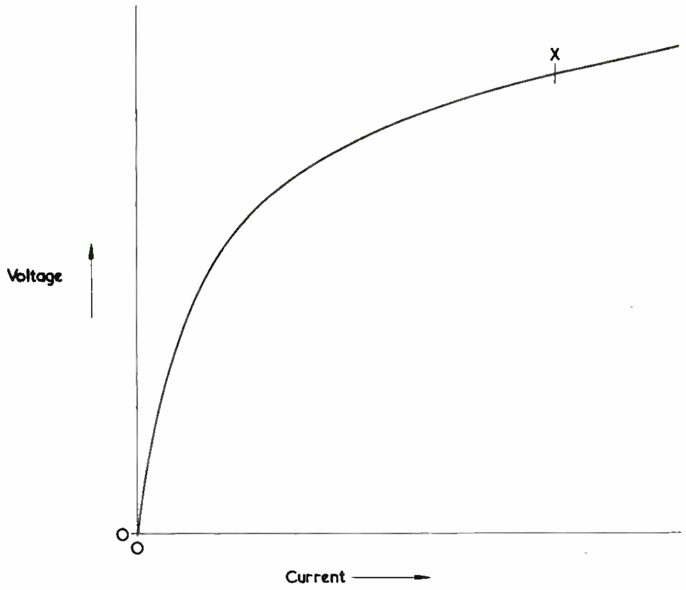


Fig. 5. The resistance of a voltage dependent resistor decreases as the voltage across it increases, giving a voltage-current curve of the type shown here. For voltages around point X on the curve, the v.d.r. offers a useful amount of stabilisation

Back To Work

"Why," asked Dick, "is the negative plate of the electrolytic in that circuit returned to the ordinary h.t. positive line? Why isn't it connected to chassis?"

Smithy raised his tin mug and finally drained its contents in one gargantuan gulp.

"Because," he replied, wiping his lips, "it will work just as well if it's connected to the normal h.t. positive line, and it can then be given a lower working voltage. And that's all for the present, except that I should mention that a few TV sets have approximately the same boosted h.t. voltage on both standards. These sets just don't have any 405–625 switching in the height control circuit at all. Dear me, just look at the time! It seems as though I'll have to finish my crossword at home tonight."

Smithy picked up his newspaper, folded it and put it in the pocket of his jacket hanging on the door. Purposefully, he returned to his bench.

"You must admit, Smithy," said Dick, as he picked up the pile of service manuals he had been studying and carried them over to the filing cabinet, "that things have got quite a lot more complicated over the last few years, now that we have these new dual-standard TV's to contend with. I rather miss having nothing to service but the old 405-only jobs."

"Not to worry," said Smithy soothingly. "The day will dawn when all the sets you fix are 625-only."

"Well, now, that *is* something to look forward to," commented Dick warmly "Just imagine having nothing to fix but single-standard TV's again!"

"They will also," added Smithy cheerfully, "be single-standard sets which reproduce colour as well!"

And with these direful words Smithy turned to his first job for the afternoon, knowing full well that he had mentioned the one and only subject which could reduce his voluble assistant to complete silence.

Editor's Note

The British Standard referred to by Smithy is B.S. 204:1960, *Glossary Of Terms Used In Telecommunication (Including Radio) And Electronics.*

NOVEL SQUARE WAVE GENERATOR

(continued from page 157)

be found for the practical circuit given by considering the reciprocal of twice the duration of a single "off" state.

$$\text{Therefore } f=\frac{1}{2t_1}=\frac{1}{2R_1C_1\,0.27}$$

$$R_1\text{, we know, is } 22k\Omega\ \therefore\ f=\frac{1}{2.22\,C_1\,0.27}$$

$$\therefore\ =C_1=\frac{1}{11.88f}=\frac{0.084}{f}\mu F$$

where f is measured in kc/s and $C_2=\frac{C_1}{3}$.

Taking $f=\frac{1}{2t_2}$ would have yielded a similar result as above but for C_2; and we would have said $C_1=3C_2$, and there we are!

Cover Feature

The "Beatamp"

by **V. E. HOLLEY**

This little amplifier has many applications, these ranging from standard workshop use to amplification of transistor radios. Both circuit and construction are simple, and the article also gives details of a suitable cabinet in which the amplifier and its speaker may be housed

This is a simple little amplifier which was built originally for service on the workshop bench, but which was later appropriated by the teenage members of the family to amplify the output from a pocket transistor radio. In this service it earned its name and a great deal of popularity. Construction is quite simple and can be undertaken with confidence by anyone having an elementary knowledge of the subject and a small soldering iron. The components are few, and many readers will no doubt find all they want in the spares box.

Circuit

Fig. 1 shows the circuit. The signal to be amplified is fed into the miniature jack socket, J_1, and through the isolating capacitor C_1 to the volume control, and is then applied to the grid of the first valve. This is a high gain pentode, type EF91. Though the EF91 is really an r.f. amplifier, it is a versatile performer and will be found to work very well at audio frequencies in the circuit shown. The usual anode, screen and cathode bias resistors and capacitors are provided and, additionally, there is in the cathode circuit a small resistor, R_4, of which more later.

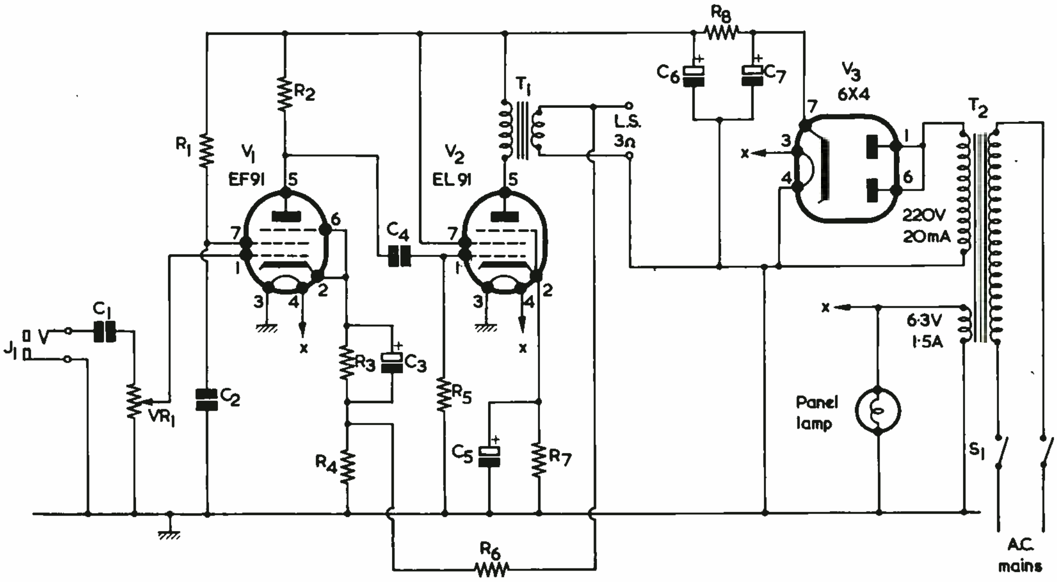


Fig. 1. The circuit of the "Beatamp"

COMPONENTS

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

R_1	1.2MΩ
R_2	220kΩ
R_3	2.2kΩ
R_4	33Ω
R_5	470kΩ
R_6	470Ω
R_7	680Ω
R_8	2kΩ, 2 watts
VR_1	500kΩ potentiometer, log track

Capacitors

C_1	0.01μF, 350V wkg.
C_2	0.1μF, 350V wkg.
C_3	25μF electrolytic, 12V wkg.
C_4	0.01μF 350V wkg.
C_5	25μF electrolytic, 25V wkg.
C_6	32μF electrolytic, 350V wkg.
C_7	16μF electrolytic, 350V wkg.

Transformers

T_1	Speaker transformer, 70:1 or 80:1
T_2	Mains transformer. Secondaries, 220V 20mA, 6.3V 1.5A.

Valves

V_1	EF91
V_2	EL91
V_3	6X4

Switch

S_1	d.p.s.t. rotary toggle switch

Jack Socket

J_1	Miniature jack socket

Loudspeaker
3Ω elliptical loudspeaker, 7×4ins

Miscellaneous
Pilot lamp, 6.3V 0.3A
Pilot lamp holder
3 B7G valveholders
2 miniature jack plugs
2 control knobs
Insulated anchor tag
2ft screened cable
Flex for mains lead
⅜in grommet
Aluminium for chassis
Wire, bolts, nuts, etc.

The amplified signal is passed by way of capacitor C_4 to the grid of the output valve, V_2. This is a small power pentode having an output of 1.4 watts, which is fed to the 3Ω loudspeaker by way of output transformer T_1. As the anode current is only 16mA, quite a small transformer can be used and, for the best results, it ought to have a ratio of 70 or 80 to 1. Negative voltage feedback is usually associated with Hi-Fi circuits, but it is worth including in any amplifier because it improves the frequency response and reduces residual hum and the less desirable distortion introduced by the pentode output valve. A feed-back voltage is accordingly taken from the output transformer secondary through resistor R_6 to the junction of R_3 and R_4. The relative values of resistors R_4 and R_6 determine the proportion of the output voltage to be fed back.

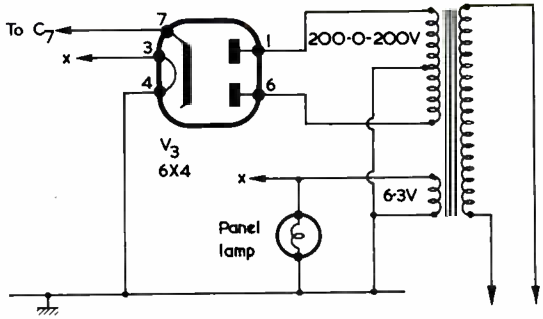


Fig. 2. An alternative power supply using full-wave rectification

Power Supply

The power requirement is very modest and a small mains transformer able to provide 220V 20mA and 6.3V 1.5A is quite adequate. Half-wave rectification is given by a 6X4, but a metal rectifier or silicon diode will do just as well provided it has a peak inverse voltage (p.i.v.) rating of not less than 800. The end of the diode or rectifier marked red, or with a + sign, is the equivalent of the valve cathode. If the transformer has a full wave h.t. secondary winding, it is better to use full-wave rectification by valve and Fig. 2 shows how this should be arranged.* A 200-0-200 volt secondary will be adequate here.

If the mains transformer primary has taps for different mains voltages, connect to the tap corresponding to the mains voltage to be used. With transformers having lead-out wires, primary taps which are not used should be carefully taped up to prevent short-circuits to adjacent conductors or the chassis. *Do not be tempted to dispense with the double-wound mains transformer in favour of a circuit in which the mains connects direct to chassis because, apart from the shock hazards associated with such a circuit, this will make the a.f. input connections live.*

The mains input is switched on and off by the rotary double pole switch, S_1. Resistor R_8 and

* At 200 volts r.m.s., the 6X4 should have a limiting resistance of 240Ω in series with each anode. With a small mains transformer, this will normally be given by the resistance of the windings themselves. In Fig. 2, the resistance of either half of the h.t. secondary, plus the resistance of the primary, should be 240Ω or more. If less, insert physical resistors, to make the total resistance up to this value, in series with each anode. In Fig. 1, the resistance of the h.t. secondary plus the resistance of the primary should, preferably, be 280Ω or more. If less, insert a physical resistor, to make the total resistance up to this value, between the h.t. secondary and the anodes.—Editor.

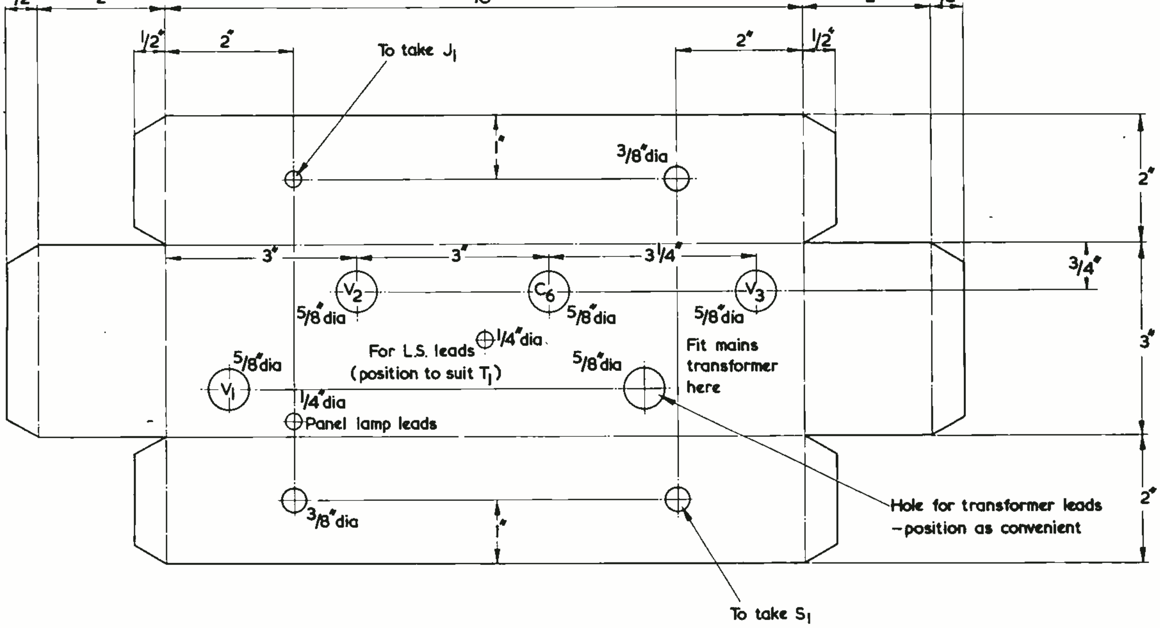


Fig. 3. Plan view of the chassis before bending. The end ½in flanges, at right and left, are bent outwards. The hole for C_6 may require a different diameter with some capacitors. The material is 18 s.w.g. aluminium

capacitors C_6 and C_7 provide smoothing for the rectified h.t.

Construction

If small components are employed for the mains and speaker transformer, all the parts may be assembled on a chassis measuring 10×3×2in, as shown in Fig. 3. The constructor should first check that these dimensions are suitable for the particular transformers obtained before cutting out the chassis. If the transformers are large and bulky, the chassis dimensions may be modified accordingly. The position of the speaker transformer may be ascertained from Fig. 4. If a speaker transformer with flying leads instead of a tagboard is used a small tag-strip may be mounted close to the transformer to provide anchors for the primary and secondary connections. The chassis used for the original was slightly shallower than the 2in shown in Fig. 3, and the speaker transformer had a rather large tagboard. These two points made it necessary to cut a rectangular aperture in the deck of the chassis to enable the transformer to be fitted. This problem should not be so troublesome with a chassis depth of 2in.

The chassis may be made of 18 s.w.g. aluminium. The original fitted compactly into a small wooden cabinet, together with a 7×4in elliptical speaker.

Tinned copper wire of 22 s.w.g., covered with systoflex, is suitable for all the wiring, which can be tackled in any desired order. The connections to be made are all shown in Fig. 4. Some of the wires may appear rather long in this diagram, but in construction they should be kept to the minimum necessary length. For instance, C_1 will pass directly across the chassis instead of in the manner shown, for clarity, in the diagram. It should be noted that the connections to the primary of T_1 may have to be reversed if it is found, on completion, that feedback is positive instead of negative.

In the original, C_7 was wire-ended whilst C_6 was contained in a can. C_6 could, alternatively, also be a wire-ended component. Another alternative could consist of having both C_6 and C_7 contained in a single can and mounted in the C_6 position. If this is done, the high ripple section, usually marked red, is the one to use for C_7.

Testing

When construction is complete, it is advisable to check with a meter to see that there are no short-circuits in the h.t. wiring. Switch the meter to a high ohms range and connect it across C_7. There should be a large initial deflection, decreasing slowly to a reading of the order of 1MΩ or more as C_6 and C_7 become charged from the meter battery. If the meter leads are applied with incorrect polarity, the final high resistance reading may not be obtained due to the presence of the electrolytic capacitors, whereupon the leads should be reversed. With conventional testmeters switched to an ohms range, correct polarity for the insulation test will

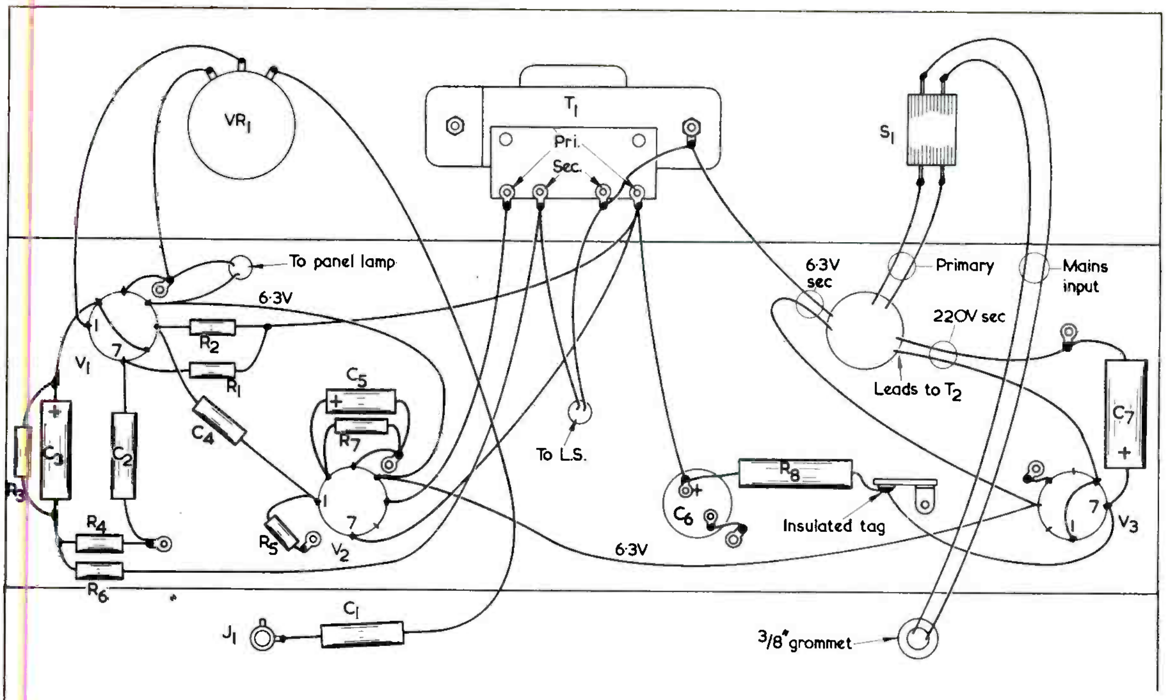


Fig. 4. Details of the wiring. The tag layout shown for speaker transformer T_1 applies to the component employed in the prototype; other transformers may have a different tag layout and the connections shown here should be modified accordingly

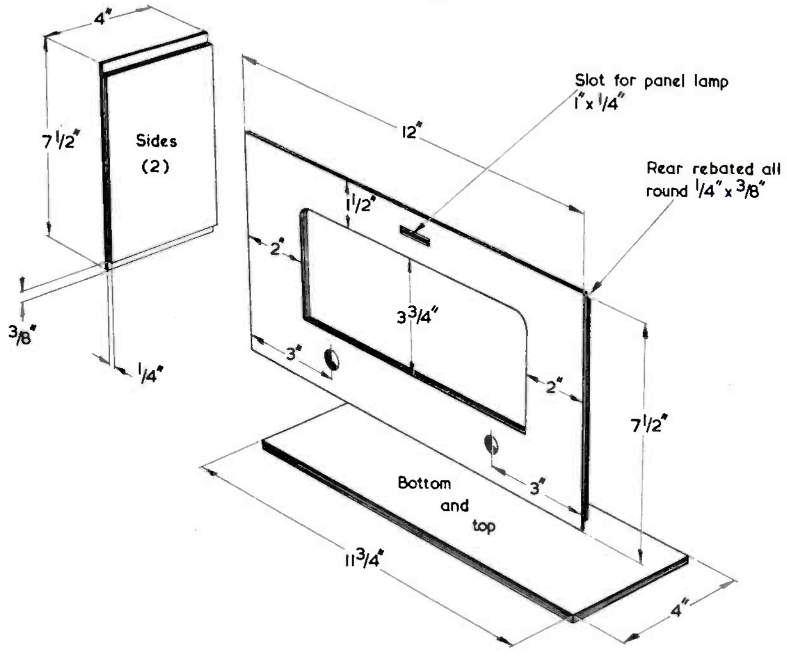


Fig. 5. Making a cabinet for the "Beatamp". The material is faced plywood ⅜in thick. The spindle holes may be marked out from the chassis

be given with the *positive* meter lead to chassis.

If all is well, power may be applied. The speaker should, of course, be connected.

As the "Beatamp" warms up, it will scream disrespectfully at the constructor if the feedback happens to be positive. Do not reproach yourself—even the experts cannot predict the right connection. Switch off nonchalantly and with a flourish of the soldering iron, reverse the connections to the primary of the output transformer to make the feedback negative.

Operation

It remains to make up a screened lead about 2ft long with a miniature jack plug at each end. Insert one plug into the "Beatamp" and the other into the socket provided for the earpiece in a transistor receiver and all is set for the Big Beat. If the current consumption of the receiver varies with the setting of the volume control, battery life can be prolonged by using a low setting and bringing the signal up to the desired level in the "Beatamp".

Cabinet

Upon promotion to domestic service, the prototype, which had hitherto rested naked upon the bench, was given the plywood cabinet shown in the illustration. Details of the measurements and method of construction are given in Fig. 5. Faced plywood ⅜in thick is very suitable material. The joints can be secured very satisfactorily with panel pins and glue and quite a good exterior finish can be produced by staining and varnishing. The original was french polished, but this was not observed to improve the performance!

A rectangular slot was provided in the front panel for the pilot lamp. The speaker aperture should be covered with Tygan or some similar material, secured with impact adhesive. The 7×4in loudspeaker should first be fitted to a piece of ⅛in hardboard in which a suitable aperture has been cut and the whole fitted into the cabinet with wood screws.

To make the securing holes for the chassis, first clamp it in position. Then drill upwards, through the bottom of the cabinet and through the end flanges of the chassis, two holes, one at each end. If the holes in the wood are then enlarged and wood screws of suitable size inserted, they will have a selftapping action as they enter the aluminium and will keep the chassis very firmly in position. The panel lamp slot can be covered with a piece of coloured Perspex or even paper, and the lamp holder secured in position with a small wood screw.

A carrying handle at the top of the cabinet is a useful addition and four small pieces of rubber to act as feet, secured to the bottom with Evostick, will avoid scratches on any polished surface on which the unit may stand.

Electronic Thermometers

A NEW TYPE OF THERMOMETER WHICH CAN measure temperatures within the range −40°C to +230°C has been developed by Hewlett-Packard Ltd. This equipment not only has a resolution of 0.0001°, but automatically displays the temperature being measured as actual digits. The reading is indicated directly as a certain number of °C or °F and the plus or minus sign is automatically inserted.

The instruments employ a quartz resonator at the tip of a sensor probe. This resonator, which has a linear temperature co-efficient, is extremely robust. It can accept shocks of 10,000g and pressures of up to 3,000 lb./sq.in without any change in the calibration.

The information about the temperature is transmitted from the probe to the main instrument as a signal whose frequency is dependent on the probe temperature. The probe can be located at up to 1,000 feet from the main instrument without noise pick-up troubles, etc., becoming apparent.

Two models are available, the DY-2801A having two sensor probes for monitoring the temperature at two points or for taking readings of temperature differences to 0.0001°. A cheaper model, the DY-2800A, has a single probe providing 0.1° resolution. Both models have digital outputs which can be used for the operation of automatic typewriters.

The instruments are expected to find application in oceanography, deep-hole geology and for various industrial purposes.

Closed Circuit TV for Teachers

EMI Electronics Ltd. was one of four manufacturers who recently provided complete studio facilities for a teachers induction course in the use of television in education. The course was held at Wandsworth Technical College as one of the first stages in the setting up of the proposed Inner London Education Authority's television service.

Teachers from all parts of London, in groups of twelve, spent a week gaining first-hand practical experience of closed-circuit television equipment and of production. Each group produced an educational programme and at the end of the course the taped programmes were played back before an audience of teachers and invited guests.

Understanding Radio

By W. G. Morley

LINKING THEORY WITH PRACTICE

A PRACTICAL PROJECT

COMPLETING THE GENERAL-PURPOSE POWER 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 issue we introduced the first of the constructional projects to appear in this series of articles, and which are intended to give practical demonstrations of the theoretical points discussed in this series. These projects are designed for assembly with the minimum amount of metal-working and, for this reason, all chassis are based on the Lektrokit range of prefabricated component parts. Another feature of the constructional projects is that they will be capable of general use in addition to their function of demonstrating points of theory.

The item of equipment introduced last month was a general-purpose power supply unit, and details were given of its circuit design, chassis assembly and the fitting of the main components. Also published last month was the Components List.

We shall now carry on to further steps in the assembly of the power supply unit.

Mounting The Smaller Components

The next stages in construction consist of mounting several of the smaller components and of commencing the wiring. Except where otherwise stated, wiring is carried out with conventional p.v.c. covered tinned copper connecting wire, which may be either single-core or stranded. It is probable that the reader will already have previous experience in soldering. A small electric soldering iron of around 20 to 40 watts will be found most convenient; this should be well tinned and used in conjunction with a good quality radio-grade cored solder such as Multicore "Ersin" 60/40 or Multicore "Savbit". Such solders have their own fluxes in the cores, and *no other flux whatsoever should be used on any joint*. The components specified have tags which should tin instantly without the necessity for cleaning or scraping before soldering. It may be found that the tags of the mains transformer have a thin coating of impregnating wax on them. This wax need not be removed before soldering; it will melt away from the tag on application of the iron and will not impede the formation of a good joint. If the reader is inexperienced in soldering, he would be well advised to obtain a little practice with odd lengths of connecting wire and component tags before embarking on soldering the joints of the constructional project proper. The knack of obtaining a good soldered joint with radio and electrical components is very quickly acquired.

In the instructions which follow, connections should only be soldered when stated in the text.

Two of the smaller components are next fitted, these being the 5-way tagstrip (Lektrokit Part

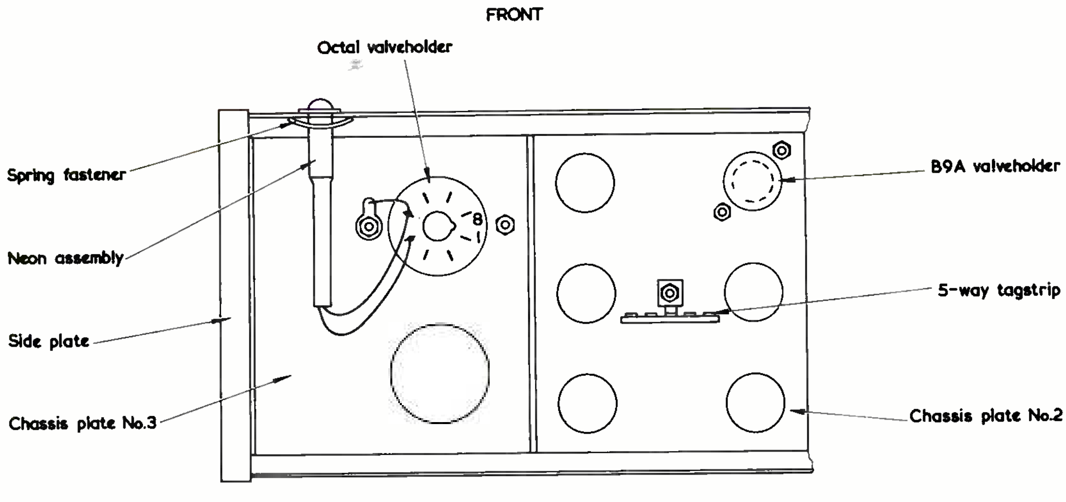


Fig. 1. Underchassis view showing how the 5-way tagstrip and neon bulb assembly are fitted

No. LK-2231) and the neon lamp assembly. The tagstrip is secured below the chassis with a single ¼in 6BA screw and nut (head above chassis) passed through the ⅛in hole in the Chassis Plate No. 2 which is mid-way between the two central valveholder holes. See the underchassis view of Fig. 1.

The neon bulb assembly is fitted to the end U-slot of the front Chassis Rail at the Chassis Plate No. 3 end, as shown in Fig. 1. It should be noted that the neon bulb assembly is secured by a spring fastener which slides forwards along the body of the bulbholder. This fastener is intended to bear against the rear of any panel to which the holder is fitted at two points only. In the present instances the neon bulb assembly is fitted to a U-slot, and the spring fastener must be oriented so that neither of the two bearing points just mentioned appears at the open part of the U-slot. This factor is of some importance since it is difficult to release the spring fastener after it has been pushed forward to its final position.

The leads from the neon bulb assembly are next cut to about 3½ins from the end of the protective sleeve and their ends bared for connection to pins 4 and 5 of the octal valveholder. It is immaterial which way round the leads from the neon bulb assembly connect to these pins. Also connected to pin 5 of the valveholder is a short length of wire from the 6BA solder tag secured under the adjacent mounting nut. Solder the connections at the solder tag and pin 5, but leave the connection at pin 4 unsoldered because another wire has to be connected here later. All the connections just carried out are shown in Fig. 1.

Mains Transformer Wiring

Since the mains transformer tags are above the chassis, it is necessary for the connections to these to pass through the Chassis Plate on which it is mounted. It would be possible to pass individual leads directly through the ⅛in holes in the Chassis Plate, but this represents undesirable practice.

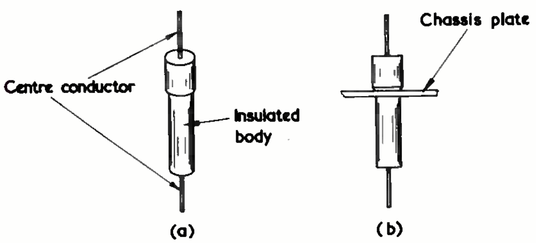


Fig. 2 (a). The Lektrokit lead-through insulator (b). The insulator is a push fit in any of the ⅛in holes of the Chassis Plates, soldered connections being made to the protruding centre conductor on either side

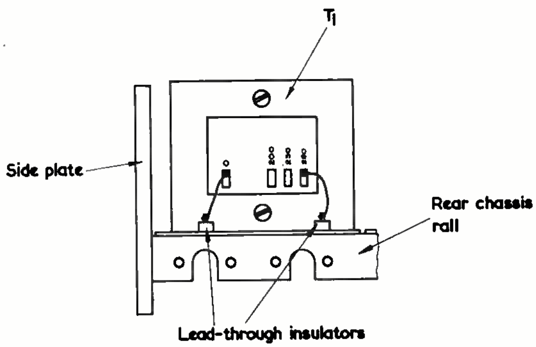


Fig. 3. Above-chassis connections to the primary of the mains transformer

If an insulated lead is passed through a hole in a metal plate without employing a grommet or similar fitment to prevent the lead insulation from chafing against the metal edge of the hole, the insulation may later break down. In the Lektrokit Chassis System, circuits on either side of a Chassis Plate may be connected together by means of lead-through insulators (Lektrokit Part No. LK-2021), as shown in Fig. 2. These form a push fit in the ⅛in holes in the Chassis Plates, connection being made to the protruding centre wire on either side. The use of these lead-through insulators increases the number of solder joints required, but they offer the advantages of reliable insulation and neat wiring. The writer found that several of the lead-through insulators employed in the prototype were a little tight in their holes, but this was cured by a touch of a file to the flash lines on their bodies.[1] The lead-through insulators may be pushed into position by causing the slightly open jaws of a pair of pliers to bear down on the upper edge of the body.

Two lead-through insulators are required to carry the mains connection to the primary of the mains transformer and these are fitted, from the top of the chassis, to two holes in the rear row of holes in the Chassis Plate No. 1. See Fig. 3. One of these insulators connects to the 0 tap of the mains transformer, whilst the other connects to the 200, 230 or 250 volt tap, according to the local mains voltage. If the local mains voltage is 240, connect to the 250 volt tap. All the connections shown in Fig. 3 are soldered. An under-chassis view of the lead-through insulator positions is given in Figs. 5 and 6(*b*).

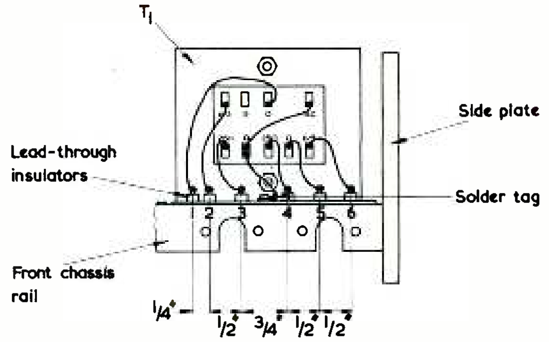


Fig. 4. Mains transformer secondary connections above the chassis. Spacing between lead-through insulators is not critical, but that suggested here will enable a neat wiring layout to be achieved. (The spacing between hole centres along the row on the Chassis Plate is ¼in)

Fig. 4 shows the secondary connections to the transformer, these being viewed from the front of the chassis. The six associated lead-through insulators are fitted, from the top of the chassis, in the second row of ⅛in holes from the front edge of the transformer clamp. Spacing between the lead-through insulators is not critical, but that shown in Fig. 4 will enable a neat wiring layout to be achieved. The first lead-through insulator to the left is fitted to the furthermost left hand hole in the row.

Fig. 5 shows the underchassis wiring to these insulators. To avoid mistakes, it is preferable to insert one lead-through insulator, and complete its wiring, at a time. The lead-through insulators

[1] A "flash line" in a moulded plastic piece-part is a raised irregular line of material which appears where the two halves of the mould come together.

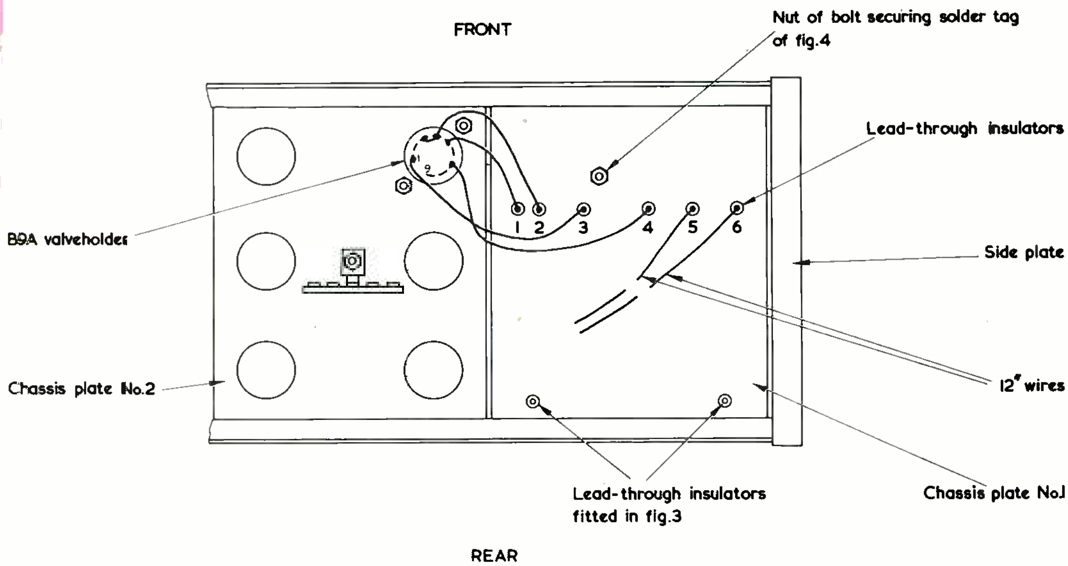


Fig. 5. Underchassis connections from the lead-through insulators of Fig. 4. The free ends of the 12in wires are connected later

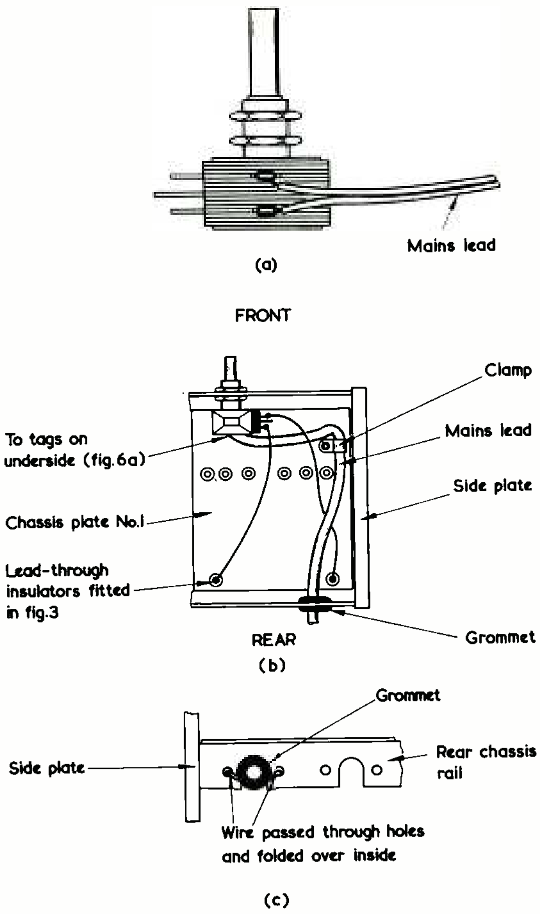


Fig. 6 (a). Before the switch is mounted, the mains lead is connected to the tags shown here
(b). Underchassis view showing the switch in position, and the mains input wiring completed
(c). How the grommet is fitted to the rear chassis rail. The securing wire is in the groove of the grommet

are numbered, in Figs. 4 and 5, in their order of insertion.

Commence by inserting the first lead-through insulator, that nearest the Chassis Plate No. 2 (on which the choke and rectifier valve are fitted), and wire this above the chassis to the 0 volt rectifier heater tag as shown in Fig. 4. Below the chassis connect this insulator to pin 5 of the B9A valveholder. Solder all connections.

Insert the second lead-through insulator and connect it, above the chassis, to the 6.3 volt rectifier heater tag, as in Fig. 4. Below the chassis, connect this insulator to pin 4 of the B9A valveholder, continuing it through to pin 3. Solder all connections except that at pin 3 of the valveholder.

Fit the third lead-through insulator and connect it, above the chassis, to the 250 volt h.t. secondary tag above it. Connect it, below the chassis, to pin 1 of the B9A valveholder. Solder all connections.

Insert the fourth lead-through insulator and connect it, above the chassis, to the remaining 250 volt h.t. secondary tag. Below the chassis, connect it to pin 7 of the B9A valveholder. Solder all connections.

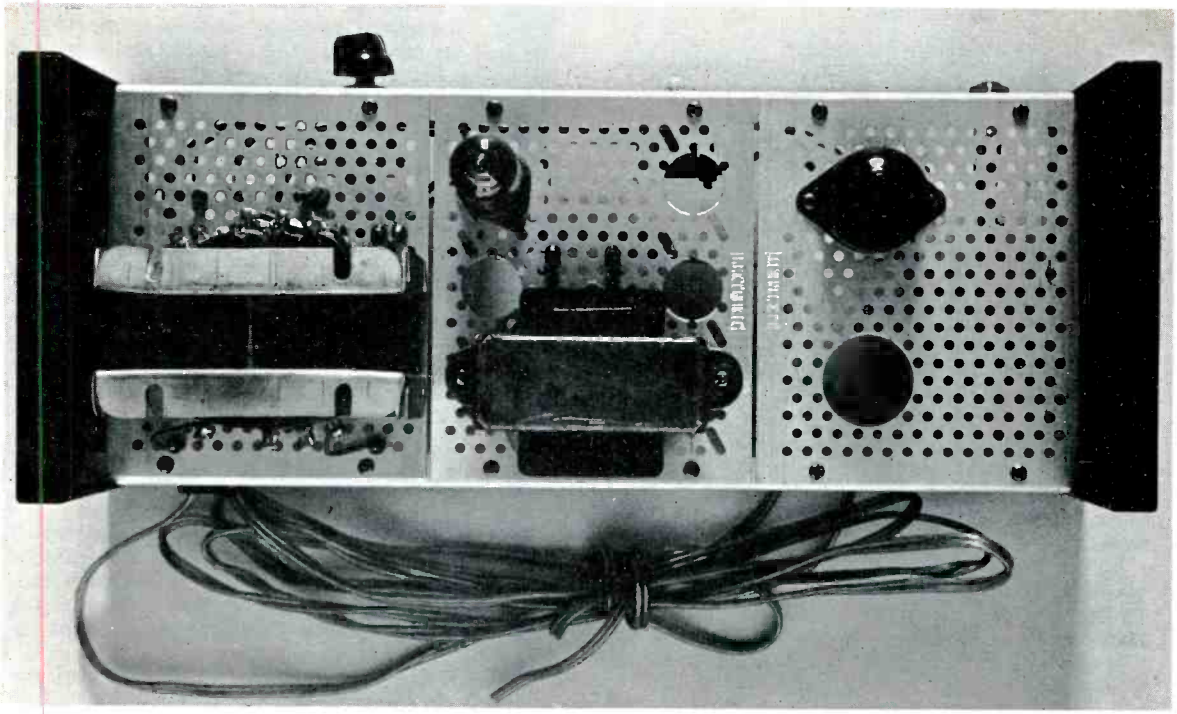
The next two lead-through insulators are in the 6.3 volt 3 amp heater supply circuit, and the connecting wire employed here should be capable of passing this current without undue loss of voltage. If single strand connecting wire is employed, the wire should be 18 s.w.g. or thicker. Stranded wire should have the same overall thickness as that associated with the wires in 5 amp flexible mains cable.

Insert the fifth lead-through insulator and connect it, above the chassis, to the 0 volt heater tag, as in Fig. 4. Below the chassis, connect one end of a 12in length of wire to the insulator. Solder all connections.

Fit the sixth lead-through insulator and connect it, above the chassis, to the 6.3 volt heater tag, as shown in Fig. 4. Below the chassis, connect one end of a second 12in length of wire to the insulator. Solder all connections. The free ends of the two 12in lengths of wire fitted in these last two steps will be connected into circuit later.

Next fit a 6BA solder tag, as illustrated in Fig. 4 (with position in Fig. 5) to a ⅛in hole in the fourth row of holes from the front of the mains transformer clamp. Connect this tag to the 0 centre-tap of the h.t. secondary, and thence to the transformer screen tag. Solder all connections. This last connection ensures that the transformer screen is at chassis potential and it also demonstrates that the h.t. negative connections in the power supply unit are made by way of the metal-work of the chassis. If we refer back to Fig. 1, for instance, we can see that we obtain our h.t negative output connection from the solder tag under the mounting nut for the octal valveholder.

The rotary toggle switch S_1 is next wired and fitted in position. First, obtain the mains lead and solder its two wires to the two tags on the longer surface of the switch, as shown in Fig. 6(*a*). These connections have to be made before mounting the switch, because they then become inaccessible. Next, mount the switch to the front chassis rail in the second U-slot from the Chassis Plate No. 1 end, as in Fig. 6(*b*). Tighten the bush-mounting nuts firmly to ensure a secure mounting. From the remaining two switch tags connect two wires to the two lead-through insulators of Fig. 3, which were connected at that stage to the mains transformer primary. Solder all connections. Next clamp the mains lead, as illustrated, using a 6BA nut and bolt. If a metal clamp is employed instead of the Lektrokit plastic clip referred to in the Components List, cover the mains lead with several layers of p.v.c. insulating tape, or with a short length of sleeving, to prevent the mains lead insulation from direct contact with the metal edges of the clamp. The mains lead passes through a ½in grommet at the rear of the chassis, this being



The components above the chassis

fitted in the end U-slot of the rear chassis rail. The grommet is held in place by a short length of thick wire (around 18 s.w.g.) passed through the holes on either side of the U-slot, as illustrated in Fig. 6(*c*).

The mains lead may be terminated in a suitable mains plug, and a knob fitted to the rotary switch. This is in the off position when the knob is rotated anti-clockwise. It should be added that a rotary switch is used in preference to a normal dolly-operated toggle switch because it is anticipated that some readers will use the power unit without a protective cover. If a dolly-operated switch were employed with the present type of chassis construction there would be a risk of the fingers touching its tags whilst switching on or off.

The Heater Wiring

The heater wiring comes next, and it now becomes necessary to mount and wire the 6.3 volt pilot lamp holder. After considering the various types of m.e.s. bulbholders available[2] it was felt that a neat, inexpensive and easily mounted component would be the popular battenholder type available at Woolworths' stores. This is shown in Fig. 7, where it is fitted (after connection has been made to one of its terminals) to the U-slot in the front chassis rail mid-way between the on-off switch and the neon bulb assembly. The mounting holes in the bulbholder are spaced slightly wider than the corresponding holes on either side of the U-slot

[2] The letters m.e.s. stand for "Miniature Edison Screw" and are applicable to bulbs of the type which are fitted to flash-lamps.

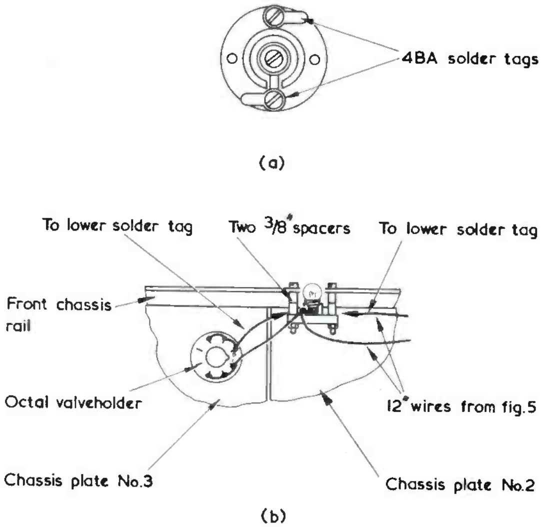


Fig. 7 (a). The bulbholder has two 4BA solder tags fitted, as shown here
(b). Mounting the bulbholder and completing the 6.3 volt wiring. The 12in wires should be run along the inside of the front chassis rail

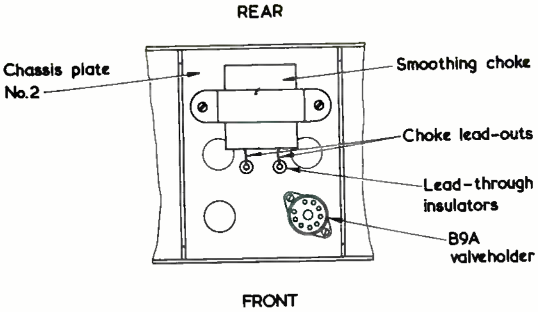


Fig. 8. Two lead-through insulators, positioned as shown in this top view, take the connections from the smoothing choke

in the chassis rail, but the discrepancy is readily taken up in the 1¼in 6BA bolts which secure the bulbholder to the chassis rail. Spacing is given by two ⅜in spacers (Lektrokit Part No. LK-2521) on each bolt.

Before mounting the bulbholder, 4BA solder tags are fitted to the terminals, as shown in Fig. 7(*a*). To the solder tag which will be closer to the Chassis Plate surface after fitting, is connected one of the 12in wires from Fig. 5 whose free ends were previously unconnected. It is immaterial which of the two wires is chosen. The wire should be cut before connecting so that it will lay neatly against the chassis front underside after the bulbholder is mounted. Also connect to this 4BA solder tag one end of a 6in length of wire similarly having a suitable thickness for the 3 amp heater circuit and solder the joint. Mount the bulbholder, as in Fig. 7(*b*). Then connect the 6in. length of wire to pins 6, 7 and 8 of the octal valveholder, shortening the lead as necessary to obtain a neat finish. Solder at pins 6, 7 and 8 of the octal valveholder.

Shortening as necessary, connect the second 12in lead from Fig. 5 to the remaining bulbholder tag. Connect another lead, of suitable thickness, between this second 4BA solder tag and pins 1, 2 and 3 of the octal valveholder. Solder all connections.

The pilot lamp may now be fitted to the bulbholder. If the glass bulb does not lie central in the U-slot this will probably be due to the threaded metal section which takes the bulb being slightly off centre in the bulbholder moulding. Remove the bulb, loosen the screw to whose head the bulb tip makes contact, adjust the position of the threaded metal section in the bulbholder moulding and re-tighten the screw.

Since it is possible for the metal body of the bulb to touch the sides of the U-slot when it is removed or inserted, removal or insertion should not be carried out whilst the unit is switched on with power applied.

H.T. Filter Wiring

All that remains is to wire in the components in the h.t. filter and bleeder circuit, and the appropriate wiring is illustrated in Figs. 8 and 9. In Fig. 9 the tags of the 5-way tag strip are numbered for ease of reference. Tag 3 is integral with the mounting bracket for the tagstrip and is, in consequence, at chassis potential. It provides, by way of the chassis, the h.t. negative connection to the reservoir capacitor, C_1, and the bleeder resistor, R_2.

Insert, from the top of the chassis, two lead-through insulators in the Chassis Plate No. 2 as shown in Fig. 8. Connect and solder the two lead-outs of the smoothing choke to these insulators.

Below the chassis (see Fig. 9) connect one lead-through insulator to tag 5 of the tagstrip and the other lead-through insulator to tag 2 of the tagstrip. Also, connect this last insulator to pin 4 of the octal valveholder. Solder at the lead-through insulators and at pin 4 of the octal valveholder.

Connect pin 3 of the B9A valveholder to tag 5 of the tagstrip. Solder at pin 3 of the B9A valveholder.

Fit sleeving over the lead-outs of the reservoir capacitor, C_1, and connect the positive lead-out (red) to tag 5 of the tagstrip and the negative lead-out (black) to tag 1 of the tagstrip. Solder at tag 5 of the tagstrip. The capacitor should take up the position shown in Fig. 9.

Connect tag 1 of the tagstrip to tag 3 of the tagstrip. Solder at tag 1.

Fit sleeving over the lead-outs of the bleeder resistor, R_2, and connect one lead-out to tag 2 of the tagstrip and the other to tag 3 of the tagstrip. The resistor should take up the position shown in Fig. 9. Solder at tags 2 and 3.

It will be noted that, in the wiring just carried out, joints are only soldered when all connections have been made to the appropriate tag. This is, of course, good practice, and it enables neater and more reliable wiring to be achieved than would occur if attempts were made to solder each new wire as it is applied to an already soldered tag.

Testing

The power unit is now complete and all it requires is checking and testing.

The wiring steps shown in the diagrams should

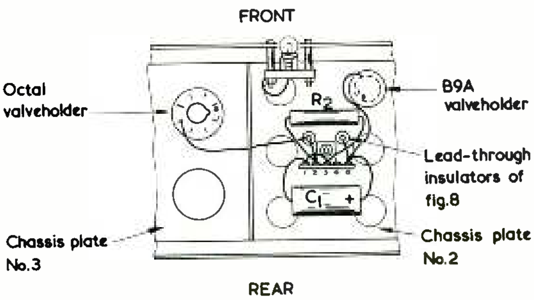
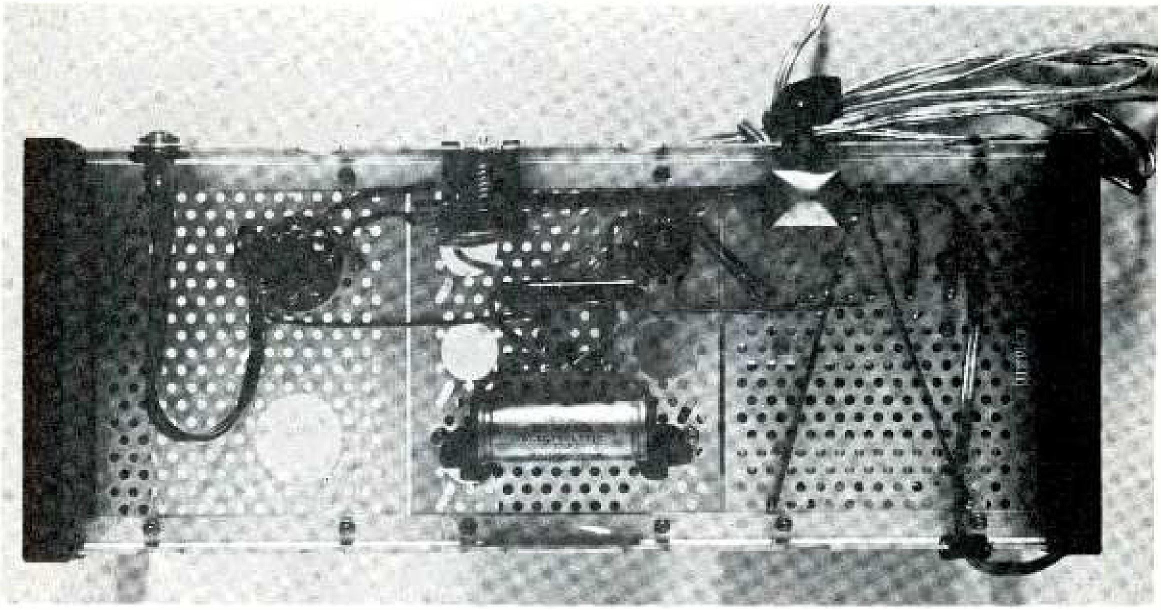


Fig. 9. The last stage of wiring. This underchassis view shows the connections in the h.t. filter and bleeder resistor circuit



Underchassis view, illustrating component layout

be checked visually, particular attention being paid to ensuring that no short-circuits exist between wiring at mains or h.t. positive potential and chassis. If stranded connecting wire has been employed, check that there are no stray strands at any joint which could touch the chassis or an adjacent solder tag. All the strands should be incorporated into the solder joint. Also ensure that no stray "blobs" of solder are left on the chassis or components. If a testmeter with a resistance-reading range is available, an electrical check for short-circuits between the mains wiring and chassis, and between the h.t. positive wiring and chassis may be made with this. When testing to the h.t. positive wiring, the presence of the electrolytic smoothing capacitor will cause the testmeter needle to give an initial "kick" as the capacitor charges, the final resistance reading to chassis being the 27kΩ due to the bleeder resistor, R_2.

The power unit should be switched off (S_1 knob anti-clockwise) and the mains lead connected to the mains supply. Insert the EZ80 rectifier. The power unit is next switched on. If all is well the m.e.s. pilot lamp will become illuminated immediately. After several seconds the heater of the EZ80 will be seen to glow. Some 10 to 15 seconds later the neon bulb will also become illuminated, thereby indicating that the rectifier cathode has reached emitting temperature and that a rectified h.t. voltage is available at the octal valveholder output socket. If a testmeter with a suitable direct voltage range is available, the voltage between pin 4 of the output socket and chassis may be measured. This should be of the order of 290 volts. However, in the absence of a testmeter, the glowing of the neon bulb offers a good indication that h.t. voltage is present.

When the unit is switched off, the neon bulb brilliance will decrease until it becomes completely extinguished after about 2 seconds. This is the result of the reservoir capacitor discharging into the bleeder resistor.

The power unit is now complete and may be used with further demonstration units to be described in this series, or with other equipment as desired. Connection to the power unit is made by way of the octal plug which fits into the octal valveholder output socket. The pin connections required are given in the accompanying Table.

Protective Cover

In its present form the power supply unit has several connections at mains potential, or at h.t.

Table
Output Socket Connections

Pin	Facility
1, 2, 3	6.3 volts a.c.
6, 7, 8	6.3 volts a.c.
4	H.T positive
5	H.T. negative and chassis

Note. For 6.3 volt outputs in excess of 1 amp use two pins in parallel, and for 6.3 volt outputs in excess of 2 amps use three pins in parallel.

positive potential, above the chassis, and it must be remembered that these can give rise to possibly dangerous shock if they are touched. If there is any risk of these points being accidentally touched, particularly where children or non-technical people are concerned, the power unit should be completely housed in a small cabinet made of insulating material. Suitable materials are hardboard or plywood, apertures being provided at the front for the switch, neon bulb and pilot lamp, and at the rear for the mains lead. Small ventilation holes in the top and bottom of the housing should be provided, the cabinet standing on runners at front and rear, or on four corner feet, to allow the ingress of cool air from below.

Next Month

In next month's issue a further constructional project, to be powered by the present supply unit, will be introduced.

RADIO TOPICS . . .

by Recorder

To say that we take for granted the electrical and electronic devices which qualify our present lives is so obvious a truism that the point does not need to be laboured. Particularly accepted in our environment is the telephone, and it rarely occurs to the layman to think of each instrument as coupling all the way to the local exchange by way of its own individual pair of wires. Or of each exchange coupling to its fellows by cables or microwave links.

These methods of coupling are economic in a compact community such as the U.K. But the economics are not so attractive in territories where considerable distances have to be spanned.

"Thin Line" Telephone System

It is with these thoughts in mind that I notice that The Marconi Company, one of our most active participants in the export field, has introduced a new radio telephone equipment which provides low-bandwidth communication over distances of up to 200 miles without any interconnecting wires or repeater stations whatever. The Marconi Company are currently meeting an order from the East African Posts and Telecommunications Administration for a system incorporating this new technique, the instalation providing six telephone channels between Mwanza and Bukoba, some 112 miles apart across Lake Victoria.

The most interesting feature of the new system is that it operates by way of tropospheric scatter. As many readers will already know, tropospheric scatter enables v.h.f. and u.h.f. signals to be transmitted well over the horizon. The transmitted energy is scattered by discontinuities in the troposphere, and a small proportion can be picked up by sensitive receivers situated a considerable distance from the transmitter.

Up to the present, the normal approach towards tropospheric scatter has consisted of using very high transmitter powers, these giving system bandwidths which are capable, typically, of providing some sixty telephone channels. But the cost of such equipment is high, and is not justified unless the comparatively wide bandwidth is fully occupied.

The new Marconi system is designed to cater for cases where a lower channel capacity is required, whereupon the reduced bandwidth allows operation with much less costly transmitter and aerial equipment. The six telephone channels in the Mwana-Bukoba link are representative of what is offered by the lower system bandwidth.

This Marconi approach is described as the "Thin Line System", and the equipment to be fitted in Africa includes solid-state transmitters working in the range of 790 to 960 Mc/s, and having an output power of 7 to 10 watts only. Also solid-state are the associated receivers. Dish aerials of thirty foot diameter are employed at both the transmitting and receiving stations. The new circuits provided by the equipment are to be integrated into the normal telephone network of the East African Posts and Telecommunications Administration.

It is stated that the Thin Line System is free from the interference and distortion which are normally associated with high frequency radio circuits. The fact that spans of up to 200 miles without the need for repeater stations are possible makes it particularly attractive in difficult territories such as occur in Africa.

Missing Number

Here's a little puzzle of the type the Intelligence Test boys turn out. What's the missing number in the following sequence?

1 2 6 12 24 — 60

I won't keep you waiting till next month for the answer; it's at the end of this month's piece. And I must acknowledge my indebtedness to the *ABS Bulletin*, the journal of the Association of Broadcasting Staff, in which I first saw the puzzle.

BSR Record Player Unit

The accompanying photograph gives a view of the new GU8 single record player unit, which is now being manufactured by BSR Limited, Monarch Works, Old Hill, Staffordshire. This is a development of the very successful GU7 and retains all the features of that unit. These include automatic switch-off at end of record, accommodation for monaural or stereo cartridges, automatic disengagement of jockey pulley when not in use and the ability to play all sizes of record at 78, 45, 33 or 16 r.m.p.

A new feature incorporated in the GU8 is a built-in 45 r.p.m. adaptor for use with 7 in records having a large central hole. Also, it is available with a choice of two pick-up arms, either in lightweight tubular aluminium or moulded plastic, both with finger lift. The photograph shows the aluminium arm on the deck at the rear.

Another point is that the dimensions of the GU8 mainplate are exactly the same as those for the BSR UA50 "Minichanger", which makes the two units completely interchangeable. Like all BSR units, the GU8 is available with motors to suit any mains voltage at 50 or 60 c/s, and also for battery operation.

The Solder Type Flip Chip Transistor

Is there any other subject which has such a wide variety of names for its devices as semiconductor electronics? One of the most recent names I've encountered is that of the solder type "flip chip" transistor which is manufactured by Semiconductors Ltd. of Swindon, Wiltshire.

This transistor is an experimental epitaxial planar n.p.n. transistor for use in linear and slow speed thin film circuits. It is coded T13/2. The three contact areas are of gold-lead-gold sandwich construction, projecting 1/1,000 to 1/500 of an inch above the chip surface. The device can be soldered to a one micron (1/10,000 cm) layer of gold evaporated onto a chromium or a glass surface, using a low power microscope for the alignment. A subminiature soldering iron with a bit of a non-corroding metal such as gold should be used, although a brass bit may be satisfactory. The iron is held in a micromanipulator and applied to the back of the chip for 20 to 30 seconds with a force of 40 grams weight.

The new BSR GU8 single record player unit, which is available with pick-up arms in either lightweight tubular aluminium or moulded plastic

Ferrite Aerial Rods

My comments in the March issue concerning the possibility of checking ferrite rod aerial alignment without moving the coil along the rod and the subsequent alternative approach put forward in the June issue by Mr. R. Wallace have prompted another reader, Mr. J. H. Brooks of Walworth, London S.E.17, to sound what may be described as an Awful Warning.

Mr. Brooks has found that, in replacing broken ferrite rods, the replacement material sometimes has either too high or too low a permeability, with the result that peaking becomes impossible with the existing coils. This occurs despite the fact that the new rod has the same dimensions as the one it replaces. It seems that the rods from some suppliers have quite a different permeability to those from others.

This is rather an awkward problem and will be due to the fact that the ferrite material employed in aerial rods is available in several grades. I would suggest that a ferrite rod which is suitable for the short wave bands as well as for medium and long waves will probably have a lower permeability than one which is normally intended for medium and long waves only. At any event, the possibility of obtaining a replacement ferrite rod with an incorrect permeability is one of those added little things to watch out for in the servicing game, and I am most grateful to Mr. Brooks for raising the point.

That Number

And, finally, that missing number in the sequence. This is forty-eight (I've spelt this instead of printing it in figures to lessen the chance of your eye accidentally picking it out from the text) and the whole thing makes sense if you think in terms of halfpennies!

TV FAULT TRACING WITHOUT INSTRUMENTS

by **G. R. WILDING**

Simple tests on TV receivers can frequently be carried out with the aid of a neon test screwdriver and a few odd components. The checks described here are applicable to 405/625 receivers with a common fault on both standards as well as to 405-only sets.

When occasion demands, and even for sheer expediency, it is possible to diagnose and locate a few TV faults with nothing more complicated than a neon test screwdriver and the odd resistor and capacitor. Some of the tests described here can be applied to mains-driven radios as well.

Open-Circuit Heater Chain

This is one of the most prevalent of all TV faults and a very quick method of finding the break consists of systematically testing down the heater chain from the switch and mains dropper with the neon tester, having first established that the chassis is at neutral mains potential. Since it is not always a valve heater that is at fault, such a method ensures that the most probable causes of failure are tested first.

Video Drive Test

The trick of feeding a small a.c. voltage to the grid of the video output valve by way of a small capacitor is too well-known for comment here. An equally effective test for checking the video circuit is to apply a small positive voltage from a torch battery to the video output grid and noting the increased level of raster brilliance. (Dual-standard sets are best switched to 405 for this test.)

Non-Running Line Output Stage

The cause of a dead line output stage can often be traced with the aid of a neon tester. Take care, however, when applying the tester to points which would normally be carrying pulse voltages, such as the line output anode, the booster diode cathode and the e.h.t. rectifier. Even though the line output stage may be apparently dead, there can still be pulse voltages present which are well in excess of those for which the neon is usually employed. Bring the neon screwdriver initially to such points without touching the end pip. The neon will frequently glow under this condition if pulse voltages are present.

If it is obvious that neither the line output valve, the booster diode or the line drive oscillator valve (or valves) has a short-circuited heater, commence by trying valve replacement in the line drive oscillator position.

The next check is to neon-test the booster diode top-cap (cathode). If h.t. is absent, it is practically certain that the diode is completely unserviceable, probably with a disconnected internal electrode lead.

If, however, ample h.t. is present at the cathode, switch off, remove the top-cap connection, switch on again and neon-test to the flying lead. Should there be h.t. on the flying lead it is fairly certain that the boost capacitor has an internal short-circuit. Very often, if this component is replaced the line output stage will commence to run. (In any conventional receiver with the booster diode disconnected, the line output transformer may receive an h.t. supply via a short-circuited boost capacitor.)

Assuming that the above checks have yielded no results, replace the booster diode flying lead and neon-test the line output valve top-cap (anode). Absence of h.t. here indicates a break in the line output transformer winding. The continuity of the e.h.t. overwind can also be checked at this stage by neon-testing at the e.h.t. rectifier anode. But it must be remembered that a break in the e.h.t. overwind will not stop the line output stage running, it will merely prevent the appearance of e.h.t. So the test is of a subsidiary nature, and it merely provides a check of the overwind.

The final checks in this series consist of temporarily removing the e.h.t. rectifier (a short-circuit in this valve may occasionally upset line output stage running) and of neon-testing the screen-grid of the line output valve (the screen-grid feed resistor may have gone high or the screen-grid capacitor short-circuit).

All these checks should be carried out quickly since the fault may be due to lack of drive to the line output valve grid, in which case this valve will be operating with virtually zero bias. The line drive oscillator stage was checked initially by valve substitution but this does not, of course, cover all instances of line drive failure. Apart from a neon test at the line drive anode (or anodes) further checks will normally require the use of test equipment and/or component substitution. Nevertheless, the simple tests given above may frequently isolate many of the faults which are likely to stop the line output stage from operating.

Reduced Line Amplitude

This is normally exhibited by low line width, with a gap at each side of the raster. The fault is frequently caused by one of the following:—

1. Low emission line output valve.
2. Low emission booster diode.
3. Low emission line drive oscillator.
4. Low h.t. rail voltage.
5. Incorrect value of line output valve screen-grid feed resistor.
6. Shorted turns in line output transformer.
7. Shorted turns in line scan coils.

Items 1, 2 and 3 can, of course, be checked by valve substitution.

Item 4 may be due to a defective valve rectifier or metal rectifier. The valve rectifier can be readily checked by substitution. A silicon h.t. rectifier will not cause this fault. The trouble may also be caused by a reservoir capacitor with reduced value. The latter can be checked by applying a 32μF capacitor in parallel. If the reservoir capacitor has its correct value (normally of the order of 100μF) the additional 32μF will have little effect. But if the reservoir capacitor is seriously low in value, the additional 32μF capacitor will have a marked effect. Should the reservoir capacitor test yield no results when a metal h.t. rectifier is employed the latter becomes suspect, particularly if it runs warm.

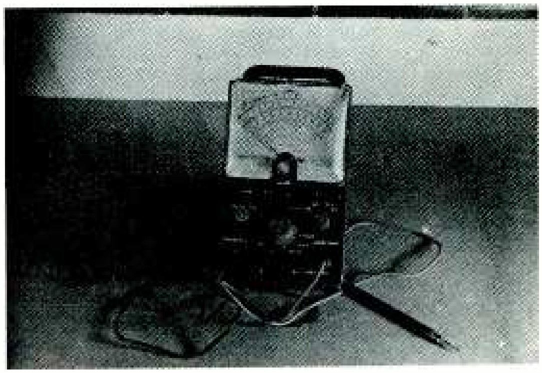
Item 5, the line output valve screen-grid resistor, can be checked fairly successfully by simple visual inspection. If it is a wirewound component it is pretty safe to assume that its value is correct. It is also pretty safe to assume that a composition resistor has correct value if the colour coding paint is intact. However, if the paint is flaking off and the resistor tends to crumble when subjected to pressure it will certainly merit replacement.

Shorted turns in the line output transformer (item 6) may also reduce the heater voltage of the e.h.t. rectifier, whereupon "blooming" takes place (i.e. the picture opens out) when brilliance or contrast is advanced beyond a certain level. Occasionally, however, the loss in e.h.t. voltage more than compensates for the loss of line amplitude, resulting in excessive raster size.

The last item, shorted turns in the line scan coils, invariably causes raster distortion, whereupon the fault becomes self-evident. At the same time, a heavy short-circuit in the line scan coils may prevent the appearance of e.h.t. voltage.

The Heathkit Multimeter

Model MM-1U



THERE IS NO DOUBT THAT THE BEST WAY TO LEARN the principles of any unit of electronic apparatus is to build it oneself, and the constructional kits by Daystrom Ltd. help fulfil this function as well as providing the opportunity of acquiring high class electronic equipment at a reasonable price.

One of the most essential instruments for the constructor of radio and kindred equipment is, of course, a reliable meter with which to measure voltage, current and resistance. The elaborateness of such a meter will depend on the exact type of use to which it is to be applied—there being no point in having a very expensive, high grade, wide-range meter if constructional or test activities are likely to be somewhat elementary. The ranges available on the Heathkit Model MM-1U Multimeter do cater for the type of ranges in current, voltage and resistance measurement likely to be encountered in the average service workshop, home constructional activities, school, and technical college teaching and laboratory requirements.

May we say, for the benefit of those readers who have so far not constructed any of the kits in the Heathkit range, that the procedure in doing so is to follow through, step-by-step, a series of instructions contained in a thoroughly detailed, well illustrated, manual provided with the kit. This manual not only provides, in the greatest detail, all the information needed to complete the kit but it additionally contains information on the manner in which the completed unit should be used. It is thus a very useful instructional textbook for the particular item of electronic equipment being constructed. Another particularly valuable feature of this series of kits is that (as all constructors of anything but the simplest equipment will know only too well) one must carry the construction through in a definite order, otherwise it is often difficult to gain access to some components in order to apply solder without risk of damage to other components, etc. The order in which each constructional stage is to be carried out has been most carefully considered in that assembly can be completed in the easiest manner possible. Furthermore, the correct type of components are provided with respect to tolerances, ratings, sizes, etc., this in itself saving much time and trouble.

★

Compact Keying Monitor

by **WALLACE STUDLEY**

The Components of this neat little monitor unit are fitted to a piece of Veroboard measuring $1\frac{3}{16}$ by $1\frac{5}{8}$in only. The board is then mounted to the tags of the potentiometer frequency control, this being fitted to the panel of the associated equipment

BUILT RECENTLY TO FULFIL A special need—that of enabling transmitter keying to be aurally monitored—the simple monitoring device described here should prove to have a wide range of interest.

It is not easy to send intelligent c.w. signals without monitoring them in some way. Whilst the station receiver, partially muted, can be made to do the job the method might not always be considered desirable, and particularly if the receiver is transistorised. This unit enables the station receiver to be completely disabled during the "transmit" period and complete safety results. The device may also be used beneficially by aspirants to G.P.O. Amateur 'ticket' status as a means of acquiring the necessary skill in reading and sending Morse code.

Circuitry

As may be seen from Fig. 1, the device consists basically of a 2-stage oscillator-amplifier pruned to leave but the minimum number of components. The circuit is "sure-fire" and the audio oscillations due to T_1, TR_1 and the associated components, are amplified by TR_2 and appear at its collector to energise a balanced armature insert. A control offering a limited range of frequencies is incorporated; this consists of VR_1 and enables a range of 500–1,200 c/s to be covered.

When the unit is used for c.w. monitoring it has to be remembered that high d.c. potentials normally appear across the transmitter key contacts, and the unit could not be connected directly to these. Instead, it is connected to the key contacts which *open* when the key is depressed, as shown in the diagram. Keying of the base circuit of TR_1 is then safe and satisfactory.

In some applications it will be preferable to use the more conventional keying system, in which the keying contacts *make* when the key is depressed. A typical instance would be given by the use of the unit for Morse practice. The unit can cater for this requirement also, the key circuit of Fig. 1 being omitted and the key inserted in the negative supply line at the point indicated by the circled cross.

The collector load for TR_2 does not seem over-critical and if no suitable insert can be obtained a discarded headphone unit or a loudspeaker may be tried. Even a 3Ω impedance loudspeaker speech coil worked when checked, although output was rather small. A 35Ω or 80Ω speaker would also be usable, and would allow a fair output to be obtained. Another alternative that may be tried is to connect a resistor of 4.7kΩ in place of the balanced armature insert and to extract the output signal from between collector and emitter of TR_2 via a 5,000pF capacitor. The unit may then be used in other connections where audio frequency oscillations are useful, e.g., to energise a C/R Bridge, modulate r.f., provide a fault finding signal, or for Morse code.

Thus, the circuit can be readily be varied to meet particular requirements.

Construction

Physically, the largest component in the prototype is VR_1, this being a pre-set potentiometer salvaged from a defunct TV receiver. VR_1 is of the type which is mounted by two screws through the panel, and may be easily recognised from Fig. 3. The Veroboard assembly is secured to this component by the two connecting wires to its tags and, since the Veroboard assembly is very light, this method of assembly has proved to be quite satisfactory.

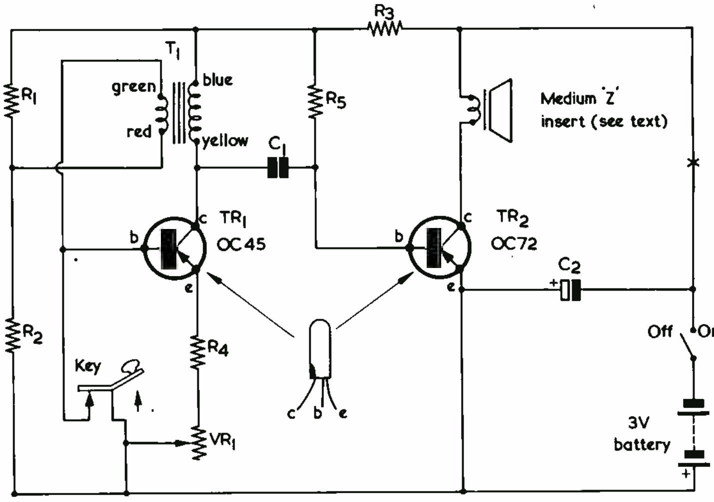


Fig. 1. The circuit of the unit. Oscillation occurs when the key contacts are opened. If it is required to control the circuit by key contacts which close when the key is depressed, these should be inserted at the point marked with a circled cross

Relatively stout wire should, of course, be employed for the two connections.

The oscillator-amplifier components are soldered to the Veroboard. The resistors and capacitors used must be miniature items, and it will be found that the pea-size transformer specified fits in nicely with the overall scheme.

The section of Veroboard employed should have a total of six conductor strips each carrying eight holes. Full details relating to the Veroboard section and its wiring are given in Fig. 2. Initially, the conductor side of the board needs minor preparation, this consisting of severing strips C, D, E and F as indicated in Fig. 2(*a*) at points "X", "Y" and "Z" using a penknife blade or small file. Holes D3 and D6 need to be enlarged slightly to accept the mounting lugs of the transformer fixing clamp. The clamp is supplied with the transformer and the lugs should be bent inward to lie along strip D, although no solder should be applied until the other connections to these holes are *in situ*. The remainder of the board assembly is clearly indicated in Fig. 2(*b*).

COMPONENTS

Resistors
(All fixed values ⅛ watt 10%)
R_1 18kΩ
R_2 4.7kΩ
R_3 2.2kΩ
R_4 470Ω
R_5 270kΩ
VR_1 10kΩ potentiometer (see text)

Capacitors
C_1 5,000pF ceramic
C_2 100μF electrolytic, 6V wkg.

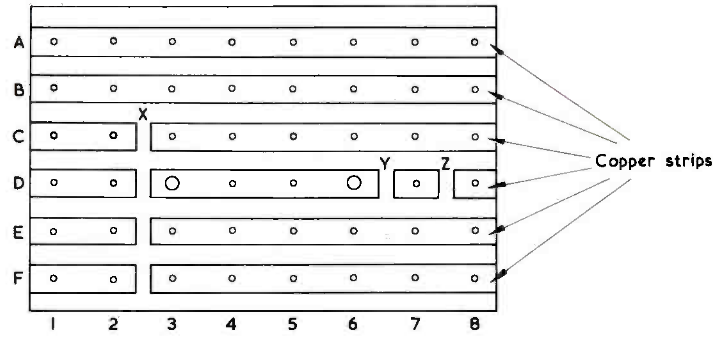
Transistors
TR_1 OC45
TR_2 OC72

Transformer
T_1 Interstage transformer type D1001 (T1097) and clamp (Ardente)

Battery
3-volt, type D22 (Ever Ready)

Switch
S_1 s.p.s.t, slide or toggle

Miscellaneous
Balanced armature insert (see text)
Veroboard, 0.2in matrix, approx. 1$\frac{5}{16}$ × 1⅝in, 6 strips by 8 holes.



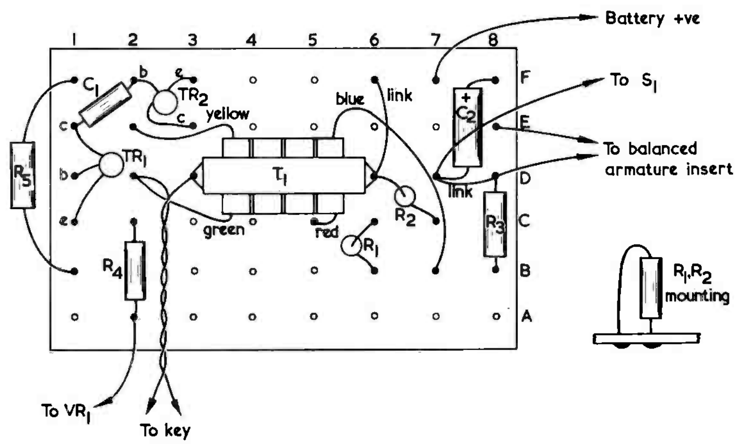


Fig. 2 (a). Preparing the copper side of the Veroboard. This has a hole matrix of 0.2in
(b). The components mounted on the Veroboard

Items external to the Veroboard assembly are VR_1, S_1, the battery and the insert. These remaining items can be fitted to a panel as convenient in company with VR_1, although a small metal or plastic box might prove more convenient.

If it is desired to key by means of contacts which make when the key is depressed, the following simple modification is required. Remove the two "key" leads from holes D2 and D3. (See Fig. 2(*b*)). Remove the link joining holes D7 and D8. Connect the two "key" leads to holes D7 and D8.

Testing

After checking the construction connect the positive side of the battery to the lead from hole F7 and clip the negative lead of a test-meter adjusted to read 0–10mA to the battery negative terminal. Clip the meter positive lead to the unconnected end of S_1. On closing S_1 a current reading of approximately 1mA should be recorded and a note should be heard when the key is depressed. The current reading should fall under "key-up" conditions and the note should not be heard due to the base of TR_1 being grounded. (If the modified keying circuit is employed, the only current which flows when the key is up is leakage current in C_2.)

The meter may then be removed and final connections made, after which the keying signal—which may be adjusted by means of VR_1 to a tone pleasing to the ear—should sound crisp and completely chirp-free.

It should be added that, when used with a transmitter, it may be necessary to couple the monitor to the key via screened cable.

Transmitter Powered Supply

When the monitor is employed with a transmitter, it is possible to

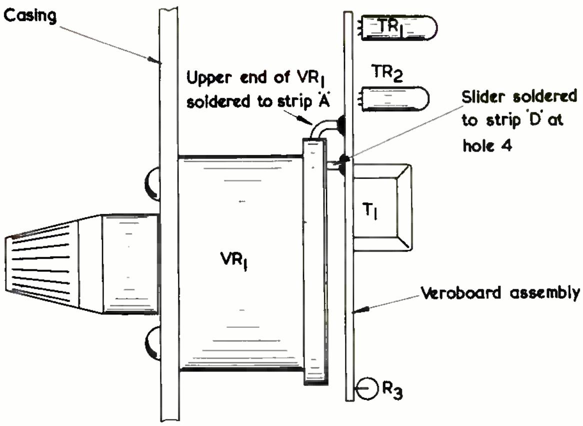


Fig. 3. The Veroboard assembly is mounted to VR_1 by means of two stout connecting wires

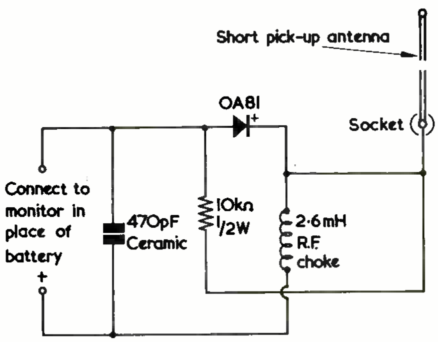


Fig. 4. A simple circuit which enables the monitor to be powered by the transmitter. The 2.6mH r.f. choke is a Denco component type RFC5

obtain a power supply direct from the transmitter output, should this be desired. The advantage conferred by this method of operation is that the battery is completely obviated, with a consequent saving in running costs.

The writer has used this principle successfully, employing the circuit shown in Fig. 4. A small proportion of the r.f. radiated by the transmitter when being keyed is picked up by the short antenna and applied to diode D_1, which rectifies it. The rectified voltage may then be applied to the monitor circuit in place of the battery.

The additional circuitry required can easily be wired up either on an oddment of Veroboard or on a small tagstrip. The socket may be of the simple type associated normally with a banana plug; it should be fitted to the upper surface of the housing used so that a simple antenna consisting of approximately 12in of 16 s.w.g. copper wire may be plugged in to stand vertically. The prototype works quite happily in conjunction with a transmitter running only 10 watts input, so there seems no valid reason why satisfactory results should not be obtained in other cases.

One possible method of working may necessitate the removal of C_2 in the circuit of Fig. 1. The monitor supply voltage then appears only when the key is depressed and ceases when it is raised, whereupon it may monitor the transmission without the necessity of connecting to the transmitter key at all.

It is desirable to ensure that too high a rectified voltage is not applied to the monitor, and the coupling between the short antenna of Fig. 4 and the transmitter should initially be loose. The coupling may then be progressively increased until the requisite voltage is applied to the monitor. This voltage can, of course, be measured with a high resistance voltmeter.

It should be noted that it will still be necessary to turn the monitor switch to "Off" when changing from c.w. to fone operation. Otherwise, power from the transmitter will still be applied to the monitor circuits.

Power Supply Protection Circuit

by **T. R. WILTSHIRE,** G8AKA

The simple protection circuit described in this article not only provides emergency lighting when the mains fails but also isolates equipment which could be damaged by a sudden re-application of the supply. It is assumed that the reader has experience of relay circuitry and may obtain suitable components through the usual surplus and equipment channels

THOSE WHO LIVE IN FLATS WITH THE "SHILLING in the slot" type of prepayment meter for electricity supply may find this device of interest. Even though it is not necessary with the author, he still prefers to use a slot-meter because it prevents the quarterly nightmares of electricity bills. At the same time, there are distinct disadvantages with the prepayment system, as may well be imagined. For instance, should the shilling run out during a session at the workbench or during a QSO on the transmitter one can very easily put a hand on a still-hot soldering iron whilst groping for the door in the darkness. The same applies, of course, when ordinary power cuts occur. With the silicon rectifiers now available there is the further danger of damage to high voltage gear due to the sudden surge when the supply is restored, and a risk of the same order is given with equipment using mercury vapour rectifiers.

The Circuit

The protection circuit appears in the accompanying diagram.[1] As well as protecting the high voltage circuitry employed in the author's workshop, the unit also provides an emergency lighting system in order to prevent accidents when leaving the room to insert a fresh coin in the meter.

With the mains supply in the normal condition, relay RLA is energised from the mains via the voltage dropping resistor R_1 and the rectifier D_1. Contacts RLA1 are then in the open position, thus preventing the emergency lighting circuit from being completed. Briefly pressing push-button S_2 energises relay RLB, which holds on via its own contacts RLB1. At the same time, contacts RLB2 become closed, allowing mains current to flow to transmitter power supplies and any other equipment which could be damaged by a sudden re-application of the mains after failure.

Upon mains supply failure, through power cuts or any other cause, the following action takes place. Relay RLA de-energises, closing contacts RLA1 and thus operating the emergency lamps L_1 and L_2. One of these may be located adjacent to the prepayment meter and the other over the work bench. Relay RLB also de-energises, breaking the circuit to the protected equipment.

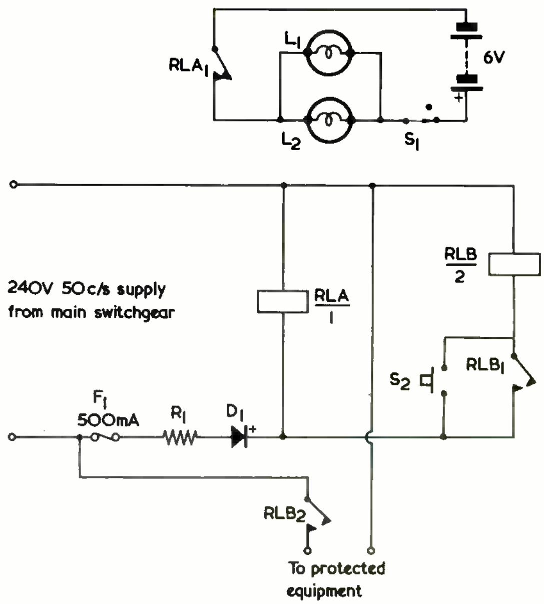
When power is restored, RLA re-energises, and its contacts switch the emergency lights off. Relay RLB will not operate, however, until push-button S_2 is closed, after which it remains in the energised position. Thus, one is given the opportunity to attend to any gear that might be damaged by a sudden re-application of the supply.

Since the circuit is permanently in operation it is essential that a suitable fuse be fitted in the F_1 position. A rating of 500mA is about the right value for this fuse, but this again depends on the type of relays used.

No constructional details are given as many variations are possible, but there are one or two points to watch. It is best to under-run all components including, especially, contacts RLB2 as a considerable current is likely to be passed if a large amount of gear is used in use. The value of resistor R_1 depends on the relays employed, as also does the current rating for D_1. This rectifier should have a p.i.v. rating of 400 volts or more, and suitable types would be the OA210 (400 volts p.i.v.), or the OA211 or BY100 (800 volts p.i.v.). The push-button, S_2, should be a well-insulated component. The 6-volt battery for the emergency lights may be a bell battery and the lamps m.e.s. pilot types. Alternative batteries and lamps can, of course, be employed. Since the relays are, normally, energised all the time, these should have high resistance coils to prevent excessive current consumption.

As a guide, the relays employed in the prototype had coil resistances of 1 kΩ, whilst R_1 had a value of 3kΩ, 20 watts. The relays were rugged components and gave no evidence of relay chatter despite the fact that they were energised from half-wave rectified a.c. Should relay chatter be troublesome this could be cleared by connecting an electrolytic capacitor across the coil of relay RLA. A value of 50μF should be satisfactory here.[2]

In service, this unit has required no attention apart from the occasional replacement of the emergency light battery. It has certainly proved its worth for the short time spent in its assembly, and it has been possible for its correct operation to be completely taken for granted.



The emergency protection circuit. Contacts RLA1 complete the emergency lighting circuit during mains failure, whilst contacts RLB2 prevent the re-application of the supply to the protected equipment. Switch S_1 may be used to override the emergency switching

[1] This diagram shows the relays with "detached" presentation. There are two relays in the circuit, the coil for relay RLA being indicated by the rectangle designated $\frac{RLA}{1}$ and the coil for relay RLB by the rectangle designated $\frac{RLB}{2}$. Relay RLA has a single contact set, RLA1, which is normally closed. Relay RLB has two contact sets, RLB1 and RLB2, both of which are normally open.—Editor.

[2] If this capacitor is fitted, it would be preferable to employ a rectifier in the D_1 position having a p.i.v. higher than 400 volts. In practice, the BY100 or OA211, mentioned in the text, would be satisfactory.—Editor.

CUBICAL QUAD AERIAL for F.M.

by **J. B. DANCE,** M.Sc.

Increased sensitivity and freedom from ignition interference on Band II are feasible with the use of a cubical quad aerial

THE USE OF A CUBICAL QUAD AERIAL FOR F.M. reception has been suggested.* This gives a gain of about 8dB over a dipole and has a much wider bandwidth than a Yagi aerial of similar gain. In the U.K. it is normally desired to receive the three B.B.C. programmes from a single transmitter, these having frequencies spaced at 2.2 Mc/s from each other. The highest and lowest frequencies are 4.4 Mc/s apart, and the question of bandwidth, is not, in consequence, unimportant. A further point is that a cubical quad matches into a 75Ω coaxial cable rather more accurately that a Yagi aerial of similar gain.

* E. D. Frost, "Pulse Counting F.M. Tuner", *Wireless World*, December 1965.

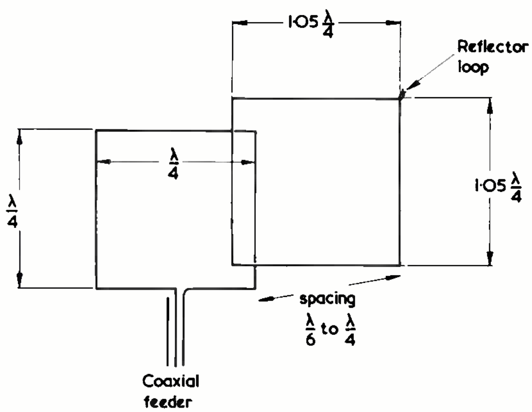


Fig. 1. The basic cubical quad aerial

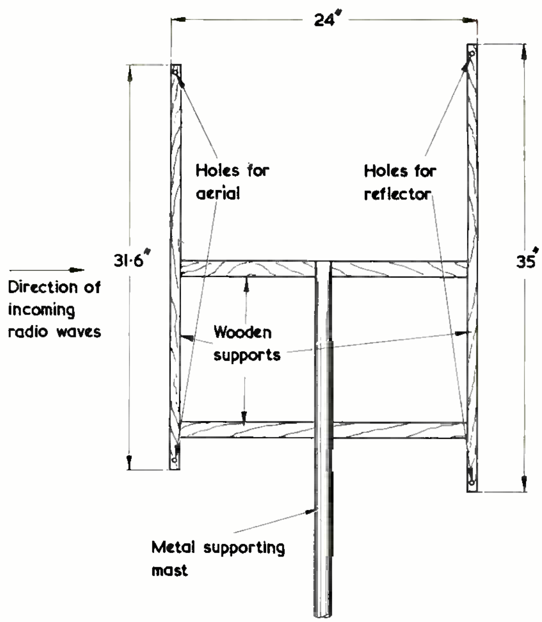


Fig. 2. A practical cubical quad aerial for 90 Mc/s. The aerial and reflector loops are perpendicular to the plane of the paper, but all of the supporting wood is in one plane. The stiffness of the wire used enables the loops to be self-supporting, with anchorages at the centres of the top and bottom sections only

Initial Tests

Although the writer lives only about 35 miles from a v.h.f. transmitter, he felt it would be interesting to carry out some experiments with a cubical quad. This type of aerial consists basically of a square, each side having a length of one quarter wavelength, with the coaxial feeder cable connected at a break in the centre of the lower section of the square. See Fig. 1. A reflector is placed behind the aerial at a distance of between about one sixth and one quarter of a wavelength. This reflector consists of a single continuous square loop of wire, and most text books recommend that each side should have a length about 5% longer than that of the aerial itself.

It should not be forgotten that the wavelength in a conductor is rather less than in free air, so the length of each side of the aerial should, in practice, be about 5% less than a quarter of the free air wavelength. Thus the length of the reflector required would appear to be equal to the wavelength in free air.

The writer set up a cubical quad aerial meeting the requirements of Fig. 1 in order to carry out some measurements. He was surprised to find that it gave a front to back ratio of about unity. That is the signal strength from the direction of the transmitter was equal to that when the aerial was pointed in the opposite direction. The reflector was removed and was found to be having virtually no effect whatsoever. Further experiments carried out with larger reflectors indicated that an excellent front to back ratio could be obtained if the length of each side of the reflector was made 10% longer than each side of the aerial, and the aerial finally made up employed a reflector having these dimensions

Because of its directivity, ignition noise has never been detected with this aerial, although it is only mounted 12ft above the ground and 10yds from a busy road. In addition to the elimination of ignition interference, the writer estimates that he has achieved a gain of some 24dB with this aerial as compared with a previous half-wave dipole, although part of this gain was due to a small change in aerial position.

The quad aerial would appear to be an ideal proposition for those who live more than some 60 miles from the transmitter.

The writer regrets he can offer no explanations as to why the reflector should be longer than most text books recommend for a good front to back ratio. It may be connected with the fact that the aerial was not very high, but this seems rather unlikely.

Assembly

The aerial dimensions should be chosen to obtain best results from the centre signal of the three local transmissions, this being the Third Programme. The wavelength in metres is obtained by dividing the speed of light (3 x 10^8 metres/second) by the Third Programme frequency of the local transmitter.

The method of construction adopted by the writer is shown in Fig. 2. The aerial and reflector consisted of 12 s.w.g. hard drawn copper wire which was passed though the holes shown in the wood strips and bent into the required shape. The wooden supports for the loops may be of the form shown in Fig. 2. Alternatively, each loop may be supported by two strips in the form of an X, the wire passing through holes in the ends of the strips to form the loop corners. The dimensions shown are suitable for a centre frequency of about 90 Mc/s, small variations of these lengths being required to suit the local transmitter frequency.

Before concluding, it should be reiterated that the reflector dimensions quoted in Fig. 1 are those normally found in text books, whilst those shown in Fig. 2 are the ones which the writer has found to be more suitable in practice.

THE "PENTONLECTOR" RECORD PLAYER

Our attention has been drawn to an error in the circuit diagram, on page 749 of the July issue, for this record player amplifier. In the diagram the screen grid of the PL82 is identified as pin 8; this should, of course, be pin 9.

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continued on page 189

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continued on page 191

SMALL ADVERTISEMENTS

continued from page 189

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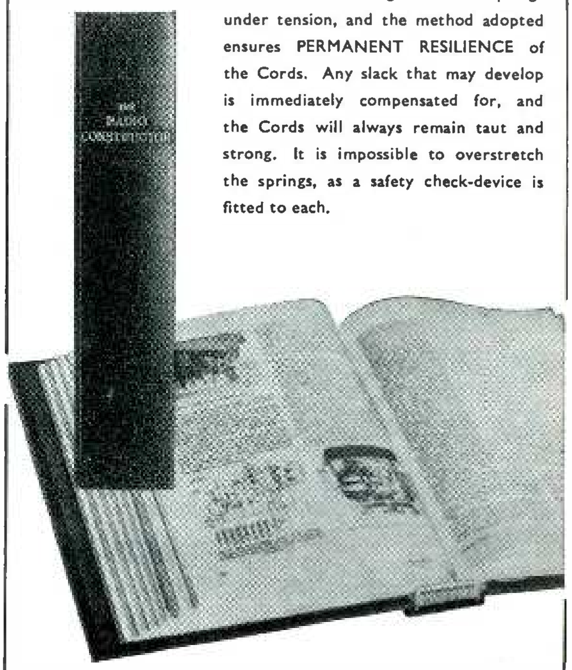

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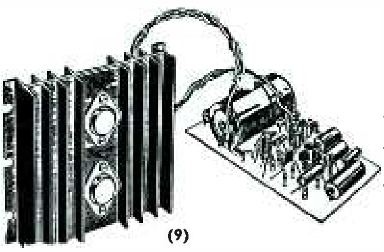

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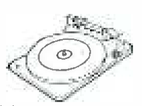

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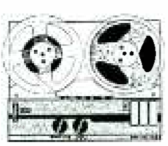

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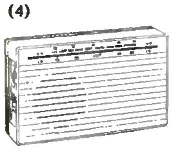

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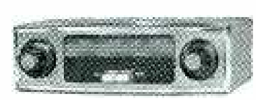

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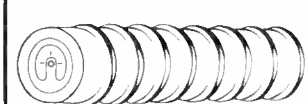

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