RADIO CIRCUITS HANDBOOK No. 4

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by J. A. FEELEY

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SECTION ONE

RECEIVERS

A SINGLE-VALVE BATTERY-OPERATED RECEIVER

The majority of people who take up radio as a hobby like to start by building a receiver. It is, perhaps, unfortunate that radio covers so extensive a field: years of study are necessary to acquire a technical background with which goes the ability to originate and develop circuits.

However, the average home constructor need not be deterred by this—for there is endless pleasure to be obtained from receiver construction and listening.

Furthermore, construction provides a valuable practical experience, which is an admirable introduction to the subject.

The first receiver to be described is a single-valve battery-operated receiver of conventional design and is intended for those with little or no experience. The receiver will be described in detail; but it may be advantageous, as a preliminary, to give a very brief explanation of the principles of radio transmission and reception.

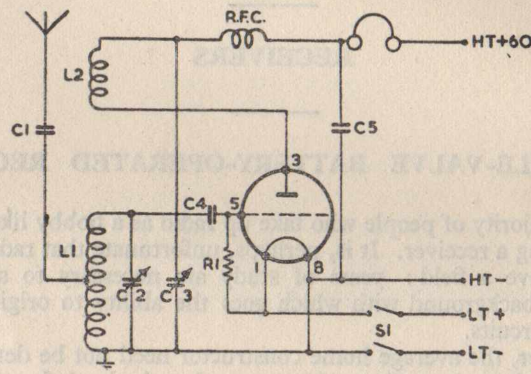
A transmission takes place by converting audible sounds in a studio into electrical impulses by means of a microphone. The impulses go through a process of amplification and are impressed upon a radio-frequency " carrier " wave. This carrier is the medium by which the programme can be radiated over considerable distances.

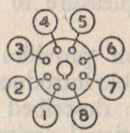
Now, at the receiver, it becomes necessary to dispense with the unwanted carrier and to reproduce only the wanted audio signals. The circuit shown in Fig. 1 is a simple regenerative detector. A detector stage is the basis of all receivers, whether simple or complicated, because it returns the audio-frequency signals to their original form, *i.e.*, as they were heard in the studio.

The resulting audio impulses are then converted into recognisable sounds by means of the headphones.

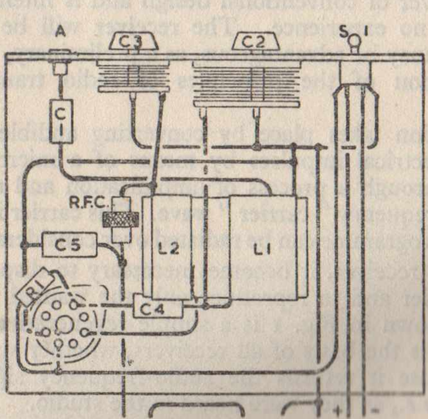
In Fig. 1, the signal arrives at the aerial and is applied to the control grid of the triode (three-electrode) valve, V1. There are, of course, many programmes being radiated simultaneously, so it is necessary to have the means of selecting the one required. This is

FIG. 1.





VALVE KEY.



COIL DATA.

FORMER 2 ½" DIA. X 3" LONG

L1. 48 TURNS 26 S.W.G. TAPPED AT 28 TURNS.

L2. 25 TURNS 26 S.W.G.

FIG. 2.

done by a " tuned circuit " which consists of the variable tuning capacitor, C2, and the tuning coil (inductor), L1. Rotation of C2 enables any wavelength between 200 and 550 metres to be selected. The Home Service programme is radiated on 330 metres and the Light on 247 metres, both within the coverage of this receiver. The shorter wavelengths are tuned in when the vanes of C2 become disengaged, and the longer wavelengths when the tuning dial is turned and the vanes become enmeshed.

For example, commencing with the vanes all out, first the Light (247m.) and then the Home Service (330m.) will be obtained. With a little experience it will be found that many Continental programmes can be tuned in at other positions of the dial. This, of course, requires increased sensitivity, and regeneration has been used in the design of this receiver for that purpose.

By this system of regeneration, R.F. signals amplified by V1 are applied from the valve via the variable capacitor C3 to L2, which is an additional coil wound close to L1.

The electromagnetic " coupling " between these two coils allows the R.F. signal to be fed back to the grid circuit for further amplification by V1.

There is, however, a limit to the sensitivity increase obtainable by this system. If C3 (which controls the regeneration) is advanced too far, the circuit will burst into oscillation—that is, become a miniature transmitter. In no circumstances should a receiver be allowed to oscillate in this way, since neighbouring receivers will be affected and their reception spoiled.

The most sensitive reception condition is reached when C3 is set just below the point where oscillation occurs.

A panel and baseboard assembly has been adopted for the construction of this receiver and full details are given in the practical diagram, Fig. 2.

Tuning Coil Data

L1 comprises 48 turns of 26 s.w.g. enamelled wire, the winding being " tapped " at 28 turns from the start. The wire should not be broken, but brought out in the form of a loop, as shown in Fig. 2.

L2 consists of 25 turns of 26 s.w.g. enamelled wire wound in the same direction as L1, and spaced from the latter by $\frac{3}{16}''$.

The whole coil is wound on a $2\frac{1}{2}''$ diameter paxolin former, $3''$ in length.

On completion, the batteries, aerial, earth and headphones should be connected, and the receiver switched on. C3 should be left with the vanes fully out (minimum regeneration), and the tuning dial dial slowly rotated until a programme is heard. C.3 may now be advanced to increase the signal level. A decrease in volume, instead of an increase, indicates that the regeneration winding, L2, is connected in the wrong direction, and that the two connections should be reversed. As C3 is turned a soft "plop" will be heard, and as C2 is rotated whistles will be heard. This indicates that the receiver is oscillating, and the point on C3 where this effect occurs will vary accorcing to the position of the tuning capacitor.

COMPONENTS LIST FIG. 1-2

RESISTORS (R)

1 2·2 MΩ

CAPACITORS (C)

1, 4 300 pF mica
2 500 pF variable
3 300 pF solid-dielectric variable
5 1,000 pF mica

INDUCTORS (L)

1, 2 See text
R.F.C. R.F. choke

VALVE (V)

V1 HL23 Mazda

VALVE HOLDER

1 British octal, baseboard mounting

SWITCH (S)

1 D.P.S.T. toggle

SUNDRIES

High resistance (2,000 Ω) headphones; terminals; wire, etc.

A TWO-VALVE RECEIVER (Mains-operated)

The next receiver to be described is a little more ambitious. Fig. 3 shows a design for a two-valve set which is powerful enough to operate a loudspeaker, and which is mains operated. Although designed for AC mains input, the modern practice of AC/DC technique has been adopted for the HT supply. This has been done for economical reasons, as T1 is simply a filament transformer, and the cost of a full-sized component with HT winding is thereby avoided. A very important point to note is that one side of the mains is connected to the chassis, and, for safety, no direct earth may be made to it. If it is found necessary to use an earth, it must be fed through a 0·01 mfd. series capacitor. As one side of the mains is virtually at earth potential the need for an external earth is unlikely.

When handling the receiver, care must be taken to avoid contact with metal parts, for they may be " live " with respect to earth.

The tuning coil used is similar to that used for the previous receiver, but this time a pentode (five-electrode) detector is used to obtain more sensitivity. The degree of regeneration is pre-set by C2, fine control being obtained with the potentiometer, R6. The detector, V1, is followed by a pentode low-frequency amplifier, V2, which will give good loudspeaker reception from many stations. The loudspeaker, when being purchased, should have an output transformer already mounted and designed to match the speaker to the EL33, *i.e.*, a primary load of 7,000 Ω. All the necessary constructional details are given in the practical diagram, Fig. 4.

Upon completion, the receiver is tested in the same way as for the single-valve design previously described, excepting that C2 should be set to enable smooth regeneration to be obtained by R6 at all positions of C1.

COMPONENTS LIST FIG. 3-4

RESISTORS (R)

1	1 MΩ
2, 7, 9	15 kΩ
3	330 kΩ
4	33 kΩ
5, 8	47 kΩ
6	470 kΩ potentiometer
10	180 Ω

CAPACITORS (C)

1	500 pF variable
2	3-30 trimmer
3	1,000 pF mica
4, 5	100 pF mica
6, 8, 9, 10	0·01 μF paper
7	8 μF electrolytic
11	25 μF 25v. electrolytic
12	16 μF electrolytic
13	16 μF plain foil electrolytic

INDUCTORS (L)

1, 2	As for Fig. 2.
3	15 henries 80 mA. smoothing choke

TRANSFORMERS (T)

1	Output (see text)
2	Filament : Primary : 200-250v. Secondary : 6·3v. 2A.

VALVES (V)

1	EF37 Mullard
2	EL33 "

VALVE HOLDERS

2	International octal

SUNDRIES

1 Selenium rectifier, Type DRM1B, Brimar; loudspeaker; suitable aluminium chassis; terminals; wire, etc.

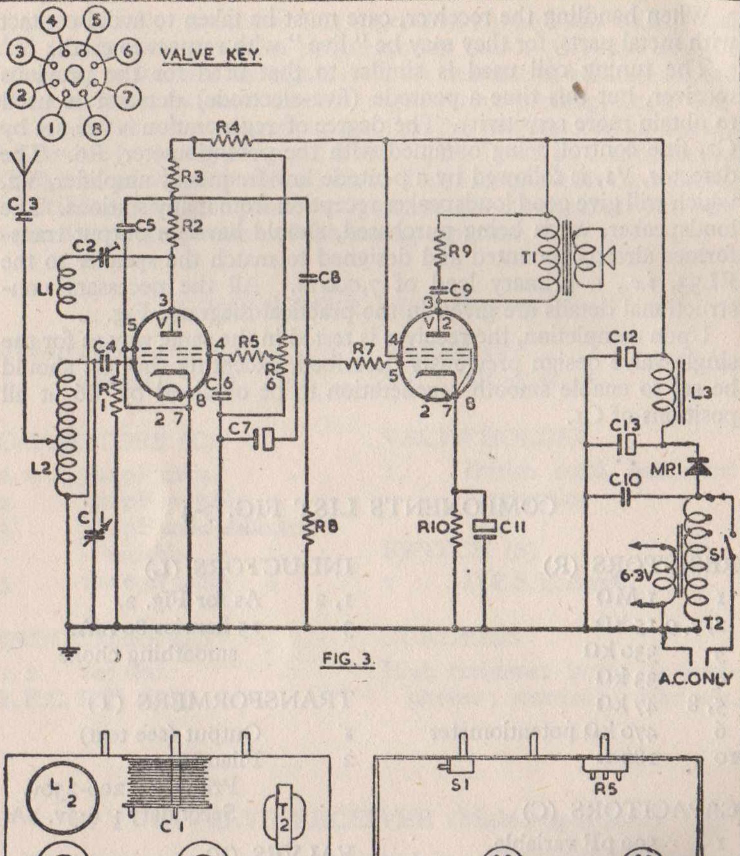


FIG. 3.

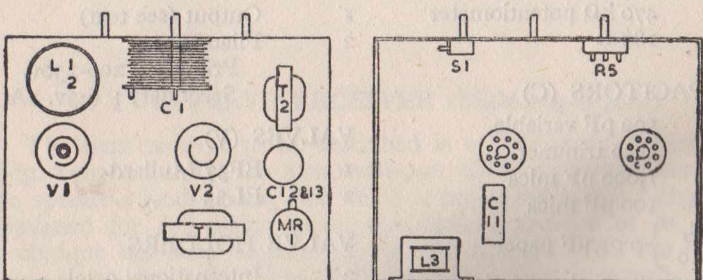


FIG. 4.

SUGGESTED LAYOUT FOR MAJOR COMPONENTS

A LOCAL-STATION TUNER

A high-fidelity unit that is both inexpensive and simple to make is shown in Figs. 5 and 6. This unit is intended to receive only powerful local transmitters, and not foreign or weak stations. The circuit consists of an RF stage followed by a diode detector and " cathode-follower " output. This detector and output feed is one of the finest available for quality reception, and a marked advance compared to older methods which are still in extensive use.

An efficient commercial coil pack, designed for both medium and long waves, is used for the tuned circuits. This unit is supplied complete with trimmers and padding slugs, the operation of which is explained later when dealing with alignment.

A small screen is erected across the coil pack as a precaution against instability. The screen should consist of a strip of copper 1" high, the shape being clearly seen from the practical diagram, Fig. 6.

No power supply is incorporated in the unit as the current requirements are small and may safely be drawn from the amplifier in most cases. To facilitate connection of the unit a power plug and socket should be fitted to the receiver and amplifier, respectively.

On completion, the unit should be connected to the amplifier and the equipment switched on. Then switch to medium waves, tune in a station at the high-frequency end of the band, *i.e.*, with the vanes of the ganged capacitor almost disengaged. C1 and C6 are now adjusted for maximum signal strength. A station at the low-frequency end of the band is now obtained, and the dust-iron slugs of L2 and L6 are adjusted for maximum signal.

The original higher-frequency station is tuned in again, and the whole procedure is repeated a number of times until no further improvement can be made. Now switch to the long-wave band and repeat with C2 and C7, L4 and L8. Once this initial alignment has been carried out no further adjustment to the coil pack will be necessary. The sensitivity control, R3, should be kept as low as possible throughout the alignment procedure.

COMPONENTS LIST FIG. 5-6

RESISTORS (R)

1	47 kΩ
2	220 Ω
3	5 kΩ potentiometer
4	33 kΩ
5	220 kΩ
6	4·7 kΩ
7, 8	100 kΩ

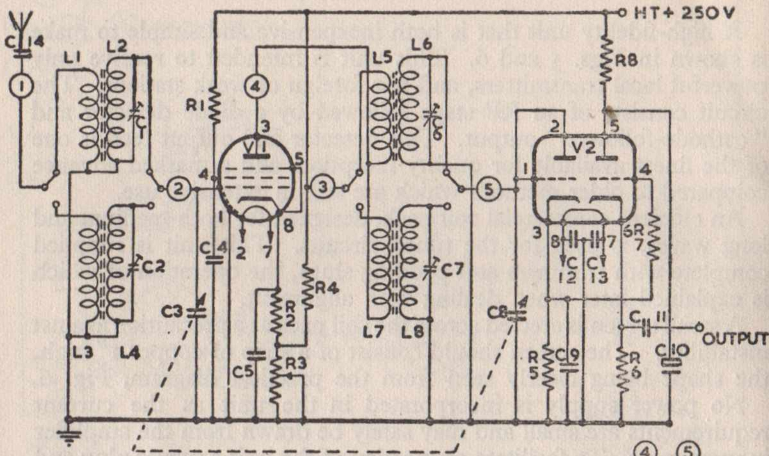
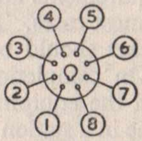
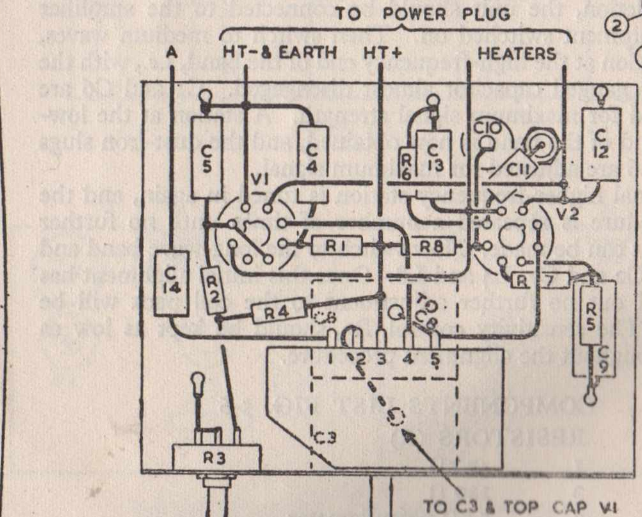


FIG. 5.



VALVE KEY



SUGGESTED LAYOUT.

FIG. 6.

CAPACITORS (C)

1, 2, 6, 7,	In coil pack
3, 8,	2 × 500 pF variable
4, 5, 12, 13	0·1 μF paper
9	100 pF mica
10	8 μF electrolytic
11	0·5 μF paper
14	300 pF mica

INDUCTORS (L)

L1-8	" Osmor " T.R.F. Quality Coil Pack

VALVES (V)

V1	EF39
V2	6SL7GT

VALVE HOLDERS

2	International octal

SUNDRIES

1 octal valve grid cap ; 1 octal valve screen ; 1 concentric plug and socket ; 1 five-pin power plug and socket ; wire ; copper strip, etc.

A PORTABLE BATTERY RECEIVER

Without using the superheterodyne principle, an efficient portable receiver can be constructed incorporating B7G " all-glass " valves. These are small compared with standard octal types, permitting small final dimensions for the equipment.

The reception range of the " straight " circuit used will be, of course, reduced in comparison with that of a superheterodyne ; but good local reception with the self-contained frame aerial can be obtained without difficulty.

In areas of poor field strength, however, an extra frame coupling winding can be used to permit the connection of an external aerial, a short length of wire being usually all that is required. Fig. 7(a) shows that the frame aerial provides the input tuning inductance, which is coupled to a regenerative leaky-grid detector. A pentode is used in this position, thus ensuring maximum sensitivity, and regeneration is controlled by variation of the screen voltage.

Dimensions and constructional details of a former for the frame aerial will be found in Fig. 7(b). Sout, smooth cardboard, of about $\frac{1}{16}''$ thickness, is a suitable material for the former ; small holes can be punched alongside the slots for anchorage of the windings.

L1 is wound first, and consists of 18 turns of 24 s.w.g. enamelled wire. The winding is taken in and out of the slots and the ends of

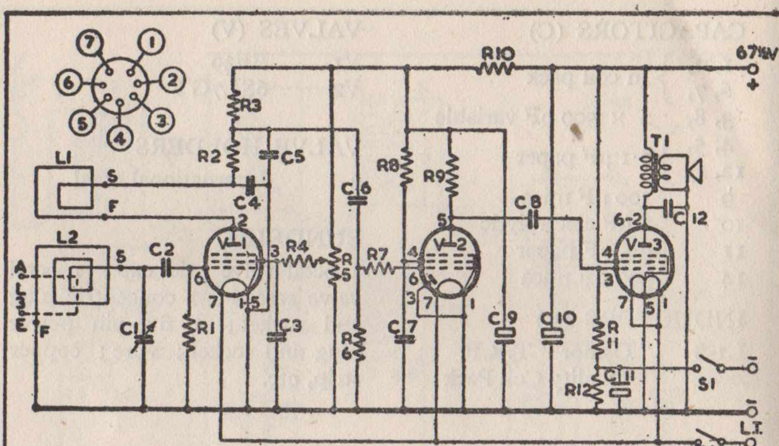


FIG. 7.

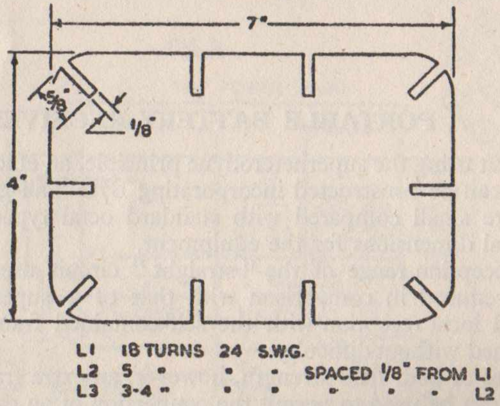
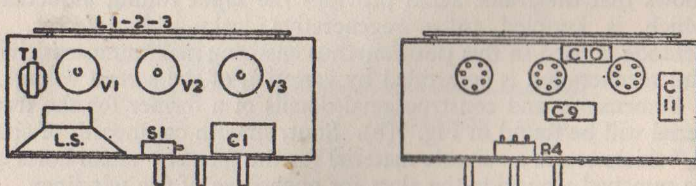


FIG 7B



SUGGESTED LAYOUT.

FIG. 8.

this and those of L2 should be identified for " start " and " finish " for reference.

L2 is wound next, and consists of five turns of the same gauge wire in the same direction as L1, and spaced from the latter by $\frac{1}{8}''$.

L3, the external aerial-coupling winding, can now be added. This consists of three or four turns of the same wire as L2 and spaced from it by $\frac{1}{8}''$.

Reference to the diagrams will show that the start of L1 is connected to the detector-grid circuit, and the finish of L2 to the anode. The polarity of the aerial and earth connections to L3 is unimportant.

It is suggested that the complete receiver be built into a small carrying case, with the frame aerial mounted in the lid.

A chassis $3\frac{1}{2}'' \times 7'' \times 1''$ will be suitable and can be constructed of aluminium, for lightness. The panel size will, of course, depend upon the dimensions of the carrying case, and may be of either wood or aluminium. A circular hole backed with silk, or a series of slots may be cut for the speaker aperture.

When assembly is complete, the LT and HT batteries should be connected and the receiver switched on. The regeneration control, R5, should be advanced to the point where oscillation occurs, indicated by a " plop " and subsequent hissing from the speaker. The control should be retarded until set just below the oscillation point, and C1 rotated until a signal is heard.

Failure to obtain regeneration usually indicates reversal of the connections to L2.

Care must be taken to ensure that the receiver is not operating in an oscillating condition, since this would seriously interfere with neighbouring receivers.

COMPONENTS LIST FIG. 7-8

RESISTORS (R)

1, 11	2·2 MΩ ¼w.
2	10 kΩ ½w.
3	56 kΩ ¼w.
4	470 kΩ ¼w.
5	1 MΩ pot.
6	1 MΩ ¼w.
7	22 kΩ ¼w.
8	3·9 MΩ ½w.
9	1 MΩ ½w.
10	15 kΩ ¼w.
12	560 Ω ¼w.

CAPACITORS (C)

1	500 pF solid dielectric variable
2, 5	500 pF mica
3, 7	0·1 μF paper
4	0·001 μF mica
6, 8	0·01 μF paper
9, 10	8 μF 150v. electrolytic
11	25 μF 12v. electrolytic
12	0·005 μF paper

INDUCTORS (L)

1, 2, 3 See text

SWITCH (S)

1 D.P.S.T. toggle or rotary

VALVES (V)

V1 DF91 or 1T4
V2 DAF91 or IS5
V3 DL92 or 3S4

VALVE HOLDERS

3 B7G

SPEAKER

2½″ P.M.

TRANSFORMER (T)

1 Output to match speaker to 5,000 Ω load

BATTERIES

H.T.—67·5v. Minimax
L.T.—1·5v. U2 cell

SUNDRIES

Connecting wire; chassis 3½″ × 7″ × 1″; soldering tags, etc.

SECTION TWO

AMPLIFIERS

A 3-WATT AMPLIFIER

Intending constructors are sometimes bewildered by the many varied types of low-frequency, or audio, amplifiers which are available to the amateur to-day. Covering anything from 3 to 50 watts, they are designed for push-pull, single-ended or, occasionally, cathode-coupled output. Many of these amplifiers are expensive to make and the constructor should have a clear idea of his requirements before construction is attempted. The first items for consideration are the type of speaker to be used and the amount of audio power output required. Cost, no doubt, will govern the choice of the speaker and, if a standard 10″ is to be used in a small room, obviously an elaborate amplifier, with a frequency range and output power in excess of the speaker's capabilities, should not be constructed.

The design shown in Figs. 9 and 10 will suit the average small home. The output is limited to 3 watts, which can be managed comfortably by a standard 10″ speaker. The gain is ample for a standard magnetic or crystal pick-up, but, before connecting this, reference should be made to the section on pick-ups and tone controls. A " top-cut " control is provided by C6-R11, so that worn records may be played without undue scratch.

During construction ensure that the grid leads to V1 are well screened and that the metal casing of R1 is connected by a soldered lead to chassis, otherwise, owing to the high gain, the hum pick-up will be very high.

When completed, the amplifier should be switched on and the input short-circuited by a piece of wire—R12 is then adjusted for minimum hum.

COMPONENTS LIST FIG. 9-10

RESISTORS (R)Ω

1	220 kΩ potentiometer
2	2·2 kΩ
3	220 kΩ
4	1 MΩ
5	47 kΩ
6	470 kΩ
7	180 Ω
8	1 kΩ
9, 10	100 Ω
11	25 k potentiometer with switch, D.P.
12	100 Ω potentiometer

All resistors are ½w. rating, unless otherwise stated.

CAPACITORS (C)

1, 5	50 μF 12v. electrolytic
2	0·05 μF paper
3	4 μF electrolytic
4, 6	0·02 μF 100v. paper
7, 8	16 + 16 μF electrolytic (plain foil)

All capacitors are 350v. DC working, unless otherwise stated.

INDUCTORS (L)

1	15 henries 60 mA

VALVES (V)

V1	EF40 Mullard
V2	EL41 ,,
V3	EZ40 ,,

VALVE HOLDERS

3	B8A

TRANSFORMERS (T)

1	Output. Primary impedance 7,000
2	Mains : Primary : 200-250v. Secondaries : 250-0-250v. 80 mA., 6·3v. 1A., 6·3v. 2A.

SWITCH (S)

1	with R11

SUNDRIES

Concentric plug and socket for input, connecting wire, etc.

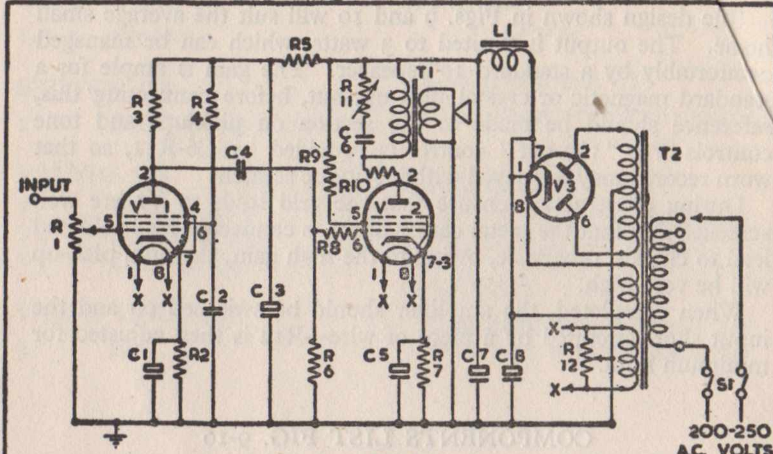
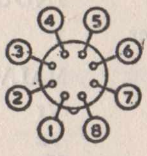
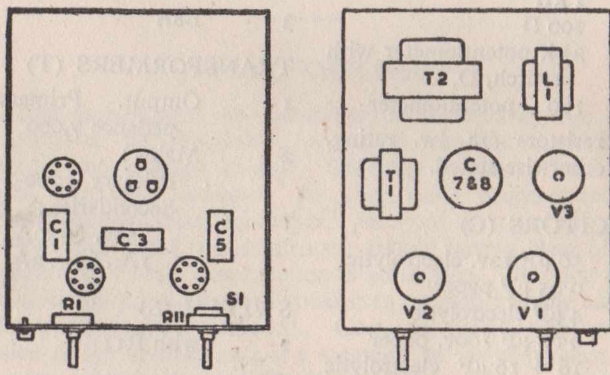


FIG. 9.



VALVE KEY



SUGGESTED LAYOUT

FIG. 10.

A 6-WATT AMPLIFIER

As an alternative to the 3-watt design, an amplifier giving an output of 6 watts is shown in Figs. 11 and 12. A measure of power in reserve avoids overloading occurring on sudden changes of volume level such as are encountered in heavy orchestral music. To improve the overall performance of the amplifier, negative feedback has been applied in one of its most simple forms. As with the previous amplifier design, it is important to ensure that the grid leads are properly screened and that R7 is set for minimum pick-up. A tone control R2 has been included. It will be noticed that two paper capacitors have been connected between the rectifier anodes and chassis. These will avoid modulation hum if the amplifier is used with a radio tuning unit. This type of hum appears only when a station's carrier is tuned in.

COMPONENTS LIST FIG. 11-12

RESISTORS (R) Ω

1	470 kΩ potentiometer
2	5 kΩ "
3	47 kΩ
4	470 kΩ
5	82 kΩ
6	22 kΩ
7	100 Ω potentiometer
8	220 kΩ
9	1·2 MΩ
10	330 kΩ
11	220 Ω 2w.
12	8·2 kΩ
13, 14	33 kΩ 2w.

CAPACITORS (C)

1, 4	0·1 µF paper
2	0·25 µF paper
3	820 pF mica
5	0·05 µF paper
6	50 µF 25v. electrolytic
7	8 µF 350 electrolytic
8	32 µF 450v. electrolytic
9	16 µF 450v. plain foil electrolytic
10, 11	0·01 µF 1,000v. paper

INDUCTORS (L)

1	15 henries 100 mA

TRANSFORMERS (T)

1	Output. Primary impedance 4,000 6w. rating
2	Mains: Primary: 200-250v. Secondary: 350-0-350v. 120 mA., 6·3v. 3A., 5v. 2A.

VALVES (V)

V1	EF37A Mullard
V2	6L6G Brimar
V3	5Z4G "

VALVE HOLDERS

3	International octal

SWITCH (S)

1	D.P.S.T. toggle

SUNDRIES

Screened grid cap and lead for V1; concentric plug and socket for input; 5-pin plug and socket.

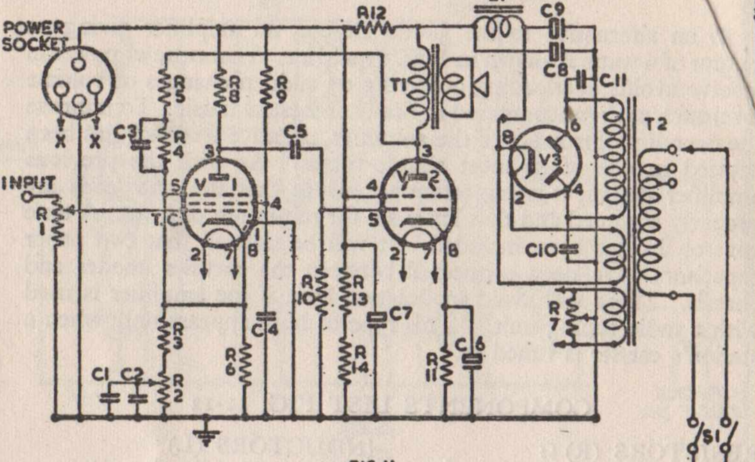
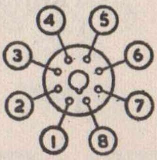
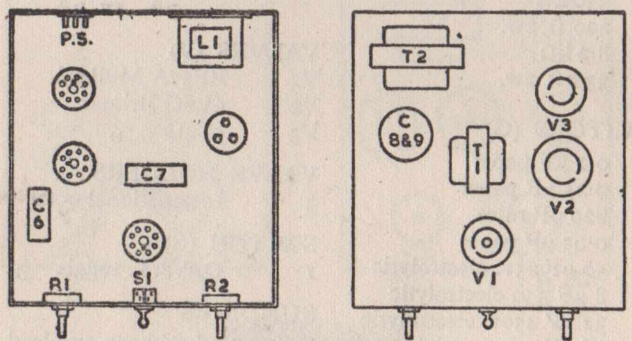


FIG. 11.



VALVE KEY



SUGGESTED LAYOUT

FIG. 12

A LOW-VOLTAGE 3-WATT AMPLIFIER FOR DC

Before leaving the small amplifier class, mention should be made of the possibilities of obtaining a reasonable audio power output from a low-voltage supply. If the source of supply is AC the question, of course, does not arise, since the power transformer will convert to whatever is required. The design in Figs. 13 and 14 is for use with a 100 or 110v. DC supply. In order that the total consumption of the amplifier may be kept within reasonable limits, valves with 0·15-amp. heaters have been used. In no circumstances may a direct earth connection be made to the chassis : it must always be connected through a condenser as shown. DC supplies in the U.K. usually have one side of the supply at earth potential and, depending on which main is earthed, it may be necessary to change the position of the choke, L1, from the positive line to the negative line, at the point marked " X " on Fig. 13. If the position of the choke is incorrect, there will be a very noticeable amount of mains hum owing to imperfect smoothing. Because the design is for low-voltage use, the series heater dropping resistor, R10, is of low value and wattage ; but in addition to this resistor a second (R11) has been included. This is a special type with a negative temperature coefficient.

When the amplifier is first switched on the valve heaters are cold and their combined series resistance is negligible. The " cold resistance " of R11 is comparatively high. As the valves and R11 warm up, the valve-heater resistance rises and that of R11 falls gradually to a low value. Thus the momentary heavy surge associated with series heater circuits (which, until recently, was one of the drawbacks to this type of circuit) is virtually eliminated. When fitting R11 care must be taken to see that it is mounted away from the chassis and other components.

The resistances required by R5 and R6 are odd values and may be made up of two resistors in series, the exact values being quoted in the components list.

COMPONENTS LIST FIG. 13-14

RESISTORS (R)

1	470 kΩ potentiometer	7	470 kΩ
2	3·3 kΩ	8	82 Ω
3, 4	270 kΩ	9	4·7 kΩ 2w.
5	474·4 kΩ (470 kΩ and 4·7 Ω 10% in series)	10	100 Ω 3w.
6	16 kΩ (15 kΩ and 1 kΩ 10% in series)	11	CZ2 Brimistor (Standard Telephones and Cables Ltd.)

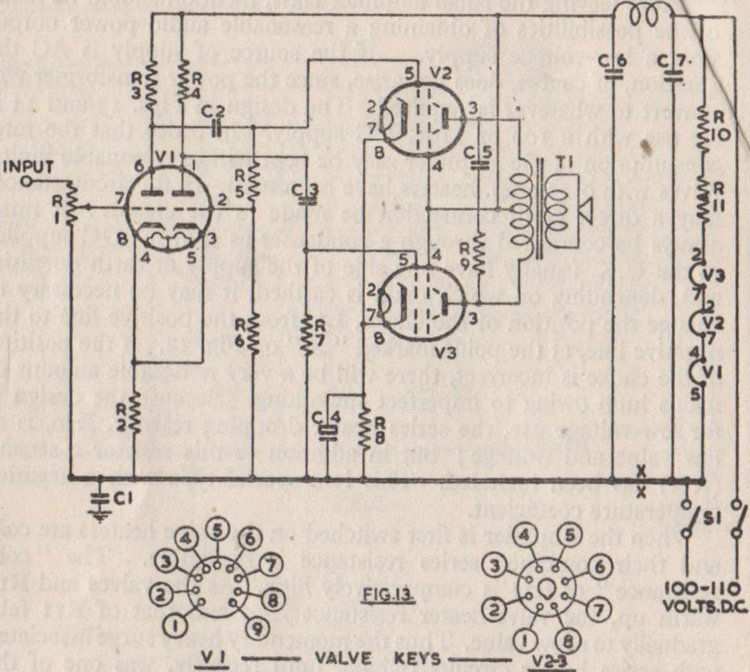
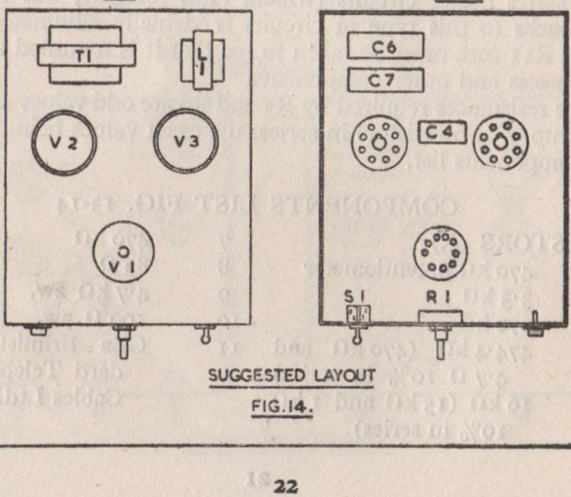


FIG.13.



SUGGESTED LAYOUT

FIG.14.

CAPACITORS (C)

1	0·1 µF 200v. paper
2-3	0·005 µF paper
4	50 µF 12v. electrolytic
5	0·025 µF 1,000v. paper
6	4 µF 200v. paper
7	2 µF 200v. paper

INDUCTORS (L)

1	10 henries 100 mA.

VALVES (V)

V1	12AX7 Brimar
V2-3	35L6GT „

VALVE HOLDERS

1	B9A with screening can
2	International octal

SWITCH (S)

1	D.P.S.T. toggle

TRANSFORMER (T)

1	Output push-pull. Primary impedance: 5,000 Ω Secondary: To suit loudspeaker

SUNDRIES

Concentric plug and socket; wire, etc.

A 6-WATT PUSH-PULL AMPLIFIER

The last amplifier to be described, Figs. 15 and 16, is for the more ambitious constructor who intends to use a high-fidelity loudspeaker. The frequency response of this amplifier is quite even and any limitations will be due solely to imperfections in the output transformer, which must be a high-grade component.

The output power is rated at 5 watts, which may appear to be rather a low value for a push-pull amplifier. In practice there will be sufficient volume to fill a small dance hall, if necessary, and the total harmonic distortion is less than 1%. (A single-ended pentode stage, rated at 3·5 watts, will often give 10 times this distortion.) The first half of V1 is a voltage amplifier, directly coupled to the second half which is arranged as a "concertina" phase-splitter. V2, a subsequent double-triode, receives the push-pull signal from the phase-splitter for further amplification. Degeneration occurring via the common cathode resistor R10 ensures a balanced output irrespective of possible valve characteristics changes.

The two output valves, tetrodes, connected as triodes, operating under AB1 conditions. A conventional power pack is used, employing a full-wave indirectly heated rectifier. The potentiometer, R22, carries out the usual function of hum-balancing. A primary-load impedance of 5,000 Ω anode-to-anode is required for the output transformer, the turns-ratio depending upon the speech-coil impedance. The formula for the calculation of this ratio is :—

$$R = \sqrt{\frac{\text{Primary-load impedance}}{\text{Speech-coil impedance}}}$$

For example, using this amplifier and a 15 Ω speaker :—

$$\sqrt{\frac{5{,}000}{15}} = \sqrt{333} = 18 : 1 \text{ approximately.}$$

It will usually suffice to provide the transformer manufacturer with the speech-coil and primary-load impedances.

If it is desired to use a radio tuning unit with the amplifier, a five-pin socket should be mounted on the chassis at a convenient point and wired to heaters and HT supply, the HT being conveniently tapped off at the junction of L1-C9.

COMPONENTS LIST FIG. 15-16

RESISTORS (R)

1	470 kΩ potentiometer
2	470 Ω
3, 5, 7, 17	22 kΩ
4, 12, 13	47 kΩ
6, 10	33 kΩ
8, 11	1 MΩ
9	680 Ω
14, 15	100 kΩ
16	240 Ω 3w.
18, 19, 20, 21	100 Ω
22	100 Ω potentiometer

CAPACITORS (C)

1, 2	8 + 8 μF electrolytic
3, 4	0·05 μF paper
5, 6	0·1 μF paper
7	50 μF 25v. electrolytic
8	8 μF electrolytic
9	16 μF 450v. electrolytic
10	16 μF 450v. plain foil electrolytic
11, 12	0·01 μF 1,000v. paper

INDUCTOR (L)

1	20 henries 150 mA.

VALVES (V)

V1-2	6SN7GT Brimar
V3-4	6V6G „
V5	5V4G Brimar or GZ32 Mullard

VALVE HOLDERS

5	International octal

TRANSFORMERS (T)

1	Output. Primary impedance 5,000 Ω
2	Mains : Primary : 200-250v. Secondary : 350-0-350v. 150 mA., 5v. 2 A., 6·3v. 3 A.

SWITCH (S)

1	D.P.S.T. toggle

SUNDRIES

Concentric input plug and socket ; 5-pin power plug and socket (optional) ; 2 valve screens ; wire ; sleeving, etc.

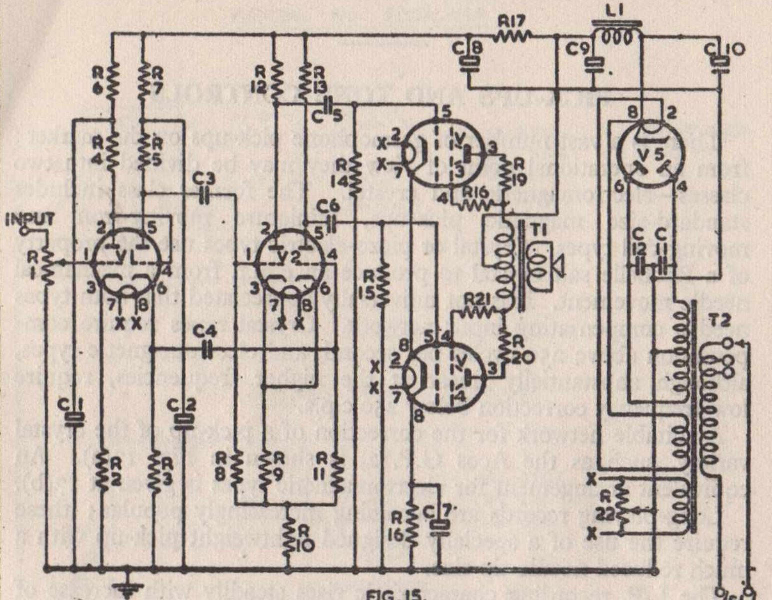
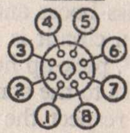
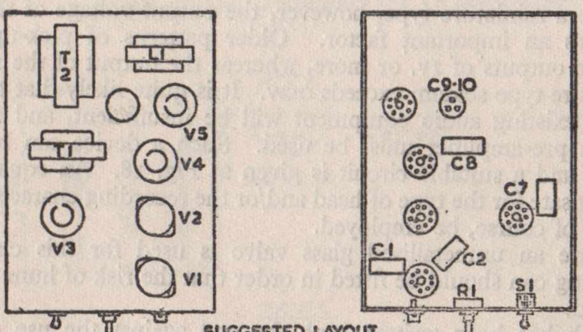


FIG. 15.



VALVE KEY



SUGGESTED LAYOUT.

FIG. 16.

SECTION THREE

PICK-UPS AND TONE CONTROLS

There is a vast number of gramophone pick-ups on the market; from an operational point of view they may be divided into two classes—electromagnetic and crystal. The former class includes standard-size magnetic pick-ups, miniature moving-iron and moving-coil types. Crystal or piezo-electric types use the property of a Rochelle salt crystal to produce an e.m.f. from a mechanical needle movement. It is not universally appreciated that both types need a compensating input network. Crystal types require compensation above 250 cycles per second, and electromagnetic types, although substantially linear at the higher frequencies, require low-frequency correction below 250 c.p.s.

A suitable network for the correction of a pick-up of the crystal variety, such as the Acos G.P.12, is shown in Fig. 17(a). An equivalent arrangement for electromagnetic types is given at 17(b).

Long-playing records are becoming increasingly popular; these require the use of a specially designed lightweight pick-up with a much reduced needle-tip size.

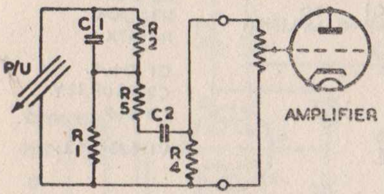
The L.P. recording characteristic rises steadily with increase of frequency, demanding a bass-boost and top-cut network for compensating purposes. Such a circuit is shown at Fig. 17(c) for use with an electromagnetic L.P. pick-up head.

One of the chief drawbacks to the standard-size magnetic pick-up lies in its weight. In this respect the miniature pick-up is much superior, record wear being considerably reduced. When changing over to a miniature type, however, the output voltage of the head becomes an important factor. Older patterns of pick-up often provide outputs of 1v. or more, whereas the output of the modern miniature type seldom exceeds 0·2v. It is quite likely that the gain of the existing audio equipment will be insufficient, and in such cases a pre-amplifier must be used. Such a device can be quite simple and a suitable circuit is given at Fig. 18. An equaliser to compensate for the type of head and/or the recording characteristics, should of course, be employed.

Where an unmetallised glass valve is used for this circuit, a screening can should be fitted in order that the risk of hum may be reduced.

Much has been written both for and against the use of tone control, but the fact remains that no recording or transmission is

CRYSTAL P/U EQUALISER

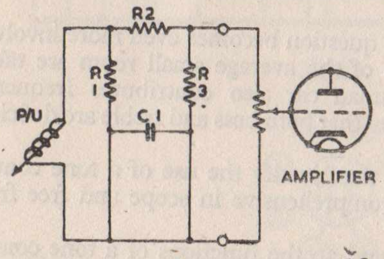


R1 220K
R2 1·5 MΩ
R3 22K
R4 100K

C1 500 PF. MICA.
C2 5000 PF.

FIG 17A

ELECTRO-DYNAMIC EQUALISER

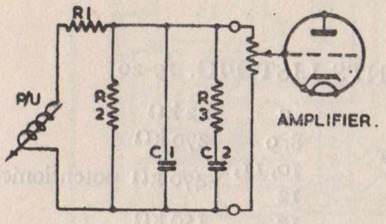


R1 220K
R2 220K
R3 22K

C1 ·02μF

FIG 17 B

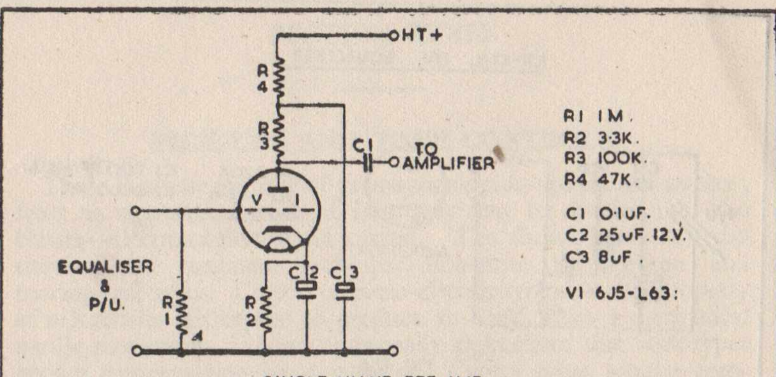
ELECTRO-DYNAMIC EQUALISER FOR LP RECORDINGS



R1 220K
R2 100K
R3 22K

C1 5000 PF
C2 ·01μF.

FIG 17C



SINGLE VALVE PRE-AMP.

FIG. 18.

perfect in tonal balance. The question becomes even more involved when the acoustic properties of the average small room are taken into consideration. The human ear also contributes frequency distortion, giving an impression that both bass and treble are deficient at low-volume levels.

These reasons alone more than justify the use of a tone control stage, provided that this is comprehensive in scope and free from harmonic-distortion effects.

In the circuit of Figs. 19 and 20 the functions of a tone control and of a pre-amplifier are combined in the double-triode valve V1. The purposes of the potentiometer controls are indicated in the diagrams.

If the pre-amplifier should not be required, this part of the circuit may be omitted, and a 6J5G/GT used in place of the 6SN7GT specified.

COMPONENTS LIST FIG. 19-20

RESISTORS (R)

1	1 MΩ potentiometer
2	3·3 kΩ
3	100 kΩ
4	47 kΩ
5	1·5 kΩ
6	470 kΩ
7	22 kΩ
8, 9	270 kΩ
10, 11, 12	470 kΩ potentiometer
13	150 kΩ

All fixed resistors are ½w. rating, unless otherwise stated.

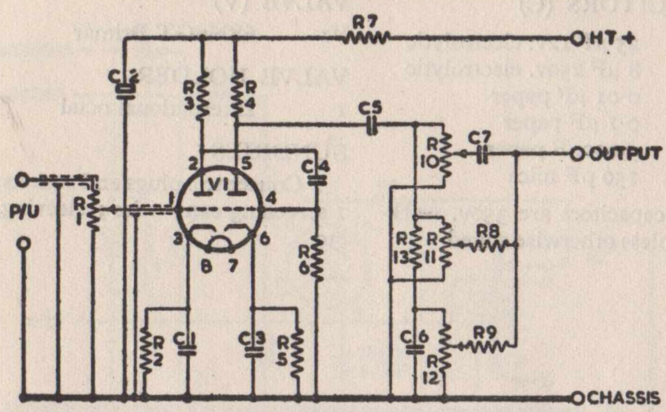
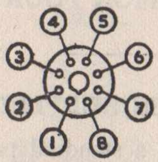
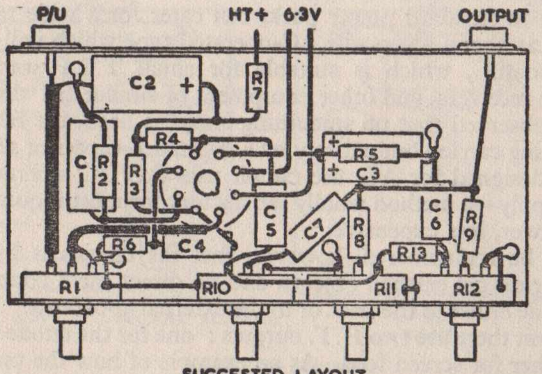


FIG. 19.



VALVE KEY.



SUGGESTED LAYOUT.

FIG. 20.

CAPACITORS (C)	
1, 3	25 μF 12v. electrolytic
2	8 μF 250v. electrolytic
4	0·01 μF paper
5	0·1 μF paper
6	5,000pF paper
7	150 pF mica

All capacitors are 350v. working, unless otherwise stated.

VALVE (V)	
V1	6SN7GT Brimar

VALVE HOLDER	
1	International octal

SUNDRIES

2 Concentric plugs and sockets; 1 screening can ; wire ; sleeving, etc.

SECTION FOUR

POWER SUPPLIES

The need often arises for a standard power supply to operate experimental equipment. With such a unit, much valuable construction time can be saved and the size and weight of experimental chassis can be reduced to a minimum.

One or two standard power packs can cater for a wide range of uses. Fig. 21 shows a versatile AC-operated type which will supply 250v. at 60 mA., which is suitable for small T.R.F. or superheterodyne receivers, and other equipment of similar HT demands. It will be observed that no smoothing choke is used, the necessary filtering being carried out entirely by a resistance-capacitor network. Although designed for AC, the circuit uses AC/DC technique for the HT supply—a method wholly satisfactory for most requirements and, moreover, less expensive.

It must be remembered, however, that the chassis is live with respect to external earthed objects, and no direct earth connections may be made either to the pack or to the external apparatus.

In the unit there are two H.T. outputs : one for the anode supply, and the other for screen feed. As an example of how the pack may be used, a skeleton superheterodyne circuit is given at Fig. 23, illustrating the method of connecting screen and anode outputs.

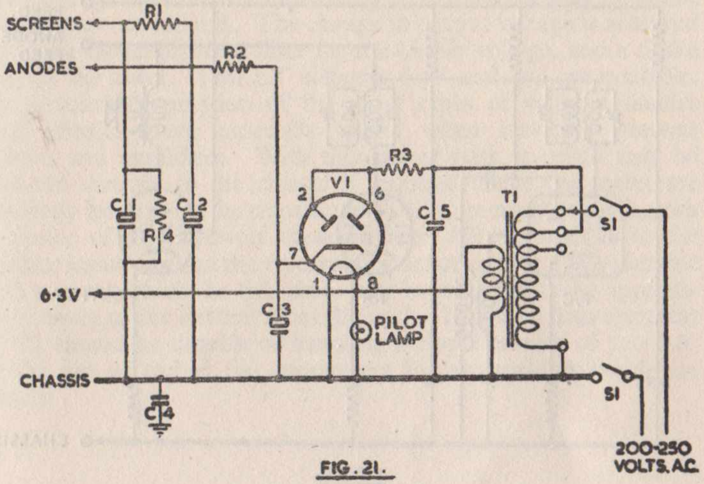
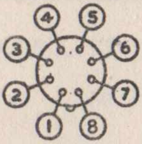
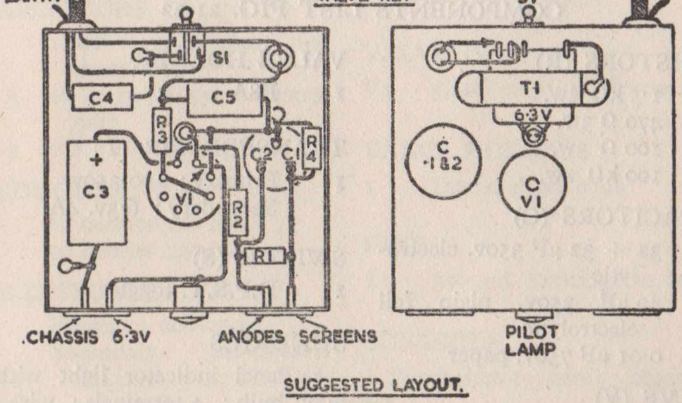


FIG. 21.



VALVE KEY



SUGGESTED LAYOUT.

FIG. 22.

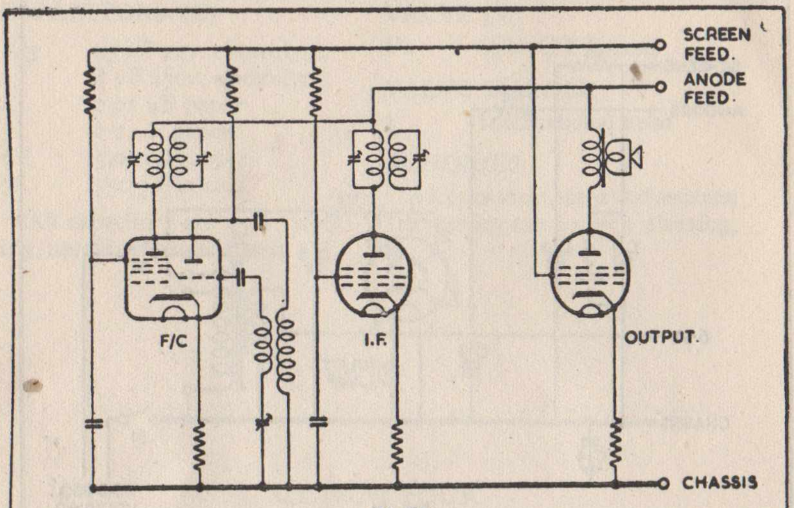


FIG. 23.

COMPONENTS LIST FIG. 21-22

RESISTORS (R)

1 1·5 kΩ ½w.
2 470 Ω 3w.
3 100 Ω 3w.
4 100 kΩ 1w.

CAPACITORS (C)

1, 2 32 + 32 μF 350v. electrolytic
3 40 μF 350v. plain foil electrolytic
4, 5 0·01 μF 750v. paper

VALVE (V)

V1 EZ40 Mullard

VALVE HOLDER

1 B8A

TRANSFORMER (T)

1 Primary : 200-250v.
Secondary : 6·3v. 4A

SWITCH (S)

1 D.P.S.T. toggle

SUNDRIES

1 Panel indicator light with 6·3v. bulb ; 4 terminals ; wire ; chassis, etc.

Where greater power at a higher voltage is demanded, *e.g.*, for large audio amplifiers or general receiver servicing, the power pack shown in Fig. 24 is to be preferred. The HT output may be either 350v. or 250v. at 120 mA. The change in output voltage is achieved by using a capacitor input filter for the higher voltage, and a choke input for the lower. Two LT voltages, 6·3v. and 4v., are available, thus permitting operation of the older types of valve, a facility which should prove especially useful when servicing pre-war receivers and amplifiers. With this power pack an earth may be connected directly to the chassis if required, since the mains are completely isolated by the transformer T1. Care must be taken with the choice of the reservoir capacitor C1. When switched to the capacitor input position the reservoir capacitor carries a considerable ripple current which, in this case, may be assumed to be approximately equal to the current from the pack. It will be thus apparent that C1 should be capable of handling a ripple current of 120 mA, and the use of etched foil condensers in this position should be avoided.

COMPONENTS LIST FIG. 24-25

RESISTORS (R)

1 47 kΩ 2w.

CAPACITORS (C)

1 16 μF 450v. plain foil electrolytic

2, 3 16 + 16 μF 450v. electrolytic

4, 5 0·01 μF 750v. paper

INDUCTORS (L)

1 10 henries 120 mA.

2 20 henries 120 mA

TRANSFORMER (T)

1 Primary: 200-250v.
Secondary: 300-0-300v. 120 mA., 5v. 2 A., 6·3v. 4 A., 4v. 6 A.

SWITCHES (S)

1 S.P.D.T. toggle

2 D.P.D.T. toggle

VALVE (V)

V1 5Z4G or 5V4G Brimar

VALVE HOLDER

1 International octal

FUSE

1 250 mA. cartridge or bulb

SUNDRIES

Fuseholder; wire; chassis; etc.

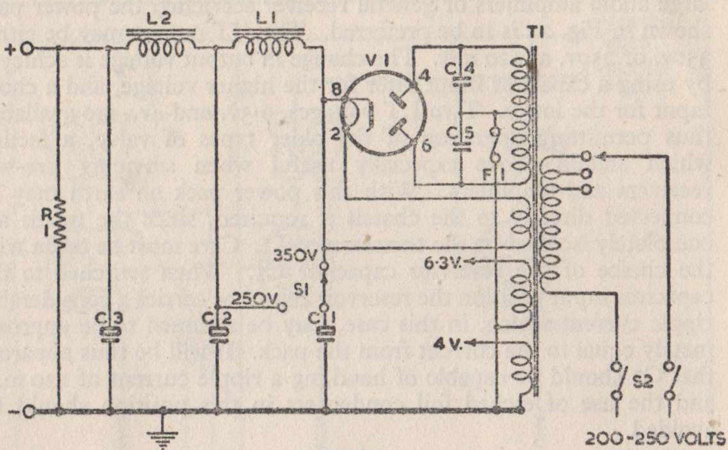
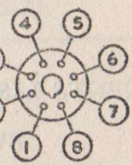
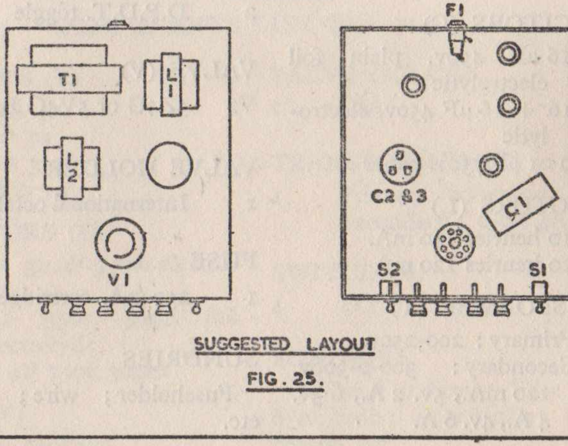


FIG.24.



VALVE KEY.



SUGGESTED LAYOUT

FIG. 25.

SECTION FIVE

MISCELLANEOUS EQUIPMENT

A TAPE RECORDER PRE-AMP.

Many constructors possess an amplifier for record reproduction, but often, when it is desired to use a microphone with it, it is found that the gain is insufficient. With the increasing popularity of tape and wire recording there will be many who wish to employ a good quality microphone with an existing amplifier, and a suitable pre-amplifier circuit is shown in Fig. 26.

This is designed to provide sufficient amplification from a crystal microphone to operate an amplifier of moderate gain. If required for use with a moving-coil microphone an input transformer must be provided to match the impedance of the former. To minimise hum the grid leads of V1 should be in screened wiring and the use of concentric connectors is recommended for both input and output connections. HT and LT supplies may be drawn from the existing amplifier; but for the lowest possible hum level, it is best to use a dry battery for the LT supply. The 8D5 valves pass only 0·15 mA each at 6·3v.—not an excessive load for dry cells.

During the past two years magnetic-tape recording has been placed within the reach of the amateur, and enthusiasm for this technique is increasing. Equipment may be built with commercially made tape decks used in conjunction with an existing audio amplifier, or, for the more mechanically equipped, the deck may be home constructed.

In addition to the sound deck and amplifier it is necessary to have a supersonic bias oscillator for recording and erasing, and the circuit of such a device is shown in Fig. 28. The circuit is that of a conventional Hartley oscillator—one of the most suitable for this class of work. It will usually be most convenient to construct the unit on a small chassis which can be mounted on the main amplifier chassis after completion. The RF transformer, L1-2, should be mounted away from other metal objects, otherwise some power will be absorbed and efficiency lost in consequence. A frequency between 30 and 40 K/cs is usually chosen for bias oscillators and no trouble should arise if the transformer is wound to the specification as given. Any small frequency adjustment required in individual cases may

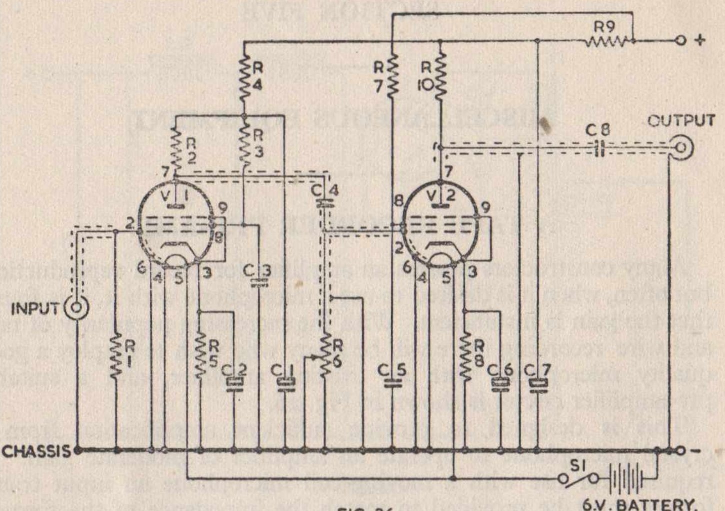
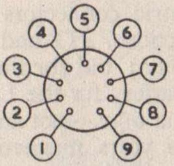
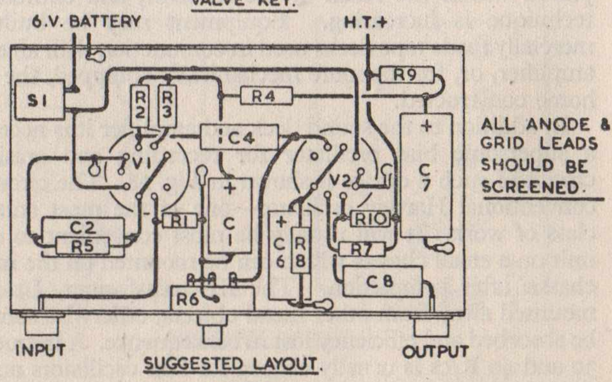


FIG. 26.



VALVE KEY.



SUGGESTED LAYOUT.

FIG. 27.

COMPONENTS LIST FIG. 26-27

RESISTORS (R) Ω

1	2·2 MΩ
2, 10	180 kΩ
3, 7	1·2 MΩ
5, 8	1·2 kΩ
6	0·5 potentiometer
4, 9	47 kΩ

All resistors are ½w. rating, unless otherwise stated.

CAPACITORS (C)

1, 7	8 μF electrolytic
2, 6	25 μF 12v. electrolytic
3, 5	0·5 μF paper
4, 8	0·1 μF paper

VALVES (V)

V1-2	8D5 Brimar

VALVE HOLDERS

2	B9A

SWITCH (S)

1	S.P.S.T. toggle

SUNDRIES

2 Concentric plugs and sockets; 6v. dry battery; chassis; wire, etc.

COMPONENTS LIST FIG. 28-29

RESISTORS (R)

1	47 kΩ ½w.
2	22 k 1w.
3	220 Ω ½w.

CAPACITORS (C)

1	1,000 pF 1,000v. mica
2	4,000 pF 1,000v. mica
3	0·1 μF 350v. paper
4	16 μF 450v. electrolytic

INDUCTORS (L)

1, 2	See text

VALVE (V)

V1	6V6G Brimar

VALVE HOLDER

1	International octal

SUNDRIES

Chassis; wire; terminals, etc.

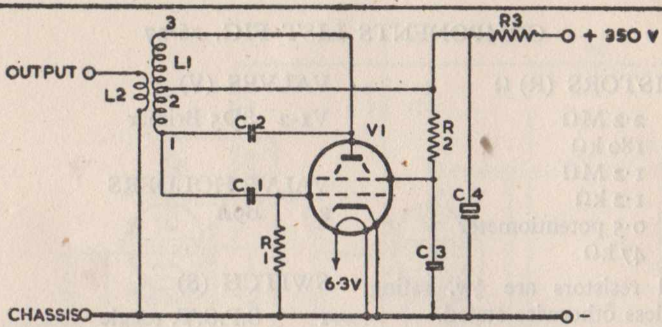
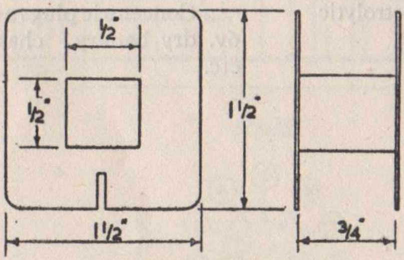
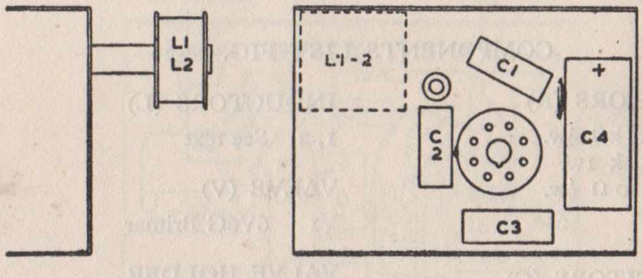


FIG. 28.



BOBBIN DIMENSIONS.



SUGGESTED LAYOUT

FIG. 29.

be effected by changing the capacity of C2. The prototype transformer was wound on a disused LF choke bobbin, with 1½" square outer dimensions and a ½" square window. It may be necessary to reduce the width between cheeks: this should be ¾", measured inside. The primary consists of 1,150 turns of 32 s.w.g. enamelled wire, the start being labelled (1). At 300 turns a tap labelled (2) should be brought out (twist up a loop of wire—do NOT solder a lead on), and a layer of empire tape wound on. At 600 turns wind on another layer of empire tape or cloth and complete the winding, labelling this connection (3). Two more layers of tape should be added and then the secondary winding may be commenced. This consists of 75 turns of 24 s.w.g. enamelled wire. The completed transformer should be mounted, as shown in the diagram, on polystyrene, perspex or some other high-quality insulant.

The primary connections, numbered as directed, are connected as shown in Figs. 28 and 29.

AN INTER-COM. UNIT

A unit such as that shown in Fig. 30 can be very useful in home or office intercommunication. The number of external points that may be used is governed by the number of positions on the selector switch. By means of a D.P.D.T. switch the loudspeaker contained within the unit functions either as a microphone or as a speaker. It is usual to house units such as these in metal cabinets, and for this reason AC/DC technique has been avoided. By the use of a transformer for HT and LT the mains are entirely isolated from the chassis and speaker wiring. Operation is simple and should be clearly followed from Fig. 30. The operator sets the selector switch to the extension required and throws the talk/listen switch to " talk." This automatically connects the extension speaker to the " listen " position and the operator may now communicate with the extension. Should an answer be required, the talk/listen switch is thrown to " listen," and the extension can talk to the operator. It will be noticed that two switches are used to control the power, switch S4 turning the unit completely on or off, and S3 in the HT return leaving the heaters operating, thus allowing immediate use of the equipment as soon as S3 is closed. The circuit is a straightforward R-C coupled amplifier using two pentodes. V1 is an " all-glass " type, designed specially for audio applications, hum and microphony being greatly reduced compared with older types. V2 is a sensitive output pentode and is also an " all-glass " type. Use of these valves provides a performance superior to the older patterns and greatly reduces the size of the equipment. The input transformer T1 is a standard small loudspeaker output transformer, and functions quite successfully in this application.

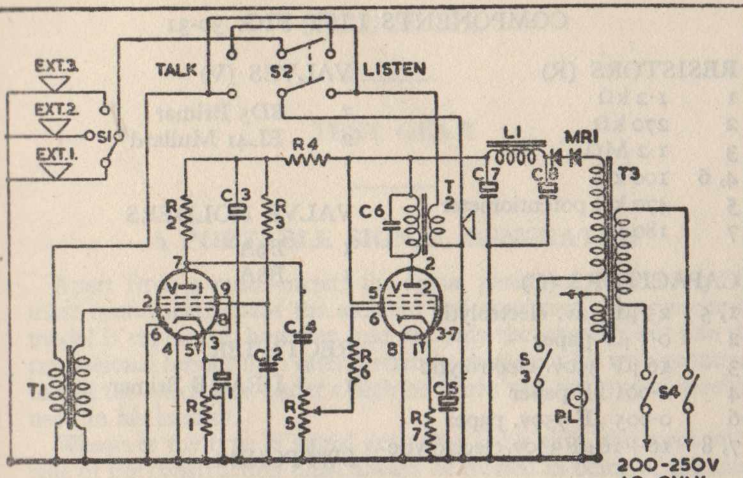
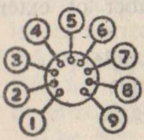
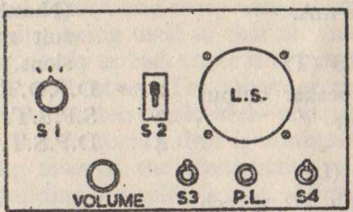


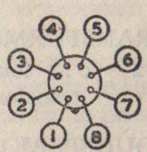
FIG. 30.



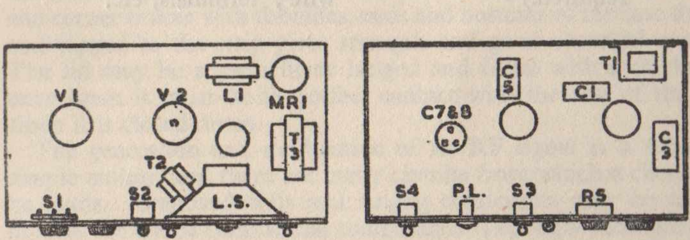
V1 KEY



FRONT PANEL



V2 KEY



SUGGESTED LAYOUT.

FIG. 31.

COMPONENTS LIST FIG. 30-31

RESISTORS (R)

1	1·2 kΩ
2	270 kΩ
3	1·2 MΩ
4, 6	100 kΩ
5	470 kΩ potentiometer
7	180 Ω

CAPACITORS (C)

1, 5	25 μF 12v. electrolytic
2	0·1 μF paper
3	16 μF 350v. electrolytic
4	0·001 μF paper
6	0·005 μF 750v. paper
7, 8	16+16 μF 350v. electrolytic

INDUCTORS (L)

1	10 henries 60 mA.

TRANSFORMERS (T)

1, 2	50 : 1 loudspeaker output transformer

LOUDSPEAKER (L)

1	5″ P.M. with 3Ω speech coil. (Extension speakers of the same pattern, as required.)

VALVES (V)

1	8D5 Brimar
2	EL41 Mullard

VALVE HOLDERS

1	B9A
1	B8A

RECTIFIER

1	DRM1B Brimar

SWITCHES

1	Single-pole rotary. (Number of contacts to suit number of extensions.)
2	D.P.D.T. toggle
3	S.P.S.T. toggle
4	D.P.S.T. toggle

SUNDRIES

Panel indicator and bulb; wire; terminals, etc.

SECTION SIX

TEST GEAR

A PORTABLE SIGNAL GENERATOR

Apart from a multi-meter, the signal generator is probably the most useful instrument the amateur can construct. A commercial model is expensive, however, and not only the amateur but also the professional service man often prefers to construct his own generator to suit the conditions under which he works and the type of receiver used in his locality.

Whatever the type of signal generator to be built, the mechanical side of the construction must always be treated as being of the same importance as the electrical circuit and layout. Every component must be anchored rigidly, and every wire soldered firmly into place, heavy-gauge wiring being used so that no knock or vibration will loosen a wire or, nearly as bad, cause it to bend out of shape and so risk upsetting the calibration. The generator must always be heavily shielded; this point is often overlooked—and good ventilation should be provided so that frequency drift is minimised as far as possible.

The first step towards the construction of a generator is the purchasing or building of a suitable case. Aluminium or, better still, copper should be used, and if the case is made up from stock with jointed corners, particular attention must be paid to the bonding of the sides in electrical contact. The use of angle brass strip as side and corner braces with the sides, ends and bottoms of the case drilled and tapped to the strip gives strength and good electrical contact. The lid may be a push fit or hinged and fitted with a catch, but once again it must be in perfect contact with the rest of the case when it is closed down.

The generation and modulation of an RF signal is a relatively simple matter, and there are many circuits from which a choice can be made. Standard coils and tuning condensers may be used—indeed, the use of commercial components is strongly recommended—and the difficulties attached to generator construction really begin with the attenuator and output circuit and reach their peak with the calibration of the finished instrument.

The attenuator is provided to give a range of output signal strengths, and it may be said straight away that this feature of the generator may be omitted as useless, whether it is of a simple or elaborate type, unless the generator screening is perfect. Even the ventilation holes must be screened, although this is a simple matter since it is only necessary to solder or bolt over the inside of the ventilation hole a piece of fine copper gauze which will give a perfect airflow and yet screen the generator.

The attenuator may be calibrated to give definite steps of RF voltage, in which case the attenuator will be of the elaborate constant impedance type arranged in several steps, or a simple " volume control " type of attenuation may be employed. It may be said immediately that a calibrated attenuator is difficult to set for constant output over the whole range, and in a home-constructed generator the calibrated attenuator should have its own built-in valve voltmeter. The simple attenuator is usually all that is required for field work, and a portable generator using midget valves and small batteries is of great value to most service men.

A good deal has been written on the calibration of signal generators by using the carriers of a number of radio stations, but, besides being a wearisome and painstaking business, the method finally presents the builder with a series of points separated by widely varying frequencies, so that the best that can be done is to prepare a drawn calibration curve to use against the dial graduations of the generator. A signal generator definitely needs a calibrated dial showing, in as many arcs as there are tuning ranges, the frequencies directly tuned, and it is now possible to obtain dials with slow-motion drives which give provision for such calibration along plain arcs printed on a dial card. These drives and dials are reasonably priced and are regularly advertised in the radio periodicals..

The generator fitted with such a dial should be calibrated against a commercial or standard signal generator whose own accuracy has been checked against radio stations—a better use for the broadcast carriers than attempting to calibrate the generator against them—and it is often possible to borrow or hire a good generator to act as a standard for the purpose. If this is impossible, however, a frequency standard can be built using a crystal and multivibrator circuit, such a standard always being of use in the workshop, and a circuit of proven merit is shown in Manual 73. Suitable crystals are easily obtainable at the time of writing as surplus stock, and are priced quite cheaply. Whilst the frequency standard gives a range of set points over the scale, unlike the standard signal generator which can be tuned in step with the generator to be calibrated, these points are regularly spaced at intervals of 100 Kc/s. so that sub-divisions are readily made between the main calibrated points on the dial, whilst further key points may be obtained, if desired, from broadcast carriers.

The generator shown, in Fig. 32, is designed for portability in order that it may be packed easily into the service bag. Midget valves of the DF91 type are used, since these give a very good output with an HT voltage of only 45 volts, and the current drain is so low that a layer-built type of battery can be used. The attenuator is of the simplest type and cannot be calibrated, as output over the various ranges is not constant. This is of little moment, however, when it is necessary only to realign IF transformers or RF trimmers in simple outside repairs.

Commercial coils of the Wearite " P " range are specified, and tuned by a small 500 pF tuning condenser.

DF91 pentodes will not oscillate at frequencies above about 20 Mc/s. unless the HT voltage is increased. It is not often that higher frequencies are required from this type of instrument, however, and in any case the second harmonics are strong and have been used up to 30 Mc/s. with good results.

In the usual way, the audio note for audio modulation is obtained from a transformer-oscillator stage. Standard values for modulation are 400 cycles modulating the carrier to a depth of 30%, but in the majority of home-built generators not too much attention is paid to standard requirements in this respect, and it is usually sufficient to tune the transformer acting as the oscillating inductances to a suitable note by a small condenser across either the secondary or primary winding. In the generator described, no tuning was needed, and since the amplitude of the audio oscillation is low no grid blocking occurs so that no grid condenser and leak are necessary.

The audio modulation is introduced into the grid of the RF oscillator and can also be tapped off as straight audio via a switch for testing gram.-input terminals and speaker transformers, etc.

Co-axial cable should be used to couple the generator into the receiver under test, the screen acting as the earth return. Since the generator is battery-operated, no precautions, other than those against shock, need be taken whether working on AC, DC, or Universal receivers.

R1 shunts the reaction winding of the PHF7 coil since on this range a high amplitude of oscillation is obtained, which could cause squegging. R1 in the original instrument was a 10k resistor. For different valves or layouts the value might require modification, or the resistor could be included in series with the winding instead of in shunt, when the value would need to be found experimentally, the starting value being about 470 ohms.

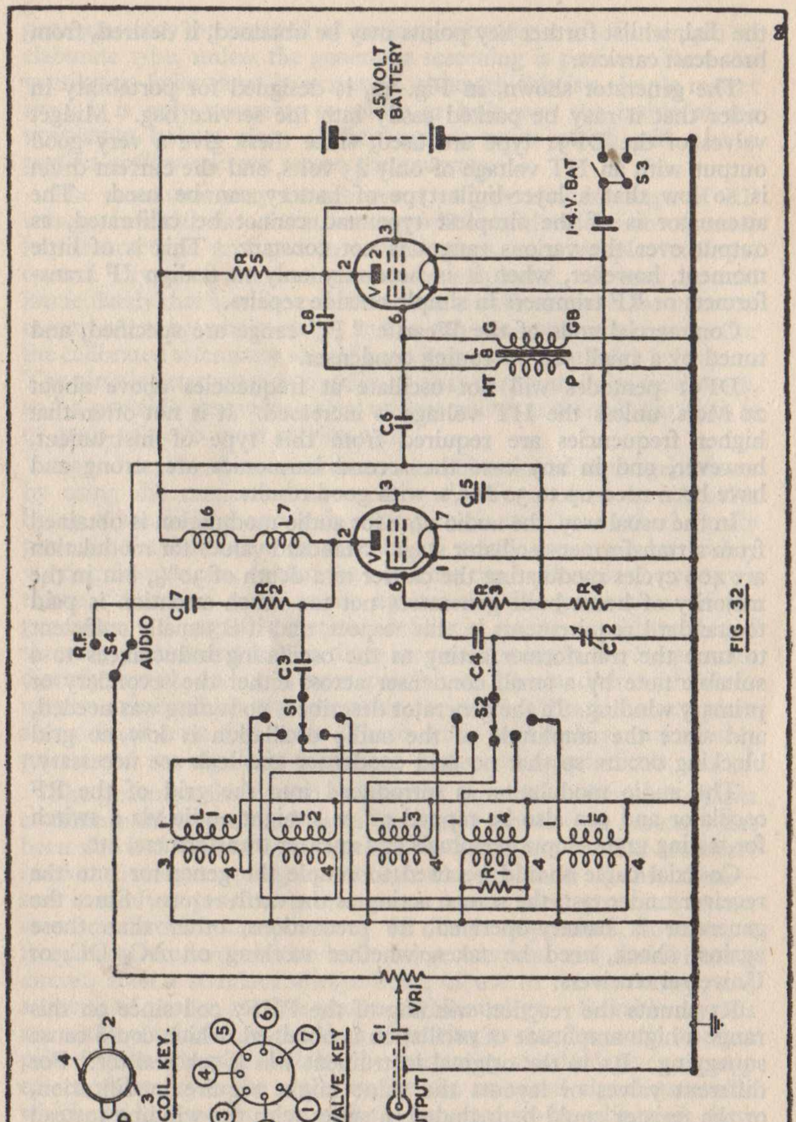

45 VOLT BATTERY
1·4 V. BAT
S3
R5
V2
C8
L8
G
GB
HT
P
C6
C5
L6
L7
V1
R.F.
S4
AUDIO
C7
R2
R3
R4
C3
S1
C4
S2
C12
L1
L2
L3
L4
L5
R1
VR1
C1
OUTPUT
RED
COIL KEY.
VALVE KEY

FIG. 32.

COMPONENTS LIST FIG. 32

RESISTORS (R)

1	See text
2	47 kΩ
3, 4, 5	33 kΩ
VR1	10 kΩ potentiometer

CAPACITORS (C)

1, 3, 5, 8	0·1 μF paper
4, 6, 7	300 pF mica
2	500 pF variable

INDUCTORS (L)

1	PHF3 16-47 metres
2	PHF5 35-100 metres
3	PHF6 95-255 metres
4	PHF7 250-750 metres
5	PHF1 700-2000 metres
6	Screened all-wave choke
7	40 turns of 30 S.W.G. enam. on ¼″ dia. former winding space 1″
8	1 : 3 audio transformer

VALVES (V)

V1-2	DF91 Mullard

VALVE HOLDERS

2	B7G with screens

SWITCHES (S)

1, 2	2 pole, 5 way, rotary
3	D.P.S.T. toggle
4	S.P.D.T. toggle

BATTERIES

A	1·5-volt cell
B	45-volt H.T. unit

Chassis and case; control knobs; concentric plug and socket, etc.