A.C./D.C. Receiver Construction Manual

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by J. R. DAVIES

BERNARDS RADIO MANUALS ★ No. 82

A.C./D.C. RECEIVER CONSTRUCTION MANUAL

First published January 1949
Second edition September 1949

Printed by A. W. Duncan Co. Ltd., Liverpool

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BERNARDS (Publishers) LTD

LONDON

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A.C./D.C. RECEIVER CONSTRUCTION MANUAL

Section 1

ALTHOUGH the A.C./D.C. type of receiver is now a very popular set, the writer has rarely seen any information on the circuits, valves, faults, etc., peculiar to sets of this type. Therefore, with the amateur constructor in mind, the author here sets out to cover this field, dealing with the theory and practice of these receivers, and giving full consideration to the " midget," and the A.C./D.C. Battery models.

A BRIEF OUTLINE

It would be of use to give just a brief outline on the actual working of these sets before we get down to the more practical factors encountered in their construction and servicing. Now, the actual signal circuits, *i.e.*, H.F., I.F., and L.F., or H.F., Det., and L.F., of these receivers differ very slightly if at all from the normal battery or mains counterpart. The main differences occur in the power supply. The power circuits of the set may be classed into two categories :—

1. Heater power, and
2. H.T. voltage

1. Heater Power. Now, the only way to heat the valves in a universal receiver is by direct connection to the mains supply, using some resistance system, if necessary, to control the current. A transformer is of course, impossible, as it could not work when the set is plugged into a D.C. source. So the only course left is to connect the heaters in series, and then, via a resistance, if necessary, to the mains. See Fig. 1. The heaters are all in series, and they must therefore all take the same current. The output valve and rectifier however, as they handle a relatively large current in their anode circuits, require more power to heat their cathodes than do the other valves. This extra power is obtained by manufacturing valves whose heaters pass the same current as the other valves in the set, but drop a larger voltage. (Of course, the cathodes, being insulated from the heaters, are not affected by the various voltages applied to the latter. This point is dealt with in more detail later.)

It will be seen that heaters connected in this fashion may be supplied from either A.C. or D.C. mains, and therefore fulfil the " universal " requirement.

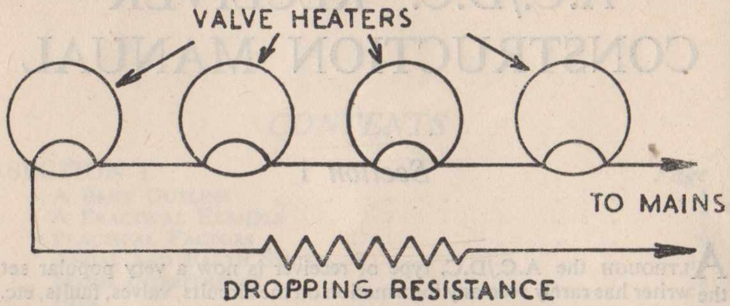

FIG. 1. *Showing method of supplying current to valve heaters in an A.C./D.C. circuit.*

2. The H.T. Circuit. The next point to consider is some means of providing H.T. voltage from either A.C. or D.C. mains. Fig. 2 shows how this is done. In this circuit the rectifier, which is an indirectly-heated type, is used in a half-wave circuit. When connected to A.C. mains the rectifier allows positive half-cycles to pass to the smoothing circuit. These half-cycles are "ironed-out" by the smoothing choke and condensers and applied to the set as D.C. (To be perfectly accurate, this rectifier does not

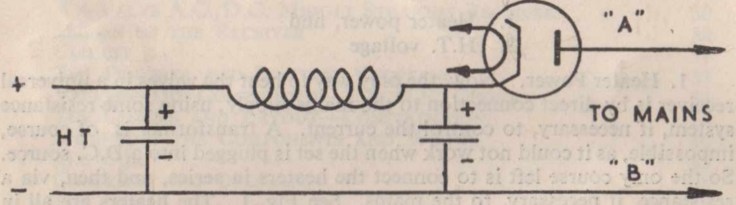

FIG. 2. *Showing simplified version of rectifier circuit.*

actually pass the positive half-cycles, but provides a return circuit for the negative half-cycles in the opposite direction, as shown in Fig. 3. The effect, however, is the same).

When the leads "A" and "B" of Fig. 2 are connected to the D.C. mains (with "A" to the positive terminal of the mains), the rectifier acts simply as a resistance. The rectifier will allow no current to pass if the leads are reversed. Thus the set may have to have the mains plug reversed experimentally when using on D.C. mains. The smoothing circuit serves to get rid of the ripple found on most D.C. mains.

It will be seen that one lead from the mains gives the H.T. Negative connection, and, as the chassis of the set is connected to H.T. negative, the chassis then becomes " live." This point is dealt with later in the book.

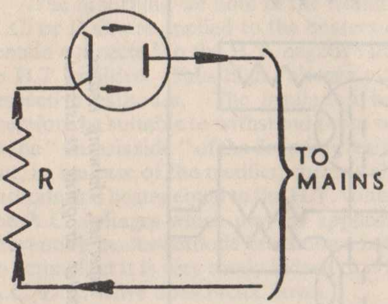

FIG. 3. *Electron flow in H.T. circuit. "R" represents the load presented by the set to the H.T. supply.*

A PRACTICAL EXAMPLE

Fig. 4 gives a skeleton circuit of a 5-valve superhet showing how the heater and H.T. voltages are applied. The valves used for this example are the American types, 6K8 as frequency-changer, 6K7 as I.F. amplifier, 6Q7 as double-diode-triode, 25L6 as output valve, and 25Y5 as half-wave rectifier. The set is fed from 110 volt mains. The heaters of all these valves take 0.3 amps., so may be connected in series. The voltages dropped across the heaters are, respectively, 6.3, 6.3, 6.3, 25 and 25. These add up to 68.9 (approximately 70) volts. Therefore, the resistance " R" (Fig. 4) in series with them must drop 110-70 volts which is equal to 40 volts.

The resistance passes a current of 0.3 amps., so, by Ohm's Law, its value is equal to :—

$$\frac{E}{I}$$

$$= \frac{40}{0.3}$$

$$= 133 \text{ ohms.}$$

Its power dissipation is equal to :—

$$I^2R$$

$$= (0.3)^2 \times 133$$

$$= 0.09 \times 133$$

$$= 11.9 \text{ watts.}$$

Therefore a resistance of 133 ohms and of at least 12 watts rating is required for this position.

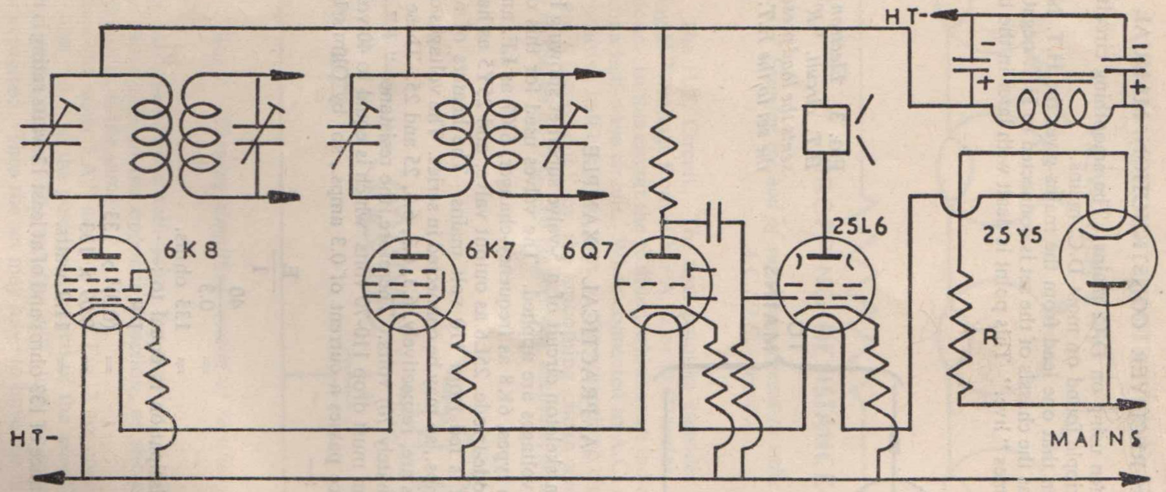

FIG. 4. *Simplified circuit of 5-valve superhet, showing heater and H.T. circuits. "R" is the heater dropping resistance.*

PRACTICAL FACTORS

The last paragraph is only a theoretical consideration of the A.C./D.C. circuit and quite a few snags are encountered before the circuit in Fig. 4 may be put to practical use. Again, we can classify these points under the two headings :—the heater circuit and the H.T. circuit. Let us first consider the heater circuit.

The first thing we note in the heater circuit is that varying voltages of A.C. or D.C. are applied to the heaters of the valves whilst their cathodes remain connected to the H.T. negative line, and, in the case of the rectifier, to H.T. positive. Thus high voltages may exist between heaters and their respective cathodes. The insulation between heater and cathode must therefore be suitable to withstand these voltages. The heaters are connected to the " chassis side " of the dropping resistance to help reduce these voltages, but, in the case of the rectifier, there is always a standing potential between cathode and heater equal to the H.T. voltage before we even begin to consider the A.C. voltages which may be applied to this heater. The only way of preventing heater-cathode breakdown is to manufacture valves accordingly. In actual fact it is very rarely indeed that the heater-cathode insulation of an A.C./D.C. valve does break down.

The varying voltages applied to the heaters also tend to introduce hum into the cathode circuits of the valves by reason of cathode-heater capacity. It is, however, quite sufficient to use normal cathode by-pass condensers of about 25 μfd. on the A.F. valves to clear this trouble. The first valve, (H.F., mixer, etc.) of the set is usually connected to the " negative end " of the chain of heaters, the next valve in the next position, and so on.

Trouble may sometimes be caused by heater-cathode emission, When the cathode is positive with respect to the heater, it may act as an anode with the heater as a filament, and a current is liable to flow. This will introduce hum, but the effect is so small that it is only noticeable when employing more stages of A.F. amplification than are necessary in the normal receiver. In normal mains amplifiers (A.C.) the usual cure for this trouble is to bias the heater by a small D.C. voltage so that it is always positive with respect to the cathode, and therefore cannot emit. By reason of the A.C./D.C. heater circuit this is impossible in a universal amplifier. Thus, the heater-cathode emission is a factor liable to limit the number of stages in an A.C./D.C. amplifier.

Another important component to consider is the dropping resistance. This resistance usually dissipates quite a lot of heat and must be placed in a position on the chassis where it gets plenty of ventilation. As it also radiates heat, some manufacturers place metal heat screens between the resistance and any components in the vicinity likely to be affected by heat.

The resistance may be replaced by a line cord. This is a cord connecting the set to the mains which has one of its leads made of resistance wire. There are two main types of line cord, two-core and three-core. Two-core is used mainly for running 110-volt American sets off 200-250 volt mains in this country, as shown in Fig. 5. Three-core is used as shown in Fig. 6, where the resistance line is used to drop the voltage to the heaters and the plain wire to supply the total mains voltage to the rectifier anode for H.T.

The use of line cords has its own chapter of accidents. The line cord has to dissipate just as much heat as the normal dropping resistance, but, as it usually is a few yards long it has plenty of radiating surface. If, however, it is coiled up near the set for the sake of neatness, its chances of cooling are much less and it is liable to become hot enough to burn out or break down. Also, if the line cord kinks, the resistance wire is liable to break internally. It can be seen that these cords are components which must be treated with care.

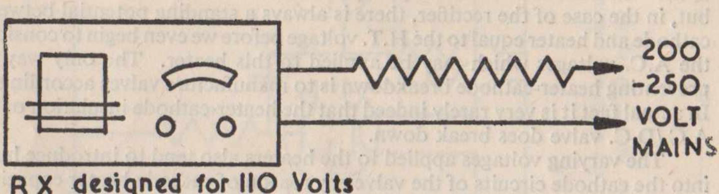

FIG. 5. *The use of 2-core line cord.*

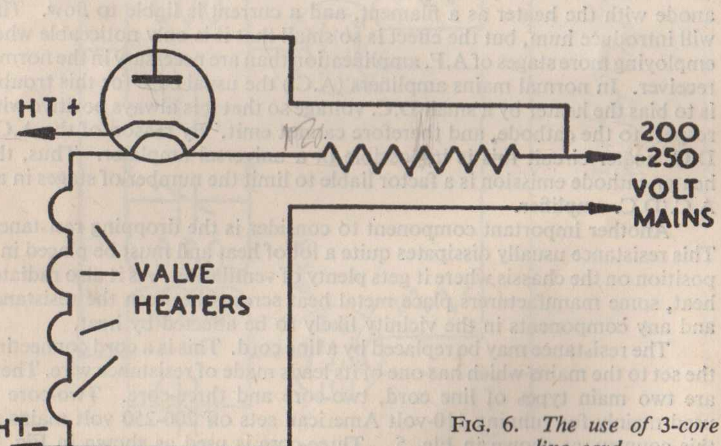

FIG. 6. *The use of 3-core line cord.*

Another form of dropping resistance is the barretter. This consists of a resistance enclosed in an envelope, the element of which is made of a wire whose resistance increases withi ts temperature. Therefore, if a set fitted with a barretter is plugged into a 250 volt source the barretter becomes hotter than if the set were used on 200 volt mains. Therefore, the resistance of the barretter is higher on the higher voltage mains and tends to keep the potential across the valve heaters constant whatever mains voltage is used. Barretters do not seem to be used so much these days, a tapped resistance usually sufficing to keep the heater voltage constant. In any case, modern valves will stand up to the discrepancies introduced into the heater circuits by connecting to mains voltages between the limits of 200 to 250 volts. The writer expects a few protests at this statement, but, in certain Service equipment, valve heaters are subjected to changes of as large as 5.5 to 7.5 volts (6.3 volt heaters being used), and do not suffer in consequence. And what serves for Service equipment (English and American), should do quite well in civilian receivers !

One point to remember when connecting up dropping resistances or line cords for A.C./D.C. sets is that the value of the resistance may vary somewhat as it becomes warm in use. One method is to connect a voltmeter across the heaters (See Fig. 7) and adjust the resistance, when warm, to give the proper reading in the meter.

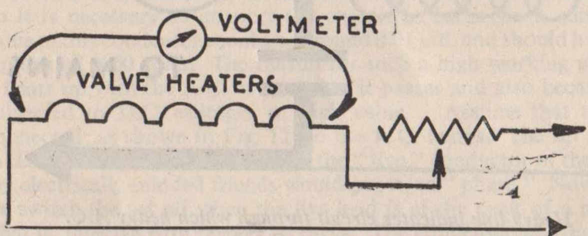

FIG. 7. *Recommended method of adjusting heater resistor.*

And now let us give the H.T. circuit our consideration.

The smoothing circuit is the first thing worthy of note. As the rectifier is connected in a half-wave circuit, the voltage on the cathode of the rectifier is as shown in Fig. 8, consisting of half-wave pulses. Fig. 9 gives the wave form on the cathode of a full-wave rectifier as used on a normal A.C. mains set. It can be seen that the half-wave rectification will need heavier smoothing than does the full-wave circuit. Especially does it need a larger smoothing condenser on the cathode of the rectifier, as this component acts as a reservoir condenser and " holds the voltage up." A value of 16 to 32 μfds. for this component is quite normal.

The second point is that, by reason of this large condenser, and the fact that only half-wave pulses are used to charge it, a heavy A.C. current passes through the circuit made by the condenser and rectifier. See Fig. 10, which

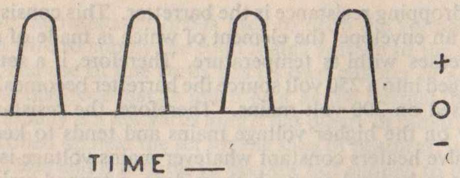

FIG. 8.
Pulses obtained with half-wave rectification.

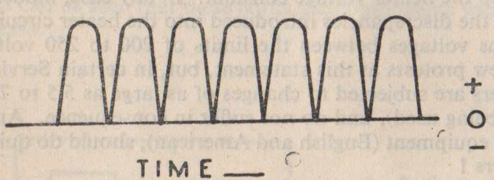

FIG. 9.
Pulses obtained with full-wave rectification.

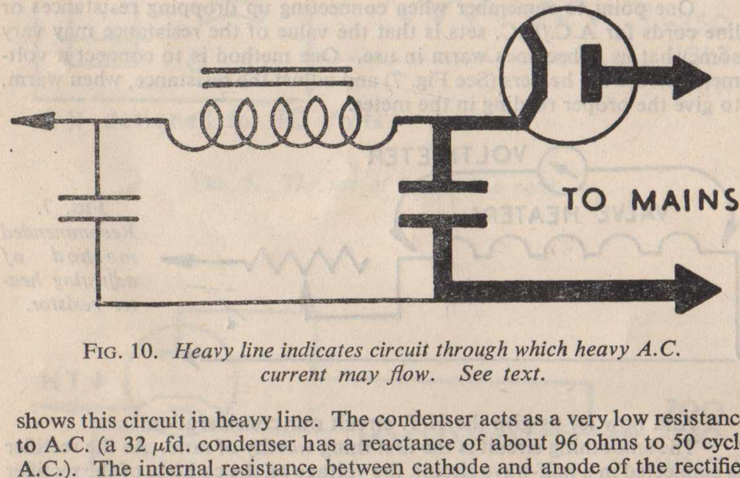

FIG. 10. *Heavy line indicates circuit through which heavy A.C. current may flow. See text.*

shows this circuit in heavy line. The condenser acts as a very low resistance to A.C. (a 32 μfd. condenser has a reactance of about 96 ohms to 50 cycle A.C.). The internal resistance between cathode and anode of the rectifier is also very low. Therefore, as far as the A.C. is concerned, there is very little reactance in the circuit shown in Fig. 10 and quite a heavy current may flow. This will tend to heat up the electrolytic condenser, causing breakdown, and/or strip the coating off the rectifier cathode. (Has the gentle reader ever tapped an A.C./D.C. rectifier that's " getting on a bit " and seen particles of the cathode coating fall to the bottom like snow-flakes?)

The best method of getting over this trouble is to insert a " limiting resistance," as shown in Fig. 11. This limits the heavy A.C. current, at the same time offering little resistance to the D.C. circuit. Its value should be between 150 and 300 ohms and should have a rating of at least 5 watts.

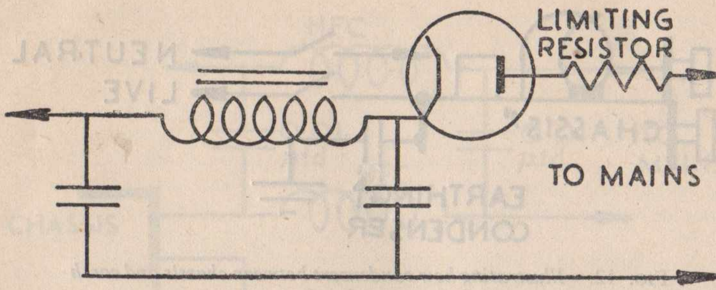

FIG. 11. *Method of connecting " limiting resistance."*

Having dealt with the heater and H.T. circuits, the next thing to consider is the " externals " and the various peculiar faults inherent in this design. Firstly then, the aerial and earth systems.

AERIAL AND EARTH SYSTEM

It is impossible to connect the chassis of an A.C./D.C. receiver directly to earth as it is connected to one side of the mains and is therefore " live." So it is necessary to connect the chassis to earth via a condenser. The value of this condenser should be around 0.01 μfd. and should have a working voltage of 1000 volts. The reason for such a high working voltage is that it heats up with the A.C. current that it passes and also because it may be subjected to D.C. voltages of high value. Assume that the chassis is connected, as shown in Fig. 12, to the A.C. mains. The set is so plugged in that the chassis is connected to the " live " conductor of the mains, or as my electrically-minded friends would put it, to " phase." Now assume that we switch the set off when the live lead is at the peak of a positive cycle. That is, positive with respect to earth. The condenser will then be charged up to the voltage of the mains at the instant when the set was switched off. This voltage may be equal to the peak voltage of the mains supply. If the mains voltage is 250 volts (R.M.S.) then the peak voltage will be equal to 250 x 1.414, approximately 370 volts. If we switch on a moment later, when the mains phase is at a full negative peak (with respect to earth) we have the instantaneous circuit shown in Fig. 13. The condenser, " C," is charged to 370 volts, and a source of supply, say, a battery, of 370 volts " B," (370 volts will be the peak value of the negative half-cycle), is connected as shown. The two voltages are in series and add up to 2 x 370 = 740 volts. Now, that 740 volts will be effectively applied to the dielectric of the condenser. (The source of supply, " B," may be considered as having an internal resistance of nil). Thus, unless the condenser can stand the voltage, it will break down. In this case, the condenser between chassis and earth should be at least 740 volts working, and in actual fact it is safest to use a 1000 working voltage component.

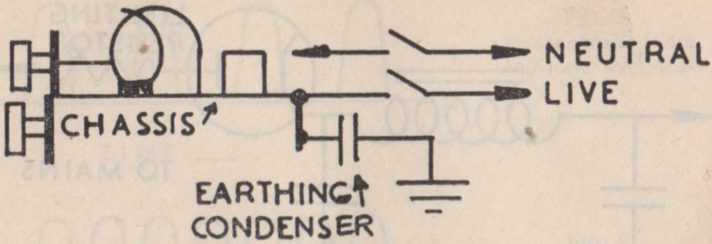

FIG. 12. *Illustrating how condensers between chassis and earth may be connected. See text.*

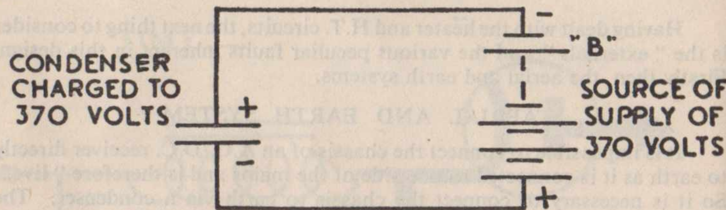

FIG. 13. *Illustrating strain on condenser between chassis and earth.*

It is not always necessary to provide an earth connection. The mains wiring, connected directly to the chassis will supply a reasonable capacity earth, or, at worst, an effective counterpoise to the aerial.

As the aerial will be connected to the chassis via a coupling coil, a condenser in series is again needed. A value of 0.001 μfd. should suffice, again of 1000 volt working.

A point worthy of note is that the American midget radio sets in this country, designed to work off 110-volt mains, having isolating condensers of 400 to 500 volt working. When the receiver is used on 200-250 volt mains these condensers should be replaced by 1,000 volt working types.

MAINS INTERFERENCE

Owing to the circuit peculiar to this type of set, the universal receiver is more prone to interference carried by the mains wiring than other types.

One way of minimising this trouble is by connecting a 0.01 μfd. condenser across the mains input. This condenser helps to by-pass H.F. in the mains leads. It also helps to reduce modulation hum and should be fitted in every set made, unless some other version of filtering is employed. A more complicated filter for interference suppression is shown in Fig. 14, in which two H.F. chokes are used with two condensers. The H.F. chokes usually

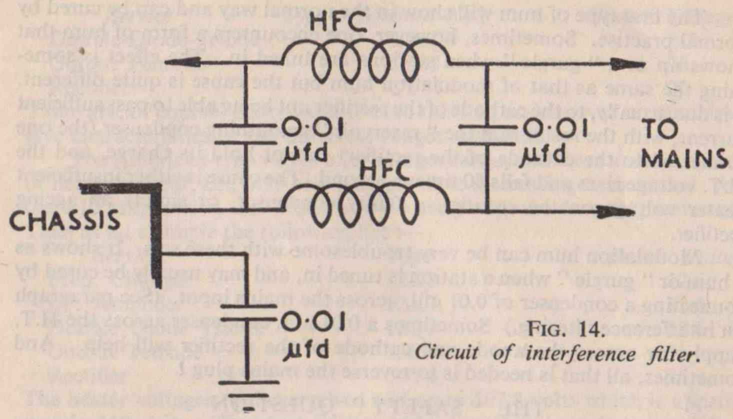

FIG. 14.
Circuit of interference filter.

consist of a score or so of turns of D.C.C. wire, although many individual types are in use. The condensers are of 0.01 µfd . capacity, and of 1,000 working volts rating, for the same reason as that for the earthing condenser mentioned above. An interesting adaption of Fig. 14 is shown in Fig. 15. The second condenser is " split," and the centre tap taken to the earth terminal of the receiver. This gives a more efficient filtering system than that of Fig. 14, as well as providing a good earth connection for the set.

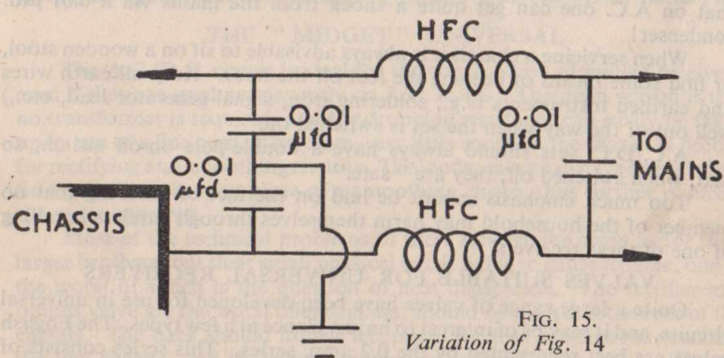

FIG. 15.
Variation of Fig. 14

HUM

Hum deserves a paragraph or two on its own. Hum troubles can be mainly divided into two categories, *i.e.*, hum due to bad smoothing, bad layouts, etc., and modulation hum.

The first type of hum will show in the normal way and can be cured by normal practise. Sometimes, however, one encounters a form of hum that shows up as a " gurgle " when stations are tuned in. The effect is something the same as that of modulation hum but the cause is quite different. It is due, usually, to the cathode of the rectifier not being able to pass sufficient current, with the result that the " reservoir " smoothing condenser (the one connected to the cathode of the rectifier) cannot hold its charge, and the H.T. voltage rises and falls 50 times a second. The cause is either insufficient heater voltage on the rectifier, a faulty condenser, or simply an ageing rectifier.

Modulation hum can be very troublesome with these sets. It shows as a hum or " gurgle " when a station is tuned in, and may usually be cured by connecting a condenser of 0.01 μfd. across the mains input. (See paragraph on interference filtering.) Sometimes a 0.01 μfd. condenser across the H.T. supply, or across the anode and cathode of the rectifier will help. And sometimes, all that is needed is to reverse the mains plug !

THE " SAFETY " QUESTION

One of the greatest disadvantages with the A.C./D.C. set is that the chassis is " live." All mounting bolts, etc., unless carefully insulated, will be " live," and therefore dangerous, if accidentally touched. The chassis must be completely enclosed, and no possible means of shock left open. A wooden cabinet offers good protection. Some manufacturers even put filling into the grub-screw holes of the knobs after fitting. Items, like pick-up leads, which usually have sheathed wire and an earthed pick-up head, must be isolated by a transformer or by condensers. And don't forget that on A.C. one can get quite a shock from the mains via a 0.01 μfd. condenser!

When servicing a chassis it is always advisable to sit on a wooden stool, or find some means of keeping the feet off the floor. Keep all earth wires and earthed instruments (*e.g.*, soldering iron, signal-generator lead, etc.,) well out of the way when the set is switched on.

A.C./D.C. sets should always have a double-pole on-off switch, so that, when switched off, they are " safe."

Too much emphasis cannot be laid on the fact of ensuring that no member of the household may harm themselves through careless handling of one of these receivers.

VALVES SUITABLE FOR UNIVERSAL RECEIVERS

Quite a large range of valves have been developed for use in universal circuits, and it may be of interest to have a glance at a few types. The English valves are best represented by the 0.2 amp. series. This series consists of valves that take 0.2 amp. heater current at 6.3 volts, with the main exception of output and rectifier valves. Thus a superhet could use the following types:

Service	*Type*	*Heater voltage*
Triode-Hexode	OM10 (Cossor)	6.3
I.F. Amplifier	EF39 (Mullard)	6.3

Service	*Type (Mullard No.)*	*Heater Voltage*
Double-Diode-Triode	EBC33	6.3
Output Pentode	CL33	33
Rectifier	CY31	20

There are, of course, many variations to this list, and any valve manual will give characteristics of the universal ranges available.

The American-type valves offer a larger range, and there are two choices of heater current, *i.e.*, 0.15 or 0.3 amps. It is interesting to note that, with the 0.15 amp. series, it is possible to do away with the dropping resistance. Take as an example the following list :—

Service	*Type*	*Heater Voltage*
Freq. Changer	12K8	12.6
I.F. Amplifier	12K7	12.6
Double Diode Triode	12Q7	12.6
Output Tetrode	35L6	35
Rectifier	35Y4	35

The heater voltages of these valves add up to 107.8 volts which is approximately 110 volts. Therefore with a series like the above it is possible to design a receiver for use on 110 volt mains that has no dropping resistance at all. As mentioned above, any good valve manual will help the constructor in making a choice. It must be pointed out that most American A.C./D.C. output valves have a maximum anode voltage of 110, or at best, 150, so some form of dropping resistance in the H.T. circuit is required when using the 200-250 volt mains for supply.

Having paid due attention to the general aspects of the universal receiver, we may now proceed to the " midget " type, and to the A.C./D.C. Battery set.

THE " MIDGET " UNIVERSAL

The A.C./D.C. circuit is ideal for the construction of midget receivers, even if they are used permanently on A.C. mains. The main reason is that no transformer is required, and the dropping resistance can easily be taken up by use of a line cord. Therefore, very little room on the chassis is needed for rectifying and smoothing circuits. The loudspeaker can have an energized field and this takes the place of a smoothing choke, thus further reducing the space required.

Most of the technical problems of these sets are the same as for their larger brothers, but their small physical size is liable to cause trouble, one of the worst of which is the question of heat dissipation. The rectifier and output valve are the worst offenders and should be placed at the rear of the chassis. The back should not be left open, for fear of someone touching the live chassis, and therefore a compromise must be reached. The set should not be placed right up against a wall as heat circulation will suffer.

The cabinets of midget sets are usually too small to permit an efficient frame aerial to be used. The mains lead cannot be used as an aerial very well as it is already effectively connected to the chassis of the set. Efficient chokes in both mains leads would solve this, but there isn't room on most midget chassis. In any case, the mains leads and wiring form quite a good earth (as mentioned above). The best solution is to use a short " throw-out " aerial of several yards which can be laid around the room or on the floor. This short aerial can actually be advantageous, because, with midget coils, whose " Q " may not be too good, a large aerial might damp them excessively, whereas with the shorter aerial, the manufacturer can cut it to the most suitable length consistent with good reception and know that his set will be working at its best wherever it is.

Some ingenious methods have been used by manufacturers to save space. By having one of the I.F. transformers under the chassis, and another above, the chassis itself screens one from the other and bulky screening cans over the coils are not needed. These and many other methods to conserve space may be used. Some of the American-type valves may help in building what could be described as " freak " sets. Valves like the 117L7 or 117N7 may be used for one-valve sets. The 117L7 consists of a half-wave rectifier and output tetrode in one envelope. The heater consumes 0.99 amps. at 117 volts, so can be put straight across 110-volt mains. Quite a tiny one-valve " toy " set could be built around this valve.

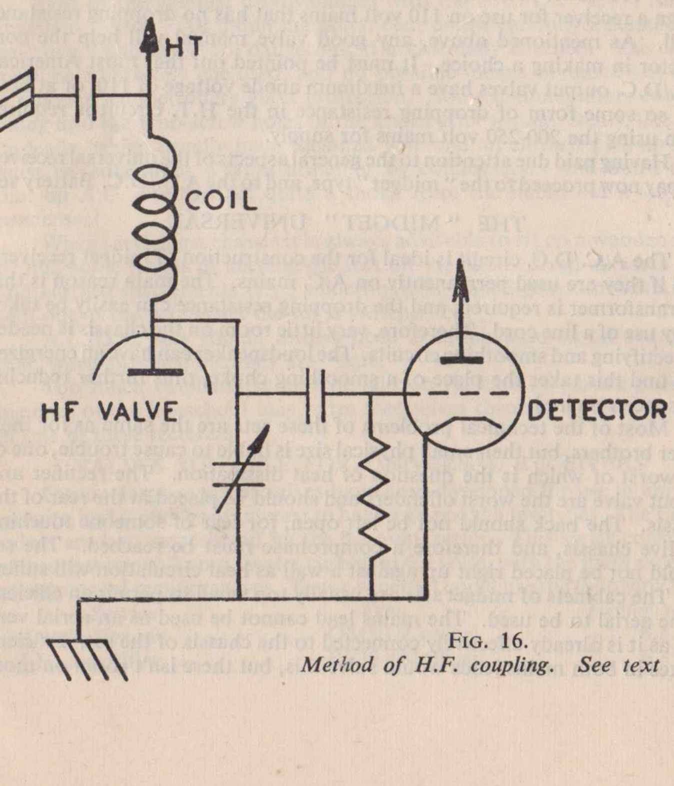

FIG. 16.
Method of H.F. coupling. See text

Sets with straight circuits can be made very small indeed, and the most popular appears to be a Medium-wave-only 1-V-1 set, with or without reaction. It should be noted here that reaction on these midget sets will sometimes give trouble of its own. The set may appear to be free from hum, etc., until reaction is advanced nearly to oscillation point, whereupon all the hum and noises inherent in the set seem amplified out of all proportion to the signal strength. Careful layout and design are needed when constructing a set of this type.

With certain midget coils, one is often tempted to use a circuit as shown in Fig. 16, which shows the coupling between H.F. anode and detector grid in a straight circuit. As can be seen, a very tight coupling indeed exists between the two valves, with resultant good sensitivity (and somewhat flat tuning). The transformer circuit shown in Fig. 17 is better, although the coupling is looser. The reason for this is that the circuit of Fig. 16 allows a

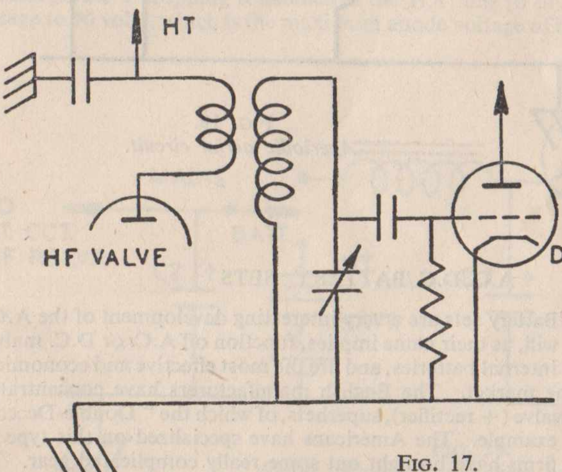

FIG. 17.
Alternative of Fig. 16. *See text.*

certain amount of *A.F.* coupling between H.F. anode and detector grid, and the small coils used (especially long-wave coils wound with thin wire), do not give the effective short-circuit to A.F. that they should. Thus, apart from instability, hum picked up on the aerial or the grid of the H.F. valve may be transferred, as A.F., to the detector grid after amplification by the H.F. valve. Especially is this so if an aperiodic circuit is used in the aerial stage as shown in Fig. 18, where the 50,000 ohm leak allows *all* signal voltages in the vicinity to be applied to the H.F. grid.

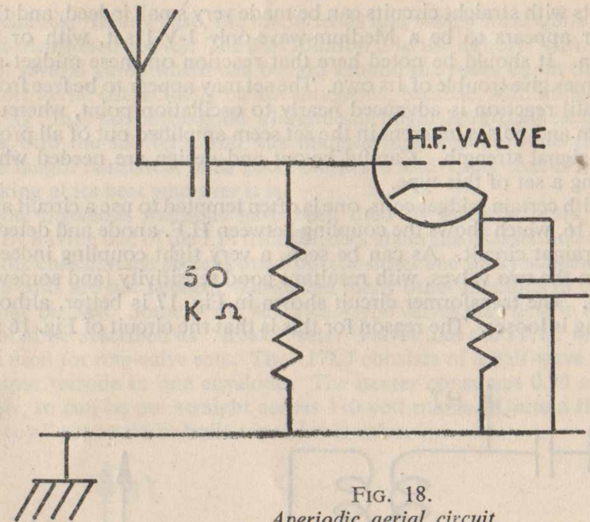

FIG. 18.
Aperiodic aerial circuit.

A.C./D.C./BATTERY SETS

A.C./D.C./Battery sets are a very interesting development of the A.C./D.C. set. They will, as their name implies, function off A.C. or D.C. mains, or off their own internal batteries, and are the most effective and economical portables on the market. The English manufacturers have concentrated mainly on four valve (+ rectifier), superhets, of which the " Double-Decca " is a very good example. The Americans have specialized on this type as well, but some firms have brought out some really complicated gear. To the writer's mind, the best example is the Hallicrafter model. This consists of a midget, (and it is midget!) communications-type receiver with band-spread tuning B.F.O., A.V.C. switch, etc. It comprises an H.F. stage, mixer, 2 I.F. valves, double-diode-triode, and output, as well as B.F.O. valve and rectifier. It has self-contained speaker and batteries, and the chassis is mounted in an earthed metal case from which it is insulated by rubber mountings. Dropping resistances are incorporated in the line cord, which, if the writer's memory serves him correctly, has at least two resistance elements. The Germans have also been making specialized sets, on the A.C./D.C./Battery principle, for the civilian or service market, but the writer has no information on the special valves and circuits used in their models

AN EXPLANATION OF THE FUNCTIONING OF THE A.C./D.C. BATTERY SET

The problem of getting a set to work off A.C., D.C., or battery supplies resolves itself, as with the A.C./D.C. set into two main categories—H.T. supply and heater supply.

THE H.T. SUPPLY

The H.T. supply is quite simple. We already understand how the A.C./D.C. rectifier works, and all we now need is a switch to connect the receiver proper to the internal H.T. battery when we are using battery supplies. Fig. 19 gives a simple circuit of this switching. Note that the electrolytic condenser, C_2, is left in circuit all the time. This condenser reduces instability when the internal resistance of the H.T. Battery rises through use. It will probably be necessary, when using 200-250 volt mains, to incorporate a dropping resistance in the H.T. line to drop the rectified voltage to 90 volts, which is the maximum anode voltage of the valves used.

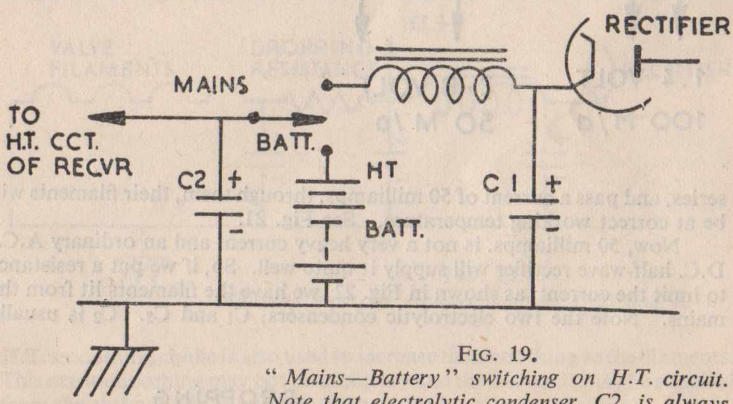

FIG. 19.
"*Mains—Battery*" *switching on H.T. circuit. Note that electrolytic condenser, C2, is always in circuit.*

THE HEATER (OR FILAMENT) SUPPLY

The next job is to heat the valves. This is simply done with batteries, but is not so easy uisng the mains source. We must use filament-type valves, because the indirectly-heated type would take too much current from the internal L.T. battery. Therefore, we have to rectify the mains voltage (when using A.C.) and apply it to the filaments in just the right quantity and entirely free from hum.

For this purpose we call upon the range of low-consumption 1.4-volt valves that are on the market. The filaments of these valves each take 50 milliamps., except in the case of the output valve which takes 100 milliamps. However, valve type 3C5 and 3Q5 may be used. These valves are constructed with a centre-tap to their filaments, so that they may be connected to take 100 milliamps. at 1.4 volts, or 50 milliamps. at 2.8 volts. See Fig. 20. Thus if we put, say, the four valve filaments of a superhet in

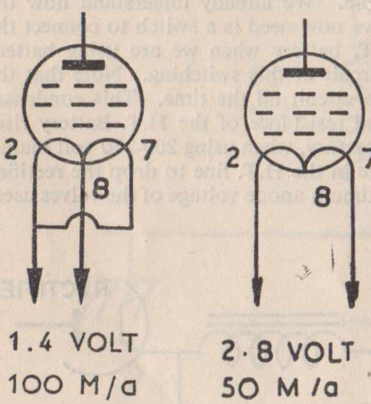

FIG. 20. *Alternative filament connections to valves type 3Q5, 3C5, etc.*

series, and pass a current of 50 milliamps. through them, their filaments will be at correct working temperature. See Fig. 21.

Now, 50 milliamps. is not a very heavy current and an ordinary A.C./D.C. half-wave rectifier will supply it quite well. So, if we put a resistance to limit the current, as shown in Fig. 22, we have the filaments lit from the mains. Note the two electrolytic condensers, C_1 and C_2. C_2 is usually

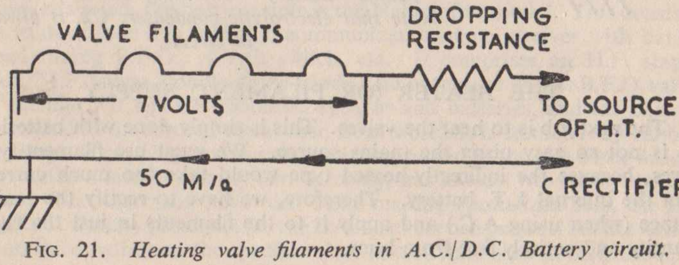

FIG. 21. *Heating valve filaments in A.C./D.C. Battery circuit.*

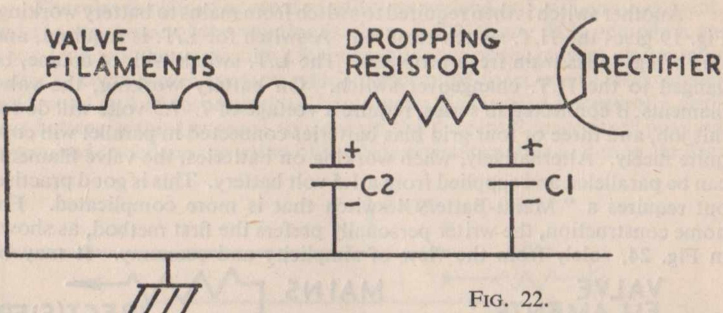

FIG. 22.
Heating valve filaments from H.T. rectifier.

of high value, around 100 μfd., so that excellent smoothing is obtained, and also for another reason dealt with later.

The rectifier used to heat the valves may also be used to supply H.T., so that we now get a circuit as shown in Fig. 23. It may be noted that the

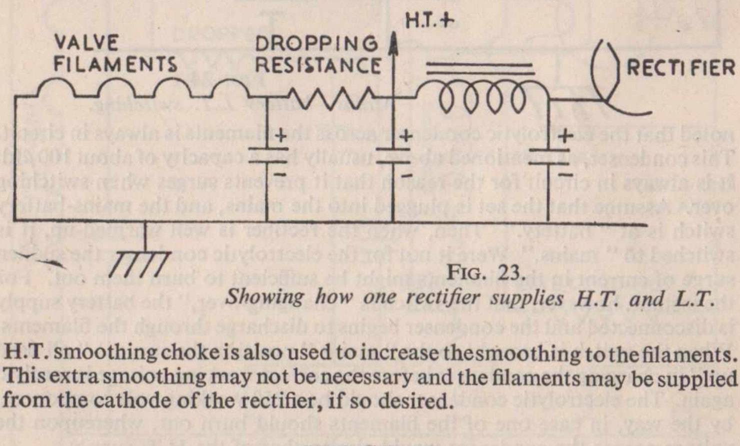

FIG. 23.
Showing how one rectifier supplies H.T. and L.T.

H.T. smoothing choke is also used to increase the smoothing to the filaments. This extra smoothing may not be necessary and the filaments may be supplied from the cathode of the rectifier, if so desired.

SWITCHING

Let us now consider the switch required to switch the set on and off. A 3-poles witch, at least, is required. This switches off mains to the rectifier, L.T. from the internal batteries to the filaments, and also the internal H.T. battery. A 4-pole switch which switches off both mains input leads would be better. A switch in the H.T. circuit is necessary because the electrolytic condenser is always in circuit (see Fig. 19), and this would cause a slight drain.

Another switch is then required to switch from mains to battery working. Fig. 19 gives the H.T. switch required. A switch for L.T. is required, and this brings in its train fresh problems. The L.T. switch will, of course, be ganged to the H.T. changeover switch. On battery working, the valve filaments, if connected in series, require a voltage of 7. 7.5 volts will do for this job, and three or four grid bias batteries connected in parallel will cope quite nicely. Alternatively, when working on batteries, the valve filaments can be paralleled and supplied from a 1.5 volt battery. This is good practise, but requires a " Mains-Battery " switch that is more complicated. For home construction, the writer personally prefers the first method, as shown in Fig. 24, solely from the view of simplicity and economy. It may be

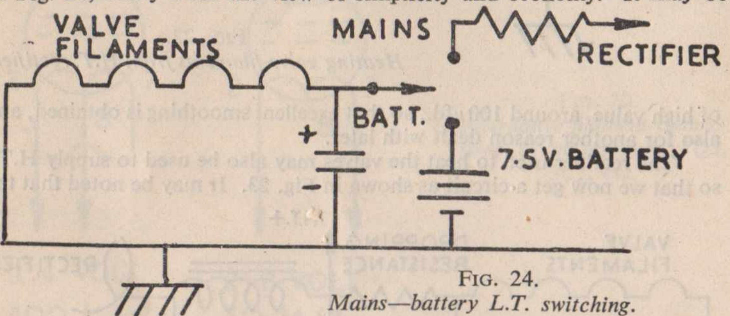

FIG. 24.
Mains—battery L.T. switching.

noted that the electrolytic condenser across the filaments is always in circuit. This condenser, as mentioned above, usually has a capacity of about 100 μfd. It is always in circuit for the reason that it prevents surges when switching over. Assume that the set is plugged into the mains, and the mains-battery switch is at " battery." Then, when the rectifier is well warmed-up, it is switched to " mains." Were it not for the electrolytic condenser the sudden surge of current in the filaments might be sufficient to burn them out. For the instant, however, that the switch is " changing-over," the battery supply is disconnected and the condenser begins to discharge through the filaments. When the switch is brought to the " mains " position the surge is " all used up " in charging the condenser before the correct working voltage is reached again. The electrolytic condenser should be a 250 working-volt component, by the way, in case one of the filaments should burn out, whereupon the voltage across the condenser would rise to that of the H.T. supply.

Instead of a panel-mounted switch, the mains-battery switching can be done quite comfortably by means of a relay. This can be worked directly from the mains, but that method has the disadvantage that on A.C. mains the relay might " chatter." One would also have to wait until the rectifier warmed up before the set began to play. The writer has designed a relay circuit (Fig. 25) which overcomes this trouble, and which, although probably not original, he feels would be of interest to other constructors. This relay has given excellent service in constant use.

The relay itself is of a type that will close under 4 or 5 milliamps. current, and the resistance of the winding is about 2,000 ohms. It is actually a re-wound job, but there are quite a few suitable types on the market. It operates a pair of change-over contacts which perform the functions of the switches in Figs. 24 and 19 respectively. If automatic bias is used instead of a grid-bias battery, a third contact, to close on the " mains " (energised) position is required to reduce the value of the bias resistance, this is due to the fact

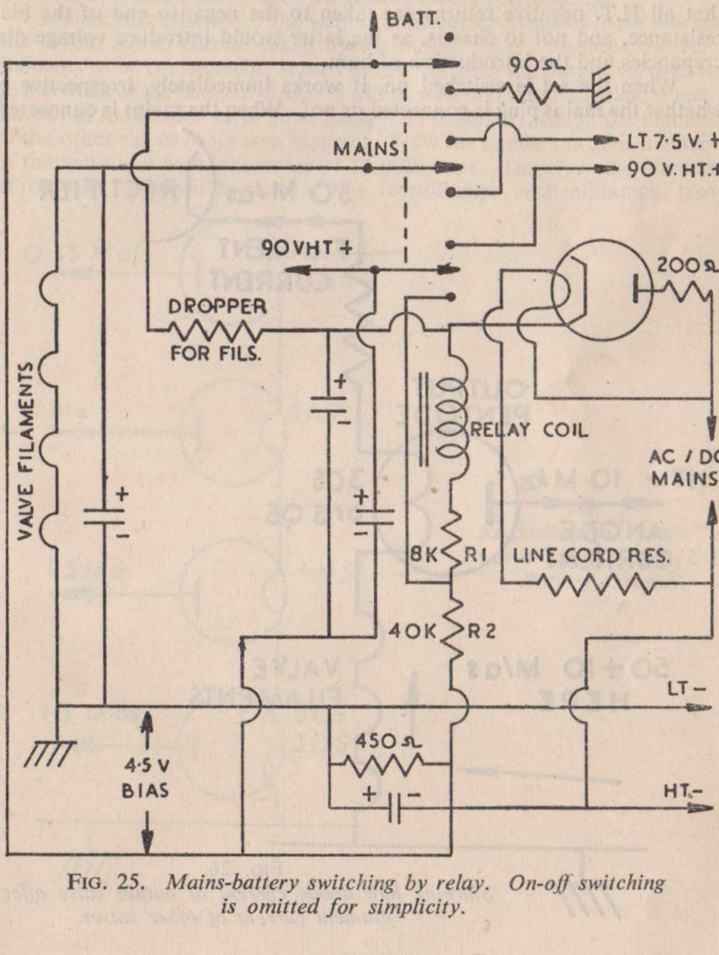

FIG. 25. *Mains-battery switching by relay. On-off switching is omitted for simplicity.*

that 50 milliamps. more current (the filament current), will be flowing through the bias resistance when the set is using mains supply.

As soon as the rectifier has warmed up and starts to pass current, the current flows through the relay and potentiometer circuit, R_1 and R_2, and closes the relay thereby making the set mains-operated. The potentiometer, R_1 and R_2, then tends to keep the H.T. to the receiver reasonably constant, and giving better regulation than a series resistance would. At the same time the relay winding acts as quite an efficient choke. The reader will note that all H.T. negative returns are taken to the negative end of the bias resistance, and not to chassis, as the latter would introduce voltage discrepancies and the introduction of hum.

When the set is switched on, it works immediately, irrespective of whether the mains plug is connected or not. When the mains is connected,

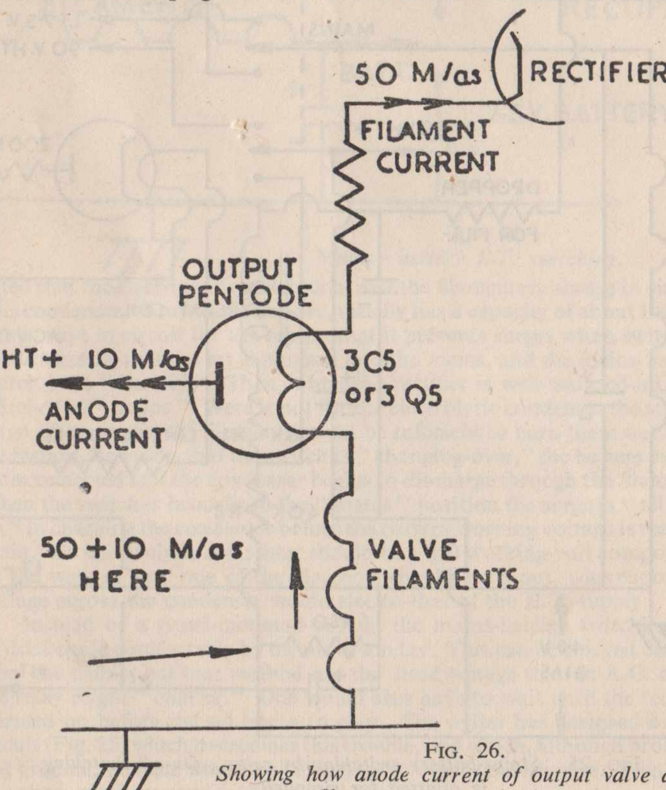

FIG. 26.
Showing how anode current of output valve affects filament current of other valves.

the set remains battery-operated until the rectifier has warmed up sufficiently to operate the relay, whereupon the set becomes mains-operated. Immediately the mains connection is broken, the relay opens and the set is battery-operated again. By reason of the large electrolytics in circuit there are no " clicks " whatsoever as this switching takes place and the changeover is unnoticeable.

PRACTICAL POINTS

And now a few paragraphs on putting theory into practise.

A snag encountered by the writer in the construction of these sets was due to the anode current taken by the output valve. Assume the valve filaments to be connected as shown in Fig. 26, with the output valve at the positive end of the filament chain. It will be seen that the anode (and screen), current of the output valve flows from H.T. negative through the filaments of the other valves to its own filament. Now the anode and screen current of the valve will be of the order of 10 milliamps. Therefore the filaments of the other valves will be passing 50 + 10 milliamps. = 60 milliamps. Now,

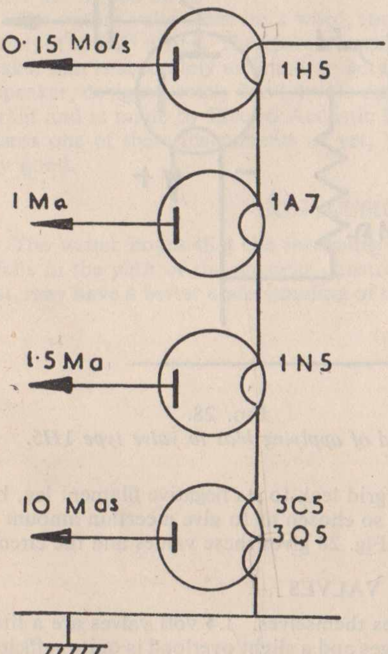

FIG. 27.
Recommended " chain " of valves for A.C./D.C. Battery superhet.

when this 60 milliamps. was passing through these filaments it was found that each filament had about 1.8 volts across it. A disastrous and expensive addition, as these low-consumption valves soon lose their emission or burn out on slight overloads. The solution is to have the output valve at the negative end of the chain. A recommended " series " is shown in Fig. 27.

Having cleared this point, the bias question is the next. Bias for the output valve is provided by automatic bias, or grid bias battery, bias for the mixer and I.F. amplifier is obtained by connecting all grid returns to the negative leg of their respective filaments. Bias for the diode-triode (usually

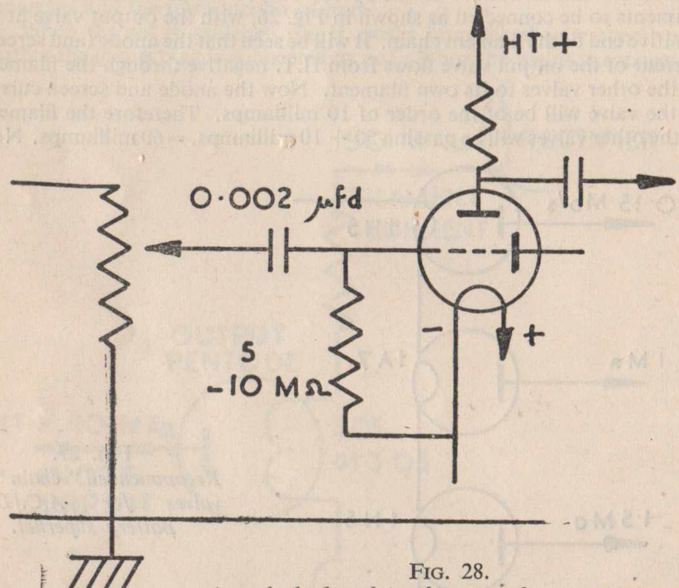

FIG. 28.
A method of applying bias to valve type 1H5.

1H5) is given by connecting the grid leak to its negative filament leg, but values in the grid circuit may be so chosen as to give a certain amount of leaky-grid bias on loud signals. Fig. 28 gives these values and the circuit.

VALVES

Finally, a word on the valves themselves. 1.4 volt valves are a little touchy about their filament voltages and a slight overload is quite sufficient to make them unserviceable. Therefore great care must be taken when servicing or constructing sets using these types. When constructing a new set, if it is desired to adjust the value of the filament dropping resistance, it is always advisable to check the voltage across the filaments under working conditions, and adjust the resistance accordingly. Start adjustments by using a resistance value that is too large and gradually reduce it until the correct reading is obtained. (" Cold " values have a disastrous habit of not working in practice!). And it should not be forgotten that the internal resistance of A.C./D.C. rectifiers sometimes becomes slightly lower as they warm up in the first quarter of an hour or so. The rectifier should be thoroughly warmed up before experiments are made. The best advice is to get the set working well as a battery job before attempting the mains circuits.

Whilst dealing with the valves, the writer would like to point out the shortcomings of the mixer and output valves in the 1.4 volt range. The most popular mixer is the 1A7 but this valve does not oscillate so readily as its big brothers. Using commercial coils, it may be found necessary to use an oscillator grid leak of as high as 200,000 ohms, where a mains valve would use 20,000 ohms.

The output valve deserves a word, too. The 3C5, 3Q5, etc., only give an output of 0.25 watts. Therefore it is necessary to have a really sensitive speaker that is accurately matched, to get the most out of the output stage. A speaker, designed solely for 1.4 volt output valve has just come on the market and is made by Electro Acoustic Industries. The writer does not possess one of these instruments as yet, but the trade reports have been very good.

CONCLUSION

The writer hopes that the foregoing has cleared up some snags and pitfalls in the path of the amateur constructor, and that the beginner, at least, may have a better understanding of these interesting receivers.

A.C./D.C. RECEIVER CONSTRUCTION MANUAL

Section 2

INTRODUCTION

In this section, the author sets out to give a full description of two receivers in the " midget " class which can be quite easily and economically built by the home constructor. These consist respectively of a four-valve " straight " set and a five-valve superhet. In each case, the writer has designed sets that can be made with a reasonable variety of components of differing manufacture so that the constructor will not have difficulty in obtaining the parts.

A 4-VALVE A.C./D.C. MIDGET STRAIGHT RECEIVER

DESIGN OF THE RECEIVER

Before proceeding with a description of the construction of this receiver a few words would not be wasted in considering the problems of design as encountered by the writer.

Firstly, what circuit line-up could be used? There are two choices: we could use a circuit consisting of an H.F. stage, detector and output, or a simpler type, consisting of detector and two L.F. valves. The first version gives the advantage of some extra selectivity, in that two tuned circuits would be used, the second version having only one tuned circuit. The selectivity to be gained by the H.F. stage does not, however, always merit its inclusion. The interference usually suffered is found on the medium-wave band after dark, when foreign stations increase in effective strength and give adjacent channel interference and whistles with the more distant B.B.C. Home stations. A selectivity of, at worst, 10-15 kc/s on either side of the required frequency is required to overcome this interference and the extra coil circuit given by the H.F. stage would certainly not give this. If large, highly-efficient coils were used, a reasonable measure of selectivity could be obtained, but midget construction does not permit this. Thus, the usual result of using the H.F. stage is an obvious increase in sensitivity, but not sufficient increase in selectivity to remove the offending foreign stations.

The writer carried out some experiments with two different receivers in various parts of the country. One set was a three-valver consisting of H.F., detector and output stages. The other, also a three-valver, consisted of a detector, L.F. and output valve. They both used similar coils. It was found, that for the same speaker volume, they both needed about ten feet of aerial wire. The set with the H.F. stage was more selective, but certainly not sufficiently selective to remove whistles from the too-adjacent interfering stations on the medium-wave band. In both cases, as night advanced and the effective strength of the foreign stations increased, it was necessary to use reaction to sort out the more distant B.B.C. stations. In most parts of the country, the local home stations were sufficiently strong to override any interference on either set, at all times of the day and night. The main conclusions drawn, therefore, were that both sets gave more or less the same performance, and that reaction in both cases, though not being necessary, was a very helpful adjunct.

Concluding that both circuits gave more or less similar results, other requirements were considered. The construction of an O — V — 2[1] would very definitely be cheaper and simpler than that of the 1 — V — 1[2]. It could also be made smaller. Instead of using a two-gang condenser a single-gang condenser would be used, and this could consist of a solid-dielectric type, thereby taking up little space. The layout problem is simplified as no screening between circuits is necessary, except for the L.F. circuit to the grid of the first valve (this consisting only of a wire from the valve's grid to the grid condenser, and being probably only an inch or so long!). There would be no contingency of R.F. instability; and the only probably trouble would be L.F. instability, a very easy problem to solve. So it was decided to design an O — V — 2 type of set.

THE CIRCUIT

The circuit finally arrived at is shown in Fig. 29, and as may be seen, it is simplicity itself. Two triodes are used followed by an output pentode. The triodes are actually double-diode-triodes with the diodes disused and connected to earth. The diodes are omitted in Fig. 29 for purposes of simplicity.

The aerial is directly tapped into the coil, the Wave-change switch connecting it to either the medium—or long—wave section of the coil as required. All that is needed in most localities is about ten feet of wire for the aerial and this has negligible loading effect on the coil. Larger aerials may be connected via a condenser; and this point is discussed later. The tuning coil, L_1 and L_2, is a home constructed job. It is tuned by a .0005 μfd. solid-dielectric tuning condenser, and connects to the grid of the first

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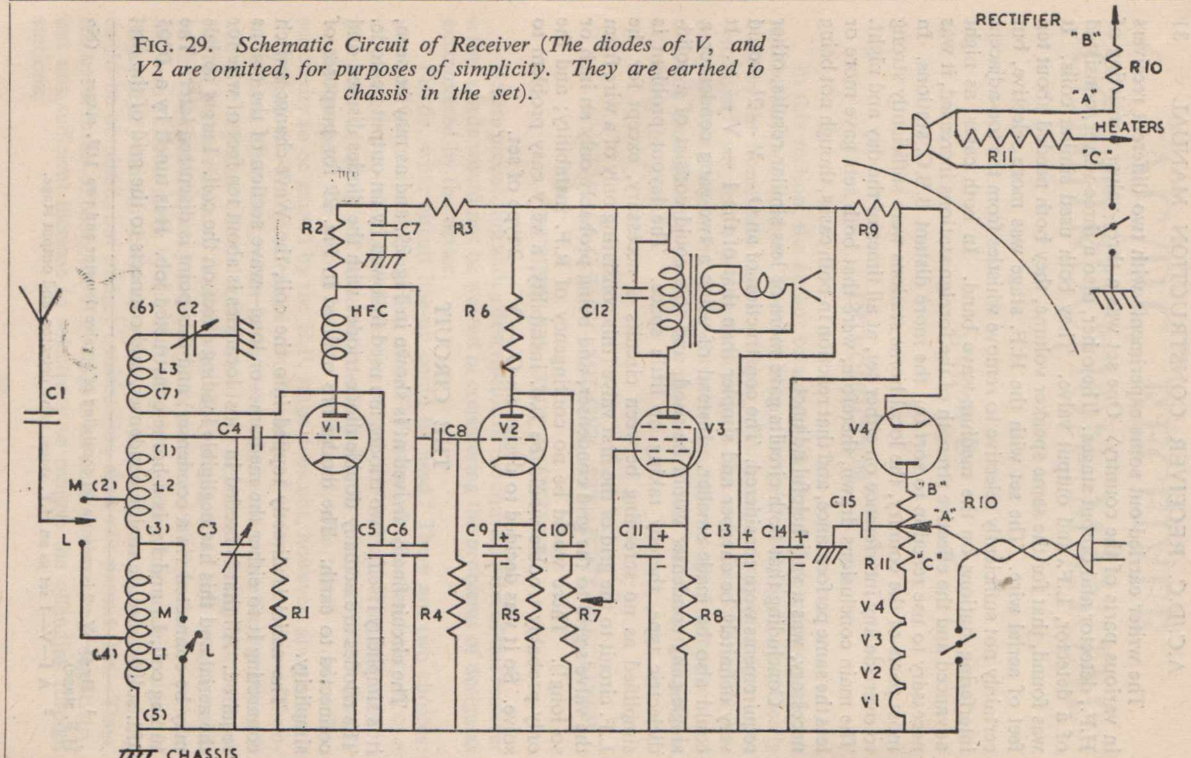
[1] By O—V—2 is meant a set consisting of a valve detector and two L.F. stages. (No H.F. stage).

[2] A 1—V—1 set as an H.F. stage, valve detector, and output stage.

FIG. 29. *Schematic Circuit of Receiver (The diodes of V, and V2 are omitted, for purposes of simplicity. They are earthed to chassis in the set).*



valve via the usual leaky-grid circuit. The cathode of this valve is tied to earth. Reaction is taken from its anode by means of a conventional condenser circuit, one reaction coil serving for both ranges. A .0005 μfd. condenser, C5, in conjunction with the H.F. choke filters away unwanted R.F. currents. The choke is described in detail later on in this chapter. Another condenser, C6, of .005 μfd., bypasses the higher A.F. frequencies to earth; this is needed due to the fact that the midget speaker used gives slightly shrill results, and a rather heavy form of tone correction is needed to counteract this. The anode load for the first valve is the usual 100 KΩ and the anode is decoupled by means of R3, and C7, a condenser whose capacity is at least .25 μfd. to 2 μfd. For this condenser, C7, either a paper or electrolytic type of condenser may be used, according to the facilities of obtaining same. Any physically small condenser of sufficient capacity will suffice here. Decoupling on the first anode is necessary to reduce any hum in the H.T. line and to prevent A.F. instability.

A.F. is passed to the grid of the second valve via C8. Cathode bias is applied to this valve, using R5 and C9, and the signal from the valve's anode is passed to the grid of the output valve, a pentode, via C10 to R7, the volume control. It was decided to fit a volume control in addition to the reaction control as this greatly extends the usefulness of the receiver. In most cases the control would hardly be used at all; it being simply necessary to adjust the tuning and reaction condensers with the volume control set to maximum all the time. However, if it is required to select a weak station, it may be necessary to advance the reaction control further than usual to obtain sufficient selectivity. With reaction thus advanced, reception may be too loud and the volume can then be turned down by means of the volume control. The volume control is applied on the last stage to ensure that it does not affect the reaction setting. It is of the type fitted with a switch and is used for switching the set on and off. But let us return to the circuit.

The output pentode drives the speaker (a 2½ inch Celestion model) through a midget speaker transformer paralleled in its primary by a .005 μfd. condenser, the latter giving further tone correction.

H.T. is supplied by means of the usual half-wave rectifier and is smoothed by two T.C.C. "Micropack" 16μfd. condensers and a 1,500 ohms resistance R9.

THE DROPPER AND LIMITING RESISTANCE

It was found, with the layout used by the writer, that it was possible by mounting the valves very close together, to find room for a small mains dropper on the chassis, and so, as this made the set much cheaper and more reliable than it would have been using a line cord (and, also, as it would be impossible to make the chassis any smaller by leaving the dropper out), it was decided to include it. Nevertheless, using the dropper will necessitate making the cabinet a little wider, because a heat screen (or asbestos sheeting) must be mounted between the dropper and the internal side of the cabinet. If this slight increase in size of the cabinet is considered sufficiently important by the constructor, he can easily use a line cord; the limiting resistance R10, which is part of the dropper, may be mounted as a separate resistance in the space left by the dropper's exclusion. It should be noted that the inclusion of the dropper on the chassis will make the cabinet wider by only about half an inch!

It should be pointed out here that the dropping resistance used actually provides us with two resistances. Most of the resistance wire is used as the dropper for the valve heaters, the remainder being used as the limiting resistance for the rectifier. Thus the resistances R10 and R11 in the circuit diagram Fig. 29 are actually the single dropping resistance tapped at point "A," the connections "B" and "C" being the ends of the resistance winding. If a line cord is used, it will be necessary to mount a 150 ohms resistance in the place occupied by the dropper. 3-way line cord will be needed and the circuit is given in the inset in Fig. 29.

VALVES

A list of the valves and their equivalents are given in the component lists at the end of this chapter. Triodes with their grids taken out to top caps are essential for V1 and V2, as sub-base grids would be too near to the heater leads and would pick up hum. The output valve is a low-power pentode, as a high-power valve may overload and perhaps damage the small speaker.

THE COMPONENTS

In the component list already mentioned, it will be noticed that most of the components recommended have no manufacturer's name supplied. This is because these components have the same physical size and the same electrical characteristics whoever their makers may be. Ex-Government surplus may be used for most of the condensers and resistances if so desired. In addition, components may be purchased these days made by such a multitude of small firms who have sprung up since the war, that it is impossible to recommend a particular type. The writer found so many different makes of output transformers and mains droppers that, in the list, he only specifies the maximum physical dimensions! So finally, as it was decided to design a set that would be easy to construct, and, bearing in mind the difficulty of obtaining components of specific manufacture, the writer was reluctantly forced to adopt this procedure of not recommending any particular make. He cannot emphasise too strongly the fact that any ex-government surplus, or anything made by a firm of doubtful repute, should be thoroughly inspected before purchase.

THE H.F. CHOKE

A component that needs a paragraph to itself is the H.F. choke connected in the anode circuit of V1. This is of the type known as a "reaction" choke, and consists simply of a small bobbin filled with thin enamelled wire, pile-

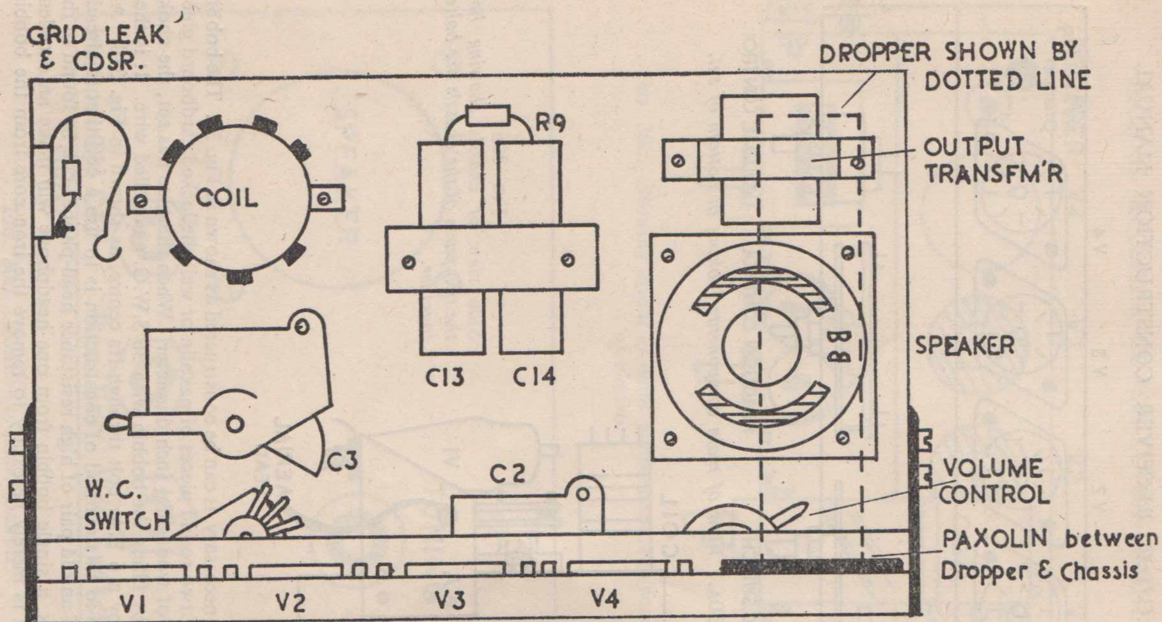


FIG. 30. *View of main components from rear of set. Valves are removed, and dropper is shown in dotted outline.*

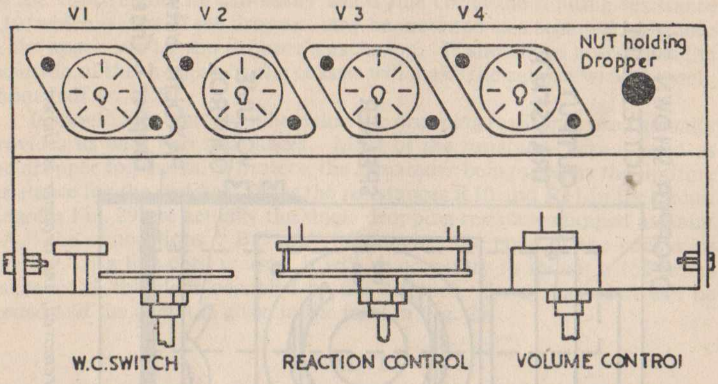


FIG. 30A. *View of main components looking at bottom of set.*

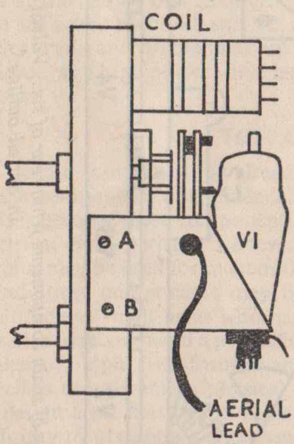


FIG 30B
Side view of chassis showing how the two parts of the chassis are bolted together.

wound. If necessary, it can be constructed as shown in Fig. 31. The bobbin consists of two round pieces of paxolin or well-shellacked cardboard glued to a piece of wood of ¼ inch diameter. When the glue has set, the choke is wound by filling the bobbin with 36 S.W.G. enamelled wire. It is then mounted by a 6 B.A. bolt through its centre, as shown in Fig. 31d. An alternative to this method of construction is to use a coil that is already wound; if an old pair of high resistance head-phones can be found in the spares box, a single bobbin from one headphone will make an excellent choke! It is merely necessary to remove the iron core from the bobbin

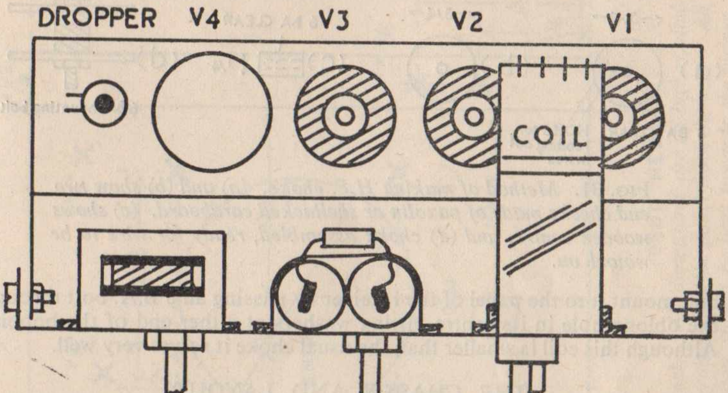


FIG 30C. *Showing layout of main components seen from top of chassis.*

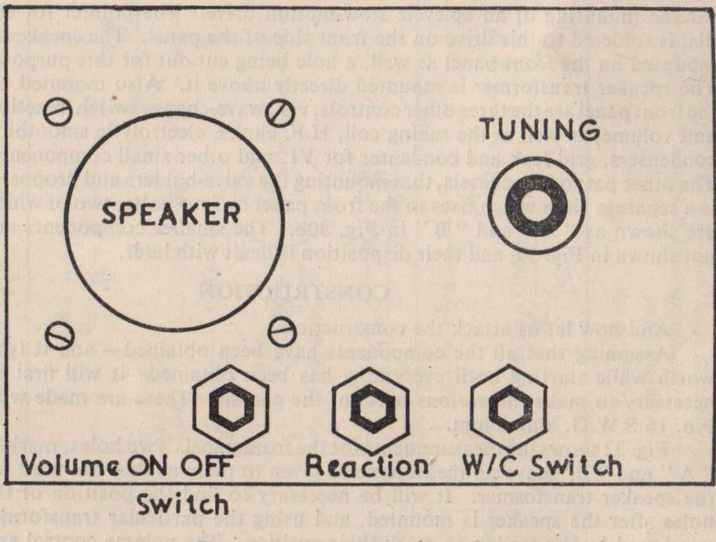


FIG. 30D. *Position of panel controls.*

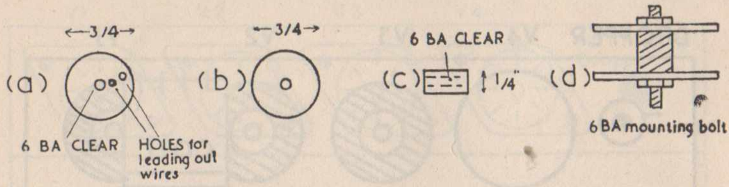


FIG. 31. *Method of making H.F. choke. (a) and (b) show two end cheeks made of paxolin or shellacked cardboard. (c) shows wooden centre, and (d) choke assembled, ready for wire to be wound on.*

and mount it to the panel of the receiver by passing an 8 B.A. bolt through the oblong hole in its centre, fitting washers at either end of the bobbin. Although this coil is smaller than the usual choke it serves very well.

THE CHASSIS AND LAYOUT

The layout of the set is shown roughly in Figs. 30 to 30d. Fig. 30d shows the view from the front of the panel. The position of the controls if remembered, will help in explaining the layout. Fig. 30 shows the back of the set with the valves removed and the dropper shown in dotted outline. The tuning condenser is mounted back from the panel on a bracket to allow for the mounting of an epicycic slow-motion drive. The pointer for the dial is soldered to this drive on the front side of the panel. The speaker is mounted on the front panel as well, a hole being cut out for this purpose. The speaker transformer is mounted directly above it. Also mounted on the front panel are the three other controls, viz., wave-change switch, reaction and volume, as well as the tuning coil, H.F. choke, electrolytic smoothing condensers, grid leak and condenser for V1, and other small components. The other part of the chassis, that mounting the valve-holders and droppers, is a separate piece which fixes to the front panel by four bolts, two of which are shown as " A " and " B " in Fig. 30b. The smaller components are not shown in Fig. 30, and their disposition is dealt with later.

CONSTRUCTION

And now let us attack the construction.

Assuming that all the components have been obtained— and it isn't worth while starting until everything has been obtained—it will first be necessary to make the various parts of the chassis. These are made with No. 16 S.W.G. aluminium.

Fig. 32 shows the measurements for the front panel. Two holes, marked " A " and " B," have no measurements given to them as they are used for the speaker transformer. It will be necessary to find the position of the holes after the speaker is mounted, and using the particular transformer purchased by the reader, to mark their position. The volume control and

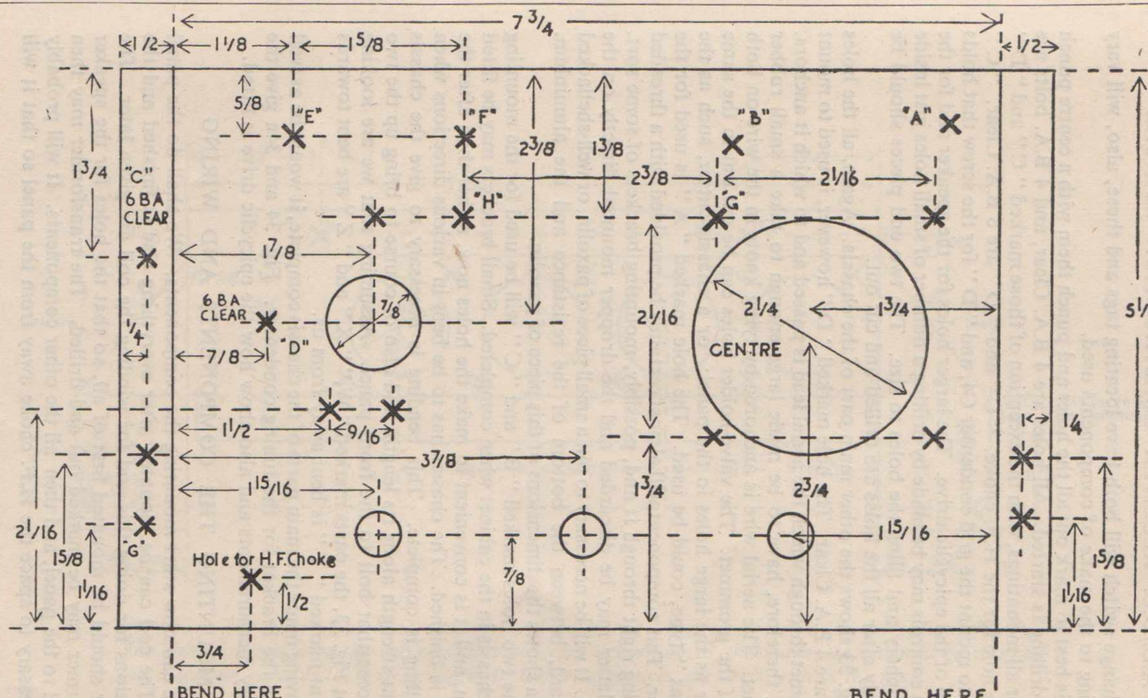


FIG. 32. *Diagram showing positions of drilling holes on main panel. All dimensions are in inches, and all holes, except three, are 4BA clear. It will be noted that this diagram shows the panel from the rear. All holes are marked thus :—" X" The two sides pieces, after completion, should be bent towards the viewer.*

wave-change switch will both have locating tags and these, also, will vary according to the make of components used.

It is best to mark out all the holes and punch them with a centre punch before drilling is started. All holes are 4 B.A. Clear, and 4 B.A. bolts are used for all mountings, with the exception of those marked " C " and " D " and the hole for the H.F. choke. " C " and " D " are 6 B.A. Clear. " C " is used to mount the grid condenser C4, and " D " for the screw that holds the stop of the epicyclic drive. The larger holes for the speaker and for the various controls may be made by drilling a number of small holes just inside the periphery and filing the holes to size. The two end pieces should be bent only after all the holes are drilled and cut out.

Fig. 33 shows the other main part of the chassis. Again, all the holes shown are 4 B.A. Clear. The hole marked " D," however, is used to mount a grommet through which the aerial lead is passed and to which it anchors. It will, therefore, have to be made large enough to take a small rubber grommet. The aerial wire is anchored by tying knots in the wire on both sides of the grommet. The valve-holder holes can be cut out in the same manner as the large holes in the panel; or a chassis-cutter, such as the " Q-Max " type, could be used. The hole marked " A " is used for the dropper. This component will almost certainly be provided with a threaded rod going right through it and, possibly, mounting brackets of some sort. These latter may be discarded and the dropper mounted directly on the chassis. It will be necessary to put a small piece of paxolin, or well-shellacked cardboard, between the bottom of the resistance and the aluminium. Fig. 33a shows the dimensions of this piece of paxolin.

The two holes marked " B " and " C " will be used for the mounting of the chassis in the cabinet when completed. Small brackets may be fitted to them, and it is convenient to make the holes now, rather than after the chassis is finished. The chassis has to be bent in various directions when the drilling is complete. This bending is necessary to give the chassis sufficient strength along its length, and also of course to bring up the two side pieces that bolt to the front panel. Assuming that we are looking down at Fig. 33, the parts marked " W," " X " and " Z " are bent towards us. That marked " Y " is bent away from us.

Having made the main parts of the chassis complete, it would be as well to make the bracket for the tuning condenser. Fig. 34 and 34a give the necessary measurements and also show how the epicyclic drive is fitted.

MOUNTING THE COMPONENTS AND WIRING

We can now start mounting the components. We shall do the panel first. The coil can be mounted after everything else is finished and the instructions for doing this and for winding the coil are given later. The speaker should be mounted first of all, so that the holes for the speaker transformer may be marked out and drilled. The transformer may then be fixed to the panel, and then all the other components. It will probably be necessary to space the H.F. choke away from the panel so that it will

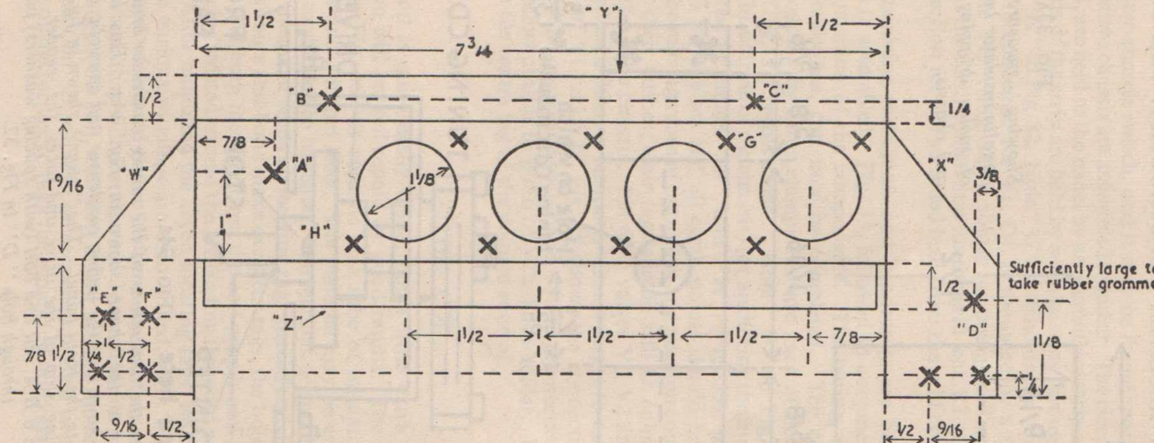


FIG. 33. *Top plan of smaller chassis. All holes are 4B.A. clear with the exception of " D." The holes for mounting the valve-holders will vary according to the make, and should be marked out after the valve holders are obtained. Other references are dealt with in the text.*

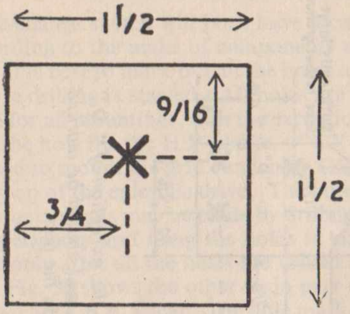
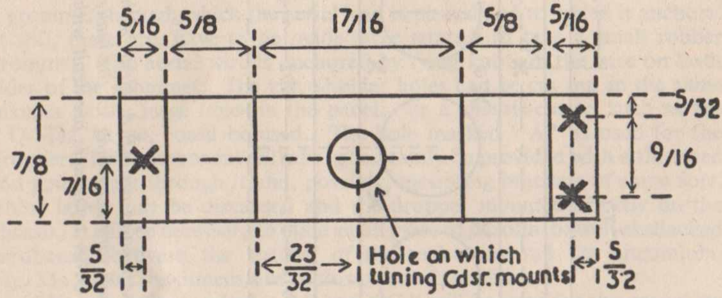


FIG. 33A.
Showing measurements of paxolin insulator between base of mains dropping resistance and chassis.



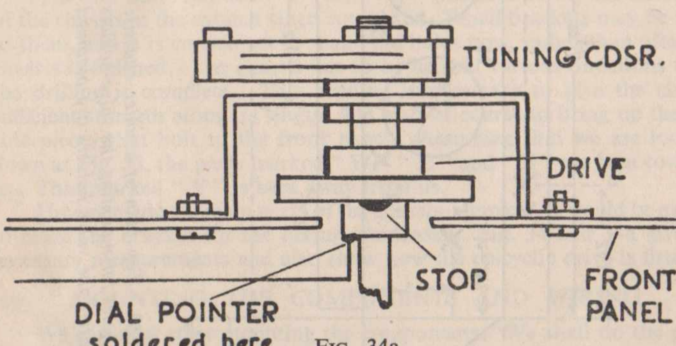


FIG. 34a.

Fig. 34. gives the dimentions of the tuning condensor bracket, which is bent to the shape shown in Fig. 34a. This latter figure also shows how the tuning condenser and epicyclic drive are mounted to the front panel. The "stop" shewn in fig. 34a is the anchoring stop of the drive and faces the reader. It is enclosed by a 6 B.A. nut and bolt (with spacing washers) passed through hole "D" in Fig. 32.

clear the wave-change switch, and it may be found more convenient to do this after the two chassis are assembled together. The electrolytic condensers, C 13 and 14, are held to the panel by an aluminium strip as shown in Fig. 30. The two ends of the strip are held by bolts passing through the holes marked " G " and " H " in Fig. 32. Hole " G " also holds one corner of the speaker.

The grid condenser for V1, C4, is mounted by a 6 B.A. bolt passed through hole " C " (Fig. 32), a solder tag being fixed under the nut. This tag provides the earth connection for the grid leak R1. It also provides the earth connection for the screened lead from the grid condenser to the grid of V1.

The remaining resistances and condensers are best connected after the chassis is assembled. Fig. 35, followed in conjunction with Fig. 35a. shows the position of the components. The wiring, except for the coil and its connections, can now be completed. The condensers C7 and C15 are mounted by using clamps and are fixed at holes " G " (Fig. 32) and " E " (Fig. 33) respectively. Hole " F " in Fig. 33 is used for a clamp (on the outside of the chassis) for anchoring the mains wire. Earthing tags mounted at points " G " and " H " (Fig. 33), provide the earthly connections for the set and all earth points should be bonded together. Although the moving vanes of the tuning and reaction condensers are already earthed by their bushes, their tags should still be connected to the other earth points on the chassis. Pin 6 on valves V1, V2 and V3 is blank and may be used as a dummy terminal. Don't forget to earth the diodes and metallising of V1 and V2. Fig. 38 shows the connections to the various valve pins. The grid leads to V2 and V3 are unscreened and that of V2 is anchored below chassis to pin 6 of V2's valve-holder. That of V3 is taken direct from the centre tag of the volume control.

THE COIL

The coil is quite easily made, but a little extra care spent on its construction will be well repaid by good results. The former for the coil is shown in Fig. 36. It consists of a tube of insulating material 1 inch in diameter and 3 inches long. The material may be anything from heavy shellacked cardboard to bakelite. Connections are made to the top end of the coil by means of seven connecting tags spaced equally around the edge. 8 B.A. brass nuts and bolts make excellent tags, the bolt being cut off close to the nut, and both the wire from the coil proper and the wire to the rest of the set being twisted around the protruding threaded part of the screw and soldered. After mounting the seven locating tags, small holes to take the ends of the various windings are then drilled, as in Fig. 36. These holes should be spaced around the coil former so that they will fall in line with the tag to which they will correspond. It is advisable to start with one tag when making up the coil, and then follow around the coil with each consecutive connection. It will also be necessary to drill two 6 B.A. clear holes at the base of the former to take the mounting brackets shown in Fig. 36a.

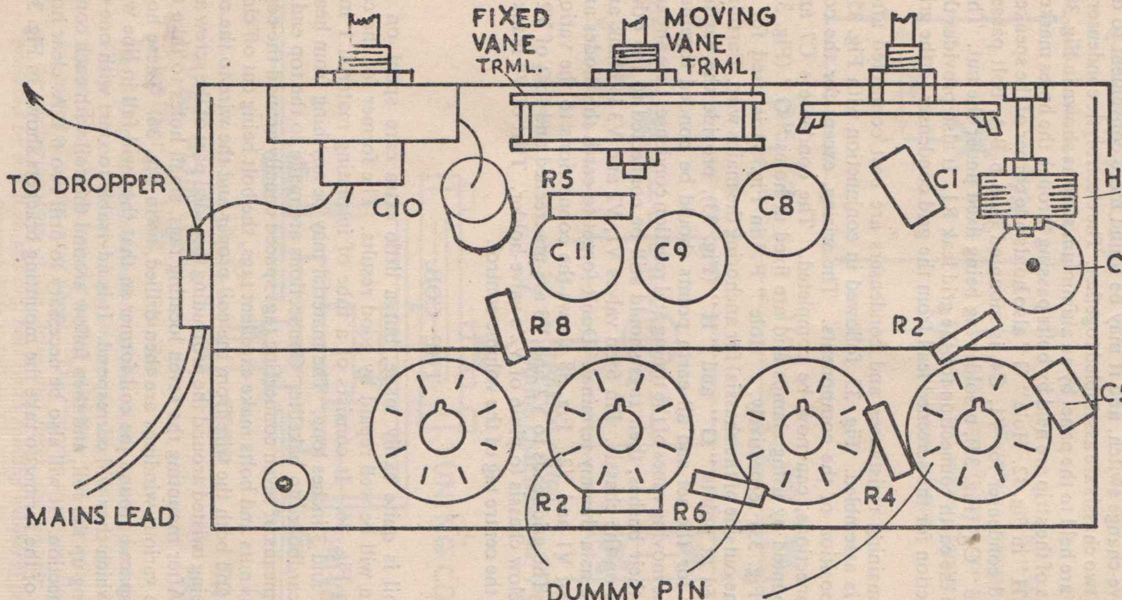


FIG. 35. *This diagram shows the position of the various components below the chassis.*

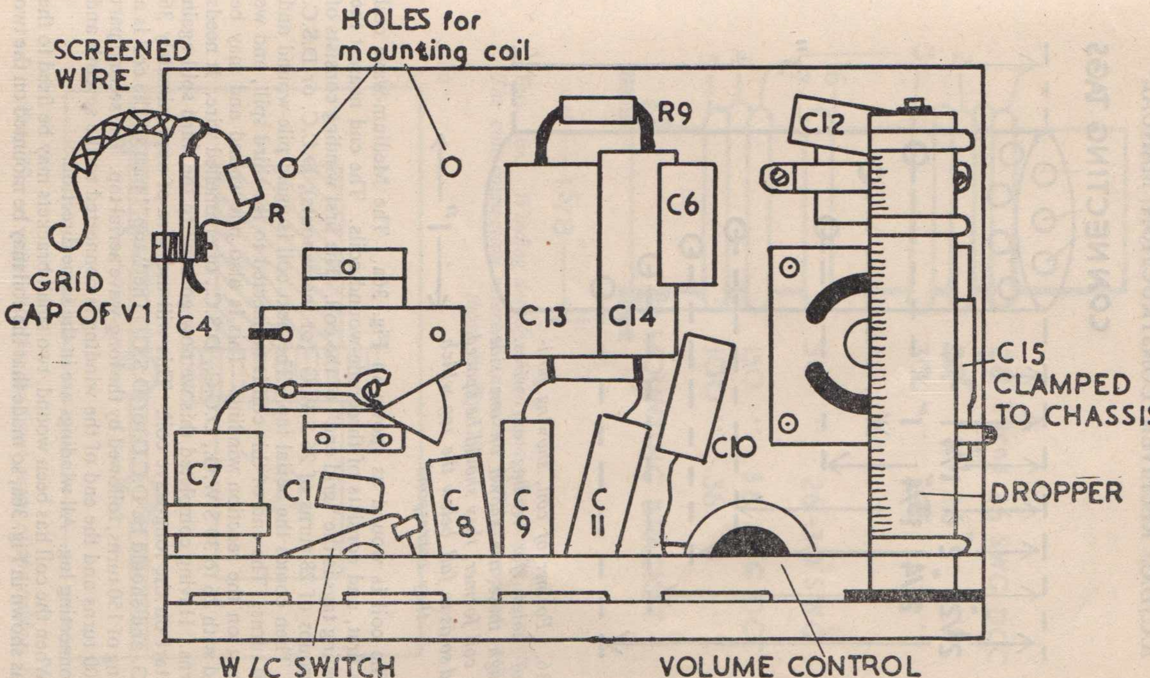


FIG. 35A. *Back view of the chassis before the coil is mounted.*

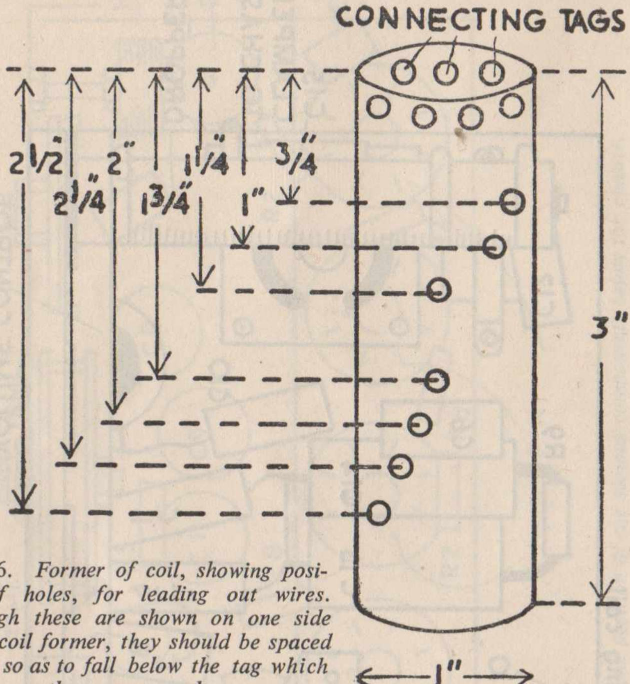


FIG. 36. *Former of coil, showing position of holes, for leading out wires. Although these are shown on one side of the coil former, they should be spaced around so as to fall below the tag which they correspond.*

The coil is wound as shown in Fig. 36a. The Medium-wave coil comes first, and consists of three pile-wound coils. The end nearest the connecting tags is the "grid end" of the coil. The first winding consists of two groups of 28 turns of 26 S.W.G (or thereabouts), D.C.C. or D.S.C. wire. Then comes the aerial tap. The next coil is again pile-wound and has 30 turns. The end of this coil is connected to the third spill, and we next put on the reaction winding. This is also pile-wound and may be wound with 26 to 30 S.W.G., D.C.C., D.S.C., or enamelled wire. It needs 50 turns. Having completed this we now go back to the third spill again and start on the long-wave coil. This will use wire of approximately 36 S.W.G. and should be D.C.C. or D.S.C. The "top" part of the coil is a winding of 150 turns, followed by the long-wave aerial tap. The second part has 100 turns and the end of the winding is connected to the seventh and last connecting lug. All windings are in the same direction.

When the coil has been wound, two small brackets may be fixed to the base as shown in Fig. 36a, so made that the coil may be mounted on the two

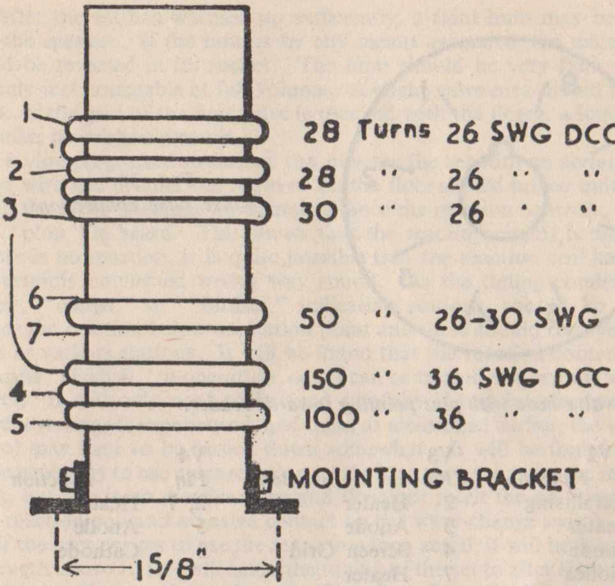


FIG. 36A. *Winding details of coil, and of mounting brackets. The coil connection reference numbers* (1-7) *correspond with those in Fig.* 29.

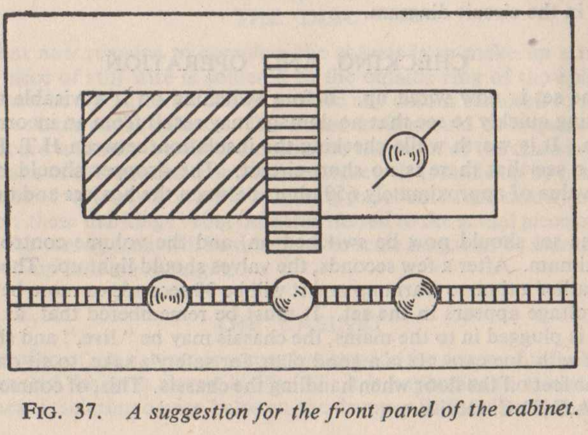


FIG. 37. *A suggestion for the front panel of the cabinet.*

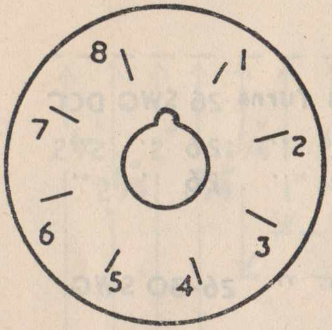


FIG. 38.
Valve base connections.

View of valve base with pins pointing towards reader.

VI and V2

Pin	*Function*
1	Metallising
2	Heater
3	Anode
4, 5	Diodes
7	Heater
8	Cathode
Top Cap	Grid

V3

Pin	*Function*
2	Heater
3	Anode
4	Screen Grid
7	Heater
8	Cathode and Suppressor Grid
Top-Cap	Signal Grid

V4

Pin	*Function*
2, 7	Heaters
5	Anode
8	Cathode

holes marked " E " and " F " in Fig. 32. The coil is then connected up as shown in the circuit diagram.

CHECKING AND OPERATION

The set is now wired up. Before switching on it advisable to check the wiring quickly to see that no damage may result from an incorrect connection. It is worth while checking the insulation between H.T. Pos. and earth to see that there is no short-circuit. The dropper should be set to give a value of approximately 650 ohms between the heaters and the mains input.

The set should now be switched on, and the volume control turned to maximum. After a few seconds, the valves should light up. The rectifier takes rather a time to warm up and it will be 30 seconds or more before any H.T. voltage appears in the set. It must be remembered that, as soon as the set is plugged in to the mains, the chassis may be " live," and should be treated with due care. It is a good plan, for safety's sake, to sit on a chair with the feet off the floor when handling the chassis. This, of course, applies to all A.C./D.C. receivers.

After the set has warmed up sufficiently, a faint hum may be heard from the speaker. If the hum is by any means excessive, the mains plug should be reversed in its socket. The hum should be very faint indeed and only just noticeable at full volume. A slight valve-hiss should also be heard. If the grid of the first valve is touched with the finger, a loud hum, or similar noise should result.

Having progressed so far, we can now try the set with an aerial. Ten feet of wire laid around the room or on the floor should suffice quite well. Switch the set to Medium-wave, and advance the reaction controls, until a faint "plop" is heard. This shows that the reaction circuit is working. If there is no reaction, it is quite possible that the reaction coil has been inadvertantly connected wrong way round. As the tuning condenser is rotated, "chirps," or "Birdies," indicating stations, should be heard. Reduce the reaction below oscillation point and these should resolve themselves as various stations. It will be found that the reaction control is by no means "ticklish" in operation, and it can be treated as a normal volume control. It will only need to be used carefully if bad interference from adjacent stations is experienced, and then, as mentioned earlier, the volume control may have to be turned down somewhat. It will be found that it will be necessary to use more reaction on the long waves than on the medium waves, but this is no disadvantage and does not merit the addition of an extra reaction coil and an extra contact on the wave-change switch.

If the user desires to use the set with a long aerial, it will be found that any length above 10 feet will cause the tuning of the set to alter slightly, and excessive lengths may damp the coil. Therefore, for aerial lengths between ten and twenty feet it is best to put a 100$\mu\mu$fd. condenser between the aerial and the set, and for longer aerials, a 50 $\mu\mu$fd. condenser.

No earth connection is needed with this receiver.

THE DIAL

All that now remains to complete the chassis is to make up a tuning scale. A piece of stiff wire is soldered to the outside ring of the epicyclic drive and acts as a pointer. It can be painted any colour required to match the colour scheme of the cabinet. The actual scale should be drawn out on stiff cardboard and may be either fastened to the front of the chassis panel or to the back of the wooden front of the cabinet. It is made up by marking the positions of various stations on to tracing paper held temporarily behind the pointer, these markings being then transferred to the actual piece of card on which the tuning scale will be drawn. The scale may then be marked out and divided up into wave lengths.

THE CABINET

The design of the cabinet is somewhat outside the scope of this chapter but a suggested design is shown in Fig. 37. It is important to mount some form of heat-insulating device between the dropper (if fitted) and that area of the inside and top of the cabinet adjacent to this component. Either asbestos sheeting, or a piece of aluminium (spaced ⅛ of an inch from the wood by washers) may be used. The back of the cabinet should give access to plenty of air for cooling purposes.

It will be found that this little chassis gives very good results, despite its small size and simplicity of construction, and the author guarantees excellent entertainment if suitable care is taken in its construction.

COMPONENT VALUES OF FIG. 29 :

C1	.0003 μfd., mica
C2	.0003 μfd., variable, solid dielectric, reaction
C3	.0005 μfd., variable, solid dielectric, tuning
C4	.0003 μfd., mica
C5	.0005 μfd., mica
C6	.005 μfd., mica or paper
C7	.25 μfd., or upwards, paper or electrolytic
C8	.01 μfd., paper
C9	25 μfd., 25 W.V., electrolytic
C10	.01 μfd., paper
C11	25 μfd., 25 W.V., electrolytic
C12	.005 μfd., paper
C13, 14,	16 μfd., 350 W.V., T.C.C. " Micropack "
C15	.01 μfd., 1,000 W.V.D.C., paper
R1	1 M.ohms., ½ watt
R2	100 K.ohms., ½ watt
R3	10 K.ohms, ½ watt
R4	250 K.ohms., ½ watt
R5	600 ohms, ½ watt
R6	100 K.ohms, ½ watt
R7	250 K.ohms, potentiometer, with switch
R8	500 ohms, ½ watt
R9	1,500 ohms, 1 watt
R10	150 ohms, 5 watt } Dropper, if fitted
R11	650 ohms, line cord } Dropper, if fitted

VALVES. See Component List

COMPLETE COMPONENTS LIST FOR THE 4-VALVE STRAIGHT RECEIVER

VALVES

	Mullard	Cossor	Ex-W.D.
V1 and V2	EBC 33	OM 4	C.V. 1055
V3	EL 32	OM 9	C.V. 1502
V4	CY 31, CY 32	OM 1	

COMPONENTS LIST (Continued)

- 1 Volume Control (250 K.ohms), with switch
- 1 Speaker (Celestion 2½ in. model)
- 1 Speaker Transformer (Max. dimensions are 2¾ in. long x 1½ in. wide x 1½ in. deep. To match mains pentode)
- 1 Dropping resistance, 800 ohms 0.2 amp. (Max. dimensions are 1 in. diam. x 4¾ in. long), *or* 650 ohms, 0.2 amp., 3-way line cord *and* 1 150 ohms, 5 watt resistance
- 1 Variable Condenser, .0005 μfd., tuning, solid dielectric
- 1 Variable Condenser, .0003 μfd., reaction, solid dielectric
- 1 Wave-Change Switch, Yaxley, 2 pole, 2 way
- 1 Slow-motion drive, epicyclic
- 1 H.F. Choke, " reaction type " (see text)
- 2 Condensers, .0003 μfd., mica
- 1 Condenser, .0005 μfd., mica
- 1 Condenser (C7), .25 μfd., or upwards (see text)
- 2 Condensers, .005 μfd., mica or paper, 350 W.V.
- 2 Condensers, .01 μfd., mica or paper, 350 W.V.
- 1 Condenser, .01 μfd., paper, 1,000 W.V.
- 2 Condensers, 25 μfd., 25 W.V., Electrolytic
- 2 Condensers, 16 μfd., 350 W.V., Electrolytic, T.C.C. " Micropack"
- 1 Resistor, 1 M.ohms, ½ watt
- 2 Resistors, 100 K.ohms, ½ watt
- 1 Resistor, 10 K.ohms, ½ watt
- 2 Resistors, 250 K.ohms, ½ watt
- 1 Resistor, 600 ohms, ½ watt
- 1 Resistor, 500 ohms, ½ watt
- 1 Resistor, 1,500 ohms, 1 watt
- 4 International-Octal valve-holders
- 1 Rubber Grommet, small
- 1 Mains Lead and Plug (If line-cord not fitted)
- 4 Knobs

Sheet aluminium, nuts, bolts, etc., etc.

A 5-VALVE A.C./D.C. MIDGET SUPERHET RECEIVER

INTRODUCTION

We now come to a more complicated type of receiver, namely a 5-valve all-wave superhet. The construction of this set is not difficult by any means, so long as the constructor is reasonably proficient with the soldering iron and other tools, and is prepared to take just that little extra care required in its construction.

A design has been chosen that makes for easy duplication, and the choice of valves has been given special attention. Components are easily, obtainable and the specifications are as follows :—

Dimensions of Chassis :—4 in. by 9½ in. by 5¼ in.

Description of Circuit :—4-valve superhet (+ 1 valve rectifier), all-wave reception (700-2,000, 200-550 and 16-47 metres), A.V.C., 3-position tone control, excellent sensitivity and good quality reproduction.

VALVES

In making a choice of the types of valve around which to build this receiver the final decision was found to rest between using 0.2 or 0.3 amp. valves. Both types are manufactured for International Octal valve bases, the 0.2 amp. types being of English manufacture only, whereas the 0.3 amp. series offers the use of both English and American type valves. The 0.2 amp. types are manufactured in one physical size only, whereas the 0.3 amp. types can be found in normal, " metal " and " bantam " sizes. To those unfamiliar with these valves perhaps the writer had better give an illustration. The valve type 6K8 G is triode-hexode frequency-changer and is made in a normal-size glass bulb of the same size as, say, an X 65 or other similar type valve. A 6K8 GT, however, is a valve having exactly the same characteristics but in a glass bulb about an inch shorter in length. And a valve type 6K8 is the same valve in a black metal case (connected, by the way, to an earthing pin on the base) and has slightly smaller dimensions than the GT valve.

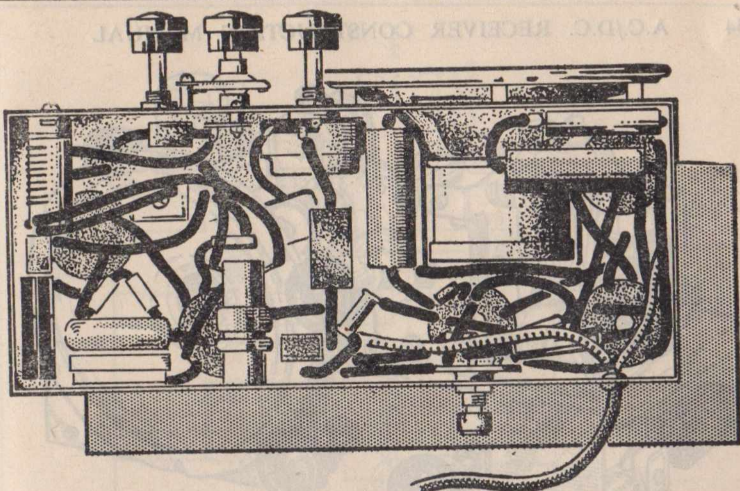
This set has been designed around valves of the " GT " or " metal " type, but, if so desired, certain English equivalents or the " G " type valves may be used just as efficiently: the only difference being that the set will be about an inch and a quarter higher. The illustrations on pages 55 and 56 show the set fitted with a mixture of " metal " and " GT " type valves and it will be agreed that they give a very compact layout.

When buying the valves, and especially when ordering through the post, the constructor should emphasise the type of valve required. In Fig. 49, at the end of this section, basediagrams of suitable valves are shown.

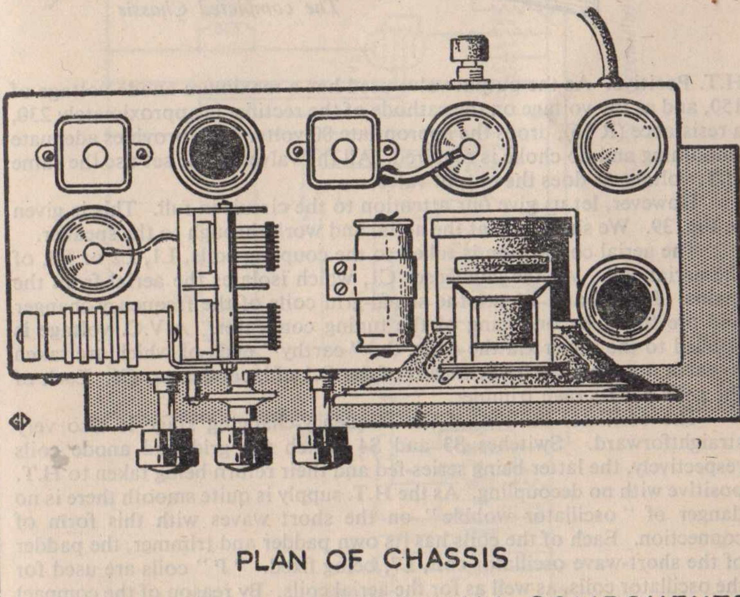
THE CIRCUIT

Having settled the valve question, the circuit is the next point worth considering.

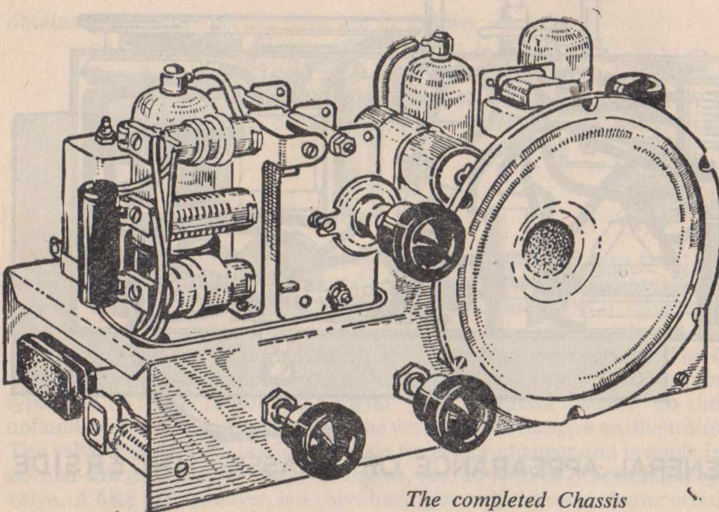
When designing a circuit for a set of this type all sorts of considerations have to be kept in mind. As far as possible, midget components help to keep the size within reasonable proportions; but, after the set has been reduced to a small size, certain components, such as decoupling condensers, are found to take up a proportionately large amount of space. For this reason very little decoupling has been used in the set, the 16 μfd. condenser, C 27, providing an excellent by-pass for all R.F., I.F. and A.F. returns to



GENERAL APPEARANCE OF CHASSIS UNDERSIDE



PLAN OF CHASSIS
SHOWING POSITION OF MAIN COMPONENTS



The completed Chassis

H.T. Positive. As the output valve used has a maximum anode voltage of 150, and as the voltage on the cathode of the rectifier is approximately 230, a resistance (R 16), drops the appropriate 80 volts. This provides adequate smoothing and no choke is required. All the valves in the set use the same H.T. voltage as does the output valve.

However, let us give our attention to the circuit in full. This is given in Fig. 39. We shall start at the aerial and work through to the speaker.

The aerial connection is taken to the coupling coils, L1, L2 or L3, of the aerial coils, via the condenser C1, which isolates the aerial from the mains. L4, L5 and L6 are the signal-grid coils of the frequency-changer and are tuned by one gang of the tuning condenser. A.V.C. voltage is applied to the mixer via the coils, the " earthy " ends of which are taken to earth (*i.e.*, to chassis) by means of the O.1 μfd. condenser, C6. Each of the coils has its own trimmer.

The oscillator section of the frequency-changing stage is also very straightforward. Switches S3 and S4 switch the grid and anode coils respectively, the latter being series-fed and their return being taken to H.T. positive with no decoupling. As the H.T. supply is quite smooth there is no danger of " oscillator wobble " on the short waves with this form of connection. Each of the coils has its own padder and trimmer, the padder of the short-wave oscillator coil, L7, being fixed. " P " coils are used for the oscillator coils, as well as for the aerial coils. By reason of the compact construction of the chassis some slight discrepancies with the manufacturer's

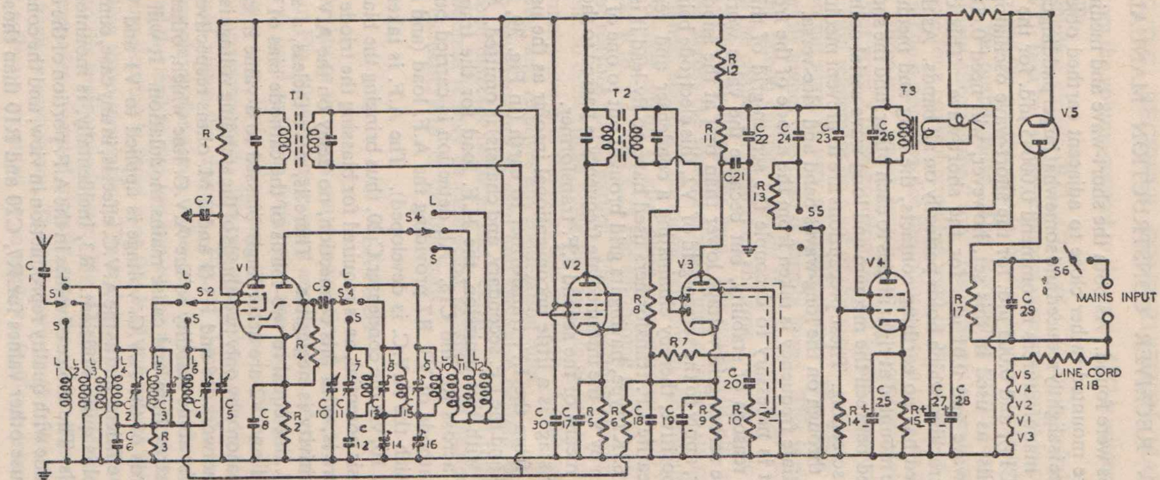


FIG. 39. *Circuit of Receiver*

padding capacities were found. As both the short-wave and medium-wave oscillator coils are mounted rather close to adjacent earthed objects their effective inductance is slightly reduced and somewhat larger padding capacities are needed. The manufacturers recommend 0.00045 μfd. for the medium wave oscillator (C14), and 0.005 μfd. for the short-wave oscillator padder (C12). These coils, as used in this set, however, will need 0.00055 μfd. for the medium-wave and 0.01 μfd. for the short-wave. This does not detract from the tracking which holds perfectly on all bands. As the wave-change switch used has no earthing contacts, the long and medium-wave oscillator coils are mounted at right angles to each other, and the short-wave aerial coil is placed between the medium and long-wave aerial coils to provide a measure of screening. These precautions are to prevent medium-wave stations breaking through on the long-waves band and vice-versa.

The intermediate frequency is taken from the anode of the frequency-changer valve. It is necessary to decouple the screen-grid of this valve; not so much for reasons of stability, but because the valve works more efficiently with the screen-grid voltage lower than that at the anode. This does not, however, apply to the screen-grid of V2, this electrode being taken directly to H.T. positive, thereby eliminating a condenser and resistance. As the midget Wearite I.F. transformers used have no fly-lead it is best to use a valve of the 6SK7 type, having its grid brought out to one of its pins. After amplification by V2 the intermediate frequency is passed to the second detector stage by means of the second I.F. transformer.

This detector stage is a little unconventional insofar as the usual I.F. bypass condenser from the I.F. transformer to earth (in Fig. 39, between the junction of R8 and the I.F. secondary, and chassis) is omitted. Actually, results are better with this omission, the H.F. load for the transformer appearing mainly across R8 and C18. All detection is carried out at the potential of the cathode of V3, R7 providing the A.F. load (and also the resistor across which the A.V.C. is developed). The A.F. is taken to the volume control, R 10, via the condenser C 20, thus bringing the bias on the grid of V3 to chassis potential, as is required for biassing the triode portion of the valve. There is, with this connection, no delay on the A.V.C., but the effect on sensitivity is neglegible. There is, nevertheless, a standing bias on the A.V.C. line equal to two-thirds of the cathode bias of V3, and the cathodes of V1 and V2 are accordingly biassed to a value in excess of this voltage. The reason why only two-thirds of the standing voltage is applied is because of the network R6 and R3 (1 and 2 M. ohms respectively). R3 is necessary to offer some stability to the A.V.C. line which, otherwise, is liable to pick up stray hum and cause mains modulation. It will be seen that only two-thirds of the A.V.C. voltage is applied to V1 and V2, but, as detection is very efficient, and as the A.V.C. effect is, in any case, cumulative, the A.V.C. control is quite sufficient. R3, incidentally, is mounted at the aerial coil terminals. The choice of values in the A.F. portion of the detector circuit has been made with quality reproduction in view, and the constructor is advised not to use other values for R7, C20 and R10 than those given.

The lead from the volume-control to the grid of V3 is screened to eliminate hum pick-up.

A decoupling circuit (R11, C21 and C22) is included in the anode circuit of V3. In a set of this compact construction it is possible for I.F. voltages to appear on the anode of the double-diode-triode and to be amplified by the output valve. The decoupling circuit removes these stray voltages without affecting the " top " response of the set to any great extent.

A simple tone control circuit is used in the anode of V3. The small size of the set does not allow for the inclusion of a variable resistance, but a single-pole, three-way wafer switch can be accommodated quite come fortably. This gives a three-position control of the " top-cut " variety, and is a most useful refinement on a set of this size.

The output stage is very straightforward. The 25L6 output valve is given a slightly higher bias than is usually found. This is simply to reduce the standing anode current through the small speaker transformer used, and reduce the chance of saturating the core. There is no noticeable loss in volume or fidelity using this bias. The usual 0.01 μfd. condenser, C26, is connected across the speaker transformer primary, its purpose being to reduce shrillness and third harmonic content in the output.

The rectifier circuit is also quite conventional. R17 is the limiting resistor and R16, C27 and C28 the smoothing circuit. R16 drops about 80 volts for reasons stated earlier. The smoothing circuit is quite efficient a very slight 50 cycle ripple being just audible at full volume. This is lost in the normal valve hiss found at this position. Condenser C29 provides an R.F. filter, and removes any modulation hum.

Three-way line-cord is used and the valve heaters are in series, that of the second detector being at the " earthy " end of the chain. If a dial lamp is required it may be connected between the heater of V5 and the resistance element, R18, of the line cord.

LAYOUT

The layout of the set is quite conventional and a top and bottom view are given in Fig. 40 with component annotations. A normal-size two-gang condenser is used as it was found that the midget types, although slightly smaller, gave very little advantage so far as reducing the overall size of the chassis was concerned. The two electrolytic condensers, C27 and C28, are mounted above the chassis: Fig. 41 showing the method of making the holding clamp for them. The positive lugs of these components are adjacent to the lead to the top-cap of the double-diode-triode, so a piece of insulating sleeving is fitted over this lead to prevent the metal screening from fouling these terminals. The aerial coils are mounted on a bracket adjacent to the tuning condenser. Fig. 42 gives the details of this bracket. The trimmers are mounted directly onto the solder tags of the coils which are bent back to save space. The trimmers on the Short- and Long-wave oscillator coils are mounted at an angle to facilitate trimming.

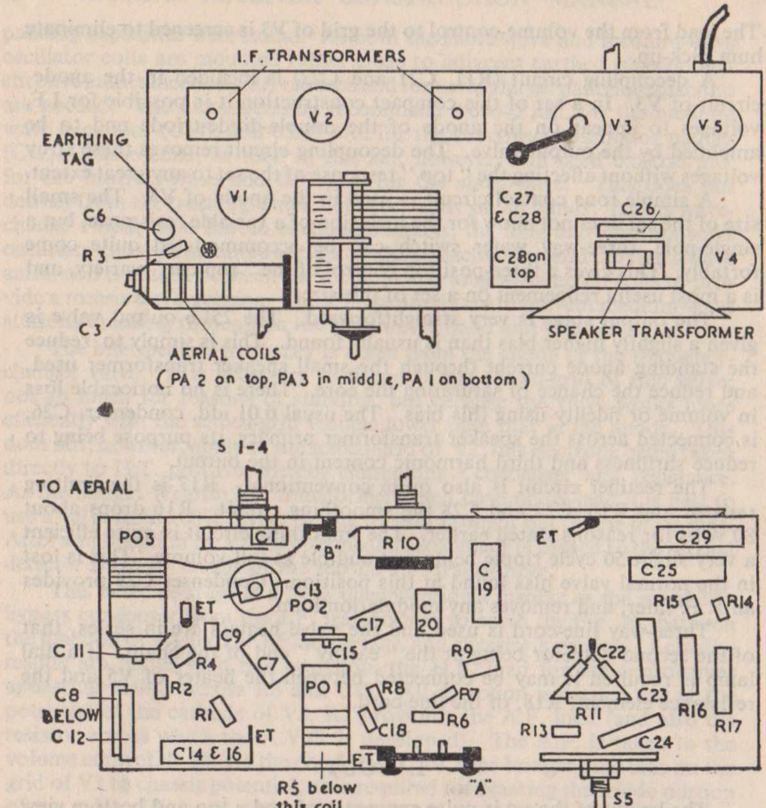


FIG. 40. *Layout of Receiver showing position of components (E.T. stands for earthing tag). The references " A " and " B " refer to the insulated anchoring tags mentioned in the text.*

CONSTRUCTION

We may now commence the construction of the set.

The first thing to do is to make the chassis. The drilling and bending dimensions are given in Fig. 43. The two half-inch pieces at either end of the chassis are bent down for additional strength. Some of the holes required are not shown (*e.g.*, those for the padders) as these will depend on the components used. These holes may be drilled as required during the wiring of the set.

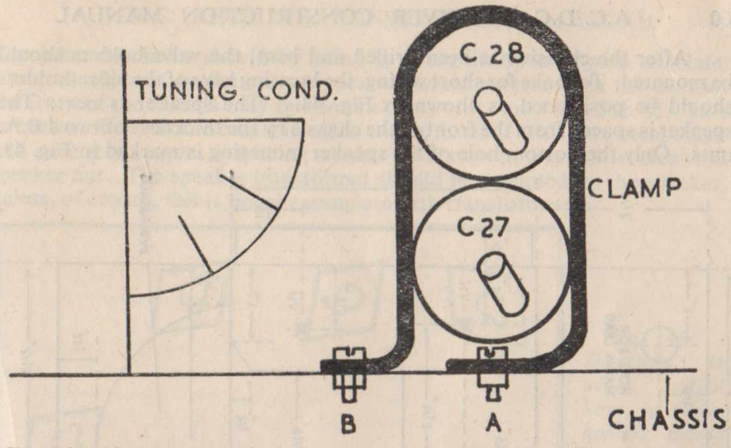


FIG. 41. *Showing method of mounting condensers C27 and C28. The clamp is first fastened by bolt " A," the strip is then bent over the two condensers and anchored by bolt " B." The strip is ¾ of an inch wide, and the condensers are positioned to just clear the tuning condenser vanes when open.*

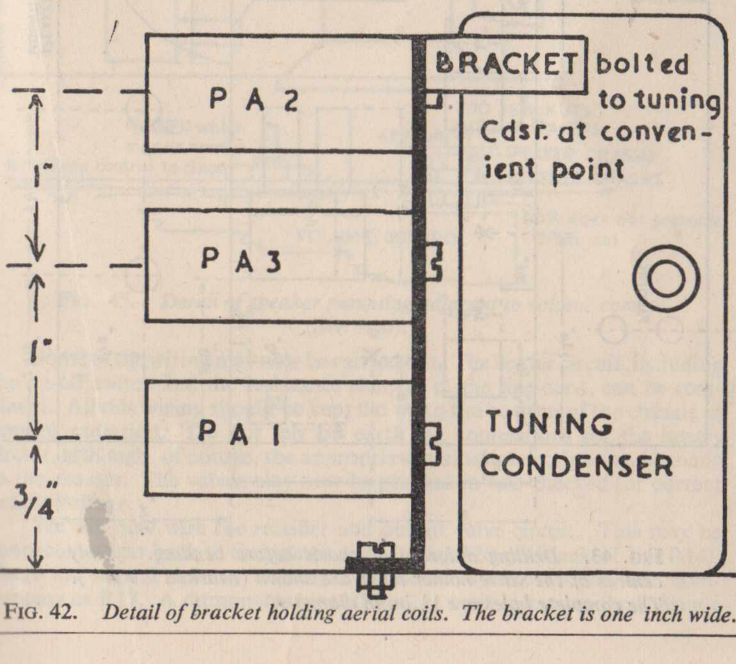


FIG. 42. *Detail of bracket holding aerial coils. The bracket is one inch wide.*

After the chassis has been drilled and bent, the valve-holders should be mounted. To make for short wiring, the locating keys of the valve-holders should be positioned as shown in Fig. 44. The speaker is next. The speaker is spaced from the front of the chassis by the thickness of two 4 B.A. nuts. Only the bottom hole of the speaker mounting is marked in Fig. 43.

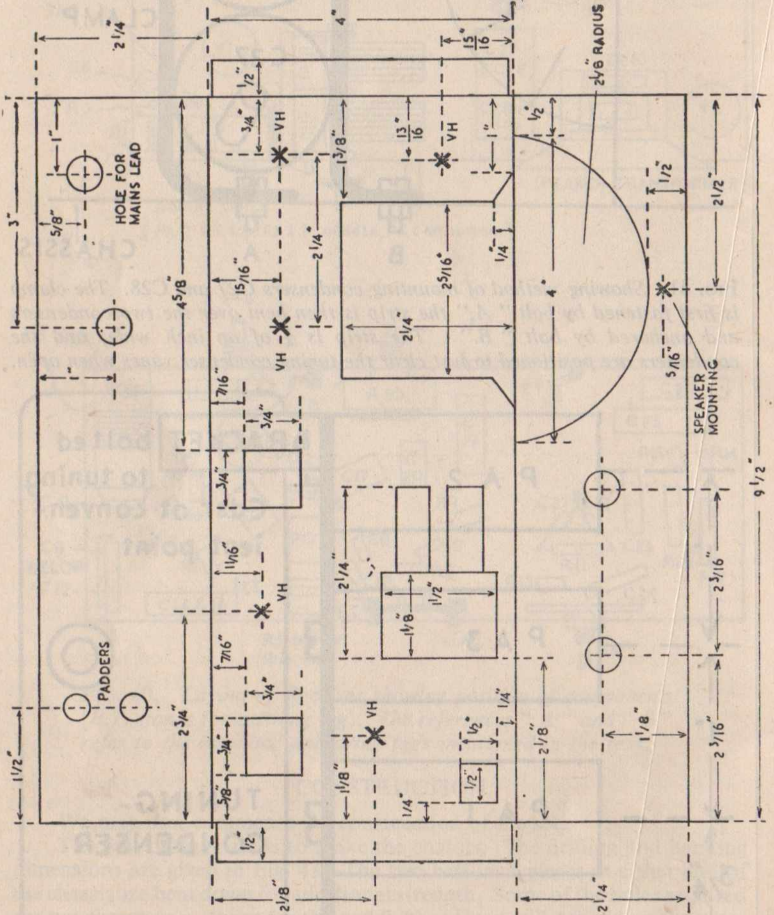


FIG. 43. *Drilling diagram of chasis before bending. Only centres of the valve-holder holes are shown (Marked " VH"). The complete holes are $1\frac{1}{8}$ in. in diameter.*

The other two holes should be found by using the speaker as a template. The bolt adjacent to the volume-control should project from the back of the front of the chassis only by the thickness of its nut. See Fig. 45. This is because the volume-control comes over this nut. This last component will probably require a spacing washer as shown in Fig. 45 to clear the speaker nut. The speaker transformer should be mounted on the speaker, unless, of course, this is bought complete with transformer.

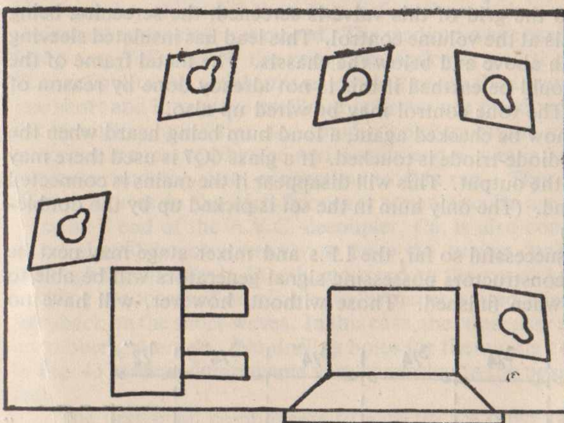


FIG. 44. *Direction in which spigot keys of valve holders should be mounted for shortest wiring.*

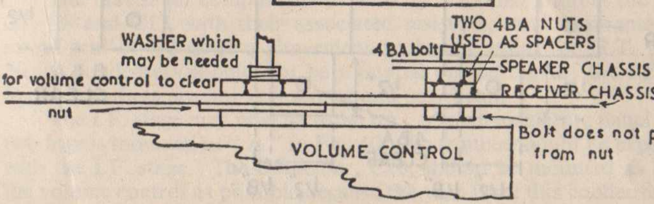


FIG. 45. *Detail of speaker mounting adjacent to volume control (See text).*

Some of the wiring may now be carried out. The heater circuit, including the on-off switch and the resistance element of the line-cord, can be completed. All this wiring should be kept flat up to the bottom of the chassis to prevent radiation. Do not rely on earth tag connections for the heater circuit, although, of course, the appropriate mains connection can be made to the chassis. The valves may now be plugged in and checked for correct heater voltage.

We can now wire the rectifier and output valve circuit. This may be connected as far back in the circuit as to include the grid-leak of V4 (R14). There are several dummy terminals on the rectifier to mount such components as R17. A dummy terminal (Pin 6) is used to mount the " Anode end" of C23 and should be left free. The screen-grid terminal of the output valve provides a convenient anchoring point at H.T. positive potential. R16 and R17 should be mounted well away from the chassis to ensure heat dissipation. When wired up, the rectifier and output stage may be checked. There should be about 150 volts H.T., and when the grid of the output valve is touched there should be a faint hum from the speaker.

We can now wire up the triode section of the double-diode-triode stage. The lead to the grid of this valve is screened, the screening being connected to chassis at the volume control. This lead has insulated sleeving pushed over it both above and below the chassis. The metal frame of the volume-control should be earthed if this is not already done by reason of its construction. The tone control may be wired up also.

The set may now be checked again, a loud hum being heard when the grid of the double-diode-triode is touched. If a glass 6Q7 is used there may be a slight hum in the output. This will disappear if the mains is connected the other way round. (The only hum in the set is picked up by the double-diode-triode grid.)

Having been successful so far, the I.F.s and mixer stage may next be wired up. Those constructors possessing signal generators will be able to check each stage when finished. Those without, however, will have no

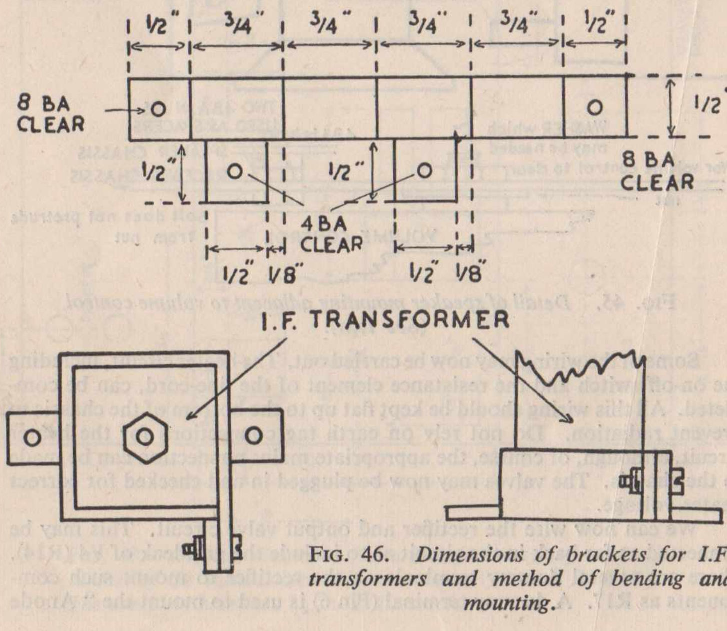


FIG. 46. *Dimensions of brackets for I.F. transformers and method of bending and mounting.*

difficulty in getting these stages lined up and working if they follow the following instructions.

Before mounting the I.F. transformers, mounting brackets will have to be made. These are shown in Fig. 46. The transformers may then be fixed to the chassis. The next component is the wave-change switch. Unless the constructor has a pencil-bit soldering-iron, he will have some difficulty in soldering the wires to the tags nearest to the chassis. If this is the case, wires may be soldered to these tags before the switch is mounted, being cut to size and connected as required. The medium-wave oscillator coil requires fixing next, followed by the two-gang condenser and the three aerial coils. Connections to the aerial coils are made through the square hole below them. The short and long-wave oscillator coils are not fitted until the set has been put in working condition and roughly lined up on the medium-waves. An earth tag is mounted by the aerial coils and a wire is led from the tuning condenser moving vane connection to this tag. This is needed because chassis returns in the high-frequency tuned circuits are not reliable. The "earthy" end of the A.V.C. decoupler, C6, is also connected to this tag. There should be no necessity to have the tuning condenser "floating," although the speaker is directly mounted on the same chassis. If, however, a tuning condenser of unreliable performance is used, there may be acoustic feed-back on the short-waves. In this case, the condenser should be mounted on rubber grummets. No drilling holes for the tuning condenser are given in Fig. 43 as these components vary somewhat in the position of their fixing feet.

The first small components to wire up are those nearest the chassis. C7, C8 and C17, with their associated resistors, can be mounted. The screen-grid of V2 gives a convenient anchoring point for H.T. positive. Heavy condensers should not be mounted on the tags of the I.F. transformers as these are not very strong and may bend.

The I.F. stage may now be wired up. A small insulating panel holding two lugs is mounted at "A" in Fig. 40. No trouble should be experienced with the I.F. stage. The condenser, C20, should be mounted as close to the volume control as possible because the wire from this condenser to the control picks up hum.

The frequency-changer stage may also be partly wired up. Ignore the signal-frequency circuits for the time being, and wire up the anode circuit to the first I.F. transformer; also wire up the oscillator circuit to the medium-wave oscillator coil so that this operates with the wave-change switch in the centre position. See that the oscillator feedback coil is connected right way round or the valve will not oscillate.

We may now check the I.F. stage and get the I.F. transformers roughly lined up. If a reasonably good aerial is connected to the top grid of the mixer valve, as shown in Fig. 47, one or two stations should be heard as the tuning condenser is rotated. As soon as a station is found the I.F. trimmers should be adjusted for maximum volume. A small trimming tool (Fig. 48) will be necessary to reach the trimmers under the chassis. If the signal is

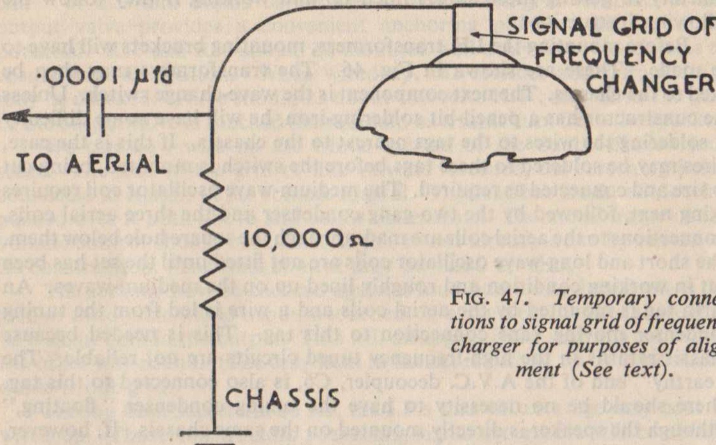


FIG. 47. *Temporary connections to signal grid of frequency charger for purposes of alignment (See text).*

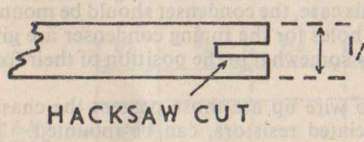


FIG. 48. *Trimming tool for I.F. transformers. The material may be wood, paxolin or any other insulating material.*

too loud it may be reduced by using a smaller aerial. It should be possible to receive the " local " with about ten feet of wire used as an aerial for this test. There may be some second-channel whistles but these will disappear when the aerial coils are connected.

Having satisfied ourselves that the oscillator and I.F. circuits are above reproach, we can rest assured that the back of the work is well broken. The aerial coils, long, medium and short, may be wired up now. An insulated terminal, mounted at " B " in Fig. 40, holds the aerial wire; this consisting of a foot of wire, ending, for greatest convenience, in a crocodile clip.

When connected, the set may be checked on the medium waves, when a few stations should be heard. This band can be trimmed and padded later. The short-wave and long-wave oscillator coils may now be mounted, taking care to keep the leads from the wave-change switch as short as possible.

ALIGNMENT

The set may now be aligned. Those without signal generators will have to use a little guesswork on the high-frequency ends of the band.

First of all we shall align the long-wave band. Tune the set to a station at the " top " end of the band (highest frequency—vanes disengaged), and with the oscillator trimmer at about half-capacity, adjust the aerial trimmer for maximum volume. Then tune to a signal at the " bottom " end of the band and adjust the padder. This will change the tuning position of the tuning condenser which will have to be rocked back and forth during padding. When the maximum position of the padder has been found, go back to the " top " end again and re-trim the aerial coil. It may be difficult to find a station at the " top " end of the long-wave band, but, if there is any interference in the locality one can easily trim to this! Alternatively, a station " lower down " in the band will have to be used. The trimming may then be checked at various points of the dial to see that the ganging is correct.

The next band to align is the medium-wave band. This is done in the same way as is the long-wave band, except that those constructors without signal-generators can be more accurate on the high-frequency end. The oscillator trimmer should be so adjusted that the West Regional station on 216.8 metres can be tuned in with the condenser vanes enmeshed by about 5 degrees (or the Light programme on 261.1 metres at about 10 degrees).

The short-wave band is a slightly different proposition. There is no padding adjustment required, as a fixed condenser is used. So all that is required is to tune to a station (oscillator trimmer with about one-third capacity) at the " top " end of the band and adjust the aerial trimmer. It is very important to see that the oscillator frequency is higher than the signal frequency on this band. It will probably be found possible to tune in a station at two positions at the high-frequency end of the band. If this is so, tune in to that position where the tuning condenser vanes are less engaged, and trim the aerial coil at this position.

All the above adjustments should be made with very small signal inputs, otherwise the A.V.C. effect will confuse the results. A signal that is just audible is best. It will probably be found that the final trimming on each band may be carried out with no aerial connected at all. The volume-control should be set to maximum all the time.

The I.F. transformers may now be finally adjusted (using a weak signal) and, if required, the R.F. circuits given a final check.

OPERATION

The set is now finished, all that is required being a dial which can easily be fixed to the front of the tuning condenser. The layout of the three knobs on the front is symmetrical and will give a pleasing effect when the set is in its cabinet.

The set will be found quite easy to control, the epicyclic slow-motion being efficient and free from backlash. The tone control may be set to the position most favoured by the user and probably will not need any adjustment except in cases of interference, etc. The quality of reproduction is good, and full benefit of the circuit could be given by using a larger speaker as an extension.

Sensitivity is very good, American stations being very well received on only a few feet of wire as an aerial. The A.V.C. circuit is fully operative on the short-waves, a point often omitted in commercial circuits, and will function on all types of fading except " high-speed " fading.

There were no cases of mains modulation on the author's prototype although the set was tested in some very bad localities. If, however, there should be any mains modulation trouble, reversal of the mains plug will cure it. (Mains modulation will only occur on A.C. mains.)

COMPONENT LIST

R1, R8	15 K.ohms, ¼ watt
R2	330 ohms, ¼ watt
R3	2.2 M.ohms, ¼ watt
R4	30 K.ohms, ¼ watt
R5	220 ohms, ¼ watt
R6	1 M.ohms, ¼ watt
R7	270 K.ohms, ¼ watt
R9	1 K.ohms, ¼ watt
R10	500 K.ohms, V/C
R11	620 ohms, ¼ watt
R12	100 K.ohms, ¼ watt
R13	47 K. ohms, ¼ watt
R14	470 K.ohms, ¼ watt
R15	470 ohms, ½ watt
R16	2.2 K.ohms, 5 watt
R17	100 ohms, 5 watt
R18	530 ohms (Line Cord
C1	0.001 mfd. mica
C2-3-4-11-13-15	50 pfd. trimmers
C5, C10	0.0005 twin gang condenser
C6-7-8-17-30	0.1 mfd. paper
C9-21-22	200 pfd. mica
C12	0.01 mica (fixed padder S.W.)
C14	600 pfd. (variable padder M.W.)
C16	200 pfd. (variable padder L.W.)
C18	300 pfd. mica
C19-25	25 mfd. 25 v.wg. electrolytic
C20	0.002 mfd. mica
C23-26-29-31	0.01 mfd. 1000 v.wg.
C24	0.005 mfd.
C27-28	16 mfd. 350 v. wg. electrolytic
S1-2-3-4	4 bank, 3 way switch (wave change)
S5	single bank, 3 way switch (tone control)
S6	on/off switch (combined with V/C)
L1, L6, PA3, L7, L10, P03	
L2, L5, PA2, L8, L11, P02	WEARITE
L3, L4, PA1, L9, L12, P01	
T1, T2	" Wearite " midget I.F. transformers.

Speaker	4 inch Rola
T3	Output trans. 2000 ohms load to suit speech coil
5	International valve holders
1	Slow-motion drive, epicyclic
	0.3 amp. line cord as required for R18

VALVES

V1	6K8/GT/G	X65
V2	6SK7/GT	
V3	6Q7/GT/G	DH63
V4	25L6/GT/G	
V5	U31	25Z6/GT/G

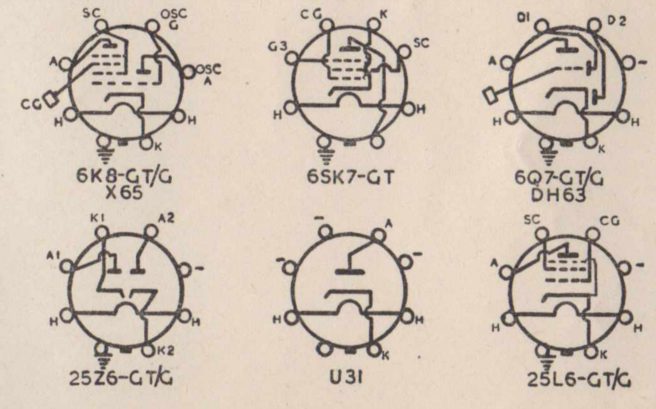


Fig. 49 *Valve bases*

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