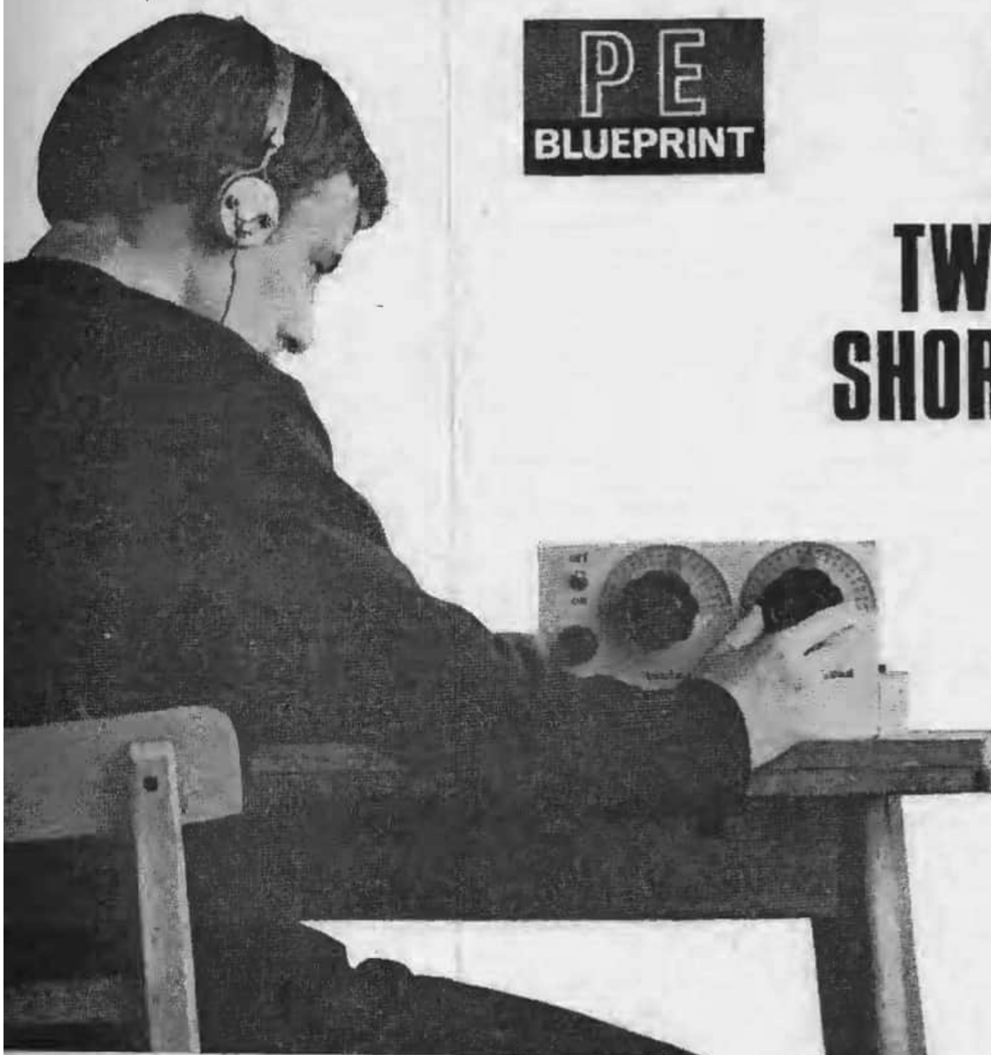
PE BLUEPRINT

SIMPLE TWO VALVE SHORT WAVE RECEIVER



by R. E. F. STREET

THE receiver featured on one of the blueprints presented with this issue has been designed especially for the newcomer to radio construction. For this reason it uses a simple circuit—but one which is nevertheless capable of giving excellent results.

The coverage of the receiver is from about 18 metres to 50 or 60 metres (or, expressed in terms of frequency, 16 to 5Mc/s), depending upon the exact components employed. Thus, it covers most of the popular short wavebands including the 20 metre and 40 metre amateur bands (or 20m and 40m, if we use the usual abbreviation "m" for "metre").

CIRCUIT DESCRIPTION

The circuit (see Fig. 1 on the blueprint) uses two identical battery-powered valves; these are 1T4's (other suitable types are CV785, W17, 1F3 and DF91). In a receiver like this, intended for the beginner, mains operation is best avoided because of the danger of shock when in the hands of the inexperienced constructor.

The batteries used here are a 90V (this means 90 volts) type and a 1·5V type, and the risk of shock from these is low.

The output from the receiver is fed to high impedance headphones—this avoids the need for a third valve to feed a loudspeaker and keeps down the battery consumption. The second valve in the circuit (V2) is the detector and is of the regenerative type in which signals are fed back from the anode to the grid to increase the gain by bringing the circuit almost to the point of oscillation. The feedback (or reaction as it is often called) is controlled by varying the screen grid potential by means of VR1.

This particular type of reaction control is not normally used in battery circuits for one main reason —in order to vary the screen-grid potential, a potentiometer must be connected across the h.t. line and this gives rise to a certain amount of wasted h.t. current. In this circuit, the current through the potentiometer (this consists of R5 and VR1 in series) is just over a third of a milliamp (just over 0·0003 amps or 0·3mA). This will not cause the h.t. battery to wear out much more quickly than it would if the usual circuit were used.

The headphones are connected to the anode circuit of V2 via a capacitor C7. This procedure means that there is no direct current (d.c.) flowing through the headphones.

RADIO FREQUENCY STAGE

The main trouble with a reacting detector is that it sometimes radiates appreciable interference when it is actually oscillating, causing howls and whistles on neighbouring receivers. Also, coupling the aerial directly to the detector stage results in "dead spots", where reaction cannot be obtained, at certain points in the tuning range.

In this receiver, these two defects are avoided by using a radio frequency (r.f.) stage before the detector. This amplifies the signals from the aerial and feeds them to the detector. Actually, the amplification is not very great and the important function of the r.f. stage is to isolate the detector from the aerial thus preventing radiation of interfering whistles, and the occurrence of "dead spots".

Most simple short wave receivers use plug-in coils to achieve wide coverage. In this receiver, however, this complication has been avoided by using a twin-gang 500pF capacitor in conjunction with one set of coils only which are permanently wired in circuit.

From the beginner's point of view, there is no need to go into more detail concerning the operation of the circuit. More will become apparent when the set has been built and used.

BATTERIES

For the high tension (h.t.) supplies the B126 (Ever Ready) is suggested, although the equivalent in another make is equally suitable.

For low tension (l.t.) supplies the following Ever Ready 1·5V types or their equivalents may be used: AD1, AD4, AD14, AD32, AD34, and AD35. The AD35 is smaller and less expensive than the others, but it will not last as long.

Plugs for the batteries can be obtained from radio component shops and it is a good idea to buy also the aluminium tops which are available for the plugs. These will make it easier to unplug the batteries when required.

It is not essential to buy a proper l.t. battery but it is convenient since this type has sockets on it for connecting the receiver. You can use ordinary 1·5V cells if you wish. An ordinary U2 or equivalent cell will give a good few hours of listening since the current drain of the receiver from the l.t. battery is only 100mA (100 milliamps or 0·1A).

If you use a U2 cell, remember that the zinc case is the negative connection and the brass cap at the top is the positive connection. If possible, solder the wires from the set on to the cell, or make up a spring-clip arrangement for connecting the wires to the cell.

CONSTRUCTION

To simplify construction, the chassis of the receiver is made from wood and hardboard covered in places with aluminium cooking foil. Of course, if you are sufficiently experienced and have the necessary facilities, you can use a conventional form of construction with an aluminium chassis and front-panel. The wood-and-hardboard method has the advantage of ease of working and relative cheapness.

To make the framework for the chassis, a 1 yd length of nominal 2in wide by ½in thick "ramin" or similar softwood will be needed. This is cut to provide two pieces 9½in long and two pieces 6in long. Make sure that you cut the ends "square" or the frame will not fit together very well.

The four pieces of wood are then screwed together as shown in Fig. 6a, using eight ½in No. 4 steel wood-screws.

FRONT PANEL

To make the front panel you will need a piece of ⅛in hardboard 10in by 6in, and you will need another piece the same size for the top of the chassis.

Drill these two pieces as shown in Figs. 8 and 9, shiny side towards you, taking care to sandpaper off any burrs left when the holes have been made. Countersink the holes marked "X".

If the twin-gang tuning capacitor VC1, VC2, you are using has a single-hole or bracket fixing, you will not need to drill the three holes indicated in Fig. 9—these are for the type of capacitor which uses three bolts for fixing. However, if three bolts are to be used, check that they conform to the spacing given in Fig. 9, and if the holes on the front of your tuning capacitor are spaced differently, make the necessary alteration. With the bolt-fixing capacitor, it is very important to make the centre hole in the panel large enough for the capacitor to fit tight against the panel when it is mounted.

Before proceeding further, check that the various parts fit the holes you have made for them. *It is very important that the holes should be the right size now and that you do not have to enlarge them later.*

ALUMINIUM FOIL

The inside of the wooden framework must now be covered with aluminium cooking foil as shown in Fig. 6b. The shape of the foil you will need is also shown—in Fig. 7. Note that on one long side of the framework, you must bring the foil over the top and down the front. The front panel will eventually be screwed to this side of the frame and the foil on it will then be in contact with the foil on the frame.

To glue the foil in position, almost any adhesive can be used including balsa cement.

Foil must also be used to cover the back of the front panel—the side with the cloth-like marks on it, not the shiny side. The underside of the hardboard to be used for the top of the chassis must also be covered with foil.

You will now need to make holes in the foil corresponding to those already present in the hardboard. If you run your finger over the foil, you will see the outlines of the holes formed on the foil and you can then cut it away in the appropriate places. Make sure that you cut the foil away close to the holes, but do not cut away more than is necessary.

ASSEMBLY

The next job is to screw the front panel to the front of the chassis framework; that is, to the side of the framework with the aluminium foil on it. For this, use ⅜in woodscrews and make sure that the heads are below the surface of the front panel when you have done—the holes were countersunk so this should be easy.

You can now mount the various parts on the front panel. The bandspread capacitor VC3 is mounted by a single nut, as are the switch S1/S2 and the potentiometer VR1.

MOUNTING THE TWIN GANG

The twin gang tuning capacitor VC1, VC2 will probably have three holes for fixing it as mentioned earlier. You should use bolts with countersunk heads, but you may have difficulty in obtaining bolts which are short enough. If the bolts are more than about ¼in long, when you screw them up tight to mount the tuning capacitor, the ends which stick through the frame of the capacitor will contact either the fixed plates, thus shorting them out, or the moving plates at some part of their travel. You will thus have to shorten the bolts if you cannot buy the correct length.

To shorten a bolt, place a large nut on it and screw it up to the head of the bolt. Grip the nut in a vice or in a pair of pliers and saw off the unwanted part of the bolt using a small hacksaw. Finally, reverse the bolt in the vice or pliers and use a screwdriver to unscrew it from the nut. This procedure makes sure that if you damage the bolt when you saw a piece off it, unscrewing the nut will restore the thread quite well. If you do not use a nut, it will be difficult to hold the bolt in the vice or pliers without damaging its thread and you may have a job to screw a nut on it when you have sawn it.

When you have mounted the tuning capacitor VC1, VC2, make quite sure that the three fixing bolts do not get in the way of the moving plates nor short out the fixed plates.

CONNECTIONS TO METAL FOIL

Here, one point must be noted carefully. Owing to the fragile nature of aluminium cooking foil, it is necessary to check carefully that all the metal parts mounted in contact with it do in fact make good electrical contact. Examine the tuning capacitor and the bandspread capacitor and also the solder tags which are fastened to the hardboard chassis and front panel to make sure that they are tightly contacting the aluminium foil.

SOCKETS FOR WANDER-PLUGS

The sockets for the wander-plugs can be fixed to the chassis using red for the two aerial sockets and for one of the headphone sockets (the one to be connected eventually to C7). Use black sockets for the earth and the other side of the headphones. The two valveholders can also be mounted—you will need soldering tags underneath the mounting bolts as shown in Fig. 2.

MAKING THE COILS

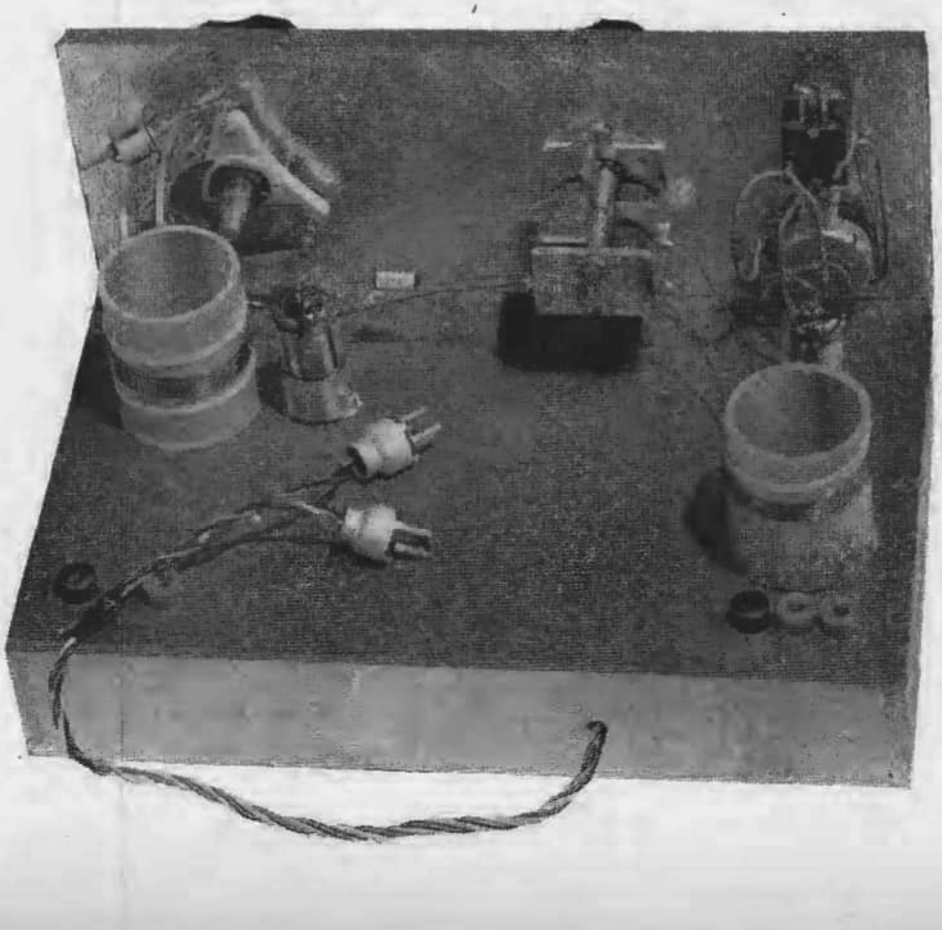
For the coils, obtain a length of cardboard tubing about 1½in in diameter. This diameter tubing is found in the rolls of paper sold for kitchen use. Cut off two 2in lengths of the tubing using a small saw such as a coping-saw to give neat edges. A sharp knife can also be used, but great care should be taken or cut fingers will result.

Cut out two cardboard discs the same size as the cardboard tubing and make an ⅛in hole in the centre of each. Glue one on each 2in length of tubing, using balsa cement, etc.

FIRST COIL, L1, L2

The first coil to make is L1/L2. Measure 1¼in from the base of the coil former (that is the end with the disc attached) and make two holes as shown in Fig. 3. Leaving a 5in length of wire for connecting later, wind on six turns of the 22 s.w.g. enamelled copper wire, spacing each turn from those next to it by an amount equal to the diameter of the wire or a little more. Note the method of threading the wire through two holes in the coil former at each end of the winding to secure the turns in position. To keep the spacing between the turns from altering, secure them to the coil former with balsa cement at one or two points.

Now wind on four turns of 34 s.w.g. double cotton covered (d.c.c.) copper wire in the same direction as the previous winding and spaced about ⅛in from it.



The turns of this winding should be close together—it should be "close-wound". Leave 10in ends on this winding for connection later.

SECOND COIL, L3, L4, L5

To wind L3/L4/L5, measure ½in up from the base of the coil former and make the two holes for securing the end of the wire. See Fig. 4. Leaving a 10in length of wire for connecting, wind on four turns of 34 s.w.g., d.c.c. wire close-wound. Leave 10in at the other end for connecting.

Then, 3/16in from this winding, wind on in the same direction six turns of 22 s.w.g. enamelled wire leaving 5in ends for connecting. The turns of this winding should be spaced from one another (as were those of L2) by a distance about equal to the diameter of the wire. The winding will occupy a length of about 3/8in.

Next, 3/16in from the top of L4, wind on five turns of 34 s.w.g. wire (d.c.c.) in the same direction. These turns should be close-wound and 10in ends should be left for connecting later.

CHECK THE WINDINGS

It is important that the turns on L1 should be wound in the same direction as those on L2. The turns on L3 should be wound in the same direction as those on L4 and L5, too. Use the diagrams of the coil-winding (Figs. 3 and 4) to check the coils you have made.

When the coils are complete, mount them on the chassis, passing the securing bolts through the holes in the discs at the bottom of the formers. Use a washer on each bolt to prevent the heads of the bolts from being pulled through the cardboard when they are tightened.

Now that all the parts have been mounted, the wiring can be carried out as shown in Figs. 2 and 5. Use insulated wire of the single strand type throughout and put sleeving on the cotton covered leads from the coils, and also on the bare leads of the capacitors and resistors.

Note that TC1 is a "concentric" type of trimmer. It is held in position by soldering its long centre pin to an "earthy" tag on VC3.

BATTERY LEADS

Leave the battery connecting leads until last. For these, you will need four plastic covered pieces of flex about 18in long—one red, two black, and one clear or transparent. These can be made by unravelling pieces of coloured twin bell-flex (obtainable from chain stores). Twist all four leads together to form a cable and then connect their bared ends separately to the tag strip near to V1 as shown in Fig. 2. Thread the leads through the hole in the rear runner of the chassis, and, about four inches from the ends of the leads, separate them into pairs—red and black; white and black. Connect these leads to the battery plugs as shown in Fig. 5 and Fig. 10.

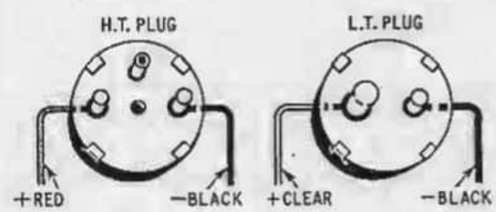


Fig. 10. Details of battery plug connections

All of the wiring should now be completed. It must then be checked very carefully against the wiring diagrams Figs. 2 and 5 and the coil diagrams Figs. 3 and 4.

Be quite sure that you have wired up the battery connections correctly. Check the h.t. wiring and make quite sure it is correct. If by chance you connect the h.t. incorrectly and it is applied across the filaments of the valves, they will be ruined at once.

TESTING

Switch off S1/S2 and connect the l.t. battery (1·5V). Switch on S1/S2 and look carefully at the two valves. The filaments should be glowing, but you may need to be in a darkened room to see the glow which is not at all bright.

Switch off again and plug in the h.t. battery and the headphones, which must be of high impedance (2,000 to 4,000 ohms). Turn the tuning capacitor (VC1, VC2) and the bandspread capacitor (VC3) to their mid-way positions. Turn the adjustable top of TC1 as far clockwise (almost) as it will go. Turn the reaction control VR1 fully anticlockwise. (It does not matter at this stage whether or not the various controls have knobs fitted since the aim is just to see if the set works.)

Plug in an aerial (to either of the two aerial sockets) and an earth too, if one is available. Now switch on and there should be a click in the headphones. Turn up the reaction control VR1 and eventually there should be a whistle or hissing in the headphones. You may also hear a station, but if not, move the tuning or bandspread capacitor a little. Once that you have heard that the set works, switch off again.

If the set does not work, check all your wiring and connections carefully once more, making quite sure that the metal parts which are supposed to be in contact with the aluminium foil on the chassis are really in contact with it.

TUNING SCALES

The next job is to make the front panel look neat and to provide a scale for each of the tuning controls. In the prototype, this was done by covering the front panel in thin white card. Scales were made for the tuning knobs from ordinary protractors as used in schools and sold for about 7d. each at the moment.

It is necessary to cut out semi-circles in the protractors so that they can be fitted in position on the front panel without the fixing nuts of the controls getting in the way. It is possible to drill holes initially in the protractors and then use a fine toothed fretsaw to remove the small piece of material. Great care must be taken when preparing the protractors since the material used cracks easily. If drilling is carried out, it must be done with the protractors on a solid surface to prevent cracking—a small piece of wood is ideal. The edges of the hole can be neatened up using a *blunt* penknife, but, even so, care is necessary to prevent cut fingers and damaged protractors.

Two countersunk holes should be made in each protractor so that they may be bolted to the front panel after the white card has been glued to it. The holes should be in a position where they will later be hidden by the control knobs.

These four holes are the only ones which you have to make in the front panel after you have fixed the foil in position. Place the protractors in their correct places and use the holes in them to mark the four that must be drilled. Remove the valves and be careful when drilling that you do not damage the tuning capacitors. Take care also to keep the dust out of them as you drill.

FIXING THE KNOBS

The knobs used on the two tuning controls should preferably be of the same type for good appearance. and as large as possible. They also need to have a pointer fitted. You can buy knobs with pointers but you can add plastic pointers to ordinary knobs by gluing them on the underside.

When you fix the knobs on to the spindles, turn the tuning capacitor to maximum capacity (vanes fully meshed) and turn the knob to read a little more than 180 degrees on the protractor before you tighten the grub-screws. When you turn the tuning capacitor to minimum capacity, the knob should read a little below 0 degrees. Do the same sort of thing with the other knob, but set the pointer exactly to 180 degrees with the bandspread capacitor fully meshed. The pointer will then read 0 degrees with the plates as open as possible.

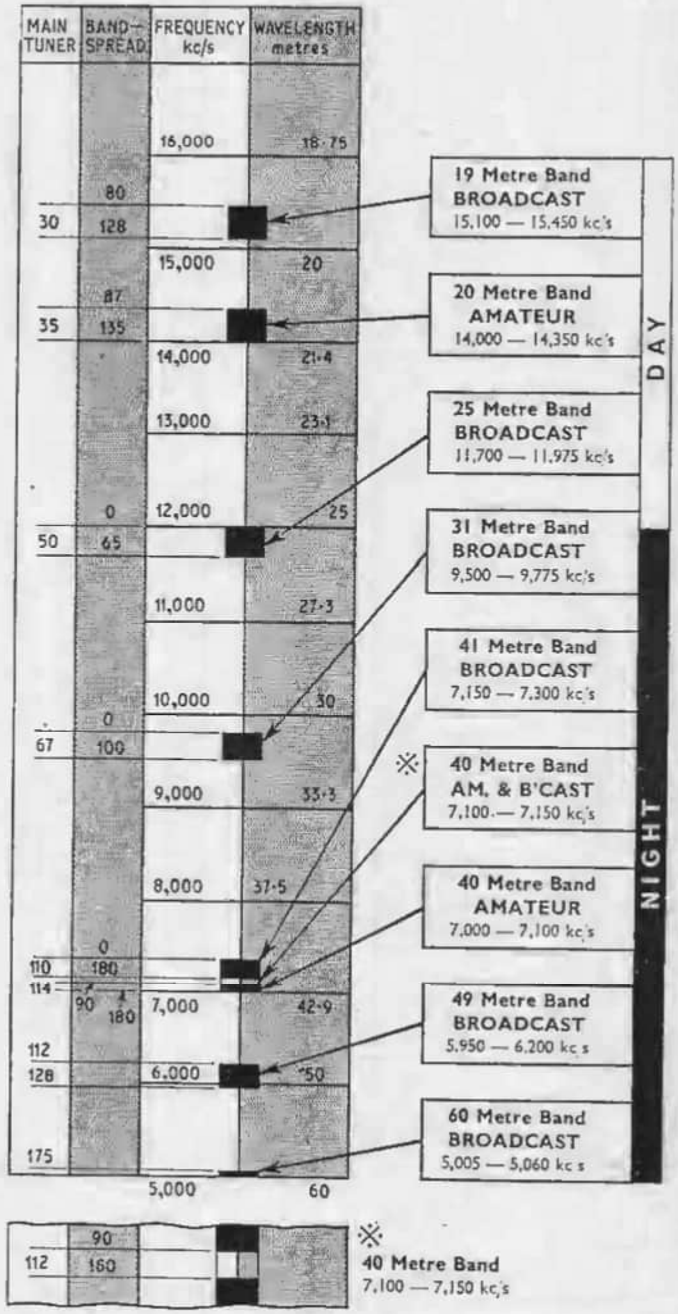


***Fig. 11.** This chart shows the approximate tuning range of the simple Short Wave Receiver.*
The well known bands used by broadcasting and amateur stations are shown. Calibration points for the main tuner and the bandspread control are provided here as a general indication. These readings will vary somewhat for each individual receiver.
Log the dial readings for each station heard. When a sufficent number of stations have been identified it will be possible to compile a calibration chart such as given in the two left hand columns of our illustration.
In daylight, the higher frequencies (shorter wavelengths) are the more active. With oncoming darkness as night approaches, the lower frequencies (longer wavelengths) become usable for long distant transmissions.

USING THE SET

Plug in the batteries and switch on. Make sure that the aerial, earth and headphones are plugged in too. Set the bandspread capacitor to 90 degrees (half-way) and the tuning capacitor to, say, 135 degrees (rather more than half-way to maximum capacity) Switch on and turn up the reaction control until some sound is heard—you may have to move the tuning capacitor a little. The best time to try the set out for the first time is in the evening when there are more stations to hear.

As you gradually turn up the control there will be a point where a whistle or hiss is produced. The aim in using the receiver should be always to keep the reaction control in such a position that if you turn it up just a little more, the whistle or hiss will be heard. The detector (V2) is then at its most sensitive —it is said to be "on the threshold of oscillation". If you do not keep the reaction control at this point, you will only hear strong stations.

You must remember that the reaction control will require continual adjustment as you alter the tuning of the receiver. The best setting varies according to the position of the tuning capacitors.

ADJUSTING TC1

To adjust TC1 for optimum results, tune the bandspread capacitor to the half-way position (90 degrees) and the main tuning capacitor to the position of maximum capacity (vanes fully meshed). Unscrew TC1 (anticlockwise) as far as it will go, and turn the reaction control nearly full up. Switch on the receiver and screw TC1 clockwise until you hear the reaction whistle or hiss. You should now find that reaction is obtainable over the whole of the tuning range of the receiver. If not, screw up TC1 a little more. You should aim at keeping TC1 set as far anticlockwise as possible provided that you can get reaction over the whole tuning range of the set.

TUNING

The tuning capacitor should be used to select the band on which you want to listen, with the bandspread capacitor set to 90 degrees. Then, tuning the bandspread capacitor will enable you to tune the receiver over the band you have selected. The operation is really quite simple.

If you have a 500pF tuning capacitor, this works out at about (500/180)pF or 2·8pF per degree of rotation. With a 15pF bandspread capacitor, the variation in capacity is only about (15/180)pF per degree of rotation which is 1/12pF per degree. Thus, if you move the tuning capacitor 2 degrees, the capacity changes by about 5·6pF. To get the same capacity change by moving the bandspread capacitor, you would have to move it about (5·6 ÷ 1/12) degrees which is about 67 degrees. Thus, if two stations were only 2 degrees apart on the tuning capacitor, they would be nearly 70 degrees apart on the bandspread capacitor.

The bandspread capacitor therefore spreads out the stations in a given band making them easier to tune—hence the name.

AERIALS

The best type of aerial for this receiver is the "longwire" which consists of a long wire suspended horizontally as high as possible. It should be about 50ft to 100ft long including the downlead. Egg-type insulators should be used to suspend the aerial from its guy ropes and the wire and rope should be threaded around each insulator in such a way that if the insulator should break, the aerial will not fall down. The correct way is easily seen if you examine the insulator carefully.

EARTH CONNECTION

In many areas, the addition of an earth will not greatly improve signal strength.

There are two ways of achieving an earth connection. If there is a cold water pipe in the room where the radio will be used, a copper earth clip can be fixed to the pipe. The alternative is to bury a copper spike or plate about 18in deep in the ground and connect a wire to it. The copper can be surrounded by earth and then small stones and finally more earth. If it is not in a position where there is much rain, it should be watered now and again to keep the earth moist and maintain a good connection between earth and copper.

The main point about earth leads is to keep them as short as possible. This is one reason why it is not good to use the earth pin of mains sockets for the earth connection to a receiver like this one.

CHOICE OF AERIAL SOCKETS

On the receiver, there are two sockets for the aerial, one going to a coupling coil L1 and the other to the "top" of L2 via a 47pF capacitor C1. When using the receiver, use the aerial socket which gives the best results from the station to which the set is tuned.

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