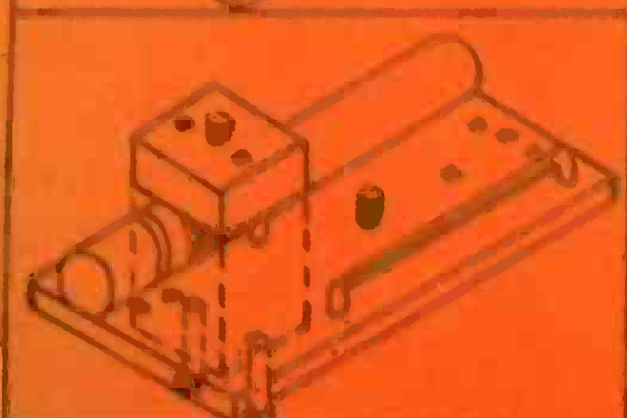
SEE AND MAKE SERIES

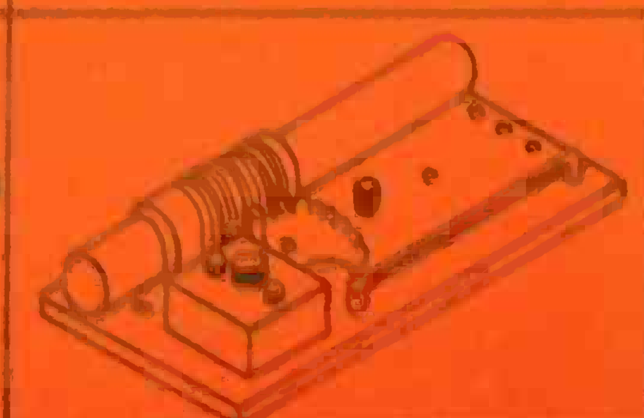
modern crystal sets

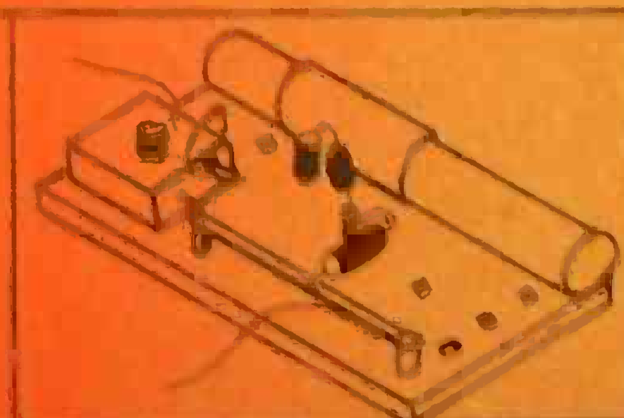
Fully illustrated step-by-step

by

R. H. WARRING







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1

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R. H. WARRING

First published 1976

ISBN 0 7188 2159 9

Printed in Great Britain by
Butler & Tanner Ltd, Frome and London

Lutterworth Press · Guildford and London

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INTRODUCTION

The crystal set is about the simplest type of radio receiver you can make. It needs only a few components—and it will work even without a battery! Its name comes from the early days of radio, when receivers used a quartz crystal as a 'detector', the connection to which was made by a 'cat's whisker'. In modern crystal sets the crystal and cat's whisker have been replaced by a more efficient component called a *diode* or, strictly speaking, a *crystal* diode, so that the name 'crystal set' still applies. Diodes are not unique to crystal sets. They are used in all types of modern radios.

There are several ways of arranging the components in order to make a crystal set work—and many more if you want to improve on the performance offered by a basic, batteryless crystal set. This, in fact, is part of the great attraction of crystal sets. They are cheap and easy to make, and there are a number of modifications you can try, once the set is constructed, to see if you can improve the performance. These are described in the various circuits, but you will understand more about this 'experimental' side if you study pages 26 and 27 which explain how crystal sets work.

In order to make the building of crystal sets easy, each circuit is illustrated with:

1. *step-by-step diagrams* showing the order in which the components should be connected into the circuit;
2. a *plan* showing where all the components go and how they are connected.

In both cases, the components, right through to the complete layout, are shown pictorially, i.e. what they actually look like. Most books on making radios give circuit diagrams instead of layout plans, and use symbols for components instead of 'pictures'. To make it easier to follow, this book adopts 'pictures' throughout, both for assembling circuits and for checking over circuits. In other words, you need absolutely no previous knowledge of radio at all to make any of the sets described—and get them working properly.

Before you start building, however, you need to study pages 4 and 5, which describe *components*: what they look like, how they have different values, and so on. The main components are the *diode, capacitors*, and *resistors*—plus a *transistor* when you go on to build other more elaborate crystal sets.

A transistor adds that 'something extra' that no basic crystal set can offer. Whilst ordinary crystal sets can pick up and 'detect' radio signals, these are inevitably very weak signals which can be difficult to hear properly. The addition of a single transistor can boost the strength of the listening signal received by up to a hundred times or more, as well as bringing in more stations too weak to be heard before. All this can be achieved for a modest additional cost.

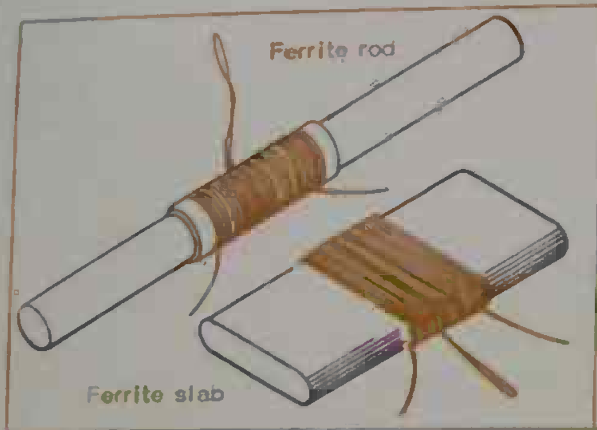
In developing the transistorised crystal set, it is shown first how a transistor can be used in place of a diode, giving about the same performance as a 'basic' crystal set. Then, by the addition of a few more components and a battery, we find out how a transistor can be used to work as an *amplifier*—both with and without the diode. Build the two different circuits and compare their performance!

In order to work as an amplifier a transistor needs power, which is supplied by a battery. Here again we have another great advantage of transistors. They require only low voltage batteries and draw quite low currents, making possible the use of small, inexpensive batteries that will last a long time. You can use anything from a single 1·5-volt pen cell up to a PP3 (9 v) transistor radio battery, depending on the type of transistor employed.

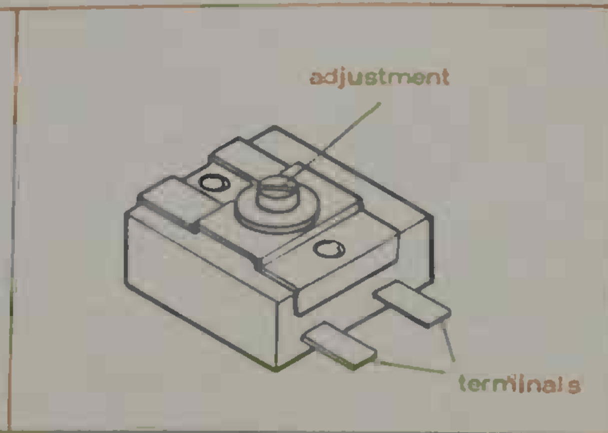
All circuits are shown laid out and assembled on a simple *circuit board*, cut from Paxolin sheet. The size of board shown is much larger than it need be. This is done to avoid crowding components together, which makes it much easier to solder components in place, check connections, and generally experiment with additional components, etc. Once you have got familiar with the technique of constructing simple crystal sets you can, if you wish, build the same circuits on a much smaller panel. In fact, if you use a much smaller aerial coil (e.g. wound on a ¼" diameter ferrite rod cut to the same length as the paper sleeve—*see* pages 8 and 9), you could build any of these circuits on a panel small enough to fit inside a matchbox!

Finally, remember that with all crystal sets the listening results obtained depend very much on where you live, and not just on assembling the circuits correctly. Some areas are particularly poor as regards radio reception. Others are very good. But even in poor listening areas you should be able to pick up at least one station at listening strength, provided you have a good *aerial*. There are ways of improving aerial efficiency, too (*see* page 28). In areas where radio reception is normally good, you may be able to get good results without using any external aerial or earth connections at all, thereby making your crystal set completely portable.

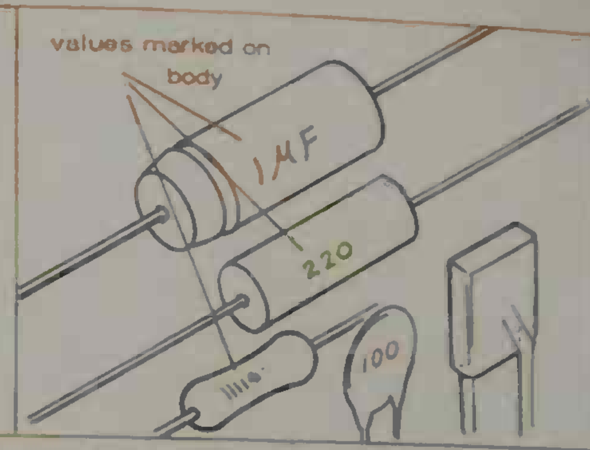
This brings out one more important point. Crystal sets form an ideal medium for experiment. Once you have made several and got them working satisfactorily you can go on to try your own ideas on what might make an even better set!



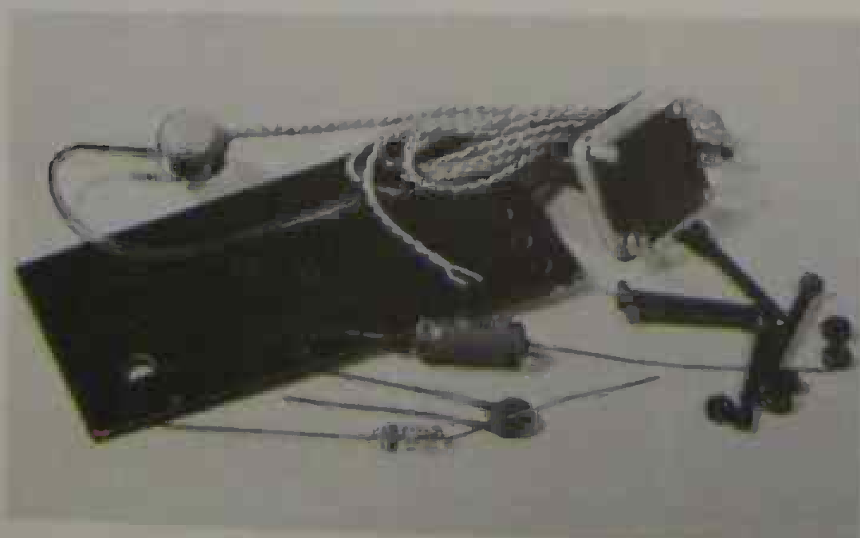
1. **TUNING COILS** consist of fine enamelled wire wound many times round a **FERRITE ROD** or **FERRITE SLAB**. You can buy these ready-made, or wind tuning coils yourself (*see* pages 8 and 9).



2. In order to adjust your completed set to tune in to different stations, a small **VARIABLE CAPACITOR** or **TRIMMING CAPACITOR** is another essential component. This you must buy.



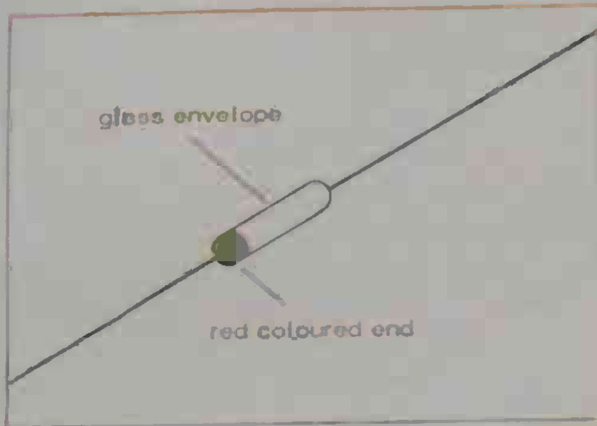
3. **CAPACITORS** come in various values—and different shapes and sizes. The most simple radio circuits need one or more capacitors. When buying, simply ask for the value(s) required.

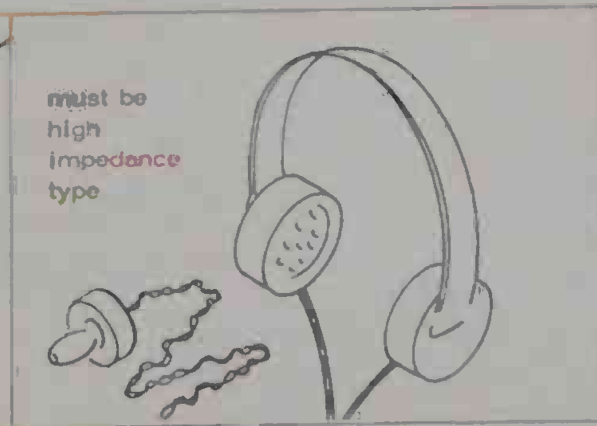


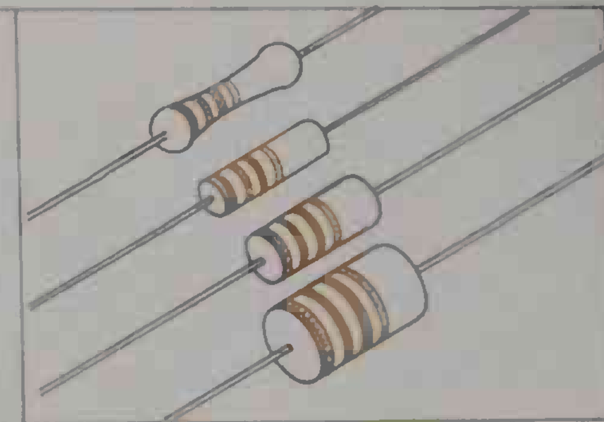
ABOUT COMPONENTS

You will need to be able to identify the various types of components used in radio circuits, and make sure that you are using the right *values* of these components. This is not difficult if you ask for (or mail order) exactly the values you require. These are given on the components list of the various circuits described.

To avoid possible confusion at first, keep *resistors* and *capacitors* in separate envelopes. The other components you can easily identify by their shape or size. Handle all components carefully, especially *transistors*.







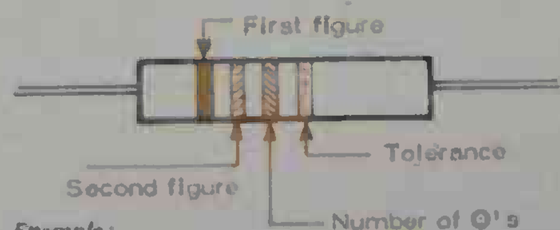
4. A DIODE is a tiny cylindrical-shaped component with a glass body, usually with rounded ends. A thin wire emerges from each end (the connecting leads). One end of the diode is marked + or coloured red.

5. For listening-in, you can use HEADPHONES or a DEAF-AID EARPIECE. Whichever you choose, it must be of the *high impedance* type. Transistor-set earpieces may not work on crystal sets.

6. RESISTORS are another important component. They are usually cylindrical in shape with connecting leads emerging from each end. Resistor values are marked by coloured rings.

RESISTOR COLOUR CODE

Marked on the body of a resistor you will usually find four coloured rings, starting closer to one end than the other. The first colour (nearest the end) gives the first value of the resistance; the second colour the second value of the resistance; and the third colour the number of 0's to add after the first two figures. The fourth colour gives the tolerance, and you can ignore this for crystal sets.



Example:
First colour Brown=1
Second colour Blue=6, making 16
Third colour Orange=3, making 16,000

This would indicate a resistor value of 16,000 ohms, or 16 kilohms.

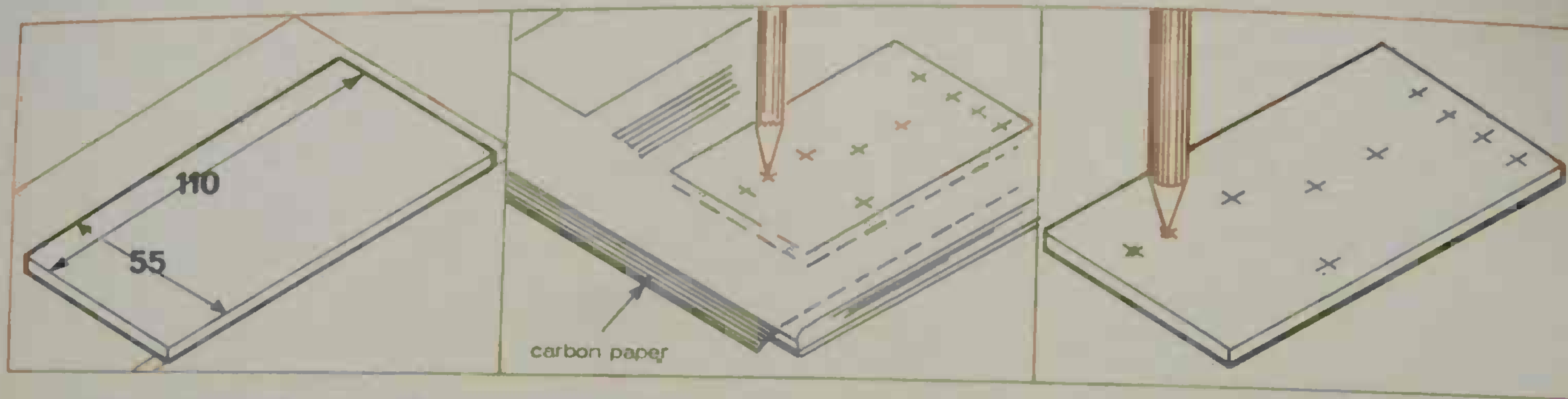
Don't worry if you find this confusing at first. Colour codes as well as resistor values are given in the components list.

Here are the values of the various colours:—

Black—0; Brown—1; Red—2; Orange—3; Yellow—4; Green—5; Blue—6; Violet—7; Grey—8; White—9.

If you are interested in *tolerance* values (fourth colour band), these are:

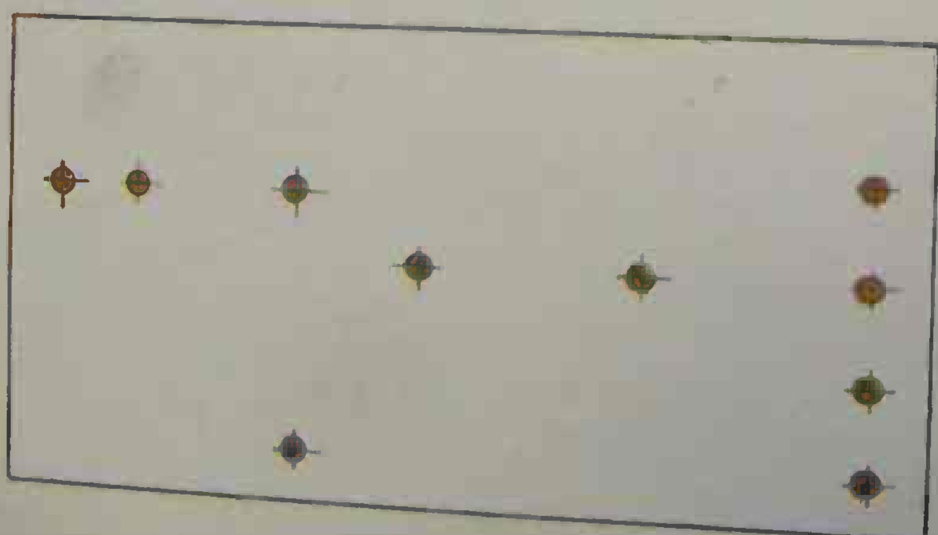
Silver—10%; Gold—5%; Red—2%; Brown—1%.



1. Mark out a rectangle 110 mm by 55 mm wide on a sheet of Paxolin and cut out carefully with a hacksaw. Smooth the edges with sandpaper, or a file.

2. Lay the Paxolin panel under the full size drawing below. Insert a piece of carbon paper between the page and the top of the panel and mark the centres of the holes in pencil.

3. Use a centre punch to make a small indent at each marked hole position by tapping the end of the punch lightly with a hammer. There are ten hole positions to mark in all.

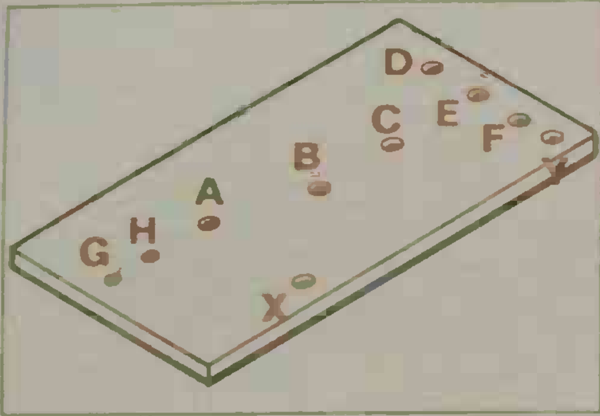


THE BASEBOARD

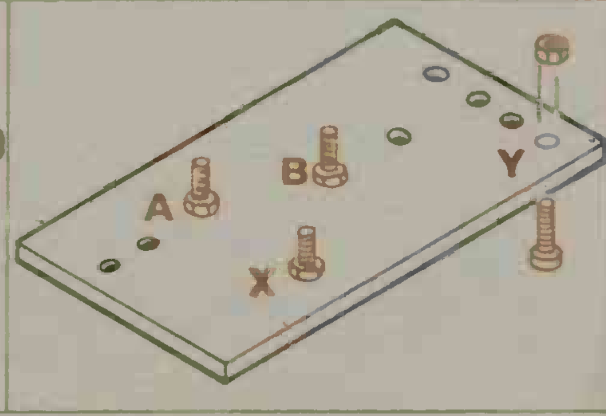
Modern radio sets are assembled on a flat board of insulating material, such as Paxolin. You can buy Paxolin sheet in various sizes and thicknesses. A 30 cm (12") square will be enough to make all the circuits described in this book. Ask for 1·6 mm ($\frac{1}{16}$") thick Paxolin as this will be easiest to drill.

The drawing on the left shows the panel used for making nearly all the sets described in the following pages *actual size*, with all hole positions in their correct position.

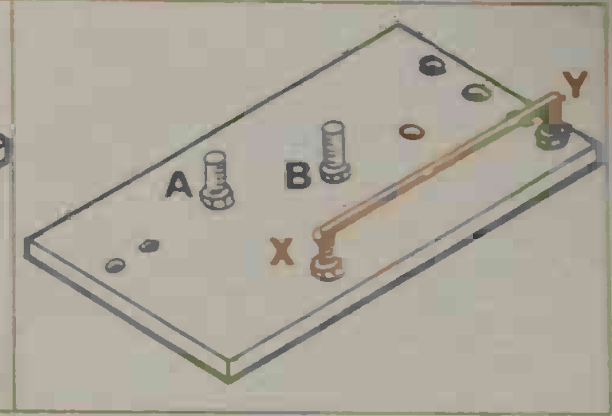
Brass screws form terminal points or connecting points



4. Use a 3 mm drill to drill holes A, B, C, D, E and F. Use the same drill to drill holes X and Y. Then change to a $\frac{1}{16}$" drill to drill holes G and H.



5. Fit 6BA brass machine screws into holes A, B, X and Y with all the heads on the underside of the panel. Fit a 6BA nut to each screw and tighten to secure the screw in place.

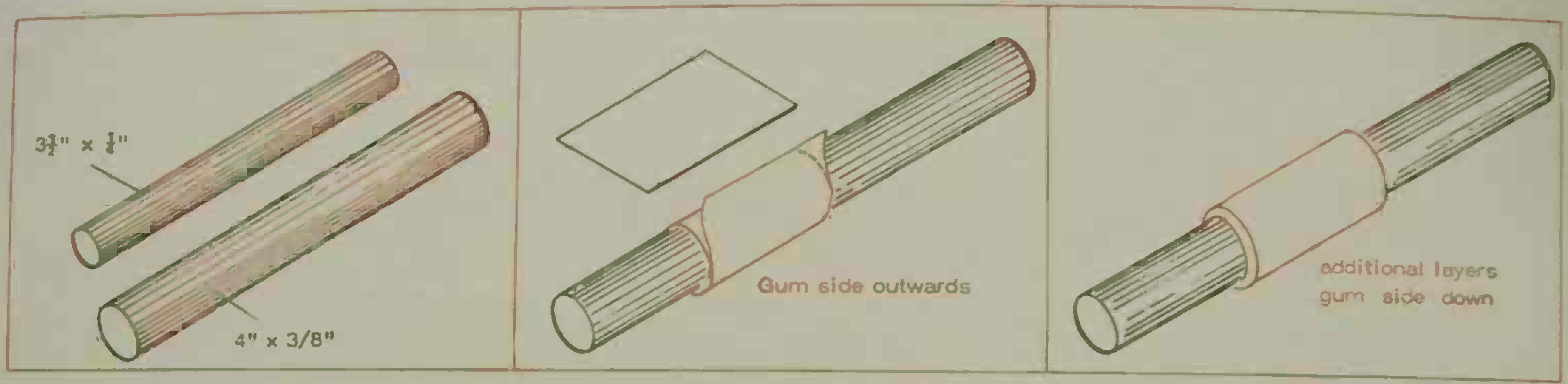


6. Cut a 100 mm (4") length of *tinned copper wire*, $\frac{1}{16}$" diameter, and solder into position between the top of screw X and screw Y. This makes a 'common' connecting line or *bus bar*,

for joining up components in the circuit. In the stages shown above (and in the photograph on the right) only two separate connecting points are shown, A and B, plus a common connecting line between X and Y. Holes C, D, E and F are not fitted with screws at this stage, as the first circuits described do not require these additional connecting points.

The smaller holes G and H are to secure the aerial wire to the panel and are not fitted with screws.

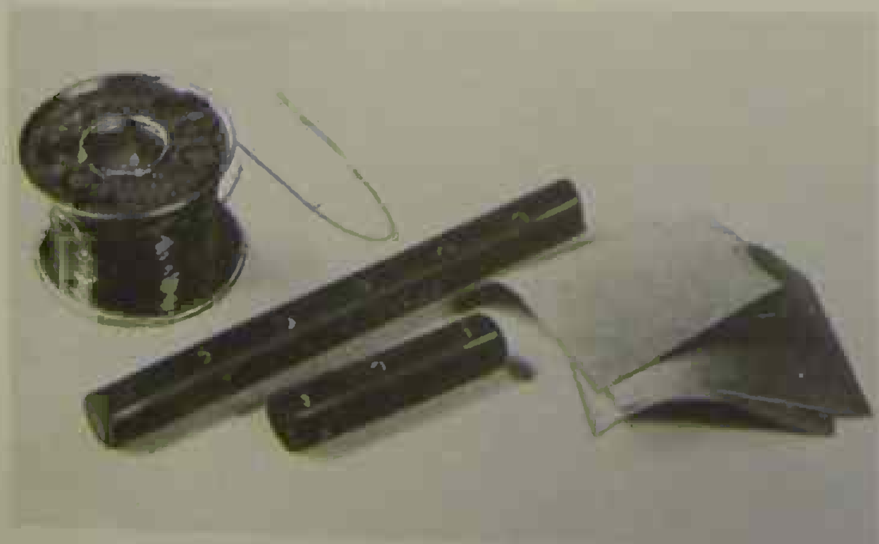
All joints made to connect components to terminal points in the circuit *must* be soldered for best results.



1. Two standard diameter sizes of Ferrite rod are shown. You can use either for making a *ferrite rod aerial.* Cut to length with a hacksaw, or mark with a sharp file and break off.

2. Cut several lengths of gumstrip (gummed paper) about 35 mm (1½") long. Moisten one strip and wind round the rod, gum side outwards to make a neat wrapping.

3. Build up additional layers of gumstrip wrapping, using a piece at a time, to make a smooth paper sleeve around the rod. Additional layers should be gum side down.



FERRITE ROD AERIALS

It is quite a simple matter to make your own aerial coils or *ferrite rod aerials.*

The materials you require are:—

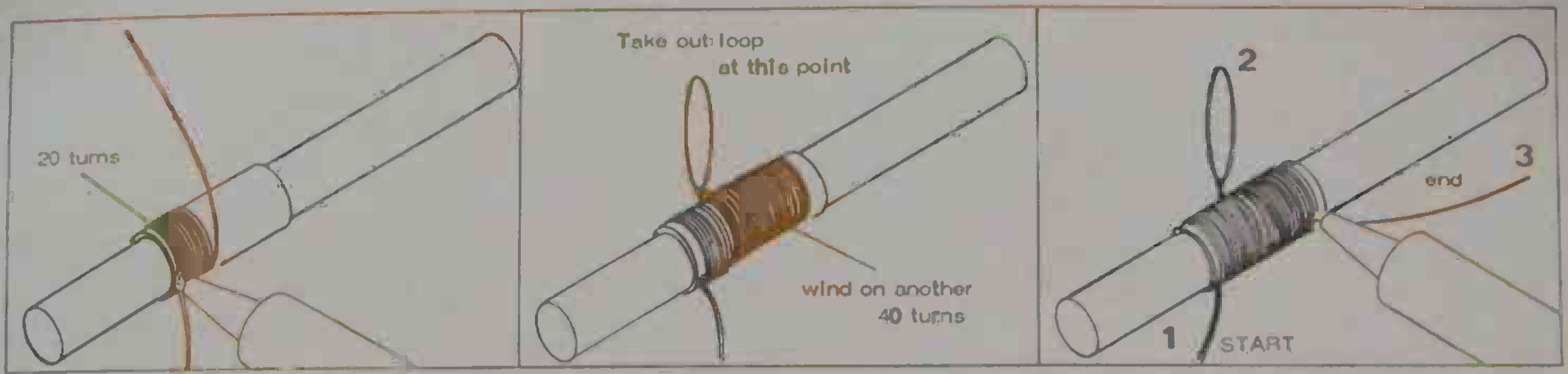
Ferrite rods, either ¼" or ⅜" diameter.

38 s.w.g. enamelled wire (usually sold in spools of 1 ounce or more).

Some gumstrip, i.e. of the kind used for sealing parcels

Quick drying adhesive, such as balsa cement or clear household adhesive.

If you follow the step-by-step directions you will have no trouble making an efficient ferrite rod aerial.



4. Secure the end of the 38 s.w.g. wire with a dab of adhesive, leaving about 3" free. Then carefully wind 20 turns on to the paper sleeve, each turn tight up against the one before it.

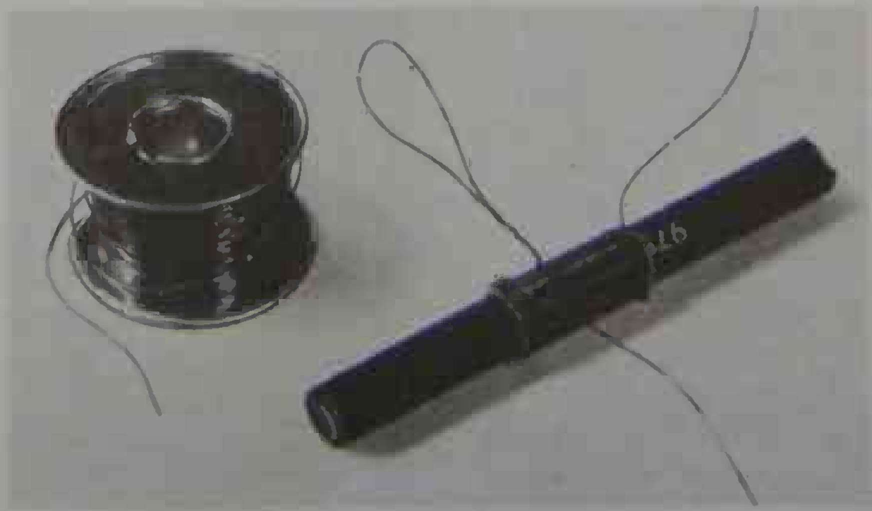
5. Take a loop of wire out sideways at this point and twist together as shown. Now continue winding on another 40 turns of wire to make 60 turns in all in the complete coil.

6. Secure the 'finish' end of the winding and cut off the wire leaving a free length of about 3". The coil now has three connecting points:—

1 (the start); 2 (the loop or 'tap' point); and 3 (the end).

The gumstrip sleeve on which the actual coil is wound should not be too thick. Just add enough layers to make it quite rigid so that it is not crushed by the winding. The paper sleeve must also be free to slide up and down the ferrite rod, so when you have completed the layers, slide the paper tube off the rod and set it aside until dry. Then there is no chance of it becoming accidentally stuck to the rod.

The turns of wire should be wound on close together, each turn touching the one before it—so try to make as neat a job of the winding as you can. Be sure that the 'start' and 'finish' ends of the winding are properly secured—otherwise the coil will tend to unwind and become loose.



SOLDERING

Wiring connections made in electrical circuits *must* be soldered for best results. Making soldered joints is quite simple, if you use the correct equipment (an electric soldering iron and cored solder), and follow the few basic rules for good soldering.

For all the circuits described in this book a 10-, 15- or 20-watt (mains) electric iron should be used with a bit size of $\frac{1}{16}$" or $\frac{3}{32}$". Solder should be of the multi-core type—it looks like soft wire about $\frac{1}{16}$" thick. You do not require soldering flux (cored solder contains all the necessary flux in it). And *never* try to use an acid-type flux to re-make a soldered joint which has not taken properly. This will only cause corrosion.

The basic rules of good soldering are:—

a. The iron must be hot. Allow ample time for the iron to heat up after switching on. The iron temperature is correct when solder offered up to the tip melts at once.

b. The tip of the iron must be 'tinned' (i.e. covered with a coating of solder) and *clean*. If the tip is dirty, wipe clean with a cloth when the iron is *hot* (i.e. the 'tinning' on the tip is molten).

c. The parts to be joined are clean. Terminal tags, component leads and the brass screw terminals on the circuit board should be rubbed gently with fine emery paper until they look 'bright clean'. After cleaning, do not touch with the fingers.

The stages in the making of soldered joints are:—

a. Allow the iron to come up to full heat (as *a* above).

b. Hold the parts to be joined together, touching each other.

c. Place the iron against this joint so that both joint surfaces are heated up. Use pliers to hold leads in place.

d. After about 3 seconds, touch the joint with solder. Solder should run freely over the joint. Remove the iron at once.

e. Hold the joint together until the solder has solidified.

If you are doing it correctly, a good joint should be completed in less than 5 seconds. If not, then the iron is not hot enough to start with, or there is another fault, such as:—

a. Solder does not run evenly over the joint—because one or both joint surfaces are dirty or greasy.

b. Solder rolls into a ball and falls off the joint—iron tip or joint surfaces greasy or dirty.

c. Solder slow to melt and when solidified has a dull 'speckled' appearance—joint surfaces not hot enough.

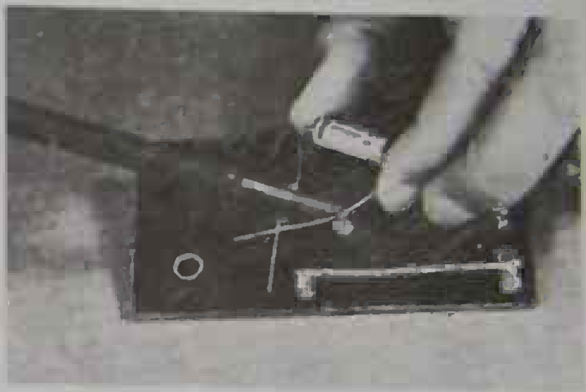
Remember—never *overheat* joints (i.e. hold the iron in place for too long) as excess heat conducted away through leads can damage components. In the case of transistors, always leave the leads fairly long (at least 25 mm); and hold the lead with pliers. This will help prevent heat rising up the lead and possibly damaging the transistor.

1. The tools you need. Electric soldering iron, cored solder, cutting pliers and a modelling knife.

5. Cut off surplus length of component leads once the solder joint has set.

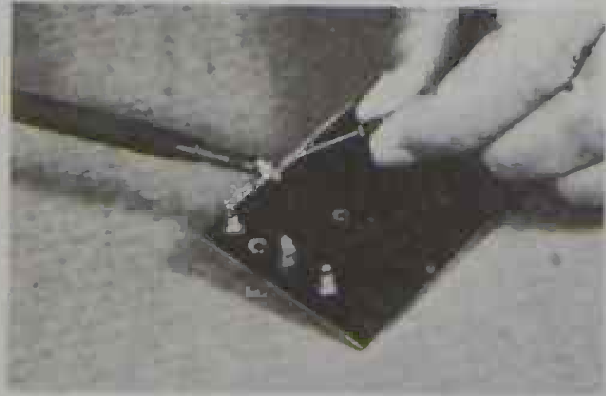
2. 'Tinning' the tip of the iron. When the iron is hot enough for use the solder will melt freely when touched on the tip.

3. 'Tinning' the 6BA terminal screws. Hold iron against top of screw. When heated up sufficiently, touch the screw with solder. Tin each screw in this way.

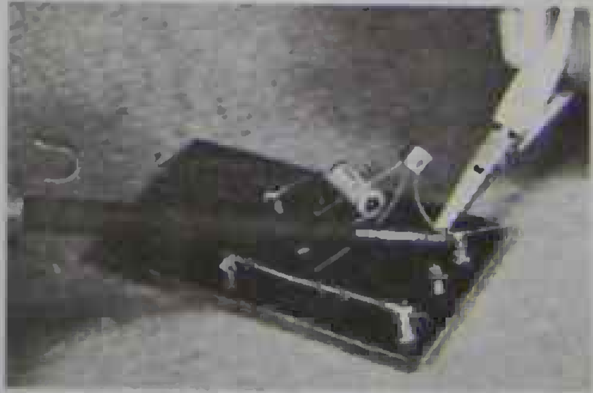


4. Technique for soldering 'bus bar' and component leads in place. Hold iron in place to heat up joint, then touch with solder, which should melt and run freely to complete joint.

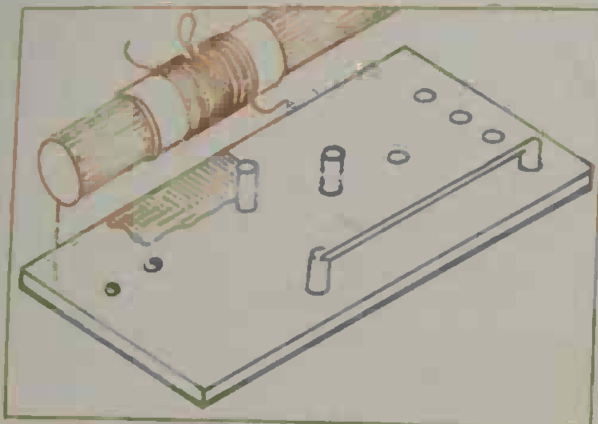
6. If component leads are not 'bright clean', a poor solder joint is likely. Clean leads if necessary by scraping carefully with a modelling knife, the cleaned component lead can then be 'tinned' with the tip of the iron.

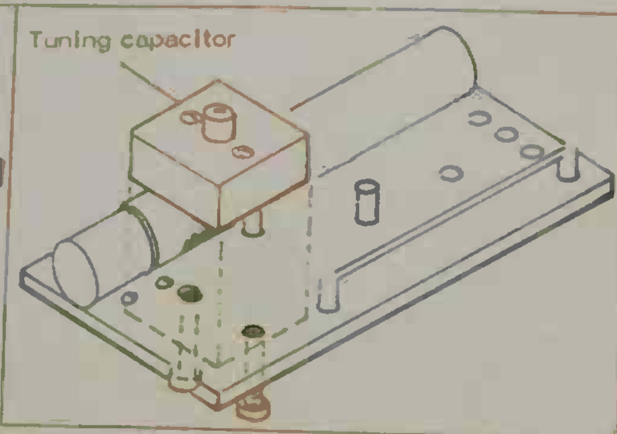


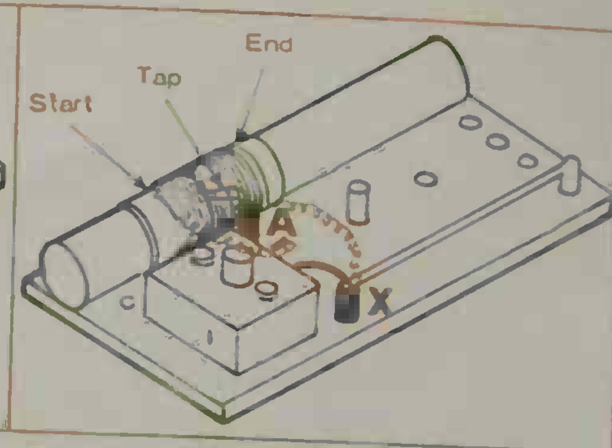
7. With a lead tinned in this way (6), the joint can be completed by holding the lead in place and applying the iron under the joint until the solder melts. Always hold a component in place until the joint has set properly (i.e. has solidified).



8. When soldering transistors it is a good idea to grip the lead being soldered with flat-nose pliers. This will prevent excess heat being conducted up the lead to the body of the transistor, which could be damaging.



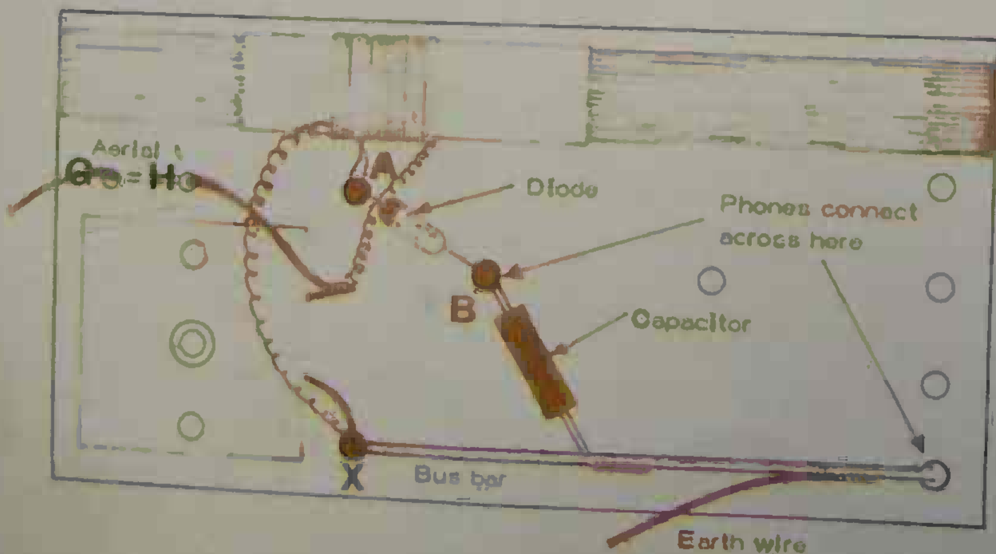




1. Position the paper sleeve about 25 mm (1") in from one end of the ferrite rod and glue down on to the Paxolin panel in line with the edge (check position with diagram below).

2. Lay the tuning capacitor in position. Then either glue down, or drill two matching holes to mount on to the panel with small (8BA or 10BA) brass machine screws and nuts.

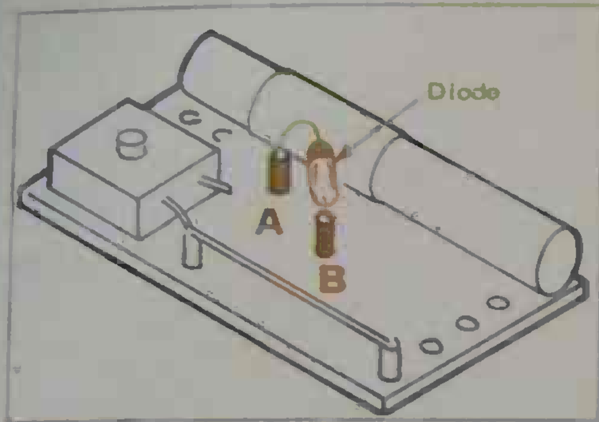
3. Connect the aerial coil as shown:—*End* to the top terminal on the tuning capacitor; *Tap* to terminal A; *Start* to bus bar terminal X. Solder a short length of wire between X and bottom terminal of tuning capacitor.



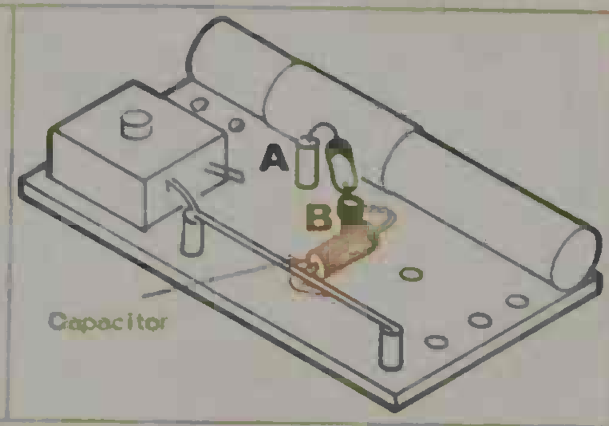
COMPLETE CRYSTAL SET

The (full size) diagram on the left shows the fully assembled crystal set. You have already cut out the Paxolin panel to size and fitted it with terminal bolts and a 'bus bar'. The other components you need to complete the set are:—

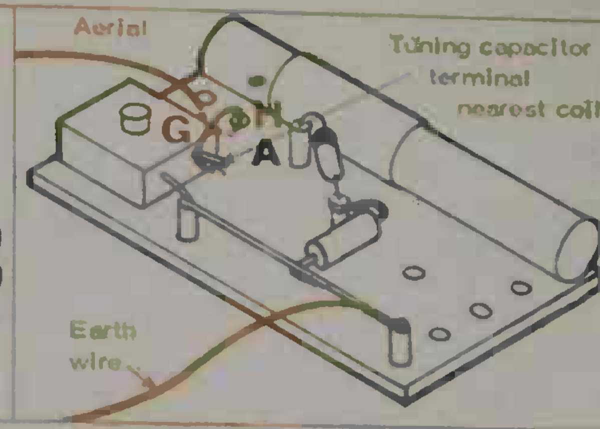
500 pF miniature tuning capacitor or equivalent value in a *trimming capacitor*
Germanium crystal diode—almost any type will do, but for best results specify an OA90, AA113, AA116 or equivalent.
0·001 μF capacitor.
Some thin insulated wire for aerial and earth connections.



4. The *diode* is connected next. Cut the leads to about 25 mm (1") long. Solder one lead to terminal A and the other lead to terminal B. It does not matter which way round the red end is.



5. The *capacitor* is connected between terminal B and the bus bar. Clean the leads before soldering to make sure of a good joint. *All* connections must be soldered.

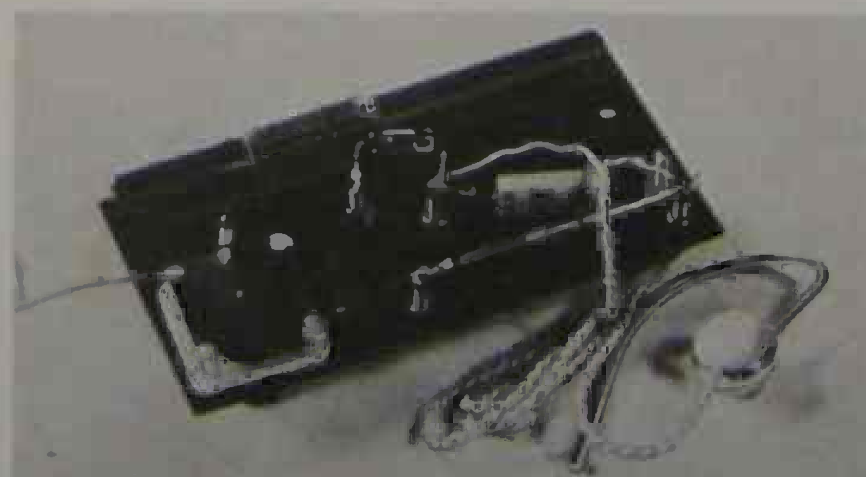


6. The aerial wire is threaded through holes G and H, as shown. Bare the end and solder to one terminal on the tuning capacitor. Solder another length of wire to the bus bar for an earth lead.

Having completed assembly of the *tuning capacitor, diode* and *capacitor*, check over all the connections carefully. Use the full size plan opposite as a guide. If any connection is wrongly made, or there is a 'dry' soldered joint, the set will not work.

To complete the set in readiness for listening in, all you have to do is connect phones (or a deaf-aid earpiece) between terminal B and one end of the bus bar. No battery is needed.

To work properly your crystal set must have a good *aerial* and also an efficient *earth* connection, so study page 14 carefully.



THE AERIAL

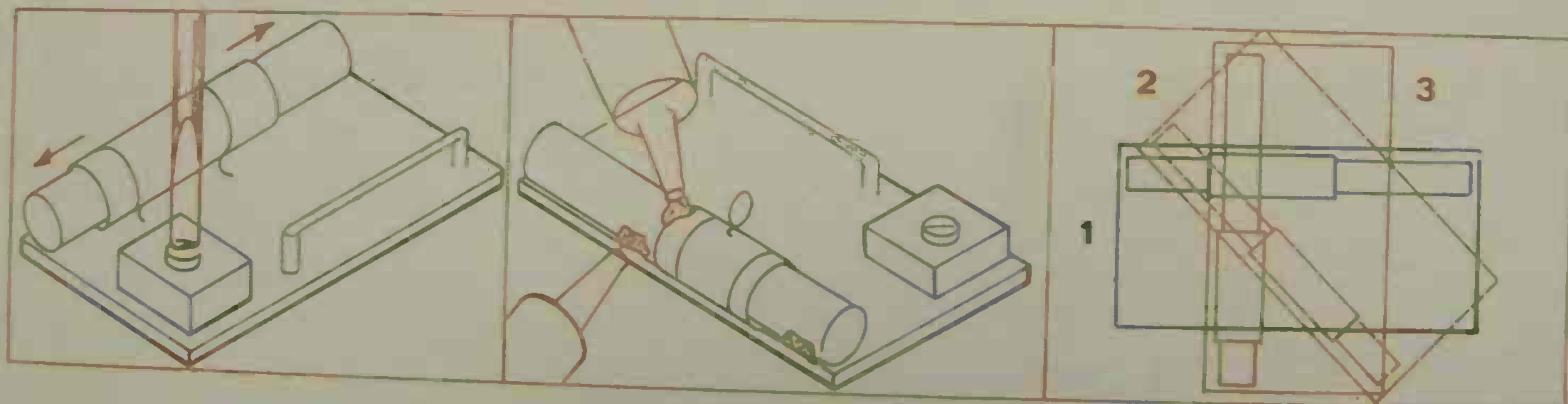
For the aerial you need a *long* length of thin insulated wire—the longer the better—taken up as high as possible. For example, if you are 'listening-in' downstairs, take the aerial wire upstairs in as near a vertical position as possible. You can join this wire to the aerial wire on the chassis by baring the ends of the two wires and twisting together. This makes it easy to detach the set from the long aerial wire when you want to put it away.

THE EARTH

About the best 'earth' connection you can find in a house is a cold water pipe—but it must be a *metal* pipe. Scrape the surface of the pipe clean and tape to it a length of bare wire (or insulated wire with a bared end). Better still, use a jubilee clip to make this connection, as you must have good contact between the 'earth' point and the connecting wire.

The earth wire is then connected to the earth lead on the set (i.e. the wire soldered to the bus bar). Make this a good connection as well.

GETTING YOUR SET WORKING . . .



Put on the headphones and find out if you can tune in to a station by adjusting the tuning capacitor. If the capacitor does not have a spindle, use a sharpened dowel or plastic knitting needle rather than a metal screwdriver to adjust the screw in the centre of the capacitor.

Try sliding the ferrite rod backwards and forwards through the paper sleeve. When you have found a position which gives you the *most* stations audible (even very weakly), glue the rod in this position with a few dabs of balsa cement.

Your ferrite rod aerial is *directional*. If you start with the set in position 1, turning through 45 degrees (2) or 90 degrees (3) can make a lot of difference to the number of stations heard, and the strength of the signal heard.

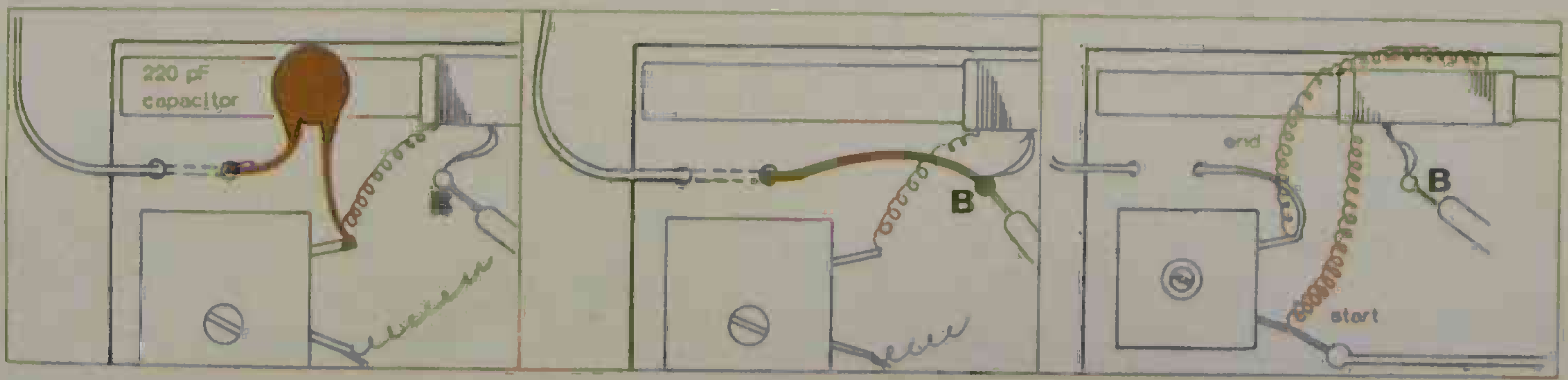
STATIONS YOU MIGHT HEAR

If you live in an area where there are strong local radio signals, you should easily be able to pick these up with a crystal set. Under favourable conditions you should also be able to hear quite distant stations—very weakly perhaps, but strong enough to be able to identify them (e.g. Radio Luxemburg or Hilversum).

Try to find and identify Radio 4. Set the tuning capacitor to its mid position (which will make Radio 4 disappear). Now slide the ferrite rod backwards and forwards until Radio 4 reappears again. If you can do this, cement the rod in this position. You should then be able to find Radio Luxemburg and Radio 1 near one end of the tuning adjustment on the tuning capacitor; and Radio 3 at the other.

If this does not work out, just adjust the ferrite rod position for maximum signal strength on one station which can be picked up quite readily.

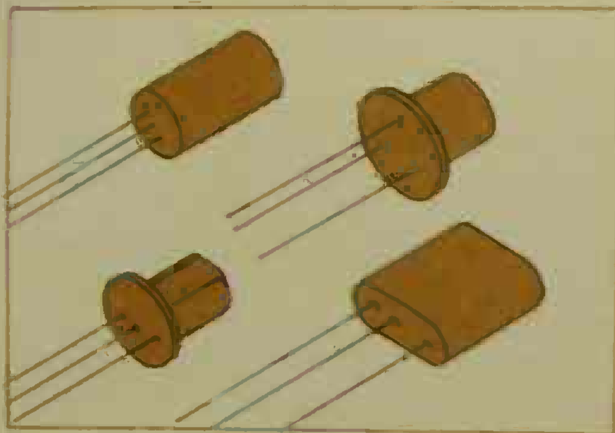
Remember, listening conditions can vary a lot—with weather and time of day. Sometimes you may get very poor reception, even for a 'strong' station. At other times you find you can tune in to several stations you have not heard before—so keep trying! There are also some further 'adjustments' you can try—*see below*.



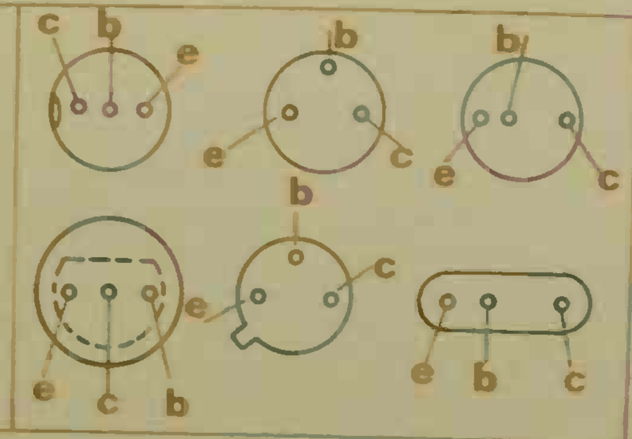
Here is a simple way of improving the efficiency of your aerial. Disconnect the aerial wire from the tuning capacitor terminal and solder to one lead of a 220 pF capacitor. Connect the other lead of this capacitor to the tuning capacitor terminal.

If that does not improve reception, try this. Disconnect the 220 pF capacitor and connect the original aerial lead to terminal B instead of the tuning capacitor. You can also try this with the 220 pF capacitor between the aerial lead and terminal B.

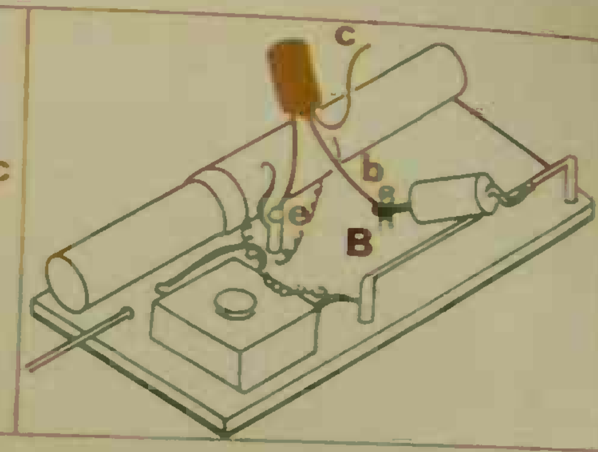
One more 'dodge' you can try. Reverse the aerial coil connection. This should enable you to tune in to *more* stations, but the listening strength will be weaker on all stations. No good if you have only weak signals to start with!



Transistors come in all shapes and sizes! For simple radio circuits you need only an inexpensive type like an OC70, OC71, NKT 214, 2N280, 2N1305, AC122, AC125, or equivalent.

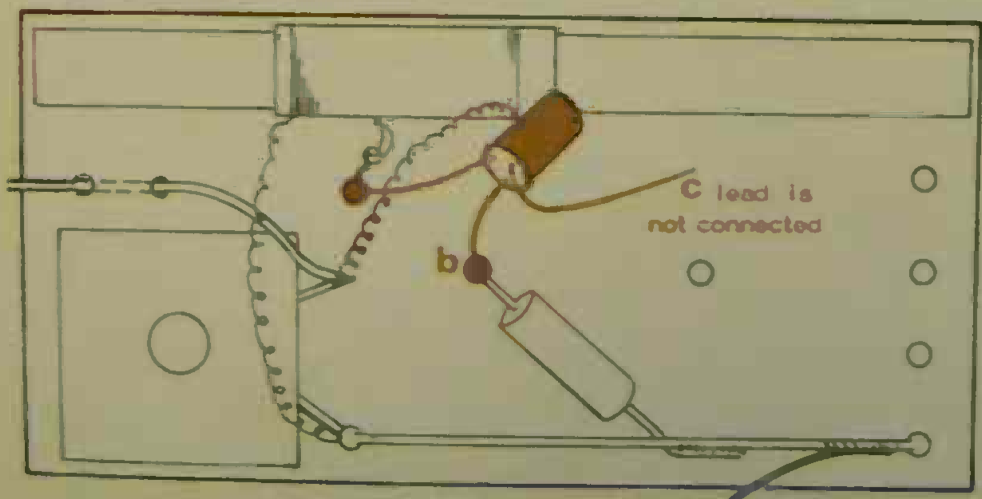


Transistors have three leads, identified as e—emitter; c—collector; and b—base. You must identify these correctly for connection. OC71 leads are shown top centre. Others may follow the diagram shown.



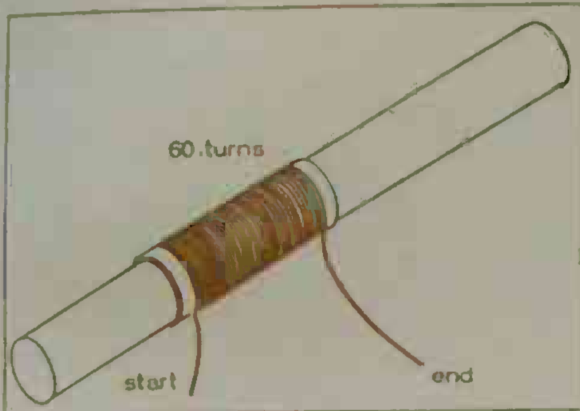
To convert your crystal set to transistor-working, remove the diode and replace by a transistor. Connect e of the transistor to terminal A and b to terminal B. The collector (c) lead is not connected.

TRY A TRANSISTOR

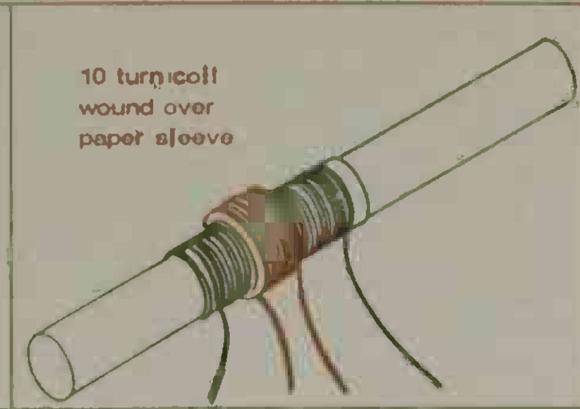


A transistor can work like a diode, using just two of its connections—the (e) or emitter and (b) or base leads. The diagram opposite shows the complete circuit—the same as on pages 12/13 with a transistor used instead of a diode. The unused (c) lead of the transistor is twisted out of the way.

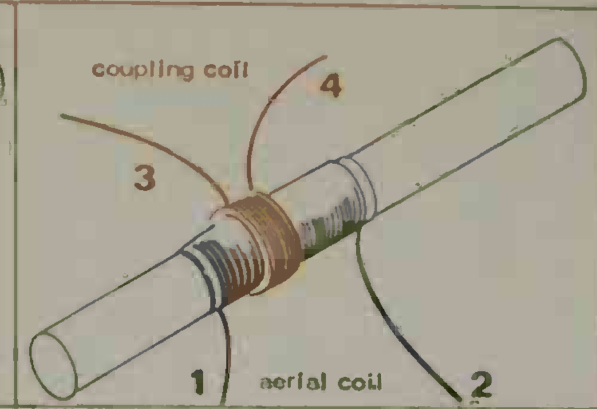
Note that no battery is required, even though you are using a transistor. Do not expect therefore much better results than you can get with a diode. However, by experimenting with different types of transistor you can improve on a diode crystal set's performance. Also you can easily *improve* the performance of a transistor set.



1. Make a paper sleeve to fit a ferrite rod, as on pages 8/9, and wind on a 60-turn coil of 38 s.w.g. wire with no tapping point. Secure the start and end with cement.



2. Make a short paper sleeve to fit over this coil. This should be a loose fit so that you can slide it up and down the first coil. The best position is found by experiment.

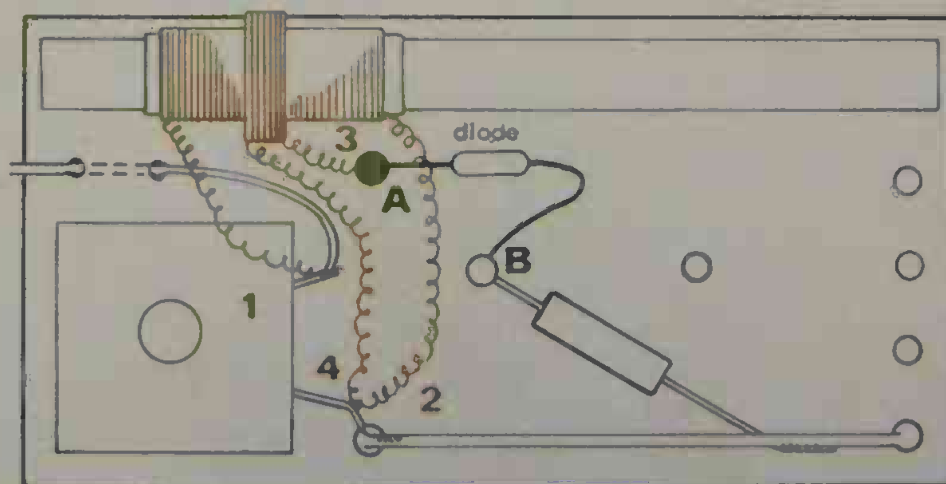


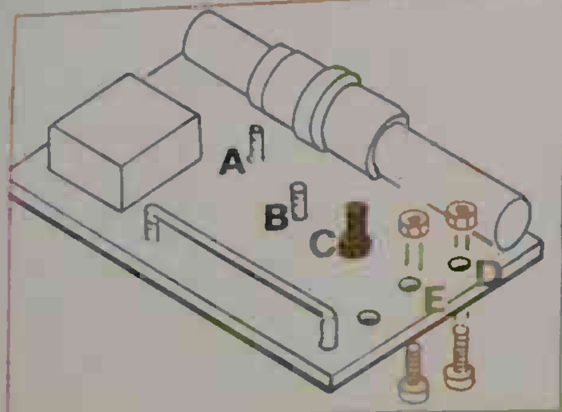
3. Wind on about 10 turns of 38 s.w.g. wire (as shown in 2.) to form the coupling coil, again sealing the ends of the wires so that the coil cannot unwind. The coil is now ready for connecting into your crystal set.

TRY A DIFFERENT COIL

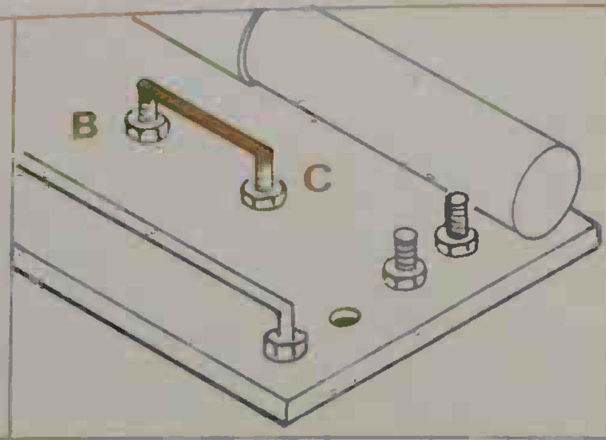
Before going to battery-powered crystal sets, it is worthwhile trying the effect of a different aerial coil. The coil we originally used connected directly to the circuit, but this 'improved' coil consists of two separate coils. One is the aerial coil, over which is wound a smaller *coupling* coil which connects to the rest of the circuit.

You can modify the original coil by adding this extra winding; or start again and wind a new coil. Connections into the circuit are as shown. The start (1) and end (2) of the *aerial* coil connect to the two terminals of the tuning capacitor. One end (3) of the coupling coil connects to terminal A; and the other end (4) to the bus bar.

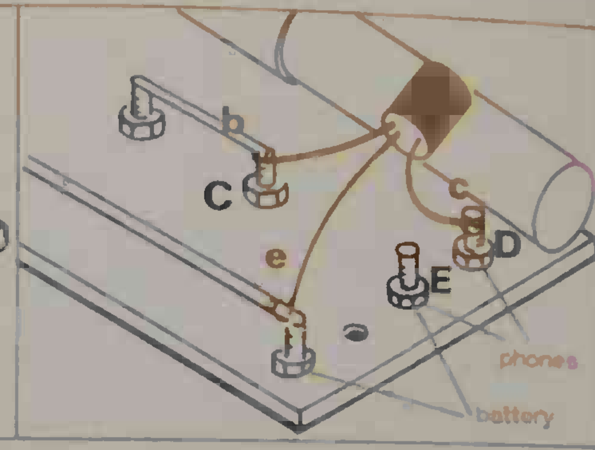




1. To accommodate the additional transistor circuit, three more terminal points are required on the panel. These are provided by fitting 6BA screws in holes C, D and E. Secure with nuts.

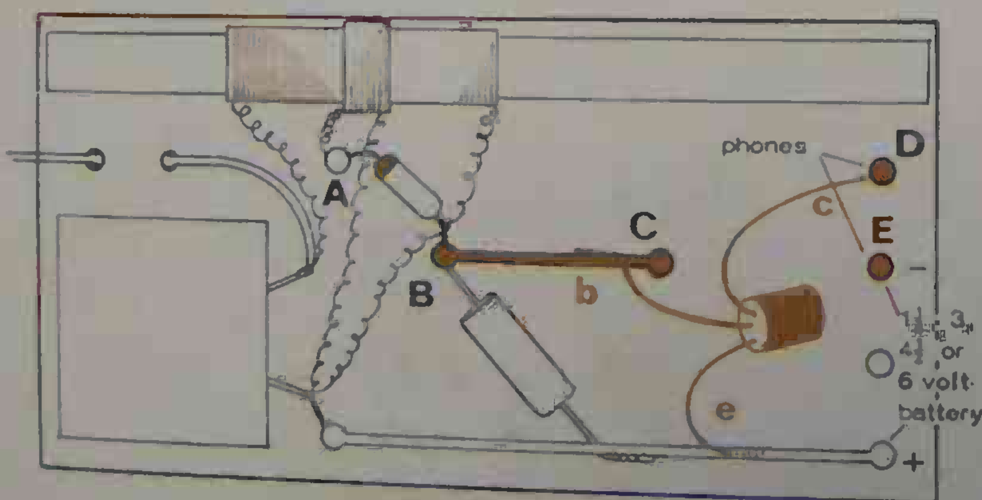


2. A short 'bus bar' is connected between terminals B and C. This is a length of tinned copper wire (or insulated wire bared at each end) which is soldered to the two screws.



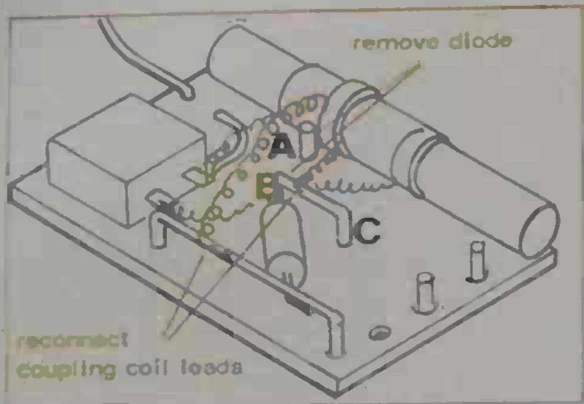
3. Transistor lead connections are: b to terminal C, e to main bus bar and c to terminal E. Phones connect to terminal D and E. Battery *negative* (−) connects to terminal D and battery *positive* (+) to bus bar.

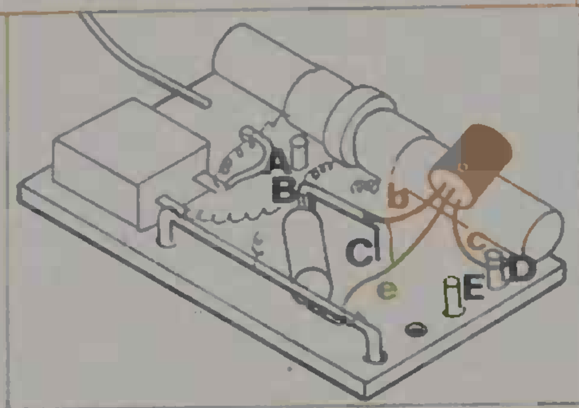
AMPLIFIED CRYSTAL SET

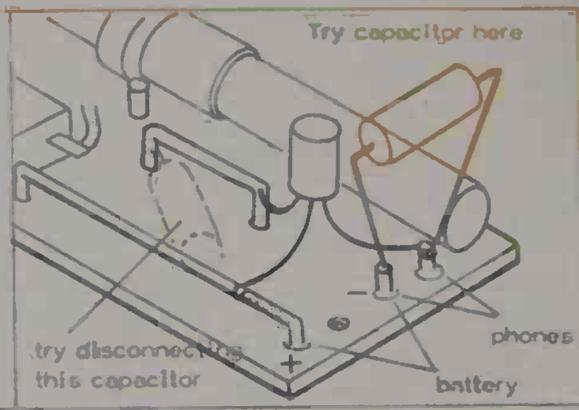


This circuit is a basic crystal set (with diode), with the addition of a transistor to work as an *amplifier* to boost the strength of the signal received (photograph, far right). This time all three leads to the transistor are connected and a battery is needed to power the transistor.

The set is exactly the same as that shown on pages 12 and 13, with the exception of the 'improved' aerial coil (page 17), and the addition of a transistor amplifier stage. Also the + (red) end of the diode must connect to terminal A. Again an OC71 (or equivalent) transistor can be used, but better listening strength (more gain) will be given by an OC75 transistor (or equivalent). It is important to connect the battery the right way round.







4. Remove the diode and disconnect the coupling coil leads taken to terminal A in the circuit on page 18. Reconnect this coupling coil lead to terminal B. This completes the modification to the 'front end' of the circuit.

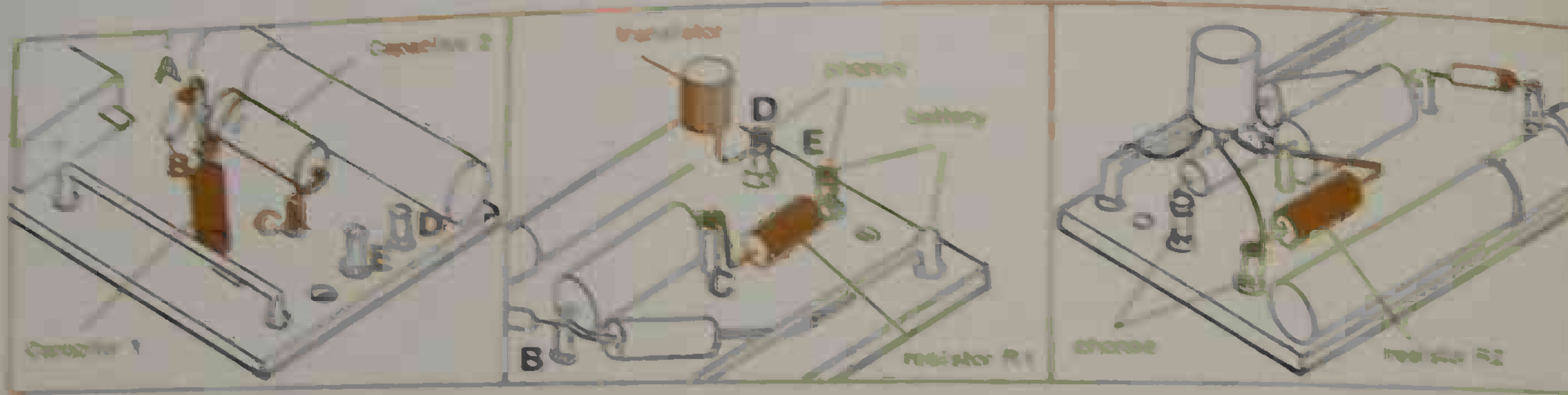
5. The transistor can be left in place, if an OC44 type or equivalent. If not, remove and replace with an OC44, connecting b to terminal C, e to bus bar and c to terminal D.

6. Connect phones and battery (plus side to bus bar), when the set should work. A 0·001 μF capacitor connected across the phones should improve the performance. Try it and find out.

TRANSISTOR DETECTOR/AMPLIFIER

A simple modification of the circuit on page 18 eliminates the diode and uses a transistor to work both as a *detector* and *amplifier* of signal. Any 'RF' transistor can be used, but an OC44 (or equivalent) is recommended with a 4·5- or 6-volt battery. Be sure to make the transistor connections correctly, and connect up the battery + side to bus bar.

The addition of a capacitor connected across terminals D and E should improve the signal *quality*. The set may work as well, or better, with the capacitor between terminal B and the bus bar omitted.

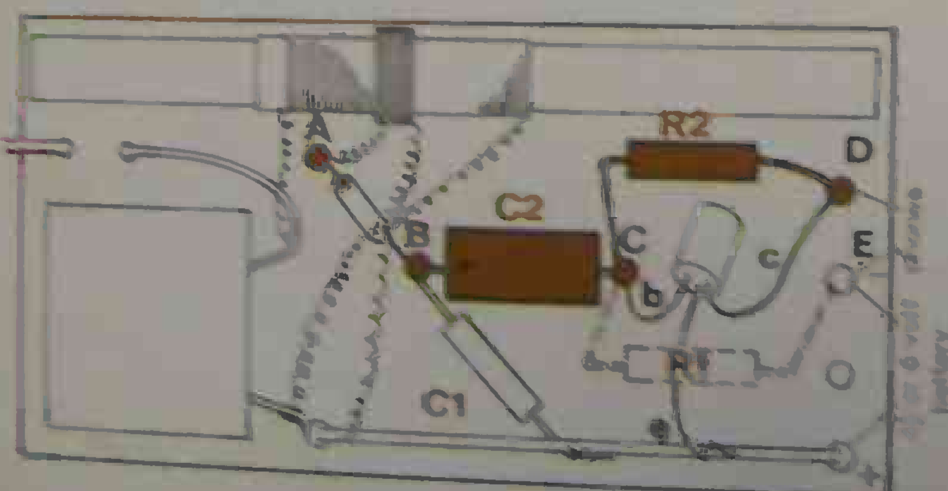


1. Assemble the panel with terminals A, B, C, D and E. Connect diode between terminals A and B (+ to A), capacitor 1 between terminals B and C (+ end towards B).

2. Connect OC71 or OC44 transistor into the circuit—b to terminal C, e to bus bar, c to terminal D. Connect resistor R1 between terminals C and E.

3. Connect resistor R2 between terminals C and D. The phones connect to terminals D and E. The battery connects to terminal E and bus bar. Use a 4½- or 6-volt battery and connect + to the bus bar.

CAPACITY COUPLING



This circuit uses indirect coupling between its stages—inductive coupling between the aerial coil and diode (detector); and capacity coupling between the diode and transistor amplifier.

Make sure that the diode is connected the right way round (+ or red end to A), and also the capacitor C2 (+ end to B). Check that transistor connections are correct before connecting up the battery—and be sure to get the battery the right way round.

Additional components shown in red:—

Capacitor C2—8 or 10 μF electrolytic

Resistors: R1—100 kilohms (brown-black-yellow)

R2—1 megohm (brown-black-green)

Note. Try with and without resistor R1 in the circuit. It may not be necessary.

NOW TRY ...

All the circuits so far described have been kept very simple, using the minimum of components. All are low-powered, meaning that you cannot expect more than just audible listening strength on a few stations. Also tuning may be subject to 'drift' — a station you are listening-in to gradually disappearing entirely.

If reception is particularly poor, or you cannot pick up any stations at all, here are some possible remedies you can try.

a. First check all connections for correctness. If you are using a transistor circuit with a battery, connecting the battery the wrong way round can damage both the diode and transistor and the set will not work at all.

b. Try to improve the efficiency of your *aerial*. Try different lengths of wire, strung up in different positions, to find out which works best (it will be 'best' only for one station probably).

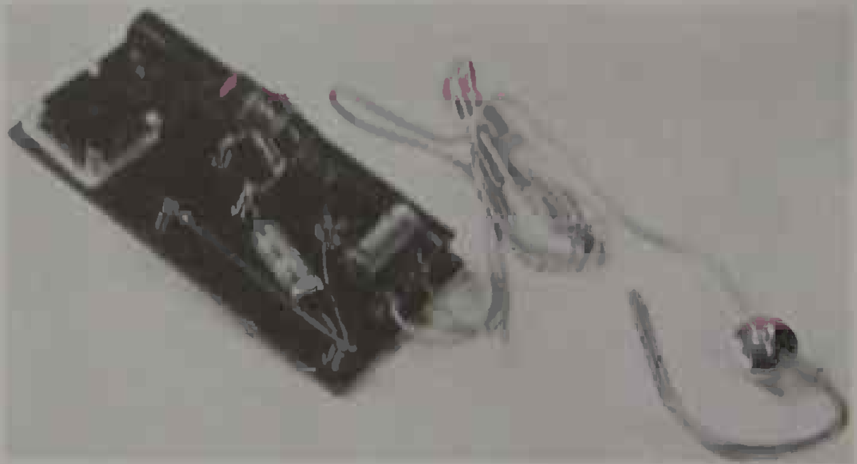
c. Try connecting the aerial lead to the springs of a bedstead. This can often prove to be a very efficient aerial!

d. See if disconnecting the earth connection makes any difference when you are actually listening to a station. If not, then you need a better earthing point.

e. Try reversing the aerial and earth leads to your set, i.e. connect earth to the aerial point, and the aerial to the bus bar. This can bring in *more* stations, but usually with weaker signals.

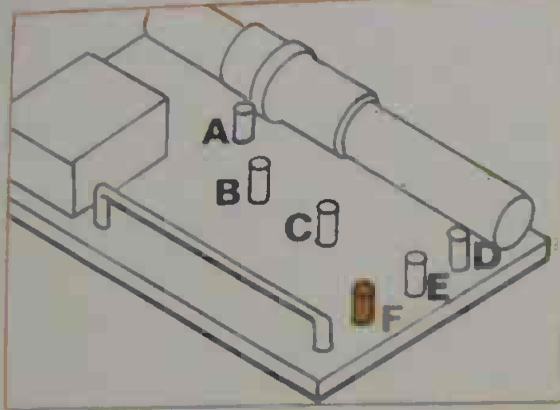
f. Try a different type of diode or transistor. This could make quite a difference.

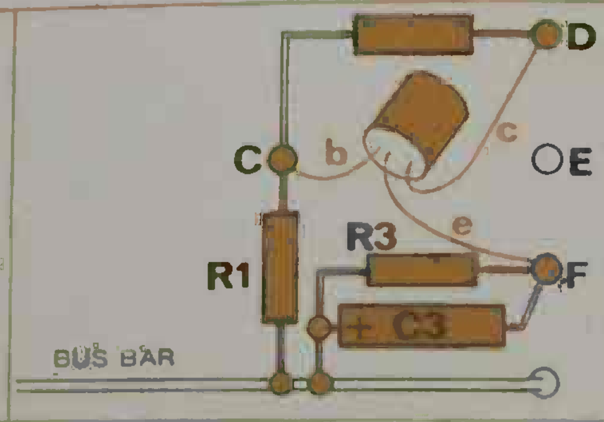
g. Try replacing your home-made aerial coil with a ready-made one (from your component suppliers). Be sure this matches a 500 pf tuning capacitor, or get another tuning capacitor to match the ready-made aerial coil.

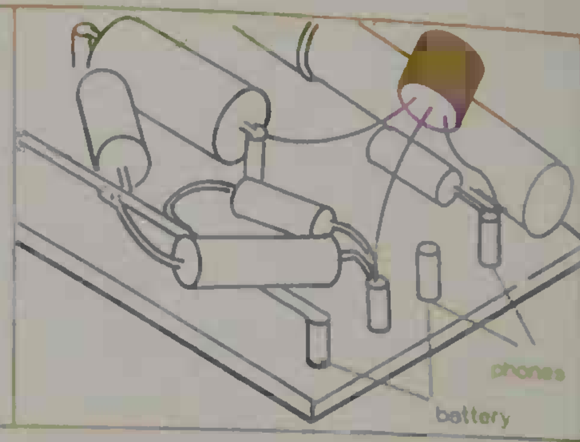


The addition of a capacitor across the phone terminals can improve the quality of reception.

Crystal set with transistor amplifier will work off small 1.5-volt battery or larger batteries up to 9 volts (e.g. PP3).





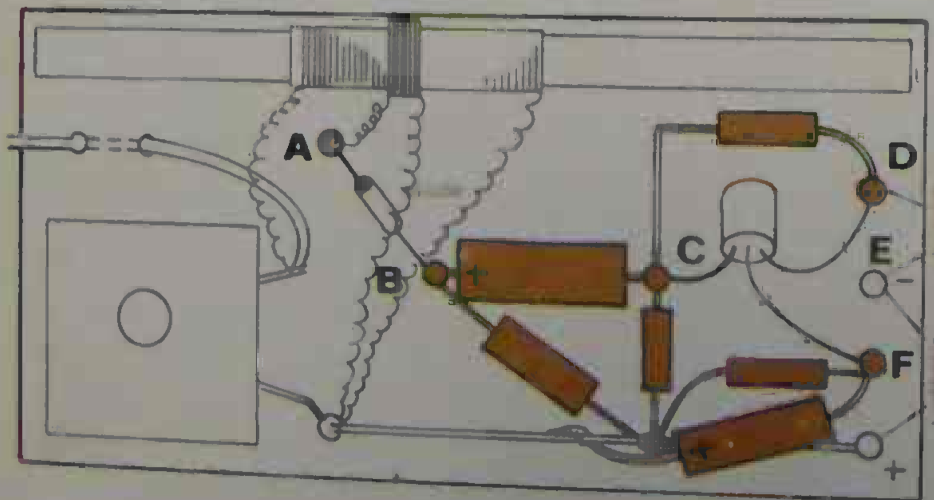


1. The circuit panel is made up as previously, but with the hole not used (F) also fitted with a 6BA terminal screw. There are now six terminal points, A, B, C, D, E and F.

2. This shows the complete transistor amplifier stage connections. Be sure to get capacitor C3 the right way round. Connections for diode, and capacitors C1 and C2 are shown in plan below.

3. Here is how the 'rear end' of the circuit should look. Phones connect to terminals D and E. Battery connects to terminal E and bus bar (+ side of battery to bus bar).

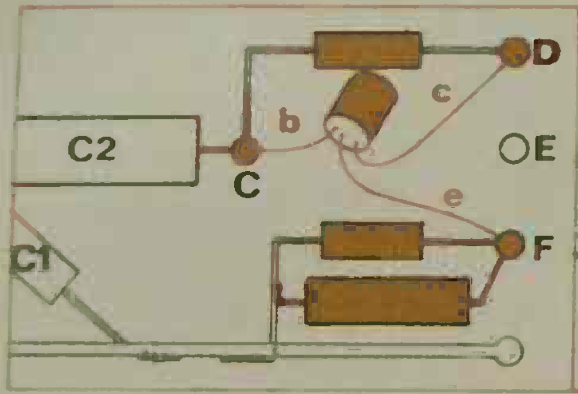
A MORE STABLE CIRCUIT

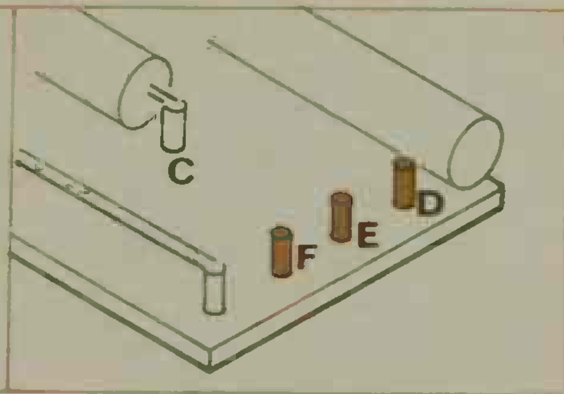


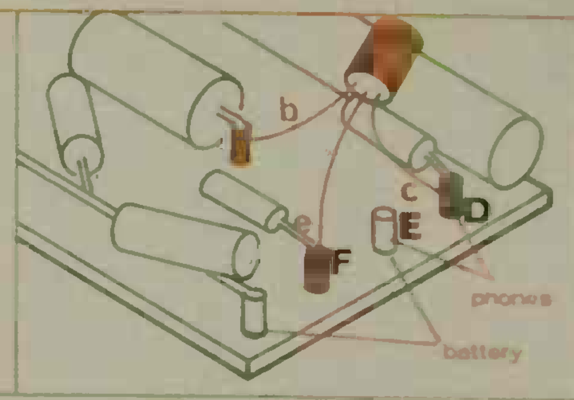
This circuit is the same as that on page 18, with *capacity coupling* between terminals B and C and the addition of several more components in the *transistor amplifier* stage; intended to 'fix' and stabilise the working point of the transistor. This should give more consistent results.

Components required are:—

Germanium diode—OA90 or similar
Transistor —OC71 or equivalent
Capacitors: C1 —0·001 μF. C2 & C3—8 or 10 μF electrolytic
Resistors: R1 —4·7 kilohms (yellow–violet–red)
R2 —22 kilohms (red–red–orange)
R3 —2·7 kilohms (red–violet–red)
Battery: —3 or 4½ volts (connect + to bus bar)







4. This is a block diagram of the transistor amplifier stage, using an N-P-N transistor. Aerial circuit connections, diode and connection for capacitors C1 and C2 are shown in plan below.

5. The circuit board is completed with all holes fitted with terminal screws. Complete the wiring up to terminal C before starting on the transistor amplifier components.

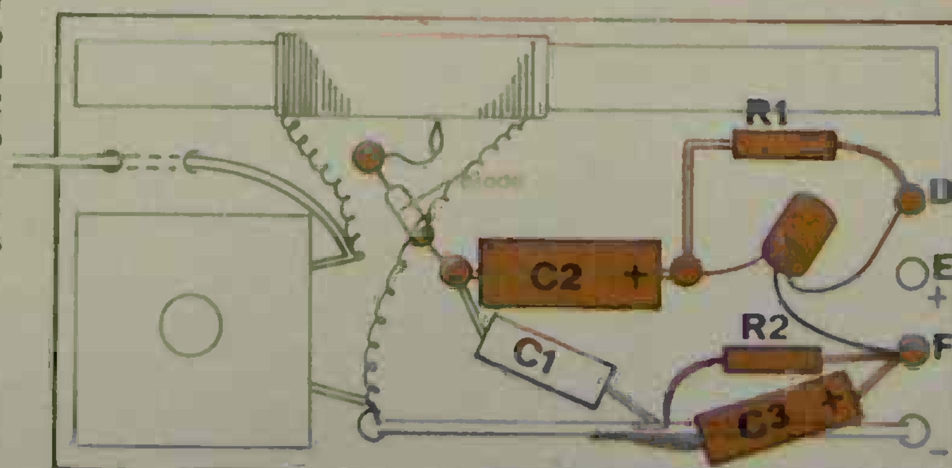
6. The transistor amplifier components in position (check connections with plan below). Phones connect to terminals D and E. Battery connects to terminal E and bus bar (battery + to terminal E).

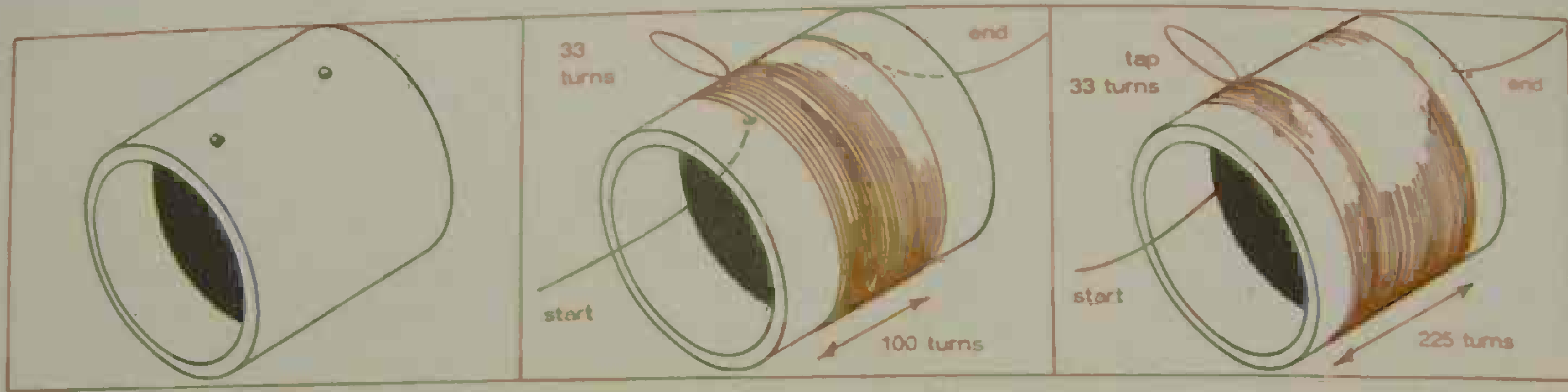
USING AN N-P-N TRANSISTOR

A silicon transistor of the N-P-N type can give better results in a simple circuit. It is important in this case to remember that battery polarity is *reversed*, compared with previous circuits. This also means that the diode and C2 and C3 must be connected up the opposite way round to what it was before.

The circuit board is made up as shown on page 22. Diode, and capacitors C1 and C2 have the same value as before. Other components are as follows:

Transistor		—silicon type 2N2712 (or equivalent)
Capacitor C3		—10 or 50 μF (electrolytic)
Resistors:	R1	—4 Megohms (yellow–black–green)
	R2	—470 ohms (yellow–violet–brown)
Battery:		—4½ to 9 volts (connect + to terminal E)



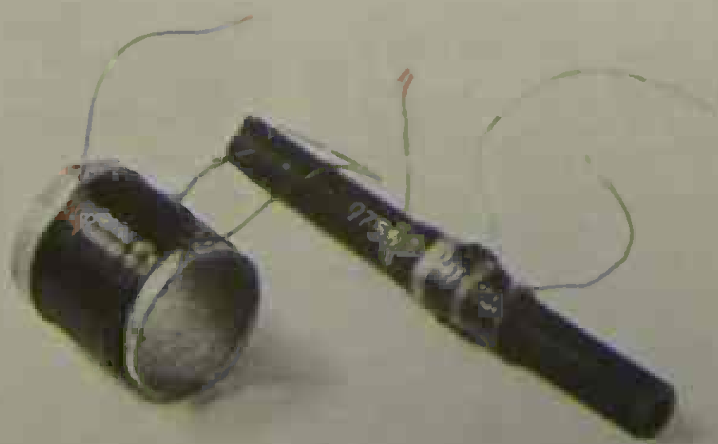


1. Find a card postal tube as near as you can to 25 mm (1") diameter and cut off a 2" length. Pierce two small holes in line, as shown, about 25 mm (1") apart.

2. Pass about 75 mm (3") of 38 s.w.g. enamelled wire through one hole in the tube. Wind a 100-turn coil with a loop or tapping point at 33 turns. This should cover the medium waveband.

3. Wind a second 'longwave' coil on a similar size of card former. This time use 225 turns to complete the coil with a tapping point taken at 33 turns, as before.

AIR-CORED COILS



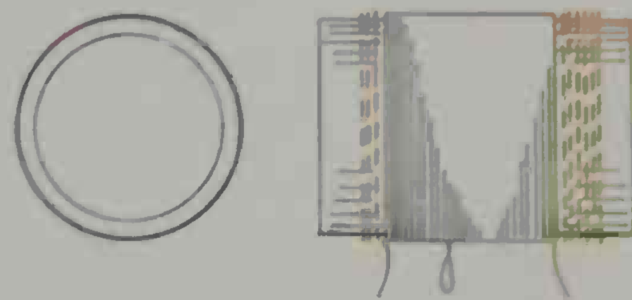
Air-cored coils are not as efficient as ferrite rod aerials, but they are cheaper to make. You can wind these coils on card tube formers—or even a length of hardwood or balsa dowel. Coil diameter should be 25 mm (1")—not smaller. You can use a larger coil former (in which case reduce the number of turns), but this produces a more cumbersome coil. The size shown in the illustrations matches a 500 pF tuning capacitor.

The advantage of air-cored coils is that you can easily make up several to give different tuning ranges for your crystal set, trying each in turn if necessary until you get the results you want. They should not be tried in areas where radio reception is generally poor.

Left Air-cored coil aerial; *Right* Ferrite rod aerial.

REMOVING TURNS

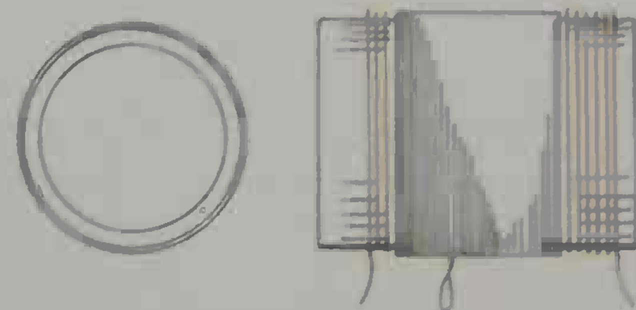
Removing turns from a coil will have the effect of decreasing its *inductance*, or shifting the *tuning range* of the aerial circuit towards lower frequencies, e.g. bring in stations like Radio Luxemburg, which might be off the end of the tuning range with the coil described on page 24. Turns must be taken off *each* end of the coil in a ratio of 1 to 2 to keep the *tapping point* in the same position.



ADDING TURNS

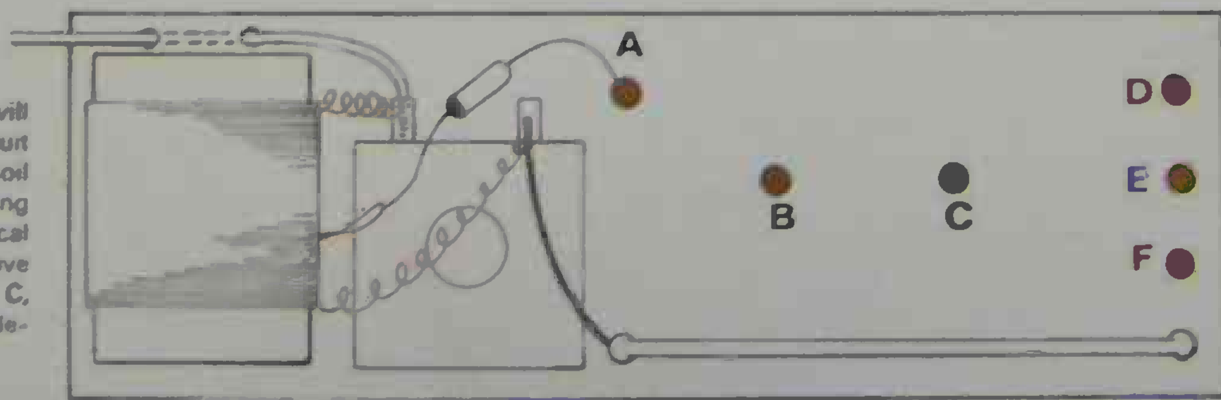
Adding turns to an aerial coil will bring in stations at the lower frequency end (i.e. longer wavelengths). We saw this in the 'longwave' coil (although the tapping point is in a different position).

Remember to keep the coil "balanced" about the tapping point, so for every turn added at the end nearest the tapping point, two turns must be added at the other end.

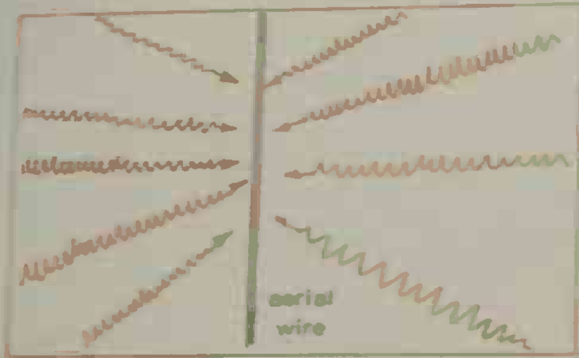


A NEW CHASSIS

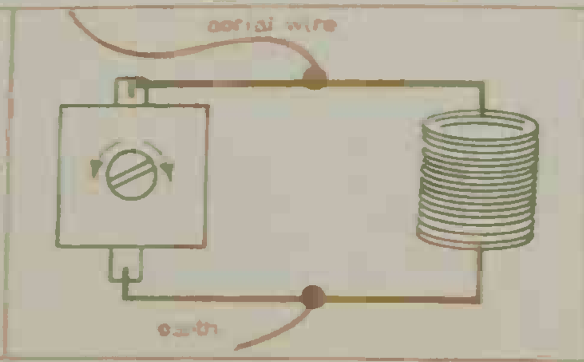
To accommodate an air-cored coil you will have to extend the length of your circuit panel—as shown here. You can mount the coil horizontally or vertically. Horizontal mounting (as shown) is rather more efficient, but vertical mounting can be more convenient if you have a long coil to cope with. Terminals A, B, C, etc. will accommodate any of the circuits described on previous pages.



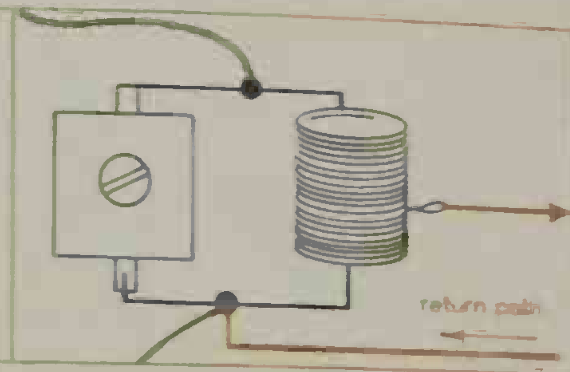
WHY IT WORKS



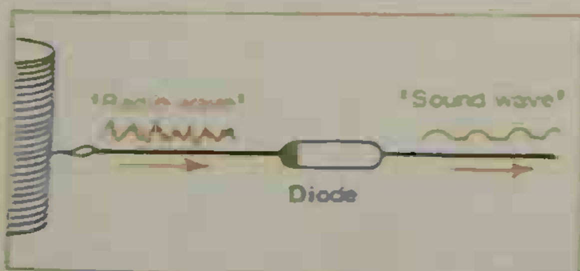
1. The air is full of radio signals transmitted from broadcast stations all over the world. These signals vary a lot in strength, as well as wavelength (or frequency). But each signal received will *induce* a very, very tiny signal in a length of wire, or *aerial*.



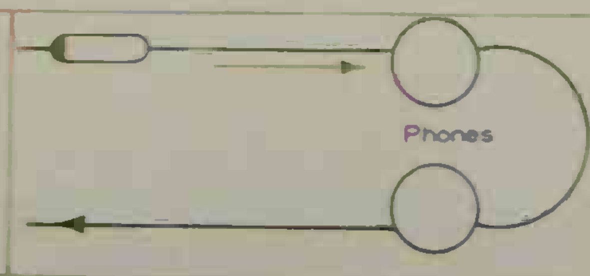
2. If the aerial is connected to a *capacitor* and *coil* which can be *tuned* to a particular frequency, tiny radio signals received at that frequency will be magnified in the aerial circuit. Signals at other frequencies will not be magnified.



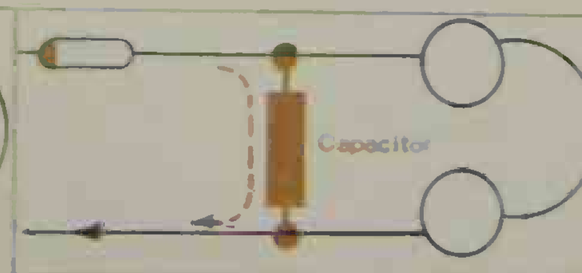
3. This means that when the aerial circuit is tuned to a particular frequency it can pass on a magnified signal at that frequency, whilst other signals received by the aerial are so weak that they become negligible by comparison.



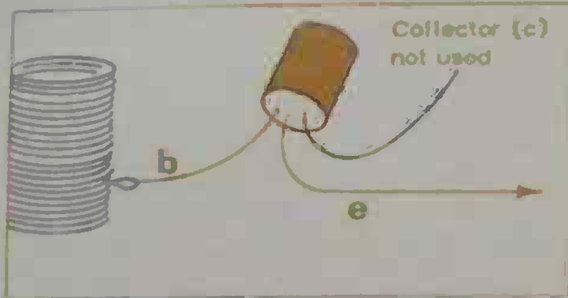
4 A broadcast signal consists of 'sound waves' superimposed on 'radio waves'. A diode can act as a *detector* to separate the sound wave content from the radio waves and pass this on.



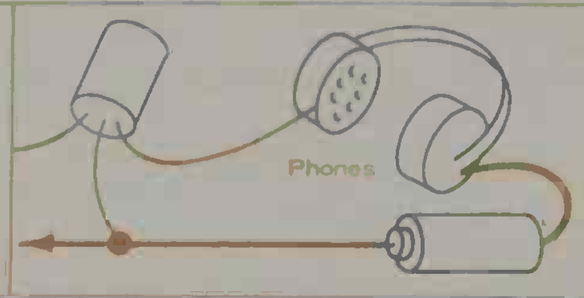
5. If this electrical signal from the diode is passed through high impedance earphones it can be heard—provided the aerial circuit has done its job and produced enough magnification of the signal.



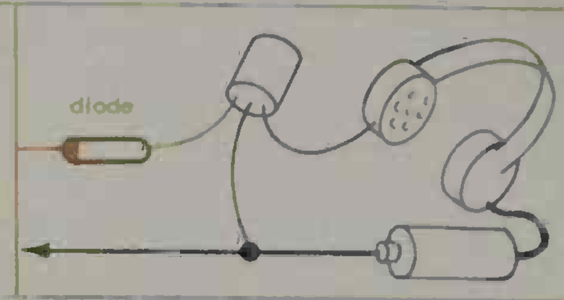
6. To improve the 'listening signal' a capacitor connected across the phones by-passes any stray 'radio' signal which has got past the diode. This makes the 'listening signal' easier to hear.



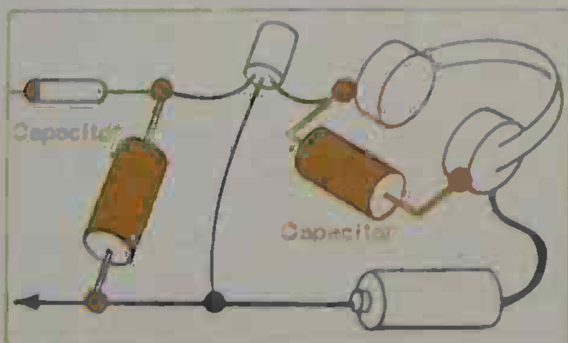
7. A transistor can work as a detector, just like a diode, using only the b (base) and e (emitter) connections. In such cases the 'sound wave' content of the original radio signal is passed on in the form of a minute fluctuating direct current.



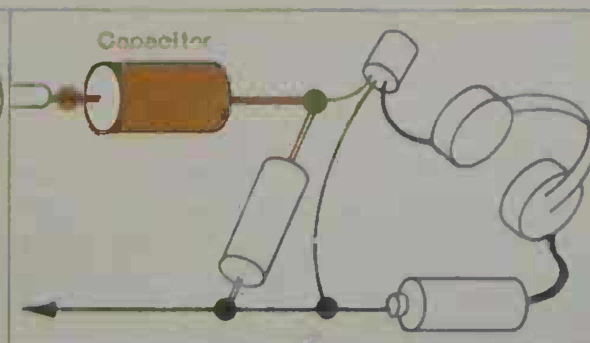
8. A transistor also has the property of acting as a magnifier of signals or *amplifier*, when all three leads are connected. It is possible to make a single transistor work both as a *detector* and *amplifier* in a simple circuit like this. It needs a battery.



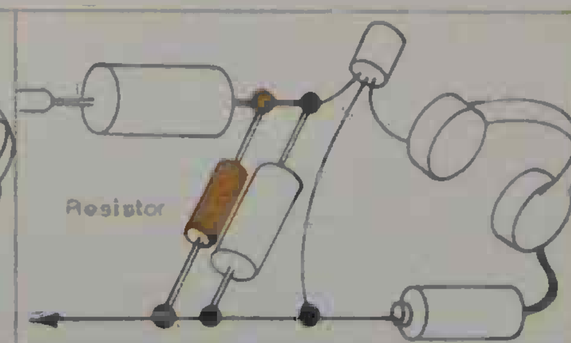
9. Using a diode as the detector, followed by a transistor for amplification of the 'sound signal', even better results can be obtained, because the transistor can be selected to work best with 'sound wave' frequencies. Again a battery is required.



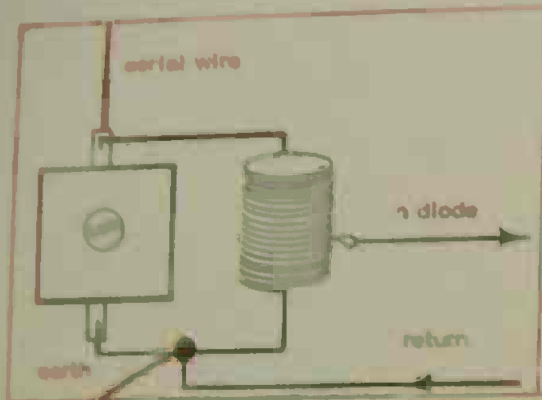
10. Detection is never perfect and so a capacitor connected across from the diode to the return path can improve performance. Also a capacitor connected across the headphones can smooth out unwanted noise.



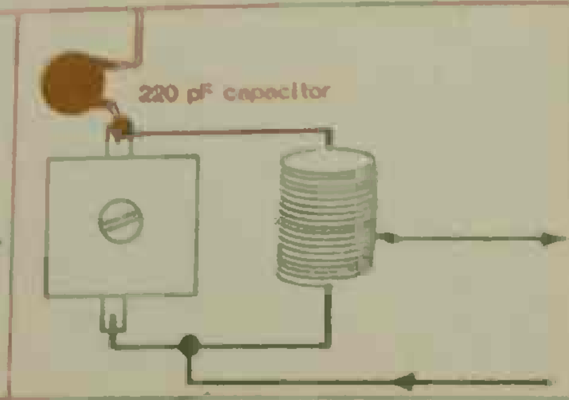
11. Another way of filtering out unwanted signal components is to connect the diode (detector) to the transistor (amplifier) via a capacitor. This usually improves signal quality.



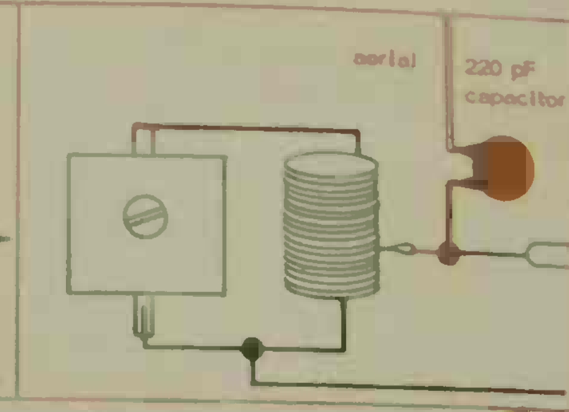
12. Finally, as well as a capacitor by-passing stray radio frequencies and 'noise' to the return, a resistor connected in parallel with the capacitor can further improve reception.



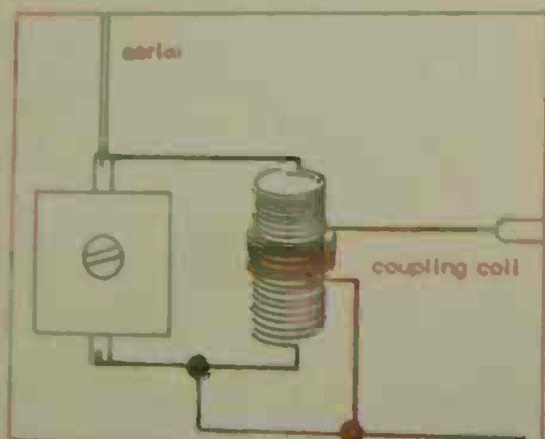
The point at which the aerial coil is tapped to feed the diode detector has an important effect. For best results, this should be towards the return line or 'earth' side of the circuit.



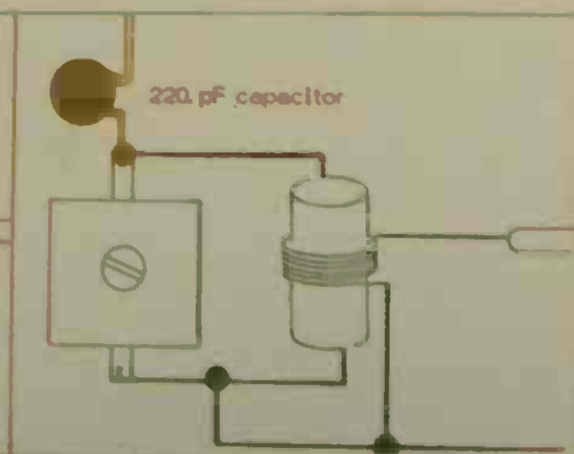
A trick which often improves the efficiency of the aerial circuit—and so gives better signals to pass on to the diode—is to insert a 220 pF capacitor between the aerial wire and aerial circuit.



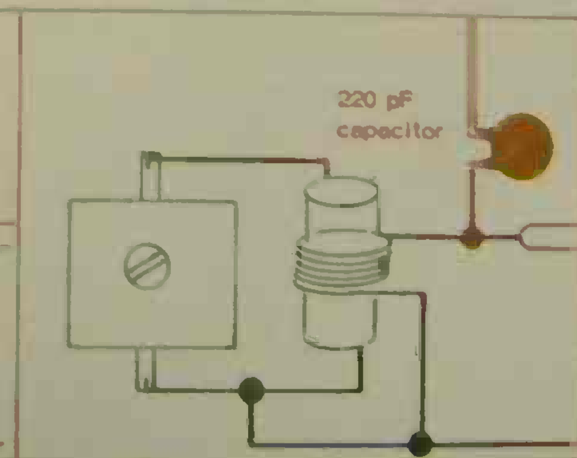
Sometimes much better results are achieved by connecting the aerial wire via a 220 pF capacitor to the feed line to the diode instead of the aerial circuit. Try it!



This type of aerial coil, with an overwound coupling coil, will often work better than a single coil with a tapping point. Adjust coupling coil position up or down for best results.



Again we can use this 'double' aerial coil with the aerial wire connected via a 220 pF capacitor. Note that the main (aerial) coil is quite separate from the coupling coil as regards connections.



Back to the same trick of connecting the aerial into the diode side of the circuit. Here it has no direct connection at all to the main aerial coil—but it often works well.

AND IF IT DOES NOT WORK!

All the circuits described in this book are proven and tested, but describing how to assemble them is no genuine guarantee that they will work. Even experts can make mistakes over connections when wiring up—particularly in identifying transistor leads—so the first rule is, *double-check every connection against the plan of the circuit when you have completed it*. This is the most common cause of a non-working set.

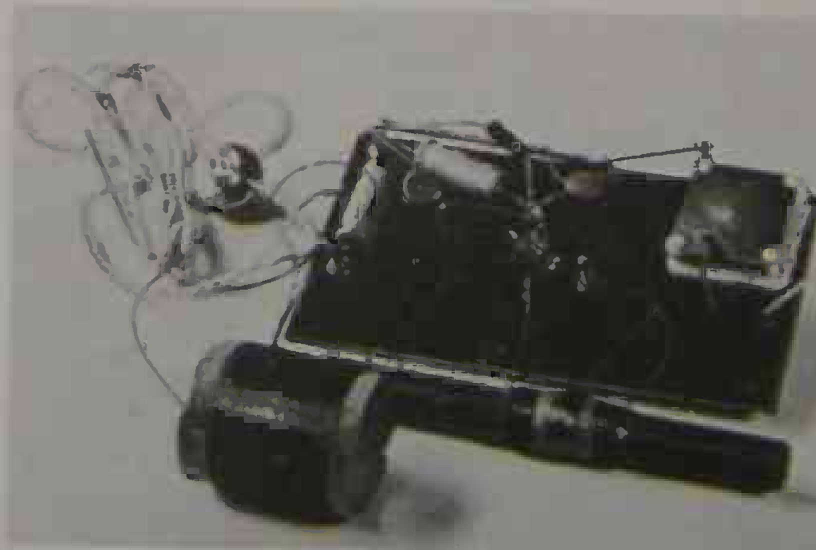
The other most common fault is—bad connections. All connections should be completed with *soldered* joints. Twisting bare wires together is not good enough (although this will often work for a time!). But even a soldered joint does not guarantee a good connection if it is a 'dry' joint. Check the section on SOLDERING again (pages 10 and 11) to see how it should be done. If in any doubt, re-make a soldered joint.

Faulty components are not usually the cause of a non-working circuit, if you buy new components to start with. But you can get poor transistors and you can damage components when assembling them by too much heat from the soldering iron (particularly in the case of transistors). If in doubt, though, do change a component. None of the components used for these circuits is expensive, and a few 'spares' are always a good idea.

If your set is correctly assembled with good connections you should at least hear something—if only a strange noise. That at least is a good sign. Failure to pick up any station is then most likely to be due to a poor aerial or poor earth connection—or both.

- Always check over the circuit completely after you have finished assembling it for *correctness of connections*, and soundness of any soldered joints.
- Buy standard miniature radio components instead of 'surplus' components (particularly in the case of transistors). They are not all that much more expensive than cut-price components, and they will be more reliable.
- Try all the different 'tricks' to improve reception, once you have got your set working. Sometimes quite a small change can make a lot of difference.
- Make sure that you are using high impedance phones or a high impedance deaf-aid earpiece for listening. Other types will not work.

Alternative aerials. Air-cored aerials are easy to make and adjust to different wavebands. Either the centre-tapped or transformer-coupled type (shown here) can replace the ferrite rod type aerial (also shown).



GLOSSARY

Aerial—the wire which picks up broadcast radio signals, and passes them on to the aerial circuit.

Aerial circuit—combination of a tunable (variable) capacitor and a coil of wire.

Aerial coil—the coil of wire (usually wound on a ferrite rod) 'paired' with a capacitor in the aerial circuit.

Amplifier (amplification)—magnifier or booster of electrical signals, used in crystal sets to boost the listening level.

Audio—something which can be heard, e.g. electrical signals at audio frequency can be transformed into sound in headphones.

Auto-transformer—aerial coil with a tapped point which connects to next stage of the circuit (i.e. the diode).

Battery—source of direct current electrical power (necessary to make a transistor work as an amplifier).

Board—the base panel on which a circuit is constructed.

Bus bar—a 'common' or main connecting line in a circuit.

Capacitor—electrical component which stops direct currents but passes alternating current.

Chassis—alternative description for a board, but usually reserved for metal boards (not applicable with crystal sets).

Coil—a close winding of several turns of insulated wire.

Condenser—old-fashioned name for capacitor.

Connection—any wire or lead connecting a component or one part of a circuit to another.

Copper wire—used for winding coils (enamelled wire), or connections or bus bars (plain or tinned copper wire).

Deaf-aid earpiece—listening device, converting audio frequency electrical signals into sound. Only a high impedance type should be used in crystal sets.

Detector—a component which extracts the audio content of a radio signal.

Diode—a component which passes direct current in one direction only; used as a detector in crystal sets.

Earphones—listening device which converts audio frequency electrical signals into sounds, which can be heard. High impedance earphones must be used in a crystal set.

Electrolytic capacitor—special construction of capacitor (for high values) which must be connected the right way round in a circuit.

Ferrite rod (ferrite slab)—special sintered iron rod used as a core for aerial coils, resulting in greater efficiency.

Headphones—*see* earphones.

Insulated wire—copper wire coated with enamel or with a plastic covering.

Mallory battery—very small battery of special construction which can be used in place of a dry battery in miniature portable radios.

Panel—material on which a circuit is mounted—*see board.*

Paxolin—flat sheet material with high insulation properties used for circuit boards.

Phones—earphones (headphones) or deaf-aid earpiece.

Plastic sleeving—useful for insulating bare wires or leads (e.g. transistor leads).

Quartz crystal—original semi-conductor device used as a detector in early radio sets.

Radio (frequency)—electrical signals of high frequency which can be transmitted through the air.

Resistor—component which offers resistance to flow of direct current in a circuit. The value of the resistor governs the amount of current flowing in that circuit.

Screws—small machine screws (usually 6BA size), which can be mounted on a panel to act as terminal points.

Semi-conductor—general name for such components as diodes and transistors.

Signal—electrical currents with 'intelligence', i.e. radio signals or audio (frequency) signals.

Tag—another name for a terminal mounted on a board or emerging from a component.

Terminal—connection point.

Transformer—two closely related coils of wire which provide a means of passing alternating current signals from one to the other by *induction* (e.g. transformer coupled aerial coil).

Variable capacitor—provides means of adjusting or varying actual capacity value; used as the tuning control in an aerial circuit.

Wire (aerial)—*see* aerial.

WHERE TO GET YOUR COMPONENTS

Most towns have at least one shop which undertakes radio repairs and here you should be able to obtain all the components and other materials you require. Or you may be lucky and have an amateur radio shop near you. If not, there are a number of firms specialising in mail-order supplies for amateur radio constructors. You can write to them and send a list of what you want, or better still write first for their catalogue and choose your components, etc. from this.

Here are the addresses of some of the leading radio mail-order firms, any of which should be able to help you with anything you need. This list is not complete. You can find others advertising in current issues of practical radio and electronics magazines.

BI-PER-PAC, 222–224 West Road, Westcliffe-on-Sea, Essex SS0 9DF.
Chromasonic Electronics, 56 Forbes Green, London N10 3HN.
C.T. Electronics, 267 Acton Lane, London WC5 DG.
Electronic Supplies, P.O. Box 3, Rayleigh, Essex (s.a.e.*).
Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB (40p*).
Harrogate Radio Co. Ltd., 2 & 3 Sykes Grove, Harrogate, Yorks.
Henry's Radio Ltd., 303 Edgware Road, London W2 1BW (55p*).
Home Radio (Components) Ltd., 234–240 London Road, Mitcham, Surrey (77p*).
LST Components, 23 New Road, Brentwood, Essex (for semi-conductors).
Marco Trading, The Maltings, Station Road, Wern, Salop (s.a.e.*).
Radio Component Specialists, 337 Whitehorse Road, Croydon, Surrey (10p*).
Teleradio Electronics, 325–327 Lower Fore Street, Edmonton, London N9.
Watford Electronics, 35 Cardiff Road, Watford, Herts.

* Price of catalogue or list at time of going to press.

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The aim of the series is to provide basic working manuals for hobbyists and other amateurs who have no previous knowledge or practical experience of the subject. In the case of the first two titles—on radio—this has been achieved by means of 2 colour step-by-step diagrams illustrating the actual components used and plans and photographs showing the finished circuits.

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- Details of all components, including numbers for ordering purposes
- List of mail order firms supplying components
- Possible refinements to improve a set's performance
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ISBN 0 7188 2159 9