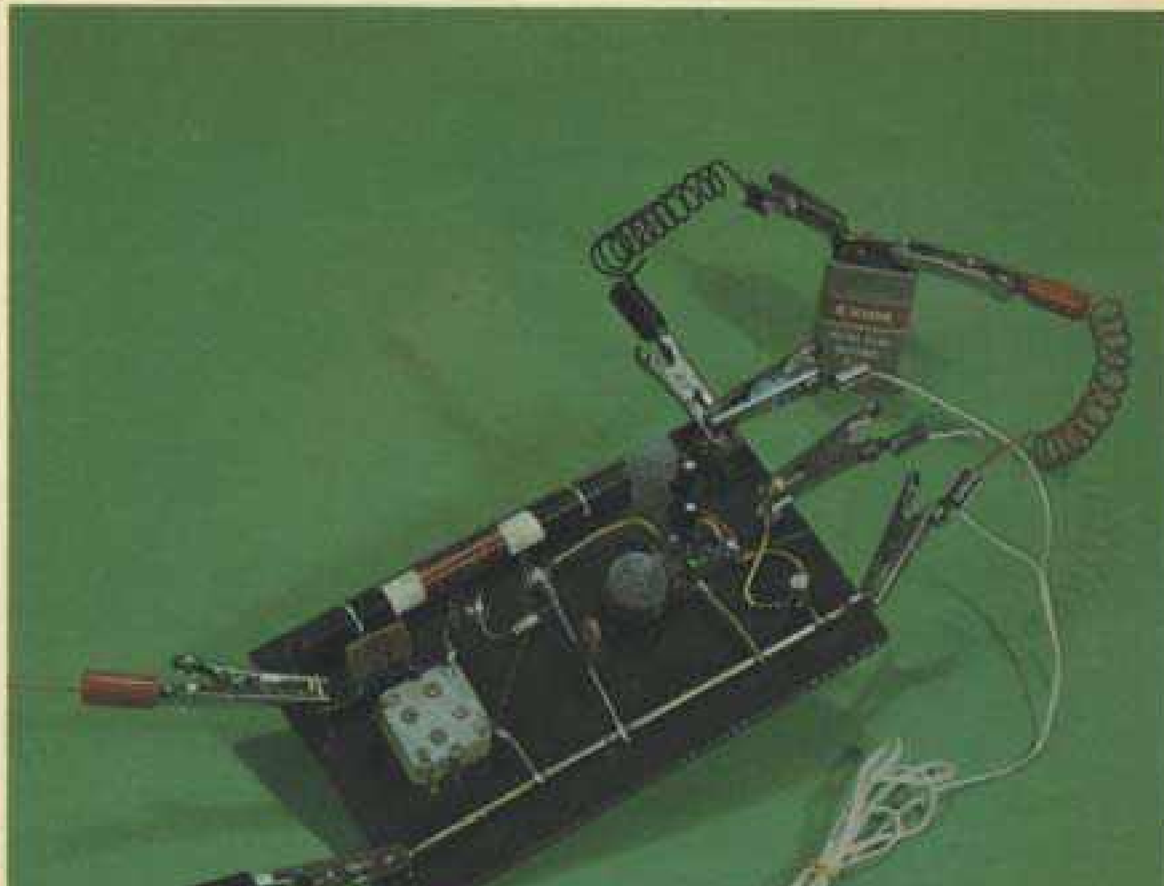
Make your own Crystal Set



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A WOLFE **FOLDAPLAN** BOOK

Make Your Own

Crystal Set

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Illustrated by Andrew Calder

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Make Your Own Crystal Set

A crystal set is so called because the very earliest radio receivers did, in fact, use a crystal and a length of wire or 'cat's whisker' to pick up radio signals. The modern crystal set uses a simple electronic component called a *diode* for the same purpose. Because the principle of working is the same, they are still called 'crystal sets'.

Crystal sets are very easy to make and require only a few, inexpensive components. They can work without a battery—provided you live in an area where radio reception is good. In poor listening areas—those distant from powerful transmitting stations—only weak signals may be received from perhaps just one or two stations.

The performance of a crystal set can be improved by adding a stage of *amplification*, which will then require a battery to work. This will boost the strength of all the signals received, and should bring in more stations.

An amplifier is only an 'added on' circuit, so the design given allows for this. You can first build the basic crystal set and get it working as well as possible. Then you can add on the amplifier stage for even better results.

The real secret behind the successful working of a crystal set is an efficient *tuned circuit* and external *aerial*—plus a good *earth* connection. A tuned circuit consists of a *coil* and a *capacitor*.

A coil, really, is only a length of insulated wire wound on a circular rod or former. A capacitor is another particular type of electronic component, designed to have a 'capacity' for storing electricity—hence its name, capacitor.

In order to adjust the tuning to correspond to different broadcast station frequencies, the capacitor used is a *variable* type (also known as a tuning capacitor).

'Frequency' is a measure of the rate at which a radio wave 'vibrates' or *oscillates*. Broadcast stations send out radio waves of a particular frequency. To tune into a particular station a receiver has to be adjusted to respond to the *broadcast frequency* of that station.

Turning the knob on the capacitor varies the electrical state of the tuned circuit, so that the set can be tuned in to different stations in the range covered by the design of the *coil*.

The coil is an item which is easy to make (although you can also buy readymade tuning coils matched to specific values of tuning capacitors).

The electrical symbols of the components which go to make a tuned circuit are shown in Fig. 1. A coil is shown at A; a capacitor is shown at B (the arrow drawn through the capacitor indicates that it is a *variable* capacitor). Coil and capacitor are then connected as shown at C. Add an aerial and earth connection, and the complete turned circuit is shown at D.

Fig.1

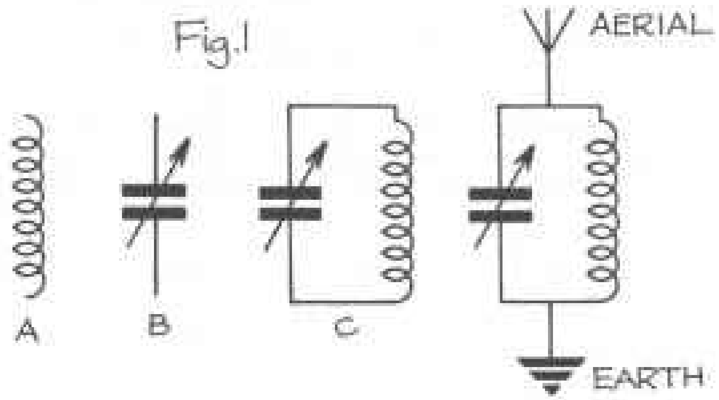
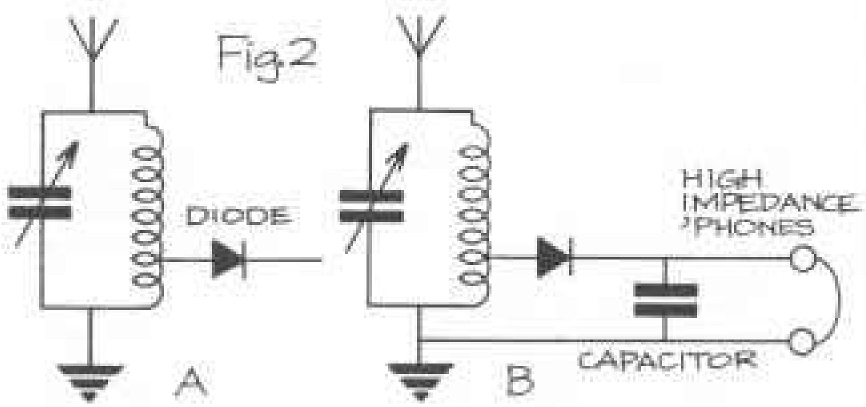


Fig.2



This circuit, when tuned to a particular broadcast signal, has a minute electric current generated in it, at the same frequency as the signal. To *detect* this current, and transform it into the type of signal which can be made audible, a diode is connected to the coil, as shown in Fig. 2A. If the other side of the diode is connected to headphones, and the other side of the headphones connected back to the 'earth' end of the tuned circuit, we have—almost—a complete radio receiver.

Just one more component is needed—a capacitor of fixed value connected across the 'phones to block out the unwanted part of the original radio signal. The complete circuit for a basic crystal set is thus as shown in Fig. 2B.

So much for the theoretical circuit. We now have to turn this into a practical, working circuit. The starting point is to make the coil.

Making the Coil

A tuning coil can be a simple winding of wire, but it is much more efficient if wound over a *ferrite rod*. A ferrite rod is simply an iron rod, but made of a special sort of iron. It is produced specially for radio work—and you buy it by asking for it by name (ferrite rod), just like other radio components.

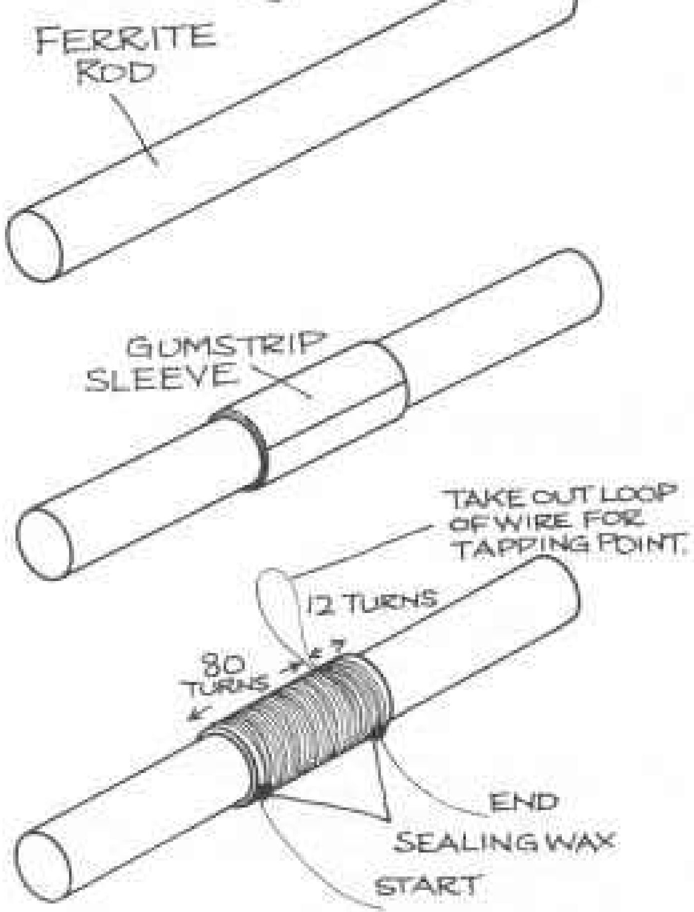
Ferrite rods are available in various sizes, the main difference being that the design of the coil (number of turns and size of wire required) varies with the diameter of the rod used. The electrical performance of the coil has to 'match' the working range of the variable capacitor in order to make the complete circuit tunable over a particular broadcast band.

The coil shown in Fig. 3 is based on a $\frac{1}{4}$in. diameter ferrite rod about $2\frac{1}{2}$in. long (the actual length is not important), and designed to cover the *medium waveband*.

First cut some wide gumstrip into 1in. lengths. Wrap one piece, gum side up, around the rod, and then add three or four more layers (gum side down) to make a paper sleeve fitting snugly over the rod. Do not make it such a tight fit that the sleeve cannot be slid along the rod. You will need this freedom of movement for adjusting the set for best results.

The coil is then wound on to the paper sleeve, using 28 gauge enamelled copper wire. The complete coil consists of 80 turns wound close together, the wire then taken out into a loop, and finally another 12 turns wound on (92 turns in all with the loop or 'tapping point' 80 turns from the starting end). Secure the start end of the coil winding with a dab of sealing wax.

Fig. 3



This coil will be a 'match' for a 350 pF or 500 pF variable capacitor. It may be found necessary to adjust the coil windings later on; or to try different coils. But this particular coil should be a good starting point, provided you use the component values specified in the components list on the Plan Sheet.

The rest of the construction of the set can be followed through the step-by-step stages shown on the Plan Sheet.

Preparing the Base Panel

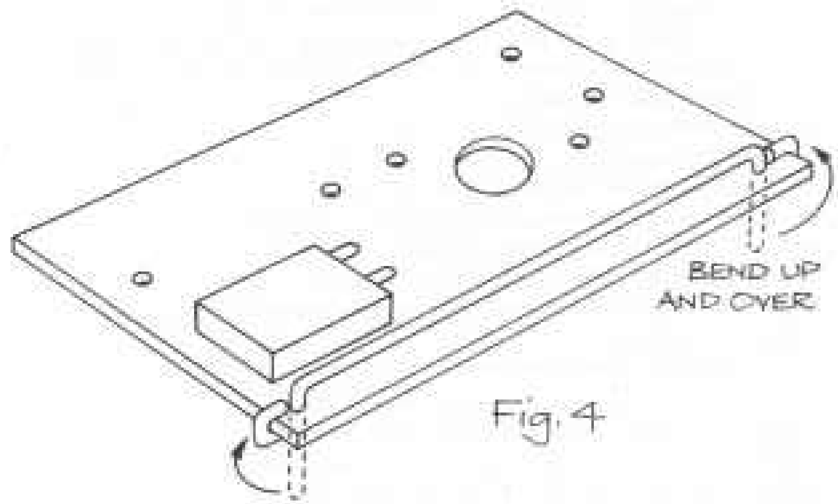


Fig. 4

This is a $5\frac{1}{2}$in. × 3in. rectangle of Paxolin sheet. (Paxolin is a special kind of hard plastic, made in sheet form, to use as a base panel for mounting radio components on.) If you cannot buy it this size you will have to cut from a larger sheet, using a hacksaw. Check the dimensions by laying over Plan Sheet Diagram 1, which is full size.

Make a tracing of this plan and transfer to the Paxolin to mark the hole positions to be drilled. Holes A and B are drilled with a $\frac{1}{16}$in. drill. Holes C, D, E, F, G and H are drilled with a 3mm drill. Hole J is drilled to match the mounting sleeve size of the variable capacitor (now identified as C1). Hole K is drilled to match the mounting size of the 5K *potentiometer*.

Plan Sheet Diagram 2 shows the next step. The tuning capacitor (C1) is mounted by its nut, with the spindle and knob on the underside of the panel. The six $\frac{1}{2}$in. long 6BA brass bolts and nuts are fitted through holes C, D, E, F, G and H, with the bolt heads on the underside. These all form terminal points.

Cut off a 6in. length of 16 gauge tinned copper wire. Bend one end at right angles, about ½in. from the end, and pass through hole A. Now bend the other end to pass through hole B. Bend the spare wire back over the edges of the panel, as shown on Plan Sheet Diagram 3 and Fig. 4. This is the common or 'earthy' connecting line of the circuit.

The tuning coil is then mounted on the Paxolin panel in the position shown on Plan Sheet Diagram 4. The easiest way of mounting is to stick the coil to the Paxolin with a blob of sealing wax. Check that you can slide the ferrite rod smoothly backwards and forwards through the paper sleeve.

Plan Sheet Diagram 5 now shows the *wiring connections* to be completed. All joints should be *soldered*, using an electric soldering iron and resin-cored solder. Just make sure that the wire ends are clean, and you should have no trouble making good soldered joints. The tuning coil wires should be cut to suitable length and the ends scraped clean of enamel before attempting to solder in place.

Connections to be made are:

START of tuning coil to nearest terminal on C1.

TAP on tuning coil to terminal bolt D.

END of tuning coil winding to other terminal on C1.

The same terminal on C1 connected to the 'common' line (use a separate piece of enamelled wire with ends scraped clean).

The other terminal of C1 (the one connected to the start of the coil) to terminal bolt C.

Capacitor C2 *connected between terminal bolt E and the 'common' line.*

Terminal bolt E connected to terminal bolt H with a spare length of wire.

The diode *connected between terminal bolts D and E.*

This completes assembly of the basic crystal set which can now be tried out for working.

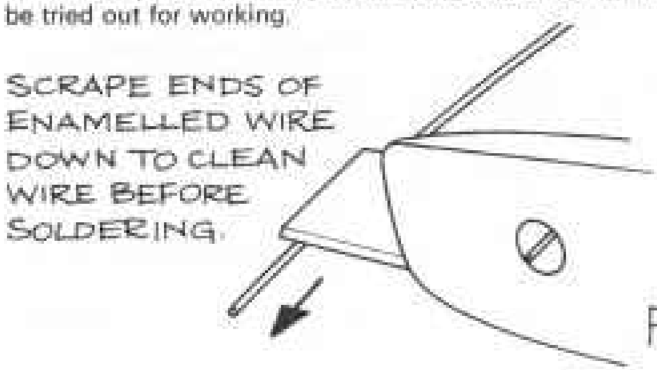


Fig. 5

Checking the Set

A *good* external aerial is absolutely essential. The aerial can be a length of any thin wire—the longer the better and taken up as high as possible. This wire is connected to terminal bolt C.

Another length of wire is soldered to the 'common' line at point A and taken to a *good* earthing point. The best earthing point to be found in most houses is a *cold water pipe* (making sure that the pipe is scraped clean where the wire is attached, to ensure a good electrical connection).

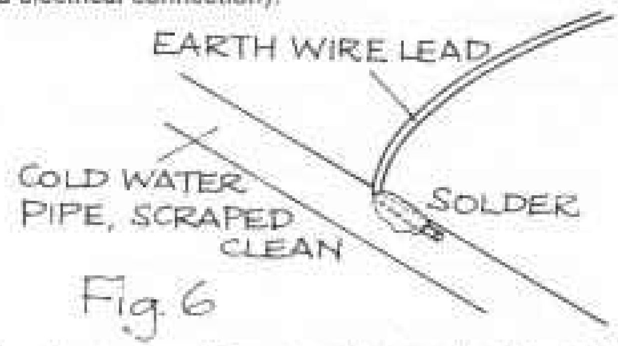


Fig. 6

Once these connections have been made, the set should be 'working', and only requires the connection of 'phones to terminal points H and B to listen in. The 'phone used *must be of high impedance* type—preferably a deaf-aid earpiece which is more convenient to use than headphones.

'Impedance' is really the effective *resistance* of 'phones. Both headphones and deaf-aid earpieces are made with 'high impedance' or 'low impedance'. It is important to buy the right type.

Turn the knob on the tuning capacitor until the tuning vanes are closed, then turn back a little. Slide the ferrite rod forwards and backwards through the paper sleeve until a station is heard. You should be able to pick up Radio 3 in this way, with the tuning capacitor near one end of its tuning range. If not, try adjusting the capacitor to try to bring the station in. Also try turning the set from side to side, as this will vary the strength of the signal. The ferrite rod aerial is 'directional' and picks up maximum signal strength in a certain position.

Once you have picked up Radio 3 with the tuning capacitor set near to one end of its range, you can fix the ferrite rod to the paper sleeve with a dab of sealing wax. You should then be able to tune the set over the whole of the medium waveband without further adjustment of the ferrite rod.

IF THINGS DO NOT WORK OUT

If you get no results at all, then the first thing to do is to check that all your connections are correct—and there are no bad soldered joints. If connections are all good (and correct) you should be able to hear *something* when adjusting C1 over its full range—if only a weak crackle or two. That at least will show that the set is working!

Here are other things you can try if you are not getting proper results:

(*i*) *If signals are so weak as to be almost inaudible, see if you can improve the external aerial. Use a longer length of wire, draped in various positions. Or you can try connecting the aerial wire to the springs of a bed (these often make a very good aerial!)*

(*ii*) *Try an alternative earthing point connection—say directly to a tap.*

(*iii*) *Try swapping over the aerial and earth connections—i.e. aerial wire to A and earth to C. Sometimes this works well.*

(*iv*) *Remove the connecting wire between terminal point C and the tuning capacitor and replace with a capacitor (C3). This can often considerably improve the efficiency of the aerial.*

(*iv*) *The tuning range of the coil can be adjusted by taking off (or adding on) an equal number of turns from each end of the coil. This is something you can experiment with to extend the working range of your set, and bring in more stations.*

Remember, you can only expect very weak signal strength from a basic crystal set. Also reception conditions vary a lot from day to day, and even hour to hour.

Further Experiments

Plan Sheet Diagram 6 shows another 'trick' you can try. Instead of connecting the aerial directly to the tuning capacitor (or 'coupling' through capacitor C3), connect to terminal point D. Try with, and without, capacitor C3.

Another idea which often gives improved results is to use an *inductively coupled* tuning coil. This comprises two separate windings—the main tuning coil with a separate *coupling coil* wound on top, as shown in Fig. 7 and Plan Sheet Diagram 7.

The idea with *inductive coupling* is that instead of a direct connection, varying electric currents are transferred from one coil to another electromagnetically. This can be better than direct coupling sometimes.

Replace the original tuning coil with this new version and complete the connections as shown. Changing the tuning coil can often make quite a difference; and you can also make different coils to cover different wavebands. Some alternative designs are shown on the Plan Sheet.

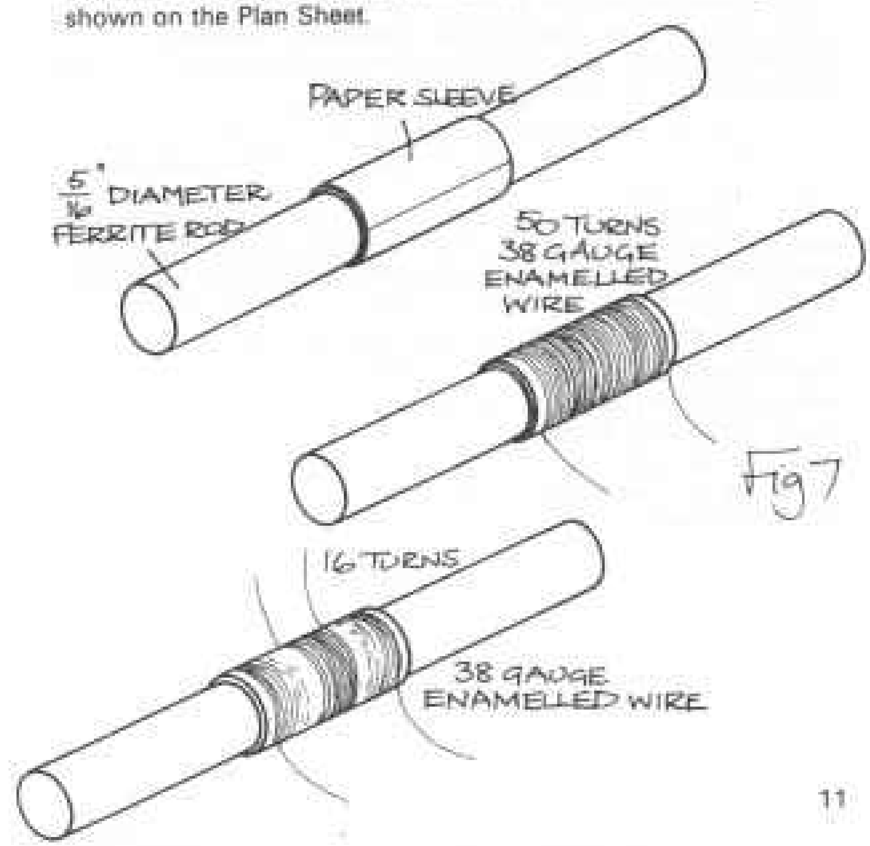


Fig 7

Improving the Crystal Set

Once you have got your basic crystal set to work, it is obviously worthwhile thinking about getting some more volume out of it. This can be done by adding an *amplifier stage* as shown in Plan Sheet Diagram 8. The additional components required are a potentiometer (VR), a capacitor (C4), a transistor (TR) and a resistor (R). Almost any type of audio transistor will do, with the value of the resistor selected to match, although this is not very critical. The potentiometer provides a means of adjusting the amplifier stage to work.

'Audio' means something that works at hearable or 'audible' frequencies—much lower frequencies than radio signals. Some transistors are designed specially to operate at 'audio' frequencies; others at 'radio' frequencies.

The potentiometer is mounted in the spare hole K in the Paxolin panel, spindle side downwards. Disconnect the wire joining terminal point E to H. Then wire up the circuit as shown on Plan Sheet Diagram 8. Use the following as a check:

Connect one terminal tag on the potentiometer to E.

Connect the other end terminal tags on the potentiometer to the 'common' line.

Connect capacitor C4 to the centre *tag on the potentiometer, and the other lead of the capacitor to terminal bolt F, making sure it is the* right way *round (plus marked on capacitor to potentiometer tag).*

Connect the resistor (R) between terminal bolts F and H.

That leaves the transistor to be connected to the circuit. Here it is very important to be able to identify the leads correctly. Transistors have three wires emerging from their bottom which must be identified as *emitter* (e), *base* (b) and *collector* (c) connections. These are not marked on the transistor and have to be identified by their *position*.

Connecting the Transistor

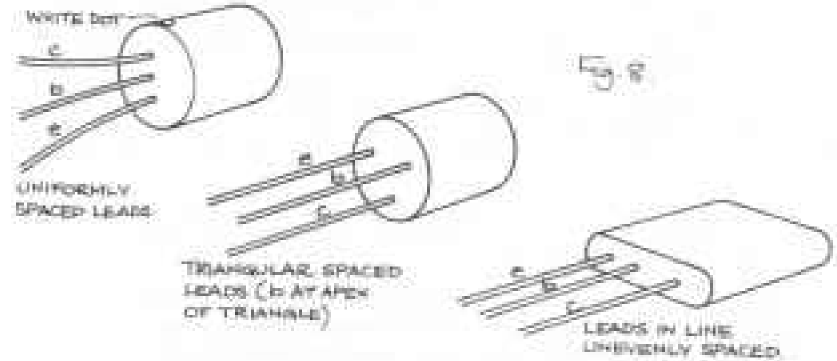


Fig. 8 shows various lead configurations for transistors and this diagram should be used to identify each lead correctly. In connecting the transistor to the circuit:

Emitter (e) connects to 'common' wire.

Base (b) connects to terminal bolt F.

Collector (c) connects to terminal bolt G.

Leave the transistor leads quite long—e.g. about 1in.—and grip with a pair of pliers when making the soldered joint. The pliers will then soak up heat which might otherwise damage the transistor.

FINAL CONNECTIONS

The 'phones in this case (high impedance type again) connect to terminal bolts *G and H*. To work, this circuit also requires a battery, which can be 4½, 6 or 9 volt. Battery connections are made to H and the common line, as shown.

The *polarity of the battery is most important*. Using a PNP transistor (as specified in the components list), the *positive* of the battery connects to the *'common'* line.

The *polarity of the diode* is also important. The 'plus' end of the diode is identified by a red marking on the glass envelope. Thus the 'red' end must connect to terminal bolt D. Check this before connecting up the battery.

If an NPN transistor is used, then *the polarity of the battery must be reversed* (plus to terminal bolt H); and also *the diode must be connected the other way round.*(red end to terminal bolt E).*

Most common types of transistor you can buy in this country are known as PNP type. They work in the same way as an NPN type transistor, except that their plus and minus connections are the other way round.

In this final circuit, the potentiometer VR will act as a *volume control*. Normally it will only be necessary to adjust it initially for maximum volume when the set is tuned in to any one station. It can then be left in this position to give maximum volume with any other signal tuned in.

* *It does not matter which way round the diode is connected in the basic circuit since there is no applied battery voltage.*

Notes on Soldering

For soldering electrical joints you should use only an electric soldering iron and resin-cored solder.

The two most important things about making a good soldered joint are a *hot iron* and *clean* or 'tinned' surfaces to be joined. Leads on radio components are already tinned. But even a tinned surface will not solder properly if it is dirty or greasy. If in doubt, scrape the surface clean with a knife, or rub with emery paper. Where enamelled wire is used for connections, clean the ends by scraping off the enamel to expose bright copper.

Follow this procedure in making a joint:

(i) Plug in and switch on the iron and leave for a minute or two to warm up to full heat. Check by touching the tip with solder. The solder should melt immediately and run over the tip. If the solder drops off the tip, then the iron is dirty and the tip needs cleaning with emery paper.

(ii) Bring the tip of the iron into contact with the joint. Wait a second or so for the heat from the iron to heat up the joint.

(iii) Touch the joint with solder. The solder should melt at once and run over the joint.

(iv) Remove the iron at once so that no more heat is applied to the joint than necessary.

Two things can go wrong at stage (iii):

(a) The solder does not melt. Then the joint is not hot enough. Either the iron is not hot enough (or too small for the job), or it has not been held against the joint for a long enough period.

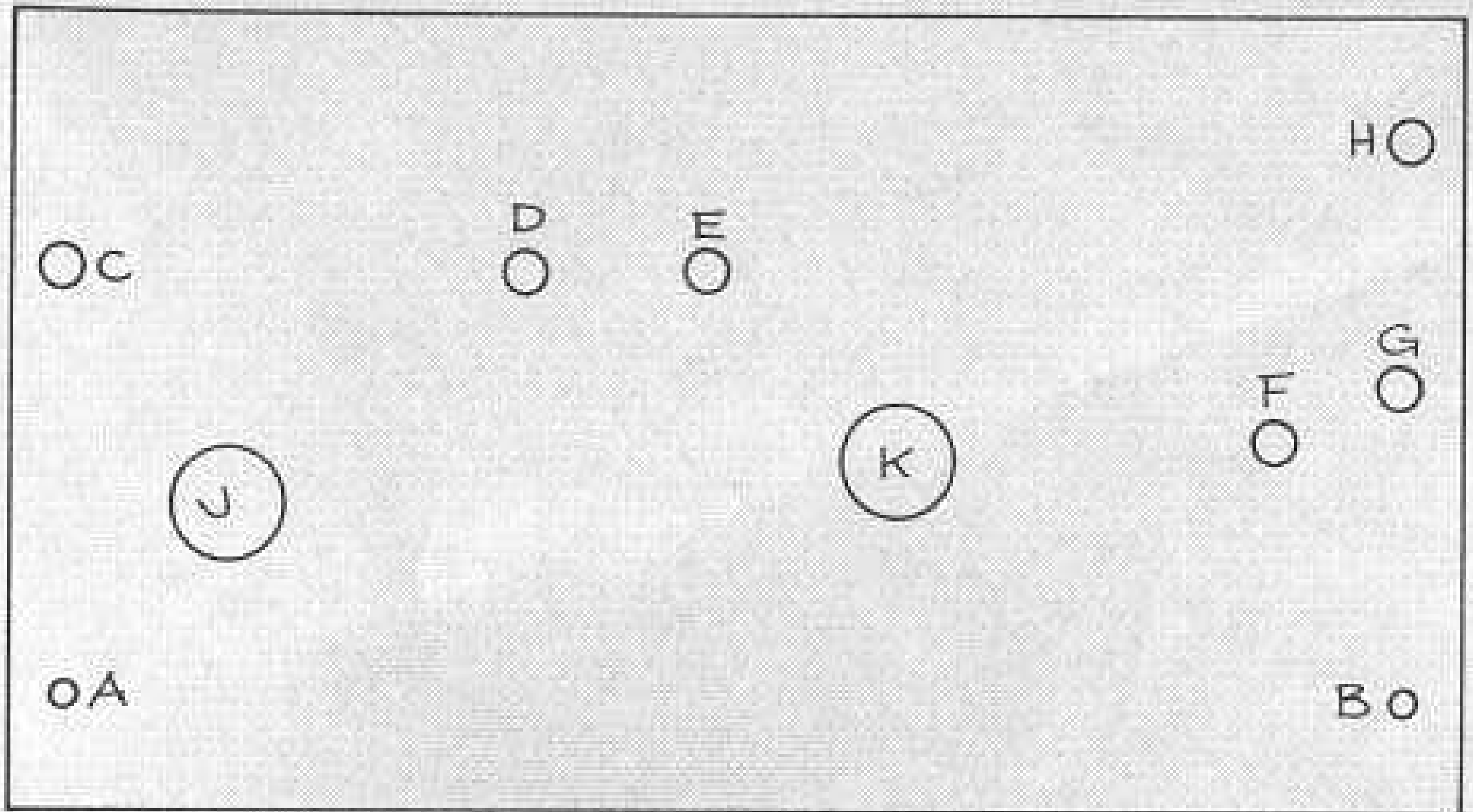
(b) The solder melts but falls off the joint. In this case the joint is 'dirty' and needs cleaning before attempting to resolder.

A good soldered joint is 'bright clean', with the solder flowing evenly over the whole of the joint area.

A 'dry' joint is where the solder sets in a rough, crystalline form. This is usually caused by not enough heat, but it can be due also to a dirty joint with too much solder applied in an attempt to complete the joint.

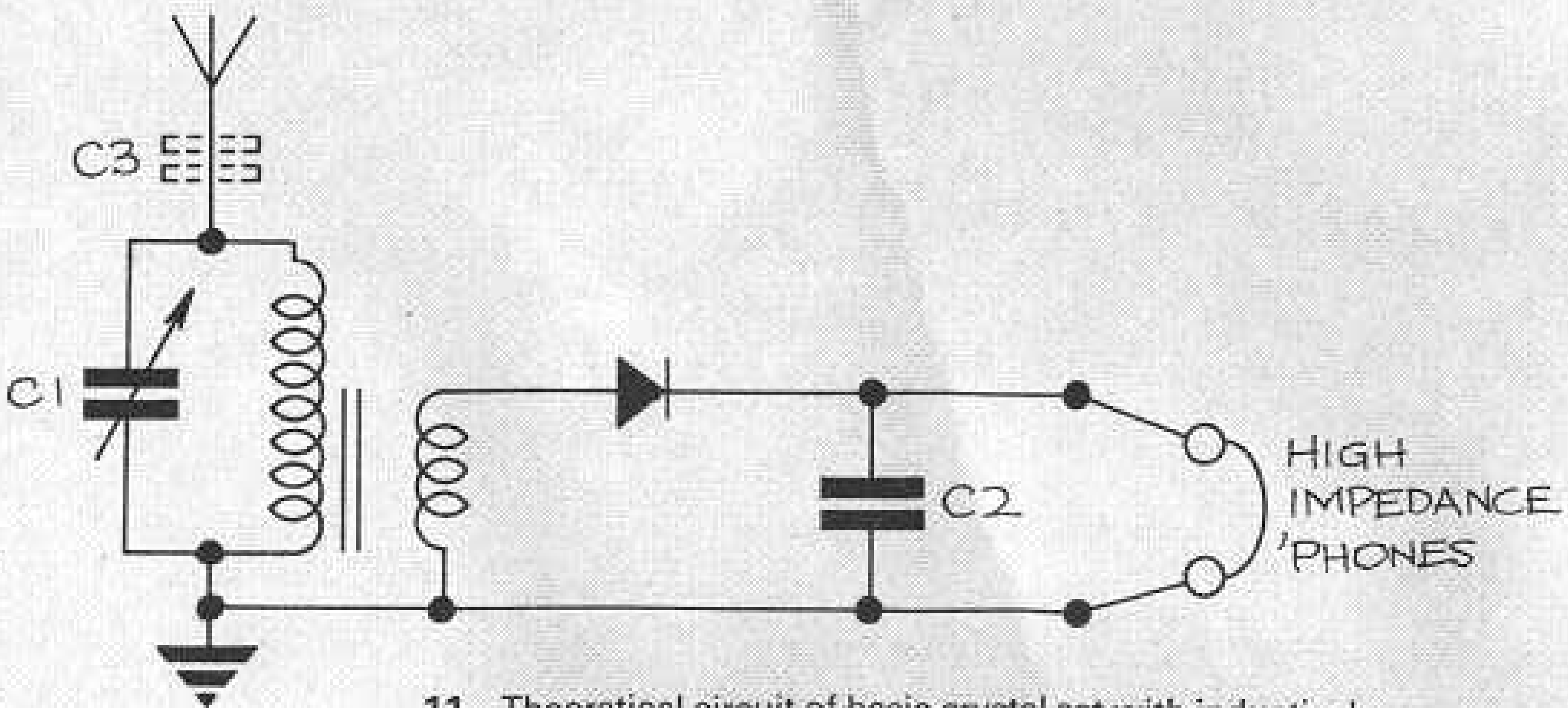
● *See illustrations overleaf.*

1



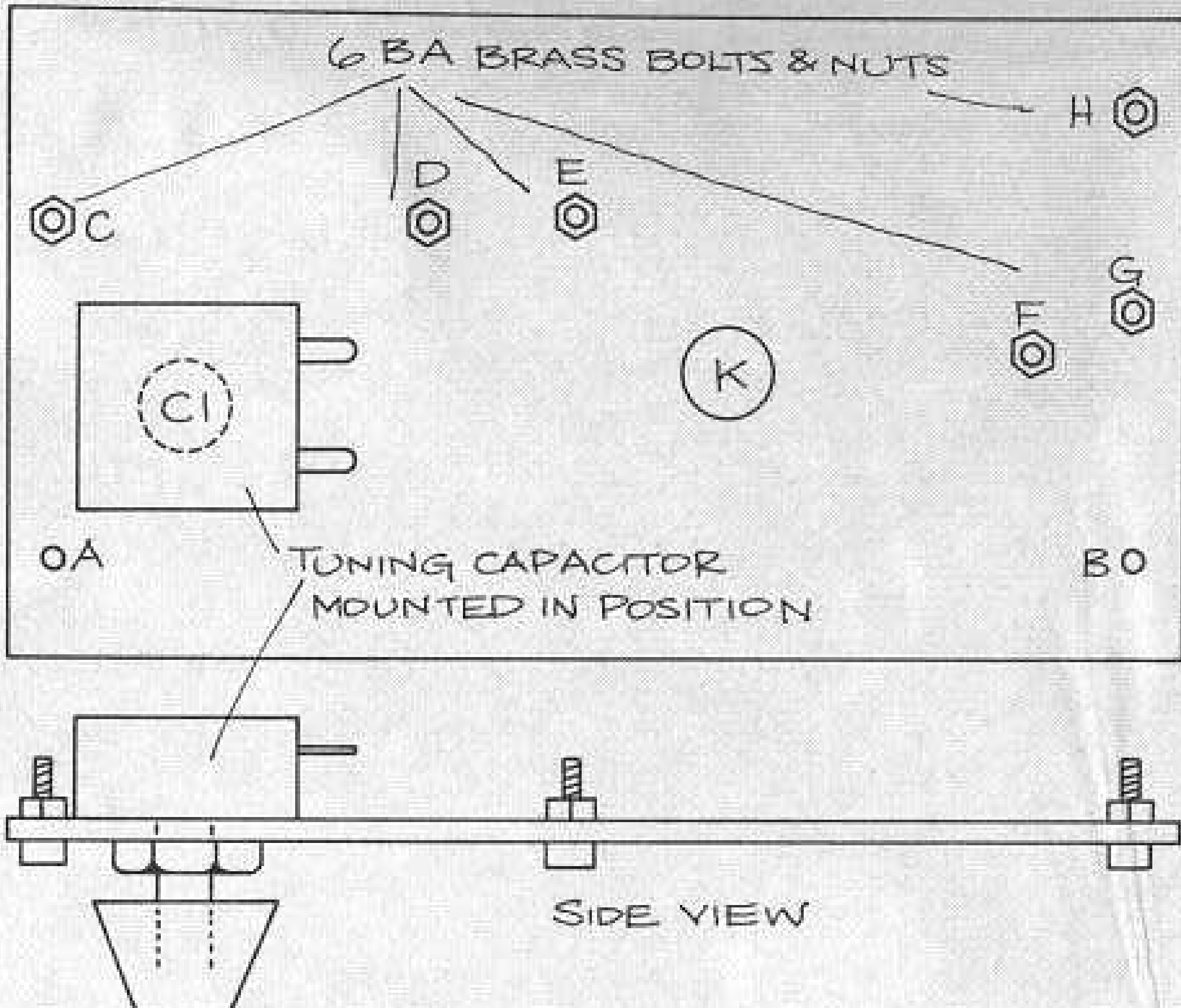
1. Full size layout pattern of Paxolin panel.
Holes A and B are drilled 1/16in.
Holes C, D, E, F, G and H are drilled 3mm.
Hole G drilled to fit variable capacitor mounting.
Hole H drilled to fit potentiometer mounting.

11



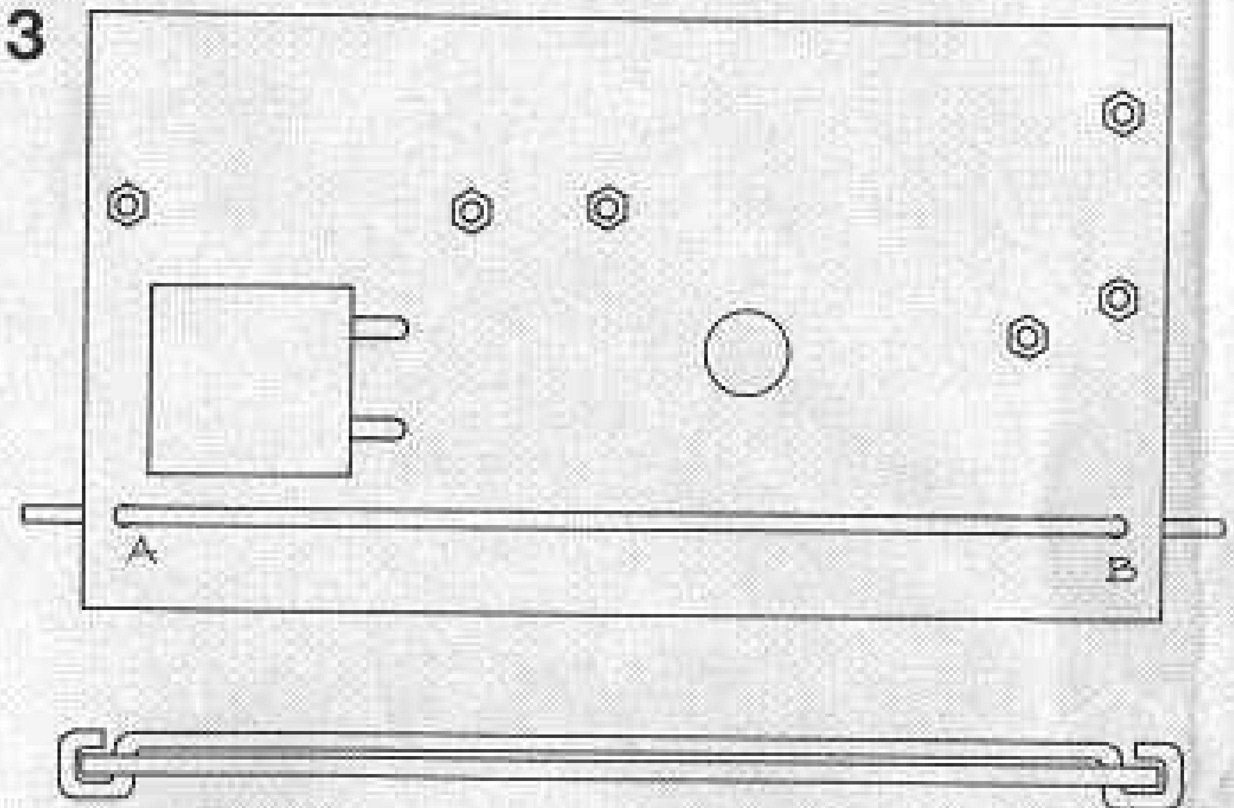
11. Theoretical circuit of basic crystal set with inductively coupled aerial tuning coil. This corresponds to Plan Sheet Diagram 8.

2



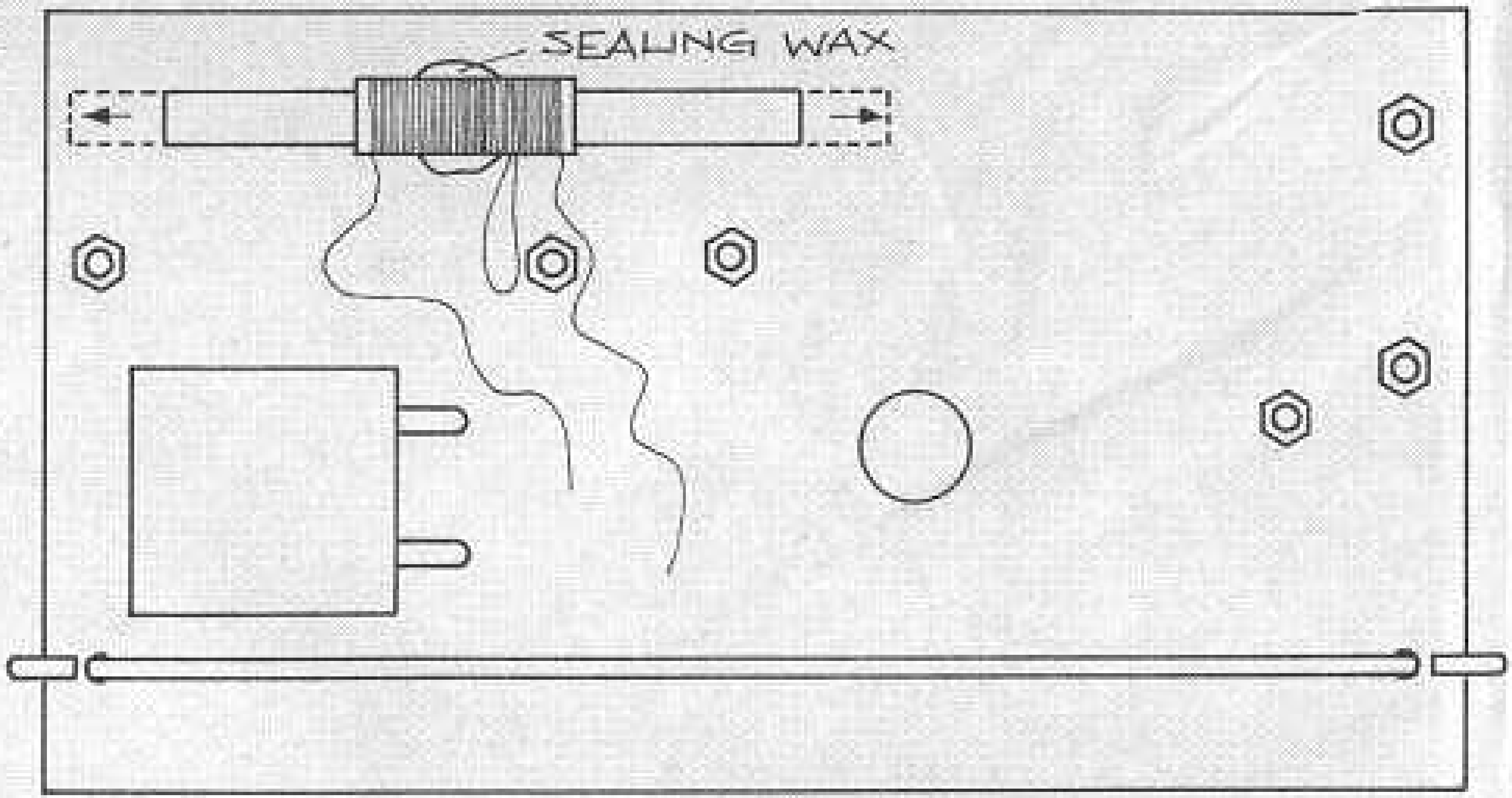
2. Variable capacitor mounted on panel through hole G; also the six 6BA brass bolts and nuts forming the main terminal points.

3



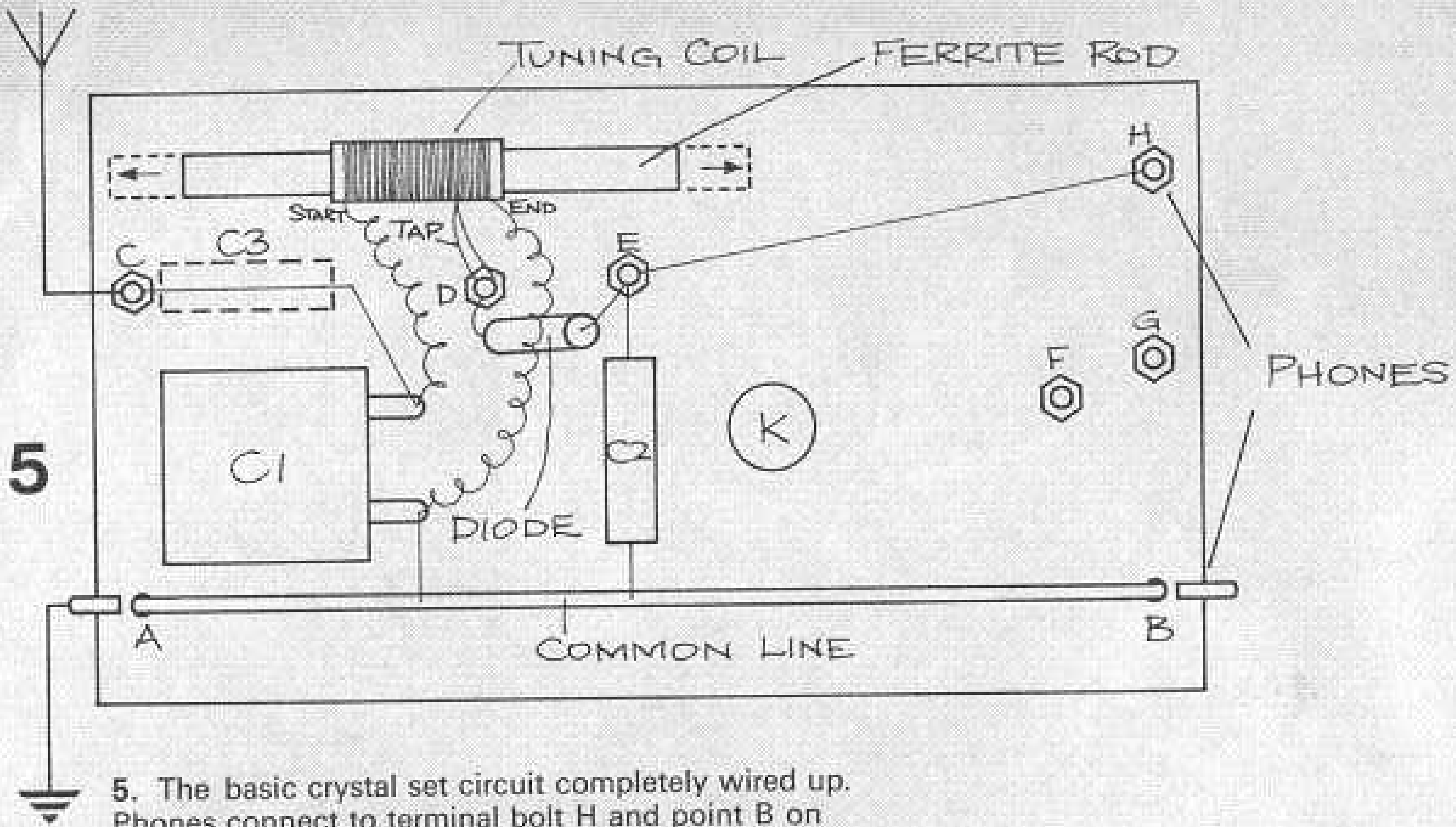
3. The 'common' earth line is 16 gauge tinned copper wire, fitted between holes A and B. Turn up ends around edge of panel to hold wire in place.

4



4. The tuning coil is mounted on the Paxolin panel in this position, secured with sealing wax. Ferrite rod must be free to slide for adjustment of tuning range.

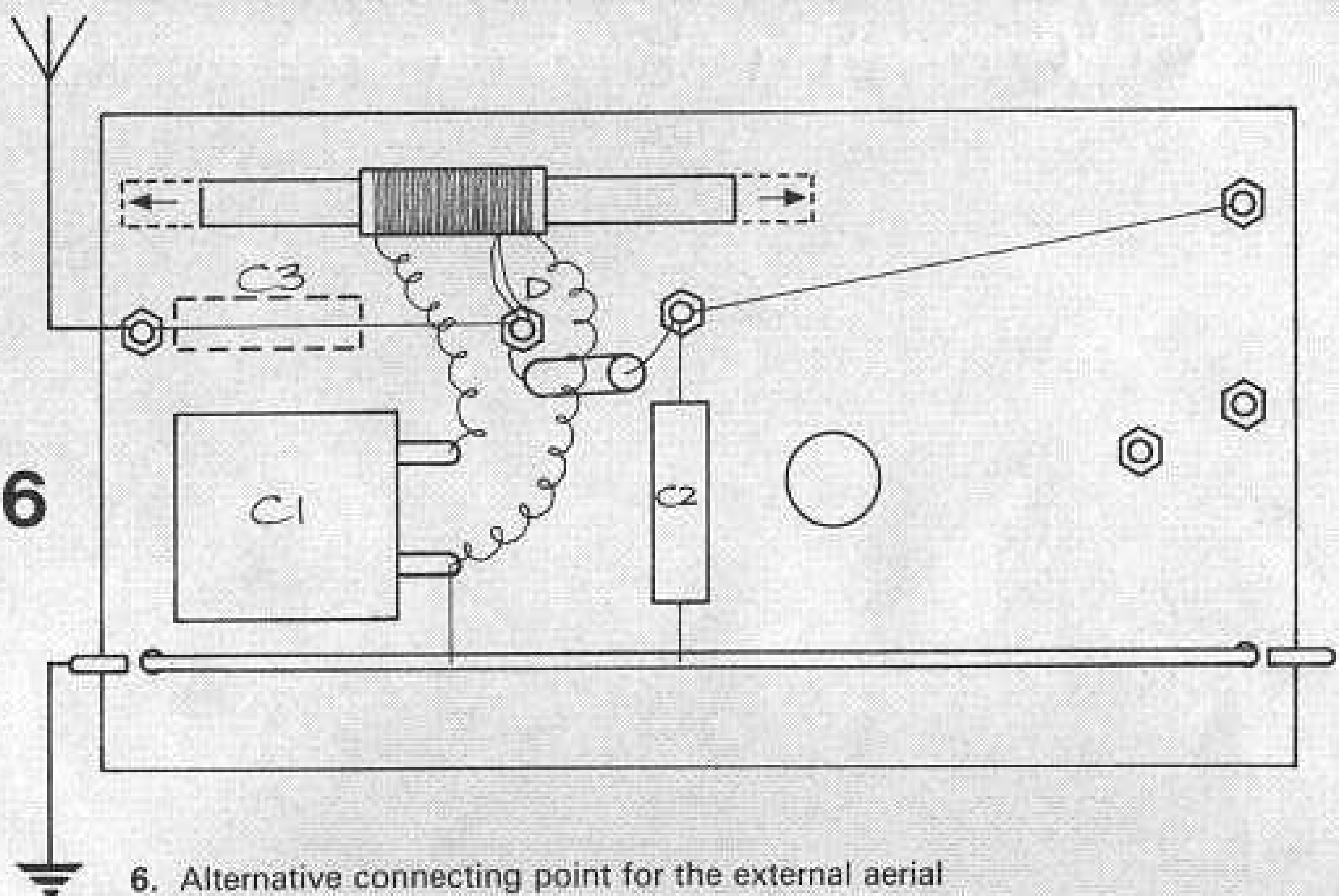
5



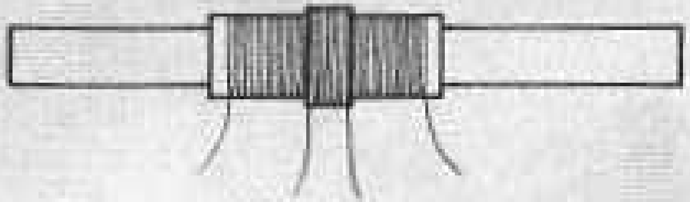
5. The basic crystal set circuit completely wired up. Phones connect to terminal bolt H and point B on 'common' wire. Check all wiring connections carefully.

Note that terminal bolts F and G are ignored. Also hole K has nothing mounted in it.

6

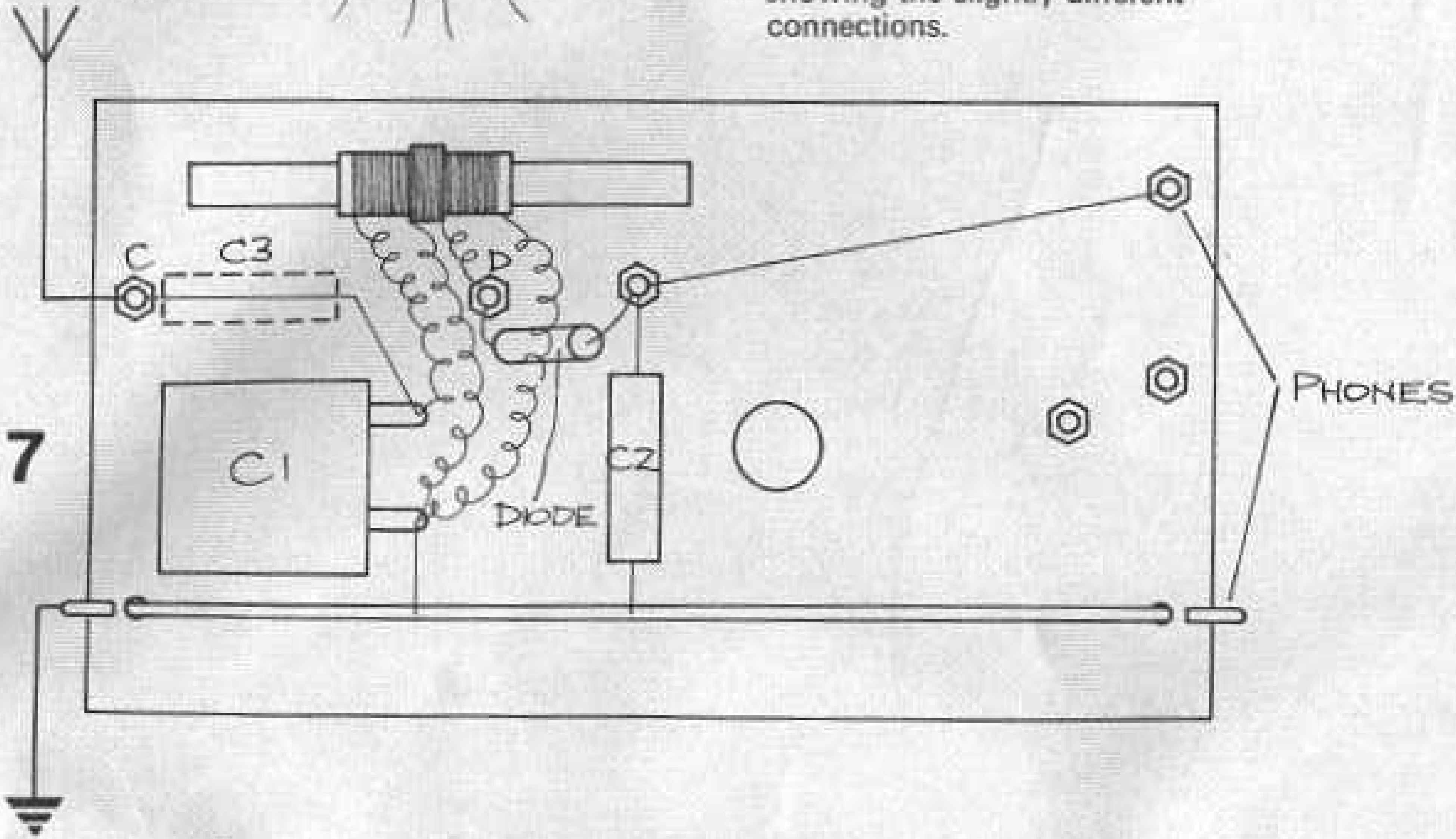


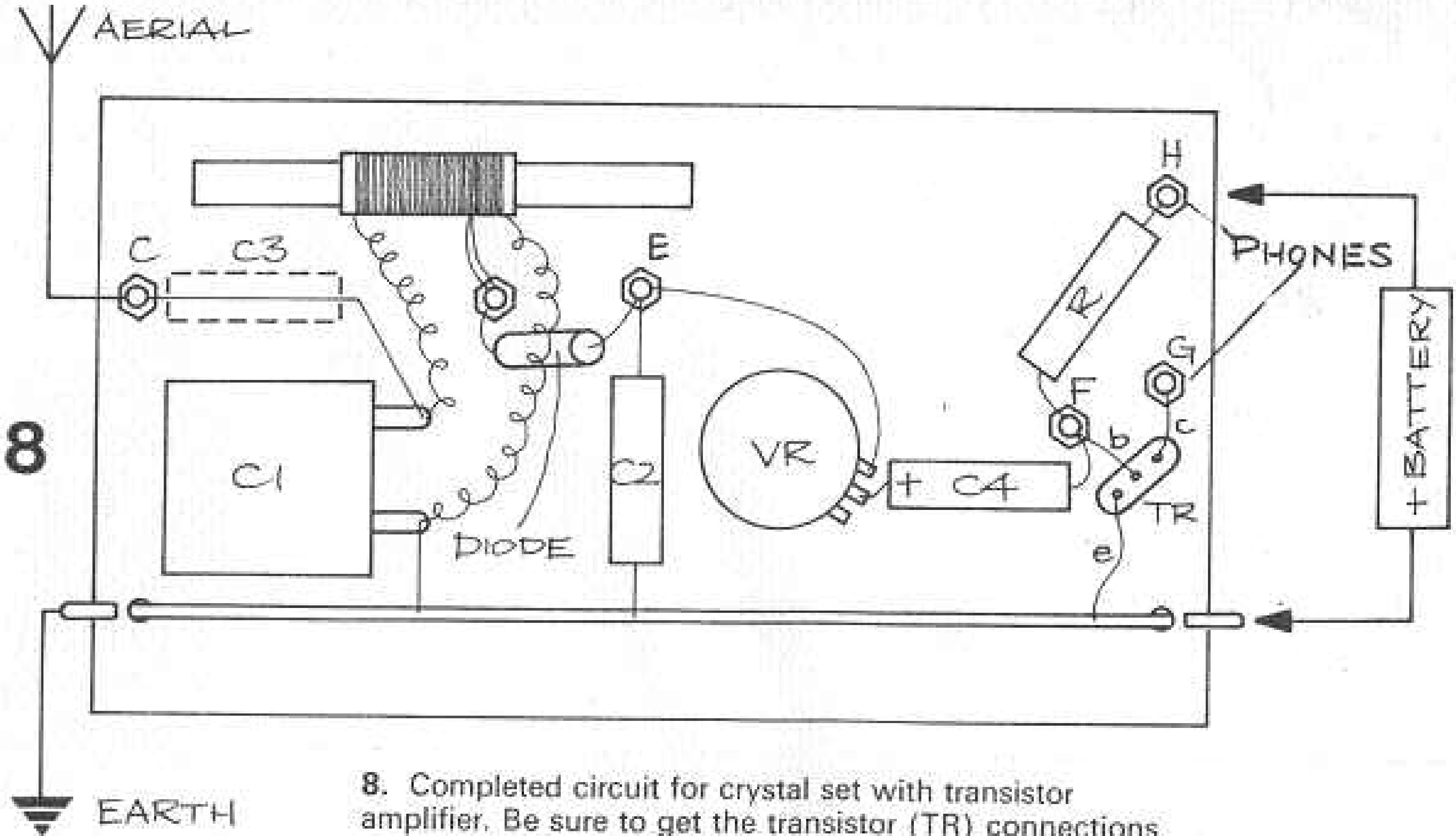
6. Alternative connecting point for the external aerial wire. The inclusion of capacitor C3 is optional. Try with and without to see if there is any difference in results.



7. Alternative 'inductively coupled' aerial tuning coil, showing the slightly different connections.

7





8. Completed circuit for crystal set with transistor amplifier. Be sure to get the transistor (TR) connections correct. Check also that the diode is connected the right way round, and battery plus goes to the 'common' line (with a PNP transistor).

9

A. 350 or 500 pF variable capacitor —single airspaced type, miniature size.

B. Alternatively, 250 pF or 150/750 pF postage stamp type mica trimmer.

C. Diode GEX 34 or equivalent. (Virtually any miniature diode will work.)

Capacitors:

D. C2—·001 μF

E. C3—220 pF.

F. C4—8 μF electrolytic.

G. Potentiometer: VR—1 megohm.

H. Transistor: OC71, OC72, or equivalent.

I. High impedance headphones or deaf aid earpiece (preferred).

J. Resistor: R/470 K ohm.

9. 28 or 38 gauge enamelled copper wire (for winding aerial tuning coils). Ferrite rod (or ferrite slab) for coils. Sizes as specified on this sheet and in general instructions.

Paxolin panel 5½in. × 3in.

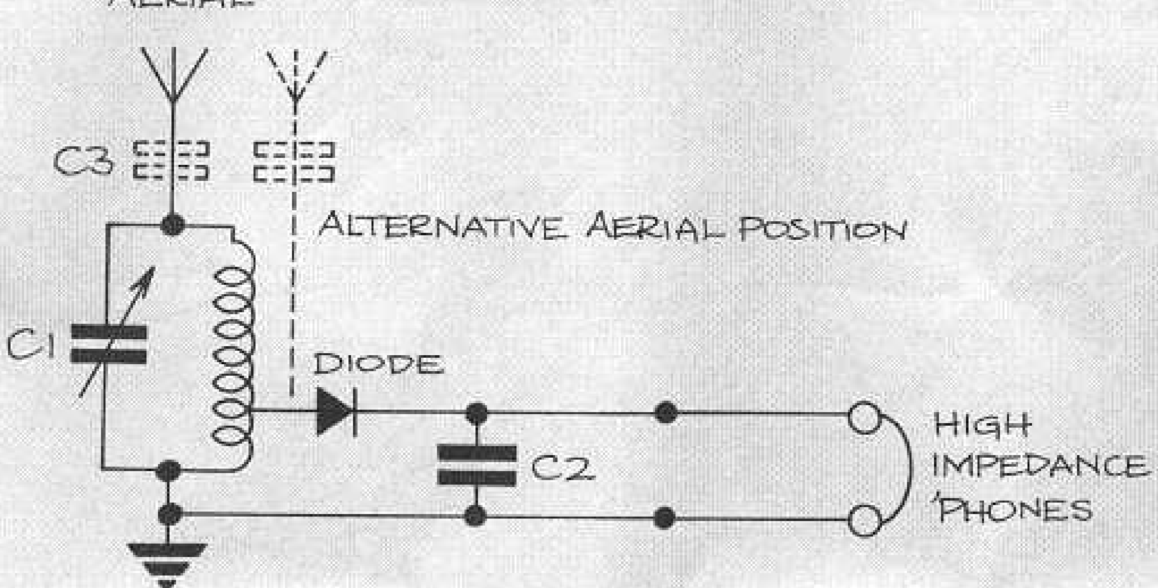
Six ½in. long 6BA brass bolts and nuts.

Length of 16 gauge tinned copper wire.

Thin bellwire for connections, aerial wire and earth connection.

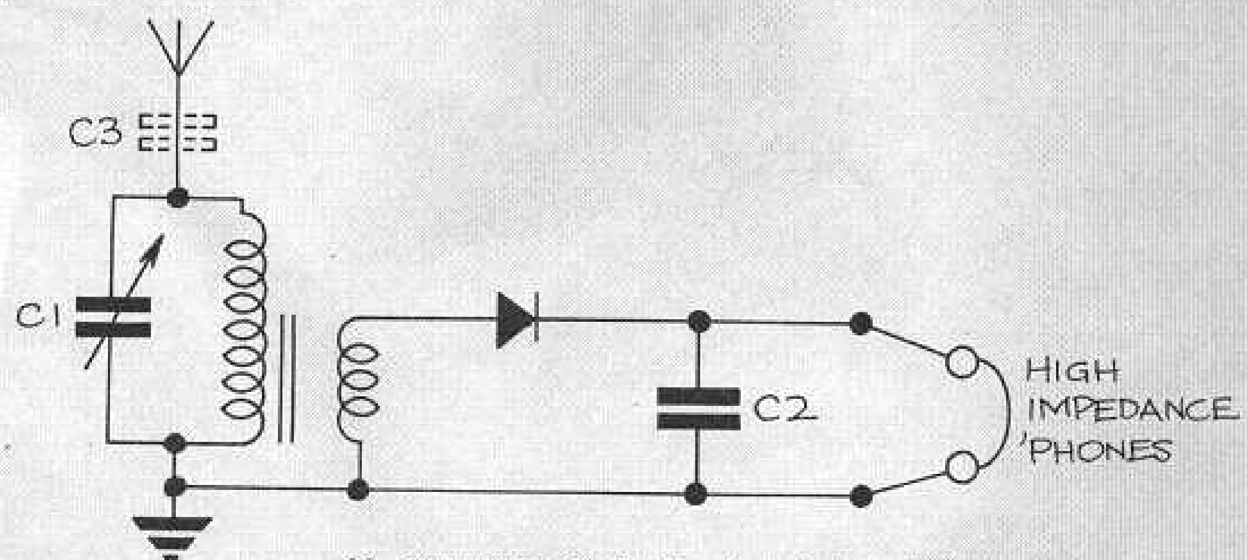
CIRCUIT DIAGRAMS

10



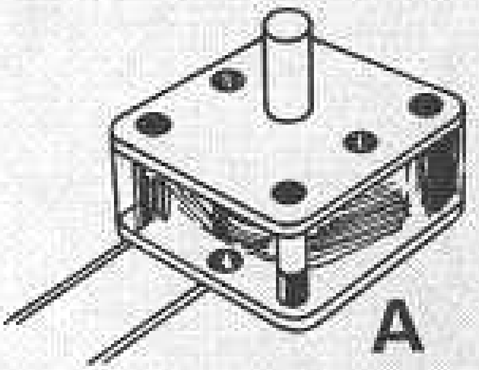
10. Theoretical circuit of basic crystal set showing alternative positions for aerial connection. These correspond to Plan Diagram 5 and Plan Diagram 6.

11



11. Theoretical circuit of basic crystal set with inductively coupled aerial tuning coil. This corresponds to Plan Sheet Diagram 8.

COMPONENTS REQUIRED



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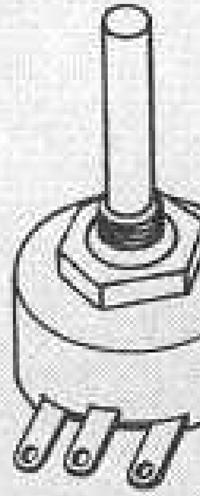

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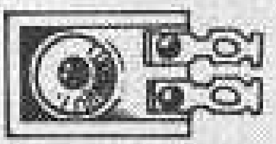

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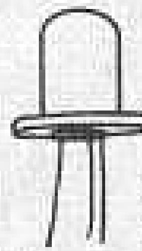
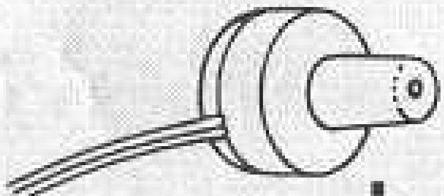


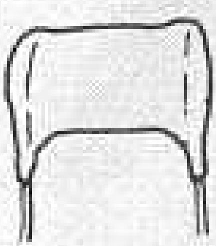
H

C



I

D



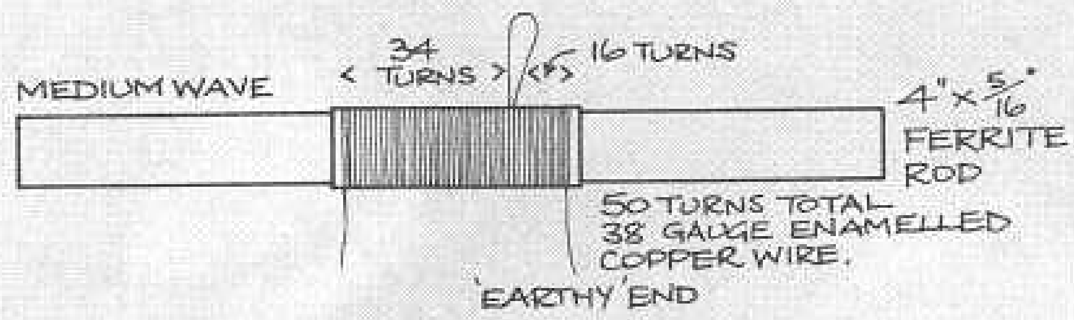
E

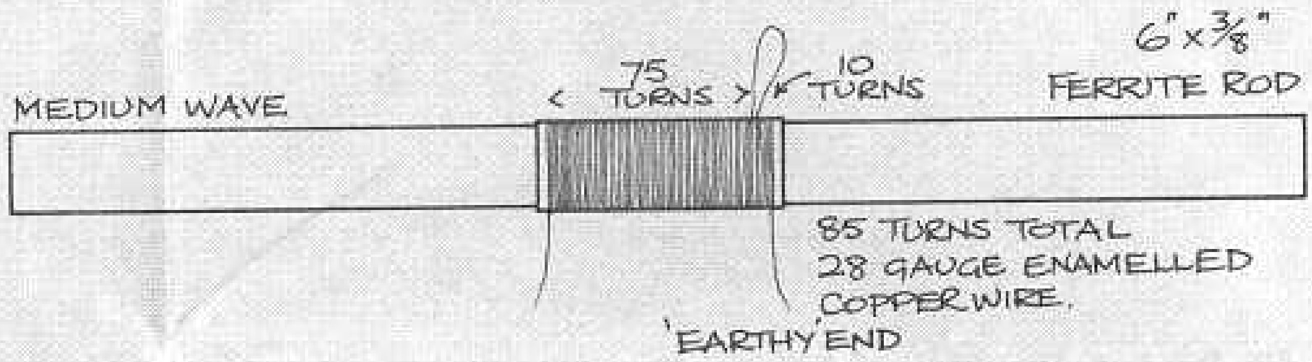
J

F

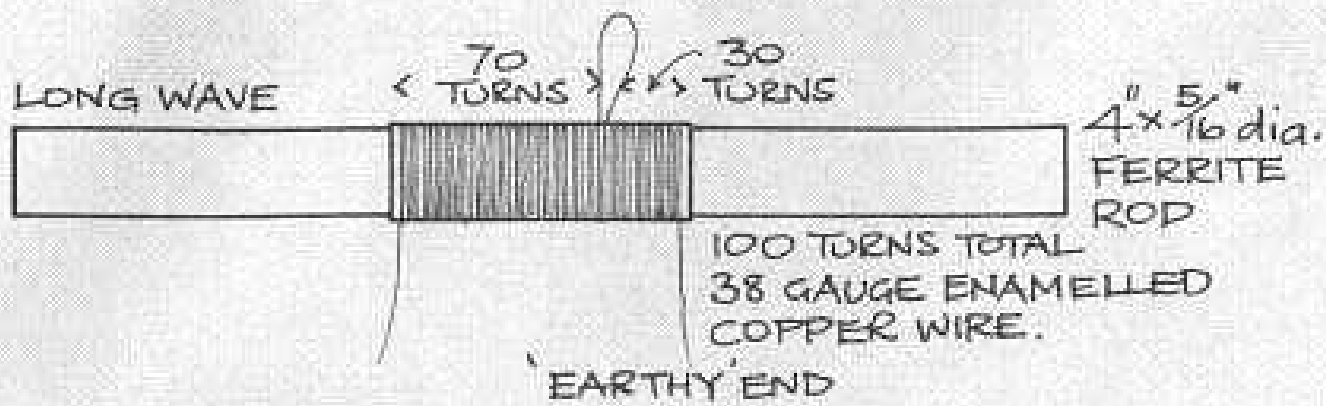
ALTERNATIVE DESIGNS OF AERIAL TUNING COILS

Here are some further winding details for aerial coils in case you cannot readily obtain the ferrite rod diameter size and wire sizes previously specified. All are designed to 'match' a tuning capacitor of 350 to 500 pF value.

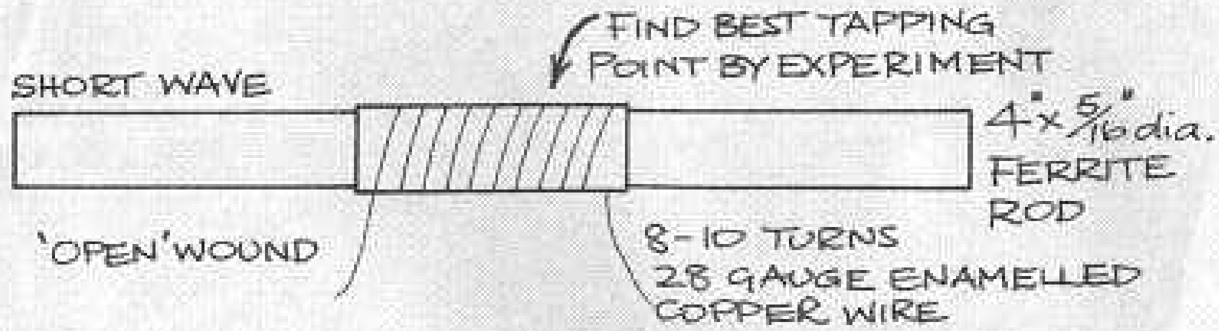




For aerial tuning coils covering the LONGWAVE band, you need about twice the number of turns of wire on the same size ferrite rod as for Medium Wave.

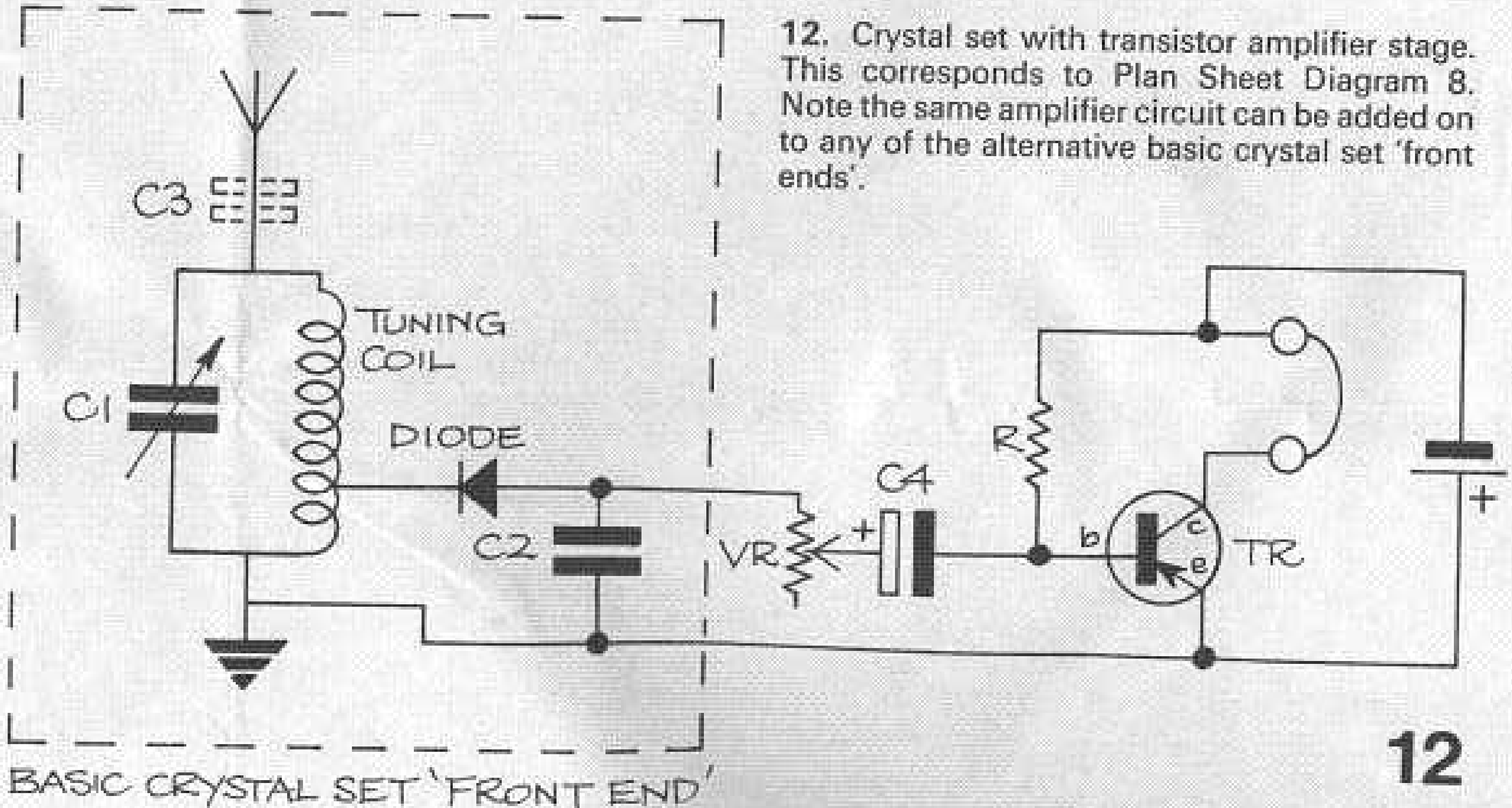


To cover the SHORT WAVE band very few turns are required on the tuning coil and these should be 'open' wound. That is, instead of each turn being laid close to each other there should be a space equal to the wire thickness, or slightly greater, between each turn. The best tapping point is found by experiment. Alternatively you can try inductive coupling, using a single turn for the coupling coil, positioned by trial and error for best results over the main coil.



If you find that the results obtained with your set are poor, or you live in an area where radio reception is known to be poor, you may find it necessary to purchase a ready-wound aerial coil. Make sure you use it with the correct size and type of ferrite rod, and also a tuning capacitor of matching range. Not all aerial coils are designed for 350 pF or 500 pF tuning capacitors.

Remember, however, that not even a high efficiency professionally made aerial tuning coil can give good results with a crystal set unless you also use a good external aerial.



12. Crystal set with transistor amplifier stage. This corresponds to Plan Sheet Diagram 8. Note the same amplifier circuit can be added on to any of the alternative basic crystal set 'front ends'.

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