MAKE A Tuning Coil and Crystal Set

IN the past two years many more B.O.P readers have become interested in Radio Set Construction, or would like to try to make a receiver of their own. So I have prepared a new series of articles which all stem out of one component I am going to tell you how to make for yourselves, a tuning coil. Every receiver must have a coil which is tuned to the frequency of the station it is desired to receive, and the more complex the receiver the more coils it will have.

The construction of this coil is described in this article and with it I show you how to build it into a crystal receiver. Next in the series I will convert the receiver into a transistor set for louder volume and follow that with a one-valve set. Each of these receivers uses just the one coil as does the fourth in the series which is a loud-speaker two-valve set. Finally, we construct two coils and make a sensitive three-valve receiver. Thus you will have a progressive series which, I hope, will interest both the beginners and the keen experimenters.

The first thing to do is to make the coil and for this you will need a piece of cardboard or paxolin tubing 2 in. in diameter and about 4 in. long. Also you will need some odd pieces of card and half a dozen 6 B.A bolts with a dozen nuts and washers. The wire used is 28 s.w.g d.c.c and you want a quarter-pound. The abbreviations mean, by the way, standard wire gauge and double-cotton-covered. First, let us consider the former on which we make our coil. If you can obtain one of bakelite or paxolin it would be ideal, but tubes of these materials are difficult to find these days.

A piece of cardboard tubing such as is used for sending documents through the post, or for containing plans, can probably be purchased at a stationer's shop and its outer diameter should be 2 in. The medium-wave coil will be wound on with the turns side by side but the reaction and long-wave windings are "pile-wound" in slots which are made by means of three rings cut out of some stiff card. These rings have an internal diameter of 2 in. to match the external diameter of the tube on to which they must firmly fit. The external diameter of the rings is about 2¾ in. which will give you, when fitted to the tube, two slots, side by side, each ¾ in. deep. Figure 1 makes all clear.

If you want to make your coil former extra effective it can be given a coat of shellac varnish both inside and out and then baked dry and hard in an oven. The rings should be treated similarly. This will prevent dampness in the air or changes of temperature being able to affect the somewhat absorbent cardboard former and causing a deterioration in the coil's efficiency.

If you live in a humid climate, and I know many B.O.P readers live outside the British Isles, it is essential to give the former the shellac varnish treatment before winding the coil and then to shellac varnish the whole of the coil again after it is wound so that the cotton covering of the coils cannot be affected by the damp. The treated coils must be dried gently (not baked-up) in a warm oven, or, if you can find any, hot sunshine.

Having obtained your coil former and cut out the rings, varnished them if you intend doing so, the next step is to fit the six nuts and bolts to the top of the former at equal distances round it about ¼ in. from the top edge. The round head of the bolt with a washer should be inside the tube and another washer and a nut on the outside. The extra nut is for external wiring purposes. Do not tighten the nuts and bolts at this stage, "finger-tight" will be adequate as the various wires of the coil have to be connected to them.

Use a Cocoa Tin

Next with pencil, or, preferably, ball-point pen, mark the former beside each nut with its number, starting at 1 and ending beside it at 6. Figure 1 makes all these points clear and you must, of course, take care that the nuts and bolts are well spaced so that there is no possibility of one touching another; the circumference of a 2-in. diameter former is over 6 in. so that there is room for an inch spacing between the bolts.

Note here that you cannot use any form of metal tubing for coil-winding although there is no objection to constructing a cardboard tube by winding it around a tin, such as a cocoa tin, of the right diameter and sticking it down along the edges. But do use stout

Gilbert Davey has written Fun with Radio *and* Fun with Short Waves, *both published by Edmund Ward Ltd. Now he is writing* Fun with Electronics

The first of a new series of Radio articles by GILBERT DAVEY. Next time he converts this simple coil into a transistor set for louder volume

cardboard if you use this method, as otherwise the tube will collapse when the wire is wound on it.

The former being completed and the terminals in place at the top edge you can now proceed to wind on the wire. All the windings must be in the same direction so that I suggest you take the former with the top, i.e. the end with the nuts and bolts, in your left hand and wind on the wire with your right hand, winding always away from your body so that all the time the direction of winding will always be the same. If you have to put the job down unfinished you can remember quite easily the direction in which the windings went so as to maintain this when you start again. If you are left-handed, of course, you will reverse the hands.

In a well-made coil all connections are taken through the former and up inside the coil to the terminals (those are the nuts and bolts you have fixed at the top). To commence winding make two holes in the former about a ¼ in. from the top just below terminal No. 2, tiny holes such as a darning-needle would make, and thread the end of your wire through one hole into the former and up out of the former through the second hole and down through the first hole again. You will find the end of the wire now is inside the former and is anchored firmly to it.

Bare that end of wire and loop it neatly round under the washer of terminal No. 2 (you will have to loosen it a little to do this). Having made a neat connection here tighten up terminal 2 carefully with spanner or pliers.

Now carefully wind on your coil-former sixty-five turns of wire, each turn closely and neatly touching the previous one. It is a good idea to push the turns together with your thumb-nail from time to time as you wind but do not let any of the turns overlap. When you have completed sixty-five turns cut the wire, leaving 4 in. or so for connecting, make two small holes and, as before, in, out, in and fix the wire firmly to the former, making sure it is pulled tight so that all the turns of the coil are kept compactly together.

The end of the wire now inside the tube should be bared and connected to terminal No. 3 but do not fix the terminal firmly yet as other wires must go on it. Next wind on ten turns for the aerial winding commencing about the space of one turn away from the last winding and fixing the coil by means of two small

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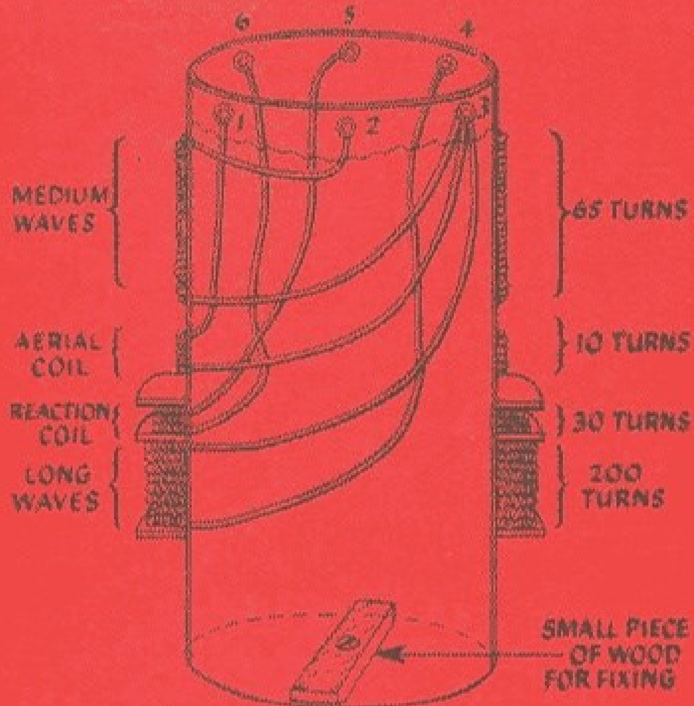


FIGURE 1

Components required for coil:
2 inch diameter former and card (see text)
½ lb. reel 28 s.w.g d.c.c wire. (Available from Webb's Radio, 14 Soho Street, London W.1)
6 × 6 B.A bolts and 12 nuts and washers to suit
Small fillet of wood, glue, etc.

FIGURE 2

COIL CONNECTIONS

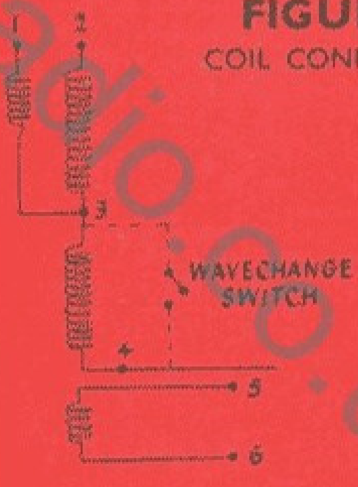
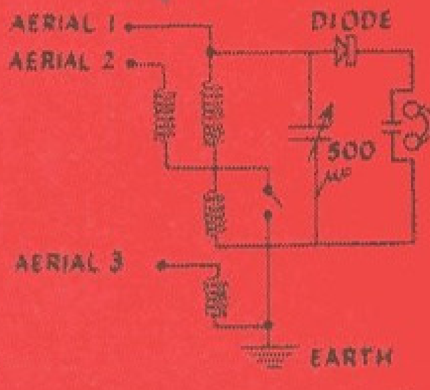
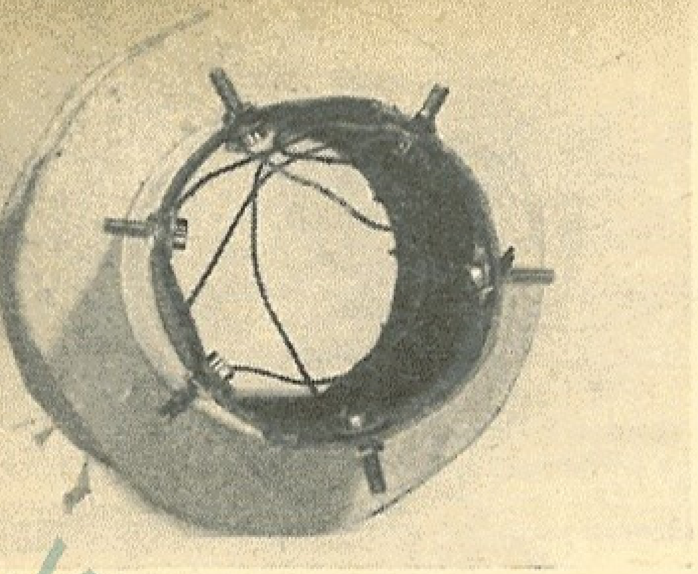


FIGURE 3

CRYSTAL RECEIVER





holes in the former at the beginning and end as before. The commencing wire of this ten-turn coil should be connected to terminal No. 1 (tighten up after connection) and the end of it goes to terminal No. 3 (do not tighten yet). Having finished the ten-turn aerial coil the first ring must be fixed to the former and the position for this is ¼ in. away from the bottom of the last winding.

Slide it on the former and force a little adhesive (preferably the waterproof type) between it and the coil former so as to glue them together. The next ring can then be fixed in the same way ¼ in. apart from the first, and then the third one leaving a space of ½ in. from the second one. You now will have to leave the former to dry overnight so that the rings are well fixed as the wire will strain them somewhat.

In the first (¼ in.) slot, the reaction winding of thirty turns is wound. Fix the wire at the beginning, as before, but simply wind the wire in the slot higgledy-piggledy, thirty turns of it. At the end you will have no room to make two holes, you will have to push your needle down the slot to make one hole and thread the end of your wire through it. If you pull it tight it should hold quite well. The beginning of this winding goes to terminal No. 5 and the end to No. 6, both terminals being tightened up.

Finally, the long-wave winding consists of 200 turns wound "anyhow" in the last slot to fill it completely. Start off by fixing your wire with two little holes, joining its bared end to terminal No. 3 with the other two wires on it, the terminal can then be tightened up. You can finish off by making a needle hole through the edge of the last ring threading the wire through it and through another hole at the foot of the former up to terminal No. 4 to which its bared end can be connected and the nut tightened up. That completes connections to all the terminals and the coil is made.

It is fixed to a baseboard or chassis by making a small fillet of wood, with a central screw-hole, just to fit inside the coil-former at the foot with the aid of a spot of glue. A screw or nut and bolt through the hole will fix the coil firmly. The connections to the coil are shown in Figure 2, an on-off switch across terminals 3 and 4 is required for long-wave purposes. When open it gives long-waves and when shut medium-waves.

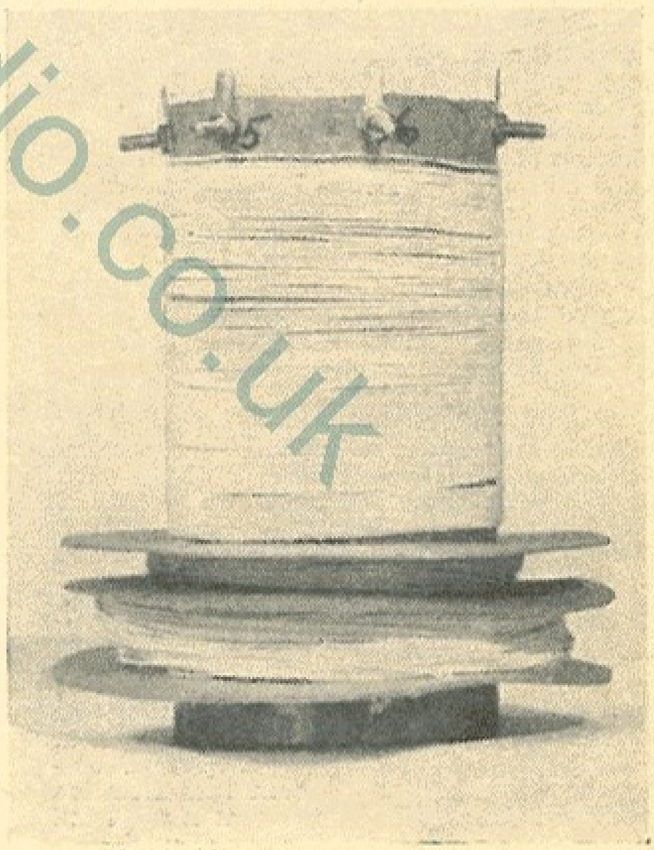
I will defer the crystal receiver until the next article which will also combine the transistor amplifier. The theoretical diagram of the crystal set is shown in Figure 3, and uses the coil I have just described.

Reply to Reader's Radio Query

I intend to make the H.T. unit transformer from your book *Fun with Radio*. I have bought all the components except the transformer and I cannot obtain this from my usual supplier. Can you please give me the address of the Radio Supply Company?

Peter White (Berkhamsted, Herts)

I am glad to have this opportunity to answer Peter White's letter in B.O.P because it enables me to mention the buying of components which so many readers seem to find difficult. I can tell Peter White that the address of R.S.C (Leeds) Ltd., for Mail Orders, is 29-31 Moorfield Road, Leeds 12. This address, and the addresses of most other suppliers of radio parts, are printed in their advertisements in the monthly radio periodicals. Unless you live in London or one of the large cities where there are a number of radio component dealers you can only buy by Mail Order and to get the addresses of such dealers you should consult the radio papers. Public Libraries usually have one or two of these in the Reading Room or available on request, but if you are keen on radio I suggest you take one of these papers in addition to B.O.P.



The two photos show different views of the completed coil with the internal connections and the numbered terminals

MAKE A TRANSISTOR RECEIVER

The second of a new series of articles by GILBERT DAVEY. The first appeared in our January 1961 issue

FIGURE 1

CRYSTAL SET. SCHEMATIC DIAGRAM

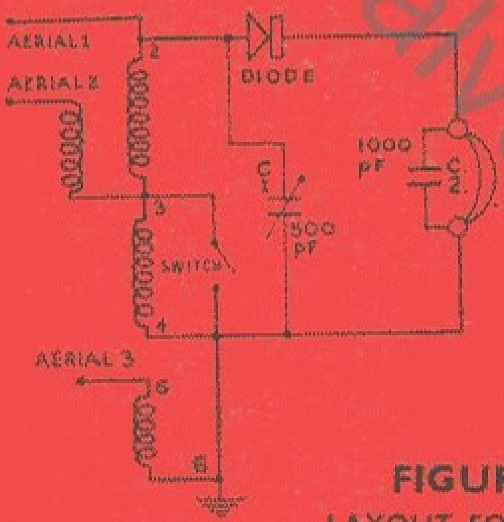
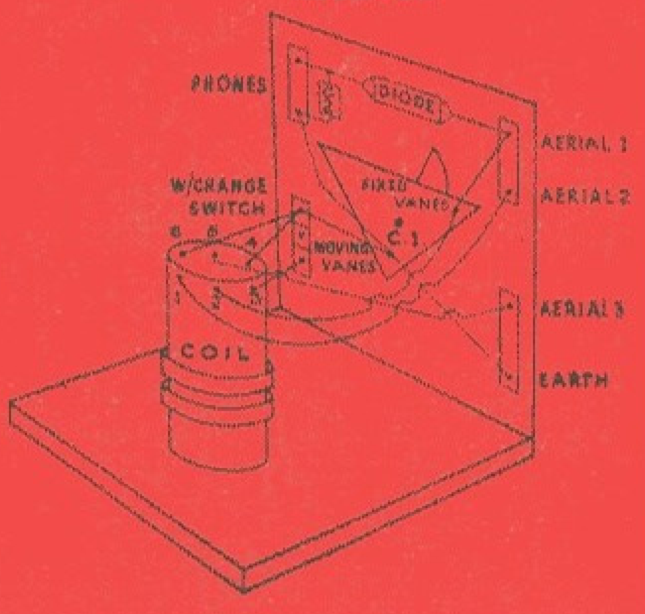


FIGURE 2

LAYOUT FOR CRYSTAL RECEIVER



COMPONENTS REQUIRED

For Crystal Receiver

Coil (see January B.O.P).
C.1 ·0005 mF (i.e. 500 pF) solid dielectric variable condenser.
C.2 ·001 mF (i.e. 1000 pF) fixed condenser.
Germanium diode.
On-off switch (for wavechange).
Three 2-hole socket strips.

For Transistor Receiver

Except for C.2 all components as above plus:
C.2 2 mF fixed electrolytic condenser (max. wkg. 15 volts).
C.3 2 mF fixed electrolytic condenser (max. wkg. 15 volts).
R.1 and R.2 each 220 k.ohms resistor (¼-watt).
R.3 4·7 k.ohms resistor (¼-watt).
R.4 and R.5 each 22 k.ohms resistor (¼-watt).
Two audio-type transistors (see text).
One four-way tag-board.
Two miniature crocodile clips.
Battery, 6 to 9 volts (see text).
Wood, hardboard, wire, solder, etc.
Phones and/or loudspeaker plus possibly o/put transformer (see text).

IN the January 1961 B.O.P I gave details of a tuning coil which you can easily wind and can incorporate in one or two receivers which I am going to describe to you during the next few months. It is a comparatively large coil by modern standards but this is necessary in a home-wound coil in order to obtain efficiency. The very small coils which you can buy owe their size to special machine-winding processes and, sometimes, to an iron-dust core.

In the January article I gave you the theoretical, or schematic, diagram of the crystal set in Fig. 3 and that is repeated here as Fig. 1. (The capacity of the tuning condenser was inadvertently given as 500 mF which is just a million times too large! It should be ·0005 mF (microfarad) or 500 pico-farad (pF).)

In Fig. 2 I suggest a layout for your crystal receiver. A wooden baseboard with a front panel on which are mounted your tuning condenser (compact solid-dielectric type) and six terminals or three pairs of dual-socket mounts. The diode is suspended in the wiring which is very easy to carry out and is done with a few inches of specially insulated connecting wire. The method of fixing the

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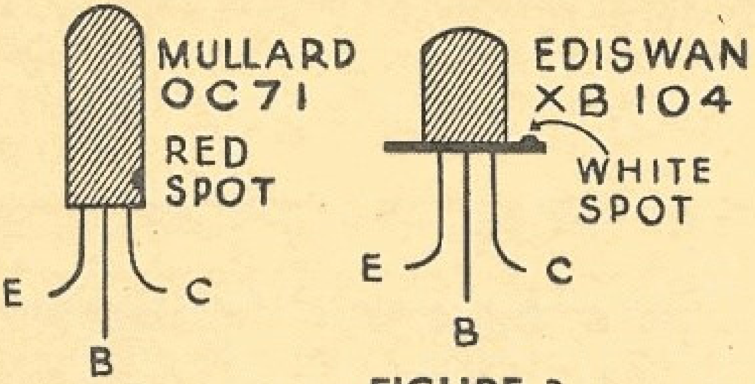


FIGURE 3

(Transistors: approx. actual size)

e—emitter COLLECTOR WIRE INDICATED
b—base BY RED, WHITE, GREEN, ETC.,
c—collector SPOT

coil to the baseboard is shown in Fig. 1 of the first article. That is all I need tell you about the crystal set, it is so simple to make. Later on I mention aerial connections and tuning both of which refer to this set and to the transistor receiver.

The latter is just as easy to construct but certain rules must be carefully followed if you are to avoid damage. Its circuit is a very simple and, in fact, consists of the crystal receiver we have just been considering followed by two stages of *low-frequency* amplification provided by two transistors. It is not a pocket receiver and it must have an aerial plus, if possible, an earth connection. However, it is cheap to build and economical to operate and will give you an interesting initial introduction to transistors. With a good aerial and earth you should be able to work a loudspeaker from the main B.B.C stations without difficulty.

Transistor receivers require a small battery to provide current for the transistors and I usually find one of six to nine volts is adequate. For miniature transistor sets there are very small batteries available but it is not necessary to obtain such a type as any ordinary torch battery will work well and last many months. Transistors are very robust but can be damaged by heat and when soldering to their leads it is necessary to use a *heat shunt* to prevent the heat from the iron running up the wire and ruining the element.

A suitable heat shunt can be contrived easily by gripping the wire with a pair of pliers whilst soldering to the end of it. It really requires three hands to do this, one to hold the soldering-iron, one to hold the solder, and the third to grip the pliers. One reader sent me an idea once for a heat shunt made out of a clothes peg. Each side of the jaw of the peg had had a piece of fairly thick copper screwed to it so that when it was clipped to the transistor wire lead the copper conducted the heat away. Another idea would be to use a small bulldog clip which could grip the lead and conduct the heat away.

Another point which has to be avoided when using transistors is connecting the battery the wrong way round. As you know a dry battery provides direct current and thus has two poles, one negative and the other positive. In working with valves it is now common practice for the negative side of the circuit to be returned to earth but in transistor work the opposite is the case and the positive (plus or +) side is earthed. To that side the Emitter of the transistor must always be connected and the collector goes to negative. Perhaps you can remember to be *positive* to *E*-arth the *E*-mitter. If the transistor is connected wrongly, even momentarily, it is possible to destroy it.

You may have noticed that very small components are used in transistor set designs but in our present receiver these are not necessary as we have plenty of room for the larger types. These are less expensive than the miniature components and need not, in the case of condensers, have a working voltage above 12 or 15, but those for higher voltages can be used if available. In fact, the whole receiver is so very versatile in regard to its building that you cannot fail, if components are in order and connections correctly made to have it going very quickly.

For this reason I have not given you any photographs of the set which I made up but have utilized the space instead for plenty of diagrams so that even a beginner should be able to make the set without difficulty. The first of these is the schematic diagram of the transistor receiver (Fig. 4) and those of you who already understand such diagrams will notice that the *front end* is the crystal set to which the transistor amplifier is added.

Fig. 5 is a general layout for the transistor re-

FIGURE 4 TRANSISTOR RECEIVER SCHEMATIC DIAGRAM

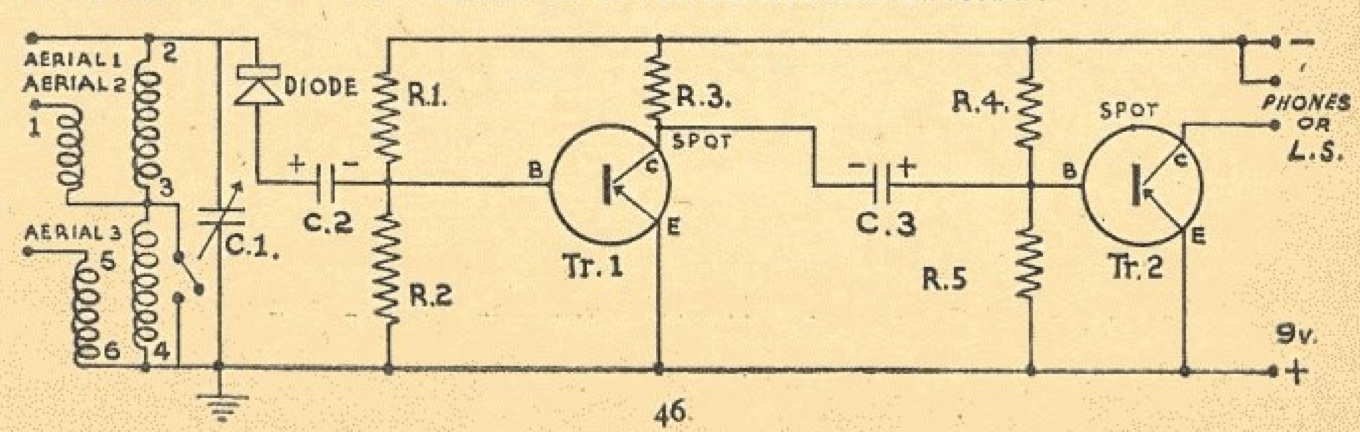
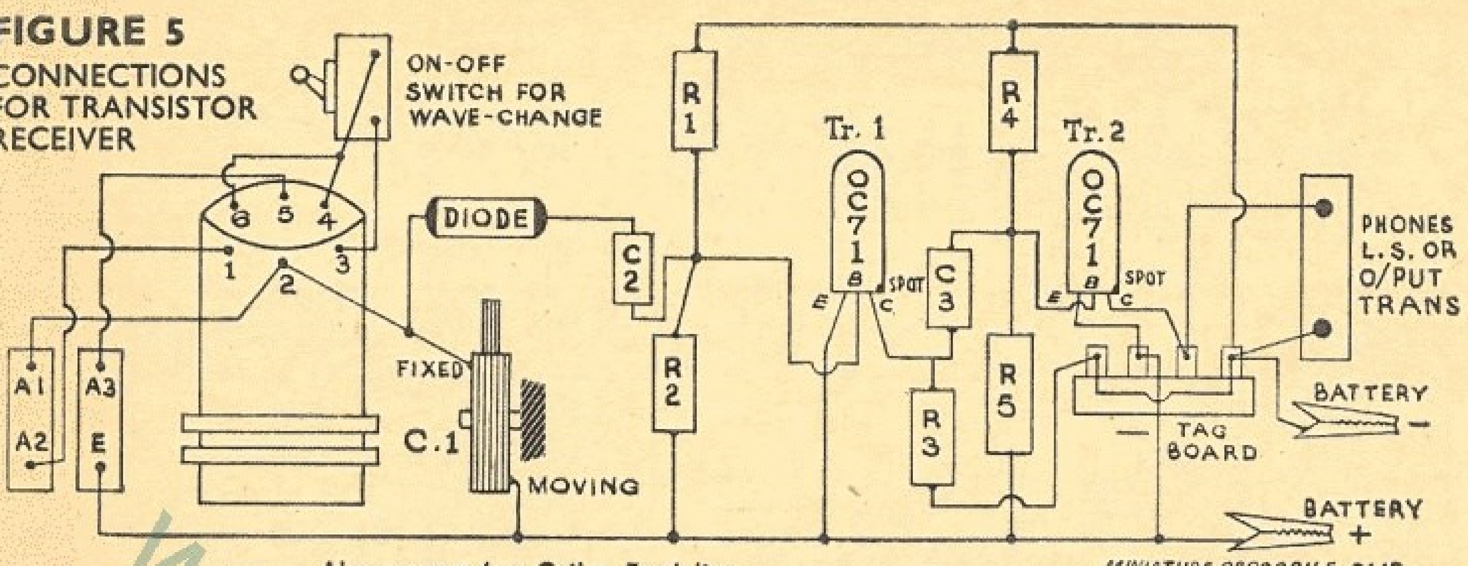


FIGURE 5

CONNECTIONS FOR TRANSISTOR RECEIVER



Also connect 4 on Coil to Earth line

ceiver and is not shown in relation to any particular form of construction. I have done this because the more experienced readers may wish to build the receiver into an existing box of some type such as a large cigar-box or perhaps a small case if it is thought that the set might be useful to take with you to camp.

However you build the set into its case this tag-board method is, I am sure, the best means of construction. One long bare wire runs right down the receiver and forms the earth *bus-bar*. To this all earthed components are connected, as is the positive (plus, +) side of the battery. They thus have a rigid anchorage on one side which rigidity is maintained when they are connected together in the correct sequence.

The last diagram (Fig. 6) is a panel and base-board layout which I suggest might be followed by the newcomer to radio set construction. The baseboard can be a piece of soft wood such as a piece cut from a soap-box or it can be five-ply wood or a piece of peg-board or hardboard mounted on two runners in order to raise it up half-an-inch or so. The panel should be a piece of one of these boards fixed by small screws or panel-pins to the front edge of the baseboard. If you are going to fix a loudspeaker to it an added refinement, in order to bear the weight, would be two triangles of wood glued and pinned in place as shown by the dotted lines.

Adding a Loudspeaker

You should try the set with ear-phones first in order to ensure that reception in your location is good enough to warrant the extra expense of a loudspeaker. If you have a loudspeaker already it is almost certain that you will require a small output transformer to match it to the transistor output. If you are buying a loudspeaker there are some available which have their speech coils specially wound to match directly into an output transistor. One such is the WB Stentorian 3½-inch type which costs 34*s*. 9*d*.

The disadvantage of buyng a speaker of this type is that it might be difficult to match it if you later wish to use it in a valve circuit. Whatever type of speaker you use, to fix in the suggested layout it should have a diameter of 3 or 3½ inches. There is no objection to using an independent speaker of larger size in its own separate cabinet.

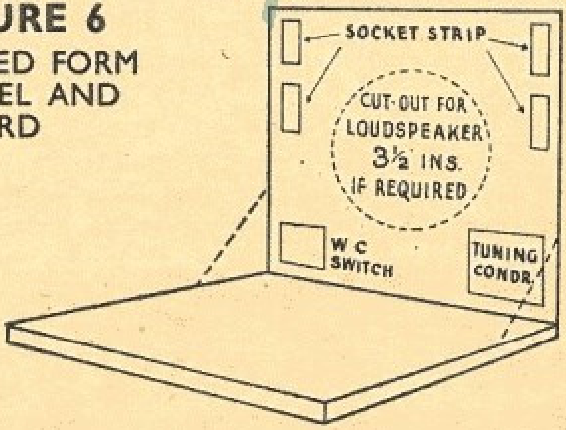
Regarding transistors which you require, the types are for audio-frequencies and there are plenty available. I always use new ones of good quality, generally, as specified, Mullard OC 71 or Ediswan XB 104. The former are listed in my catalogue at 14*s*. each and the XB 104 at 10*s*. each but I have seen them offered as "surplus" at much cheaper prices. You can, however, try much cheaper types if you wish and there is no doubt that, in a simple receiver of this nature, they would give adequate results. If results are poor and you are using cheap transistors it might be as well to return them to the dealer for testing.

I mentioned how to buy components in the answers to a reader's letter at the end of the January article or I will gladly help by post. The coil, by the way, you cannot buy. Instructions to make it were given in January B.O.P.

The next constructional article in this series will be about the use of valves and how to build a one-valve receiver. The Editor will not be able to publish this before the June issue, so please be patient!

FIGURE 6

SUGGESTED FORM FOR PANEL AND BASEBOARD



MAKE A ONE-VALVE RECEIVER

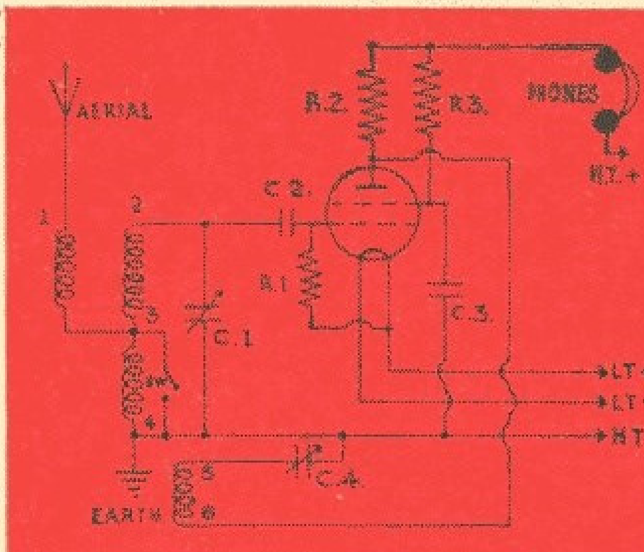


FIGURE 1 ONE-VALVE SCHEMATIC DIAGRAM

In the third article of his new series GILBERT DAVEY shows you how to make a practical radio set for £1 10s

COMPONENTS LIST

Coil—home-made, see January 1961 B.O.P.
C.1 Variable condenser, solid dielectric 500 pF.
C.2 Fixed condenser 100 pF ceramic or mica.
C.3 Fixed condenser ·1 mF electrolytic or paper 150-volt wkg.
C.4 Variable condenser, solid dielectric or air dielectric 100 pF.
R.1 Resistor 2·2 MΩ ½-watt (or smaller wattage will do) } 20 per cent. tolerance
R.2 Resistor 10 KΩ ½-watt
R.3 Resistor 22 KΩ ½-watt
On-off switch, B7G valveholder, two 2-hole socket strips.
Wire, solder, 2 knobs to suit condenser spindles, wood or metal chassis. 6 B.A nuts and bolts or wood screws.
Valve, 1T4 or Mullard DF91, etc. (see text).
Batteries 1·5 volt, 45 volt.

SO far in this series we have considered using the coil which was described in the January issue in two receivers, a crystal set and a two-transistor receiver. Both of these are limited in range because they can only pass into the headphones those signals received by the aerial which, after rectification by the germanium diode detector, are strong enough to be heard.

It is true that the transistors provide some amplification but this follows the diode and can only make louder what it has already received and rectified. These days we can obtain R.F transistors which are used for amplifying the signals before they are *detected* by the diode and which allow greater range to be obtained. It is now possible to make all-transistor super-het receivers.

Before transistors were invented we always had to use valves and had a screen-grid or pentode valve in the radio-frequency stage to give range, a similar type in the detector stage with a pentode or power-valve in the output stage. This is known as a T.R.F set and is the type we shall ultimately describe in this series. The detector stage generally has a device called *reaction* incorporated in it and this, by feeding back some of the energy at the anode of the valve into its grid, enables minute signals to be greatly amplified. Unless an R.F stage is used, careless use of reaction can cause the feedback to affect the aerial circuit and allow interference with other receivers in the neighbourhood, but this will not occur if you take care in using such a receiver. A superhet receiver, such as is normally used commercially to-day does not use reaction.

This one-valve receiver is simply the detector section of a T.R.F receiver. There is thus no R.F stage for range and no audio frequency stage to make the signals louder after detection, but it has reaction and being a valve detector has the advantage of the

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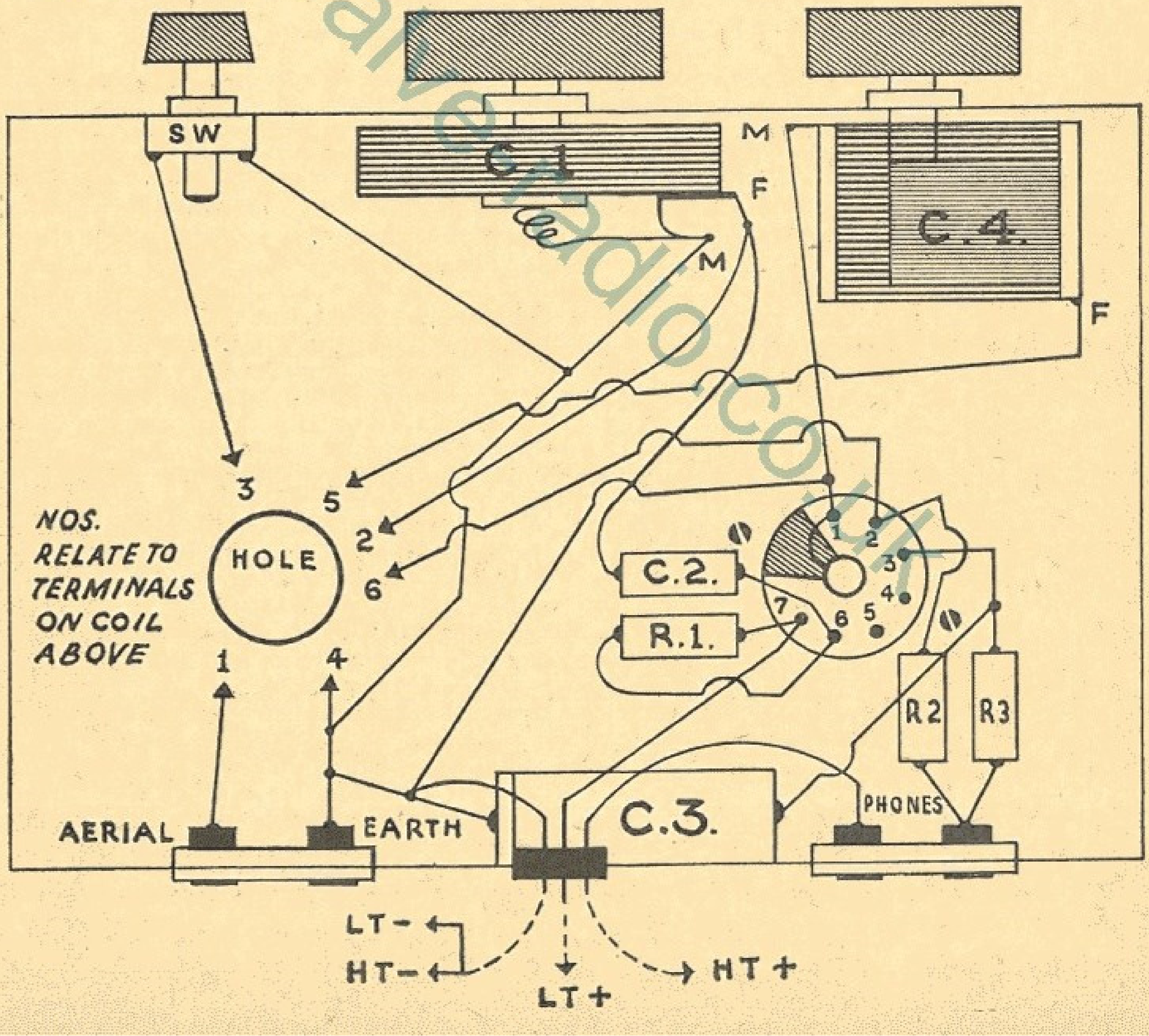
amplification inherent in the valve itself. The disadvantages are the fragility of the valve compared with a transistor and, in addition to the low-voltage battery used for filament heating, the need for a high-tension battery of between 45 and 90 volts.

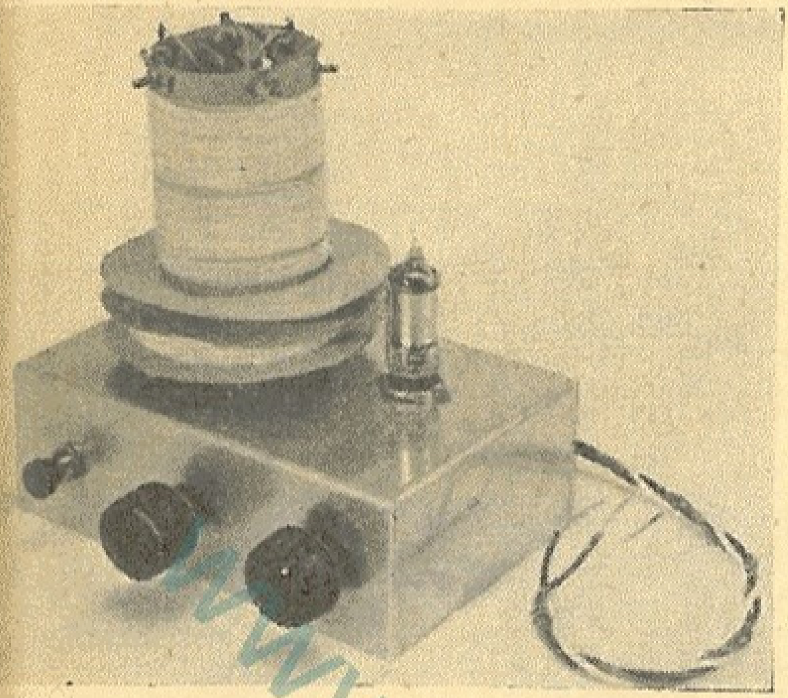
The type of valve used is a miniature radio-frequency pentode which takes a filament voltage of 1·4, and which is quite easily supplied from a 1·5-volt dry battery. Four types of valve are suitable, namely, the 1T4 which is an International type made by a number of makers and of which, in the Mullard range, the equivalent is the DF 91. Both take a filament current of 50 milliamps, as does the Mullard DF 92 which is also suitable. The DF 96, also made by Mullard, could be used and is less expensive in current, taking only 25 milliamps. All these valves are interchangeable in the valveholder, which is a B7G type and for which the connections are shown in Figure 2.

The receiver is built on a small chassis 6 inches long by 4 inches wide by 2 inches deep. I have used a small metal one of aluminium but you can easily make up one of wood or plywood or wood and hardboard. What is required is a small box of which the two end-pieces are 4 inches by 2 inches by perhaps ½ inch thick. The other two sides are of hardboard 6 inches long by 2 inches and another piece of hardboard 6 inches by 4 inches makes the bottom of the box or, when it is inverted, the top of the chassis. The whole thing is tacked together with ½-inch panel pins, a smear of glue having first been applied for strengthening purposes.

Along the front are fixed the wavechange switch, in the centre is the tuning condenser, and then comes the reaction condenser. The chassis and positions for these are shown in Figure 3. On top of the chassis are fixed the coil and the valveholder. The coil is fixed by wedging and gluing a small fillet of wood beneath it and then bolting or screwing that to the chassis. Somewhere alongside that piece of wood and underneath the coil you must drill out a hole about ½ inch in diameter through which the wires can pass through the chassis and up inside the coil to the terminals

FIGURE 2 WIRING DIAGRAM





The completed set, using the original coil. In this case an aluminium chassis was used but it can be made of wood or hardboard

at its top. A ½-inch diameter hole is also needed for the B7G valveholder.

Wiring-up the receiver is quite a simple task with a lightweight instrument soldering-iron and resin-cored solder. The point to bear in mind is the need for absolute cleanliness in order to solder successfully. The bit of the iron must be clean and so must the work to be soldered. Rubbing the bit on a piece of old sandpaper should keep it clean and cleaning soldering tags with a corner of fine sand- or emery-paper should provide a good surface on which the solder will run.

If insulated tinned copper wire is used for connecting purposes the removal of a fraction of an inch of sleeving at the end should leave exposed a piece of wire clean enough for soldering. The reason for the small holes in the tags fitted to components is to allow the wire or wires to be pushed through and bent round and so held fast. The *hot* iron and solder are both applied together, the solder runs and a good joint is made (provided all was clean to start with).

Note that the tuning condensers have moving and fixed plates, designated on diagrams respectively as *M* or *F* and connections must be correctly made as marked. The moving plates will automatically be earthed to chassis by their fixing collars and nuts if a metal chassis is used, but it is as well to make the direct connection to the plates as well. The electrolytic condenser is *polarized* and has to be connected the correct way round with its positive side to the valveholder pin and the other, or negative pole, to earth. There are various methods of marking these condensers, either with + or a red sign for positive and − or black for negative at the appropriate ends, or, possibly, merely a black ring around the end which is to be connected to the negative and earth side of the circuit.

Three wires are needed for connecting to the batteries, and in the original set I used a black PVC-covered flex for negative, a similar one in red for HT positive and a yellow one for LT positive. The two negatives, HT and LT, are joined together with a short piece of wire at the batteries themselves. These three coloured wires look neatest if they are braided together and tied at the battery end. I have not used a battery on-off switch in this receiver in order to keep the cost as low as possible. To switch off simply pull out the LT positive plug. Do not forget to do this after using the set otherwise the batteries will soon run down.

Do be very careful not to get the HT voltage mixed up with the LT side as the valve will soon "blow". It is a good idea to test the LT circuit before inserting the valve by connecting up all batteries and 'phones, then, by pushing two pieces of bare wire down the sockets numbered 1 and 7 (each side of the blank space) see if a flash-lamp bulb lights when touched across them. If it does, all is well, if it flashes up and burns out the HT is obviously in the wrong place and must be rectified before the valve is used.

For economy always buy the largest battery you can afford. A final word, be careful of oscillating, it causes interference. The right-hand knob works the reaction; use it to bring up the volume to the correct point.

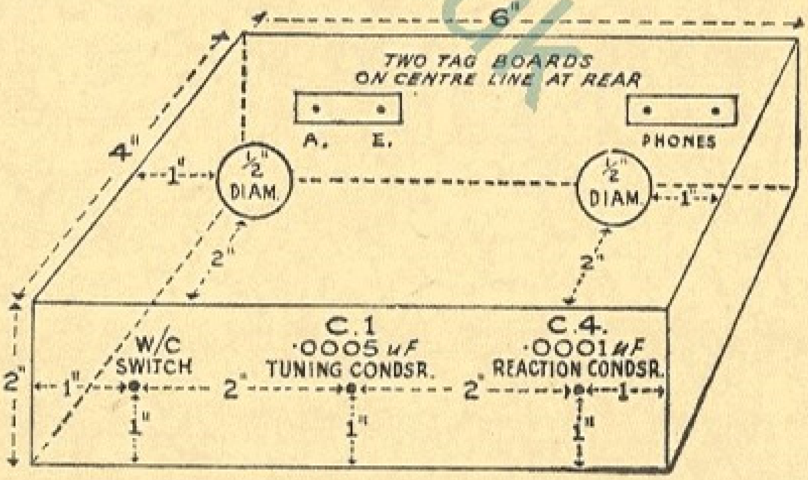


FIGURE 3
CHASSIS CONSTRUCTION