"BESTWAY" No 161

The Guide for the Wireless Constructor

HOW TO MAKE Crystal Sets

6d.

CONTENTS

Types of Well Known Crystal Sets

THE Twelve Crystal Sets shown on this page are representative of the work of some of the best known Crystal Set manufacturers, and will enable constructors to note the various methods of design and layout in constructing Sets.

1. *Cosmos Crystal Set No. 2*
2. *B. T. H. Radiola Crystal Set, Model A*
3. *Burndept Ethophone, No. 1*
4. *Ediswan Crystal Receiver*
5. *The "Fellocryst" Super Crystal Set*
6. *Gecophone Crystal Set, No. 2*
7. *R. I. Crystal Set, No. 2*
8. *The G. R. C. Crystal Set*
9. *The Ericsson Crystal Set*
10. *Western Electric Co. Crystal Set*
11. *T. M. C. Crystal Set, No. 5*
12. *Sterling Crystal Set, No. 2*


Fig. 1


Fig. 2

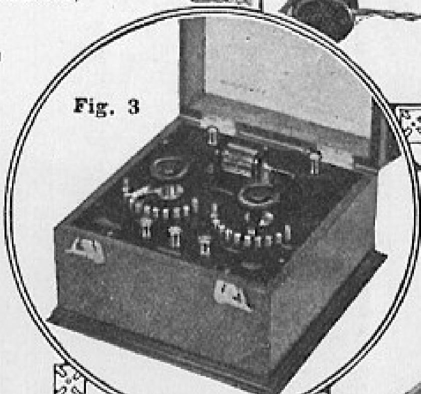


Fig. 3


Fig. 4

Fig. 5

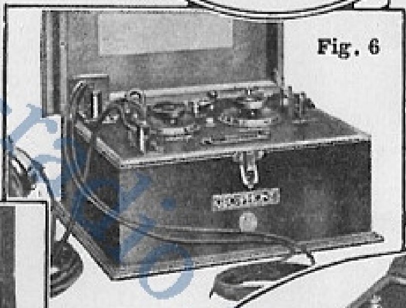


Fig. 6

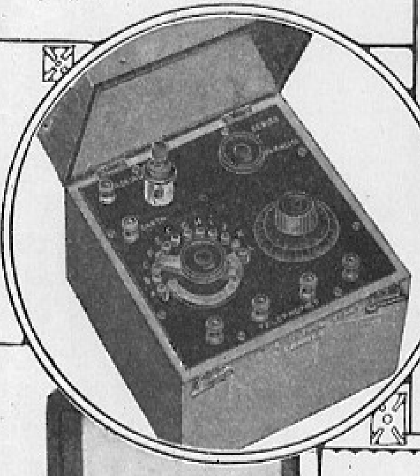


Fig. 7

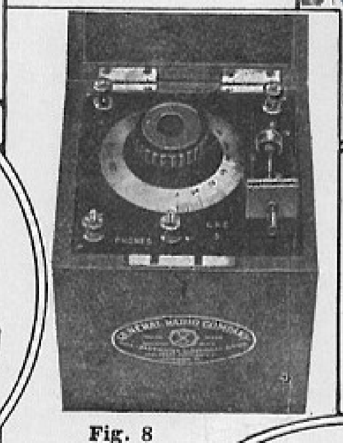


Fig. 8

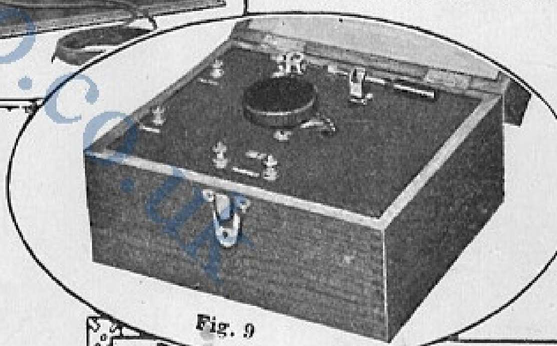


Fig. 9

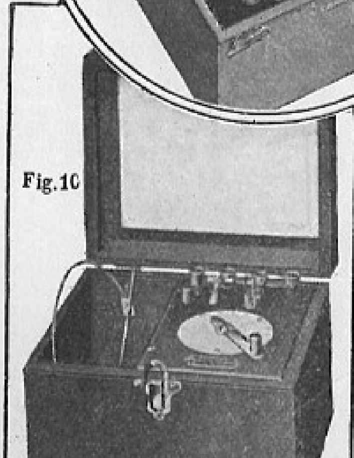


Fig. 10

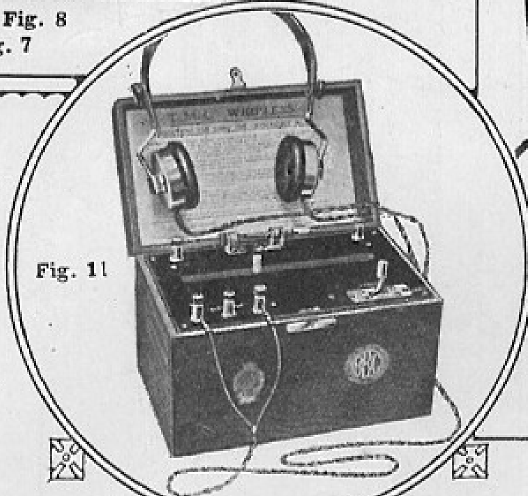


Fig. 11


Fig. 12

The photos on this page should, if studied carefully, prove valuable to the home constructor who desires to adopt alternative designs for the sets described in this book.

"BESTWAY" No. 161 CRYSTAL SETS

CONTENTS.

INTRODUCTION.

THE object of this book is to place before the amateur wireless constructor comprehensive details for the building of crystal receivers.

Much may be learned of the art of constructing wireless receivers by the careful study of photographs and pictorial diagrams, and, for this reason, art paper has been used in this issue and in the companion issue of the BEST WAY series dealing with the construction of valve sets, and no pains have been spared to illustrate as exhaustively as possible the step-by-step processes of constructing various wireless sets.

This book has been devoted to the interests of the constructor of crystal receivers, but it has been made even more comprehensive by including two articles dealing with the home construction of a one and a two-valve low-frequency amplifier.

The "Home-Constructor's First Crystal Set," the "Reliable Crystal Set," and the "Two-Circuit Crystal Set," are three sets which can be thoroughly recommended to the home constructor.

Readers will find full details about our companion book on the back cover of this issue.

These first two numbers of the BEST WAY Wireless Series will, it is hoped, be followed at an early date by other numbers devoted to all constructional aspects of the hobby of Wireless in the most detailed and most explicit form.

It has been the aim of the writer, when securing contributions to this number and to the companion number, "How to make Valve Sets," to publish articles and photographs of such a nature that, when carefully studied by the reader, will eliminate any necessity for queries on the part of the prospective constructor.

The contributors to this issue have had many years' experience of wireless work, and they have concentrated on supplying every possible detail, so that the reader, after having studied the text, will not find himself in a quandary over any little point which may prevent him from starting right away to build the set of his choice.

But further precaution has been taken, and arrangements have been made to answer any queries necessary in connection with the sets described in this issue. But only queries dealing specifically with the articles in this number can be dealt with by the Technical Staff of the BEST WAY Wireless Series. All such queries should be addressed to—The Editor-in-Chief, BEST WAY Wireless Series, The Fleetway House, Farringdon Street, London, E.C.4, and a stamped and addressed envelope for reply must be enclosed with every communication.

Readers desirous of contributing to further issues of these Series must, in the first place, communicate with the Editor at the above address, outlining any suggestions they have to make regarding constructional articles.

It only remains for me to assure readers that this and every other BESTWAY Wireless book issued will consistently supply the best and most reliable constructional articles, and that no trouble or expense will be spared in placing before the amateur the finest series of wireless books ever published.

THE EDITOR.

TEST REPORTS ON "BESTWAY" CRYSTAL SETS.

The Two-Circuit Crystal Set has switching enabling the aerial tuning inductance to be in series or parallel with the condenser, and also has a tune and stand-by switch for the secondary circuit, the latter being variably coupled, and tuned by a variable condenser.

Testing by a wavemeter, these controls were all found to function correctly, the set having the full wave-length range stated in the text. Tested for aerial reception on broadcasting the best results are obtained using the primary and secondary circuits moderately loosely coupled. The London station, 2 L O, came in at very good strength at a distance of 20 miles, reception being remarkably clear and pure and free from parasitic noise.

Using the larger valve coil as a primary the high-power station 5 X X came in very strongly.

On applying the single stage of low-frequency amplification the signal strength was increased on both stations to almost full loud-speaker strength, quite sufficient, in fact, for a small table talker, which is virtually a small loud speaker. The two-stage amplifier increased both the strength of signals and the range, the strength from 2 L O and 5 X X being sufficient for effectual operation of a Burndept Ethovox loud-speaker used in a very large room.

With this amplifier (2-stage L.F.) signals were received at audible loud-speaker strength from Bournemouth, 6 B M, and Newcastle, 5 N O, these stations being of quite good strength on the headphones.

These tests were carried out 20 miles south-east of London, and on an ordinary one-wire aerial, approximately 25 ft. in height. The station is on a hill side, and is badly screened by trees.

TEST ON THE HOME-CONSTRUCTOR'S FIRST CRYSTAL SET.

Tests with this set were carried out at Chadwell Heath (approximately 12 miles from 2 L O) and at Dulwich Village (approximately three miles from 2 L O) and proved exceedingly satisfactory.

All things considered, the circuit proved quite selective and with careful tuning and fine adjustment of the crystal detector 2 L O's signals could be heard in the telephones more than two feet from the ear. G N F, G N I, and several ships in the channel, working morse code, were clearly tuned in with this set.

Good aerial and earth connections were found most essential for the very best results.

TEST ON THE RELIABLE CRYSTAL SET.

Tests with this receiver were carried out at Putney and at Dulwich Village and the results indicated an all-round excellence which speaks highly for the constructor and designer of the receiver.

At Dulwich it was possible to add a loading coil for 5 X X and almost entirely cut out 2 L O—a good test, considering that 2 L O was but three miles or so away.

Plenty of signals from ship stations and G N F and G N I and other land stations were received, and F L's time signal from Paris was heard quite clearly with the addition of an extra loading coil

The Home-Constructor's First Crystal Set

By P. R. BIRD

THIS is a very efficient little receiver, described in detail for the listener with no experience of building wireless sets. The total cost is just under ten shillings. Variometer tuning is employed, and the constructional details are of the simplest.

THE crystal set to be described is a cheap one, with which uncommonly good results have been obtained. Its total cost is less than 10/-, and owing to the straightforward nature of the circuit and wiring, it forms an ideal set for the novice who wishes to construct his own receiver. Full particulars are given for the construction of this complete variometer-tuned crystal set, and the making of the variometer itself is described in detail.

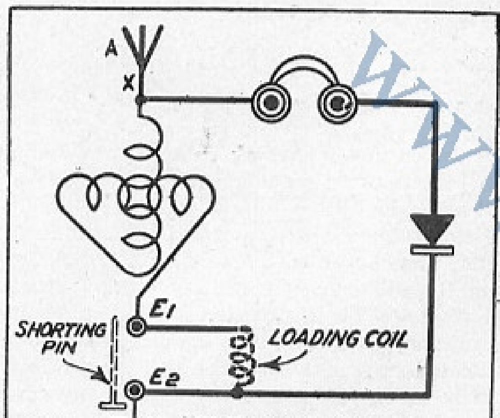


FIG. 1. THEORETICAL DIAGRAM

The necessary materials are detailed below, and the cost of the different parts will be found against each item. (These figures represent the actual prices paid in London for the components used in the original set; whilst prices may vary they give a good idea of how much the different articles should cost.)

COMPONENT PARTS REQUIRED.

		s.	d.
1	WOODEN CASE	2	9
1	EBONITE PANEL	1	0
2	CARDBOARD TUBES (for variometer)		9
1	SET OF CRYSTAL DETECTOR PARTS (with crystal)	2	3
1	2" BRASS SPINDLE (with 5 lock-nuts, control knob, bush, and spacing washer)	1	0
1	1" BRASS SPINDLE (with 6 lock-nuts and spring washer)		6
5	TERMINALS ("telephone" type)		7½
½	lb. WIRE (No. 24 d.c.c.) ..		10½
	Total ..	9	9

Referring to the components in the order given, the first item for consideration is the wooden case. That shown in the photographs is provided with a lid and clasp, and the outside dimensions are 7" × 5" × 6½". This is big enough to hold the home made variometer, but if a larger case is already on hand, or if another variometer is to be used, the other dimensions may be varied accordingly.

The size of the panel will, of course, depend upon the case, and in the original model its dimensions are 6½" × 4½" × 3/16". As the cost is very low, it is advisable to use good ebonite for this purpose.

The Crystal to Use

The cardboard tubes must be of different sizes, the smaller being 3" in external diameter and the larger 4". They are generally sold in lengths measuring one foot, but only 2" of each tube will be necessary to make the variometer.

The crystal detector may be of any type, but for those without previous experience it may be as well to mention that excellent results were obtained using hertzite and a silver cat's-whisker.

The spindle for the variometer is in two lengths (see Fig. 3). The first (which holds the control bush) is a piece of 2 B.A. threaded rod, about 2" long, fitted with five lock-nuts, a bush, and a spring washer. The lower half of the variometer is held in place by a shorter length of 2 B.A. threaded rod, which serves also for making the necessary connection to the rest of the set. It carries six lock-nuts and a spring washer.

On the panel face five terminals are necessary, because the set is fitted with an extra earth terminal. This enables the variometer to be "loaded" without disturbing any other connections, and will be explained fully later.

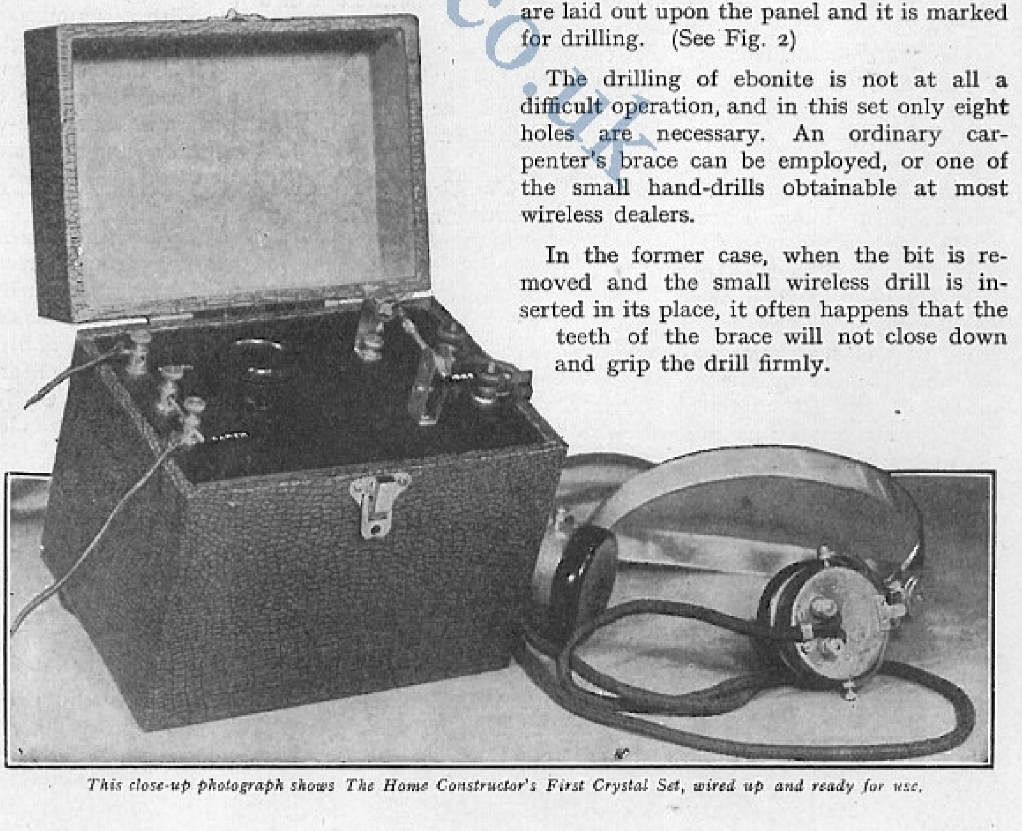
The wire shown in the list is recommended, but enamelled or silk-covered wire may be used, if desired. Rather smaller gauges of wire *may* be used if on hand, but they are not as good as the 24 d.c.c.

Drilling the Ebonite

The first step in construction is to square off the edges of panel with a file, in order to make it fit nicely into place. When the rough saw-cuts have been smoothed off in this way, the components are laid out upon the panel and it is marked for drilling. (See Fig. 2)

The drilling of ebonite is not at all a difficult operation, and in this set only eight holes are necessary. An ordinary carpenter's brace can be employed, or one of the small hand-drills obtainable at most wireless dealers.

In the former case, when the bit is removed and the small wireless drill is inserted in its place, it often happens that the teeth of the brace will not close down and grip the drill firmly.



This close-up photograph shows The Home Constructor's First Crystal Set, wired up and ready for use.

This difficulty is overcome by winding a few inches of the 24 gauge wire closely round and round the shank of the drill. This wire then forms a kind of spring, which can be slipped over the end of the drill shank to increase its size, thus allowing the brace to grip it firmly.

The Panel Lay-out

If the panel and variometer used are exactly as described the best position of the various holes will be that shown in the sketch of the panel lay-out. Where other components are employed, this lay-out can be modified slightly to suit, but remember that plenty of room must be allowed inside the case for the inner half of the variometer to rotate, and for the lower spindle.

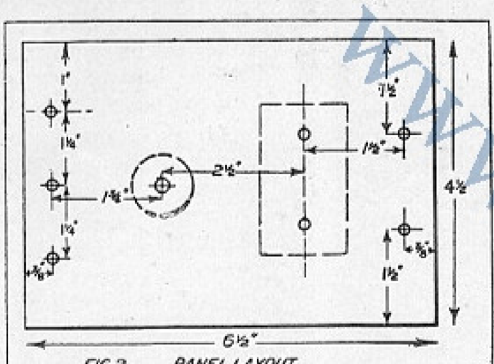


FIG. 2. PANEL LAYOUT

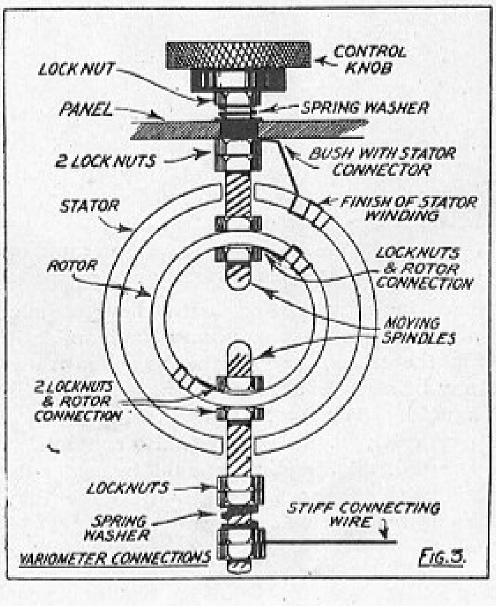
Whilst calculating the panel measurements, do not forget that parts that may work freely before being boxed-up are liable to foul the edges of the case unless this possibility is borne in mind from the first. The only component which will be likely to cause trouble in this set is the variometer, so if that instrument is to be made at home it is better to construct it before finally deciding the panel lay-out.

Making the Variometer

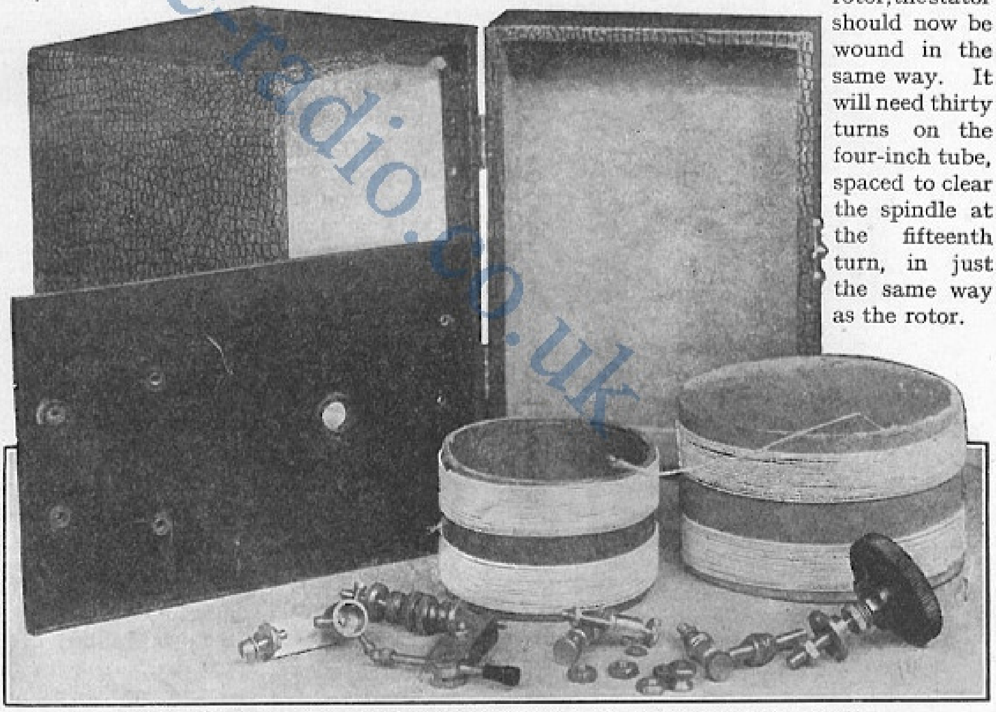
Making the variometer is probably the most difficult part of the whole business, but if the following instructions are carefully followed, a very workmanlike little instrument will result. It will be seen from the photographs that a short piece of the smaller cardboard tube is mounted on the brass spindle so as to rotate inside a similar piece of the larger tube. This rotating piece is called the "rotor," and the stationary (outer) half is known as the "stator."

Most tube formers sold for wireless are already coated with shellac varnish, but if the cardboard has not been treated in this way it should be given a thin coat of shellac varnish as a precaution against damp. When dry commence winding by fixing the wire firmly to the smaller tube, not more than a quarter of an inch from its edge.

The fixing is done by making three small holes through the former, parallel with the edge, and then pushing the wire down the first hole, up through the centre hole and finally down again through the third hole. About six or eight inches should be pulled through to allow for making connections, and then the wire can be drawn tight, and will hold securely.



VARIOMETER CONNECTIONS FIG. 3.



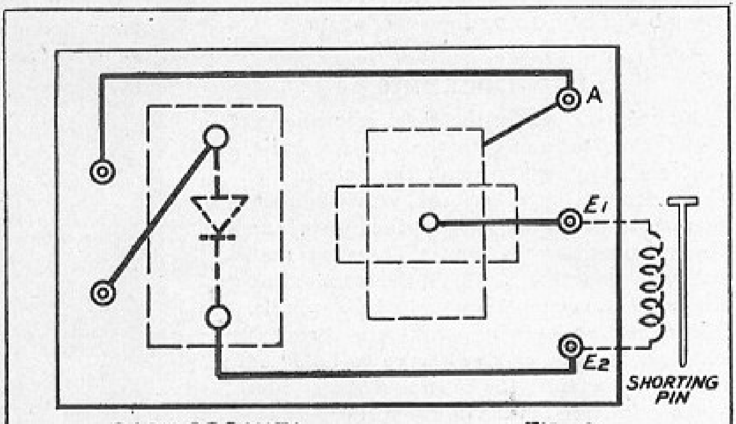
Nearing completion. This view shows the drilled panel and variometer ready for assembly.

Thirty turns of the wire must now be wound side by side round the smaller tube, but a space of about three-quarters of an inch must be left between the fifteenth and sixteenth turns so that the spindle can pass through between the two halves of the winding. A glance at the photograph on page 6 shows how fifteen turns are wound *closely together*, and then the wire crosses over to the sixteenth turn, leaving a gap between the two sections.

When the thirtieth turn is completed three more holes are made with a knitting-needle or a fine bradawl, and the wire is then cut. It is finished off securely by fixing, in the same way as was done to commence the winding.

Winding the Stator

Do not forget to leave over six inches or so for connecting up.



BACK OF PANEL FIG. 4.

The tube may now be cut off as close to the winding as possible. If an ordinary sharp saw is used, this cutting-off should be carefully done about a quarter of an inch from the thirtieth turn. If a hack-saw is employed the distance may be reduced to about one-eighth of an inch. Having wound the rotor, the stator should now be wound in the same way. It will need thirty turns on the four-inch tube, spaced to clear the spindle at the fifteenth turn, in just the same way as the rotor.

So far all has been plain sailing, but the fitting of the spindle is more difficult and needs care and some patience.

The first step is to make two holes in the tube, in the middle of the space between the stator winding. The first one should be made near the commencement of the winding, and the second one exactly opposite the first. The holes should be just large enough to allow the 2 B.A. rod to pass through, and they may be made with a drill, or burnt out with a hot wire

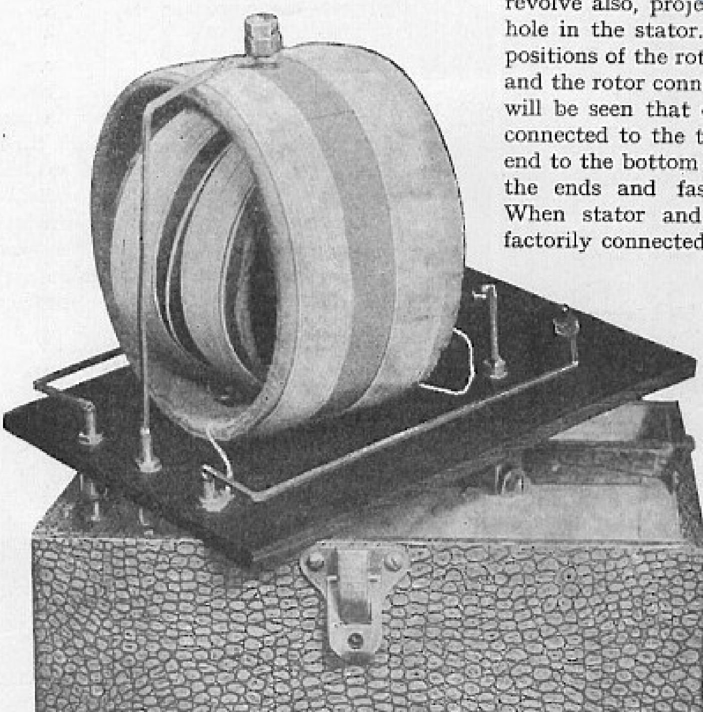
It is not wise to punch them through with a nail, because the cardboard is apt to tear.

When two neat holes, exactly central and opposite, have been made in the stator, the rotor must be carefully prepared in the same way. It is essential that the mounting of both, and especially of the rotor, is arranged with the spindle pointing straight through the centre. If this is not done, the rotor will "wobble," and there will not be sufficient clearance for it to turn inside the stator, and the job will have to be done over again.

The Locknuts

Now fit the parts together, referring to Fig. 3. Commencing with the upper spindle, first push it down through the hole in the stator, thread on a locknut, push it down further through the hole in the rotor, and thread on its lower locknut. These two nuts will screw together, and hold the rotor at any desired distance from the end of the spindle. The next two locknuts which are threaded on from the free end will serve to hold the spindle up against the bush and panel, and will regulate the tension on the spring washer. The final locknut serves to screw up against the control knob, to hold it firmly on the spindle.

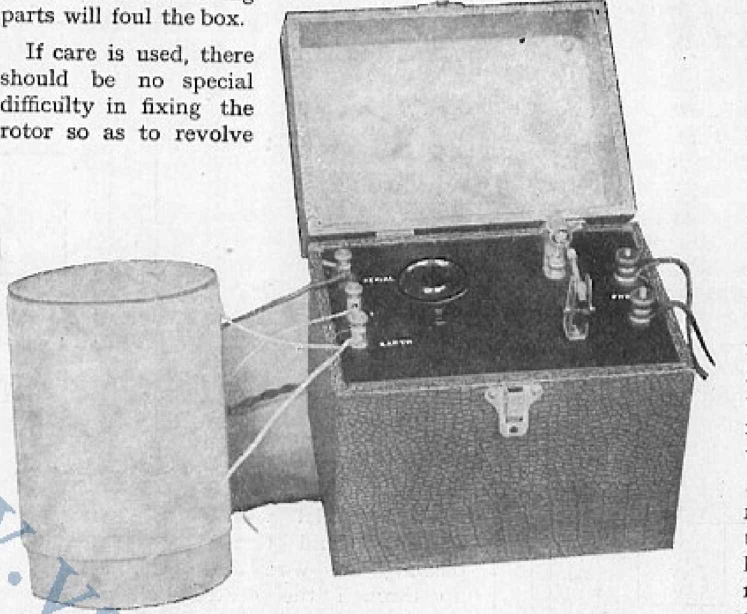
The bottom (shorter) spindle may then be pushed up through the hole in the stator, and its nuts threaded on in the same way. If the holes have been made centrally, the rotor can now be adjusted so as to turn quite freely inside the stator.



This view shows the rotor's middle winding, and also the stiff connection to the variometer spindle.

It will probably be necessary to assemble the parts several times before the position of the various nuts, etc., is understood. Finally, before proceeding to connect up, the variometer should be provisionally mounted on the panel and encased, in order to make sure that none of the moving parts will foul the box.

If care is used, there should be no special difficulty in fixing the rotor so as to revolve centrally, and when the short bottom spindle is locked to the rotor this, of course, will revolve also, projecting through the bottom hole in the stator. At this stage the exact positions of the rotor and stator are decided, and the rotor connections are finished off. It will be seen that one end of its winding is connected to the top spindle, and the other end to the bottom spindle (Fig. 3) by baring the ends and fastening to the locknuts. When stator and rotor have been satisfactorily connected together the variometer is ready for mounting.



Showing the Loading Coil for 5 X X—the B.B.C.'s high-power 1,600 metre station connected up to the set.

The set may now be prepared for assembly. Having marked and drilled the panel, its surfaces should be "matted." This is done by rubbing it with fine emery cloth (oo) till all the glossy surface has been removed. A smear of machine oil should then be rubbed over the surface with a clean rag, when a fine, dull black "skin" will result.

The Components

The next operation is mounting the components on the panel. "Telephone" terminals have been used for the aerial and earth connections, because of the convenience of this type of terminal, which has a hole in its centre in which the connected wire, etc., is held. (It will be seen that the two 'phone terminals are of a different kind, but this is only because the "telephone" type were unobtainable when required.) Be sure to mount the three left hand terminals "in line," so that a long wire or knitting needle could be pushed through all the three holes, in which the external connections will be inserted. (The reason for this will be apparent later.)

When all the terminals have been locked into place underneath, the detector and variometer must be secured to the panel.

If an ordinary connection is made between the variometer's lower spindle and the rest of the set, the constant movement of the rotor when the tuning knob is turned will certainly break the wire. Sometimes a "stop" can be arranged so that the rotor will only revolve for one complete turn, and in that case springy connections will last indefinitely. But the best method is some form of slipping contact. This allows the moving rotor connections to be taken to one end of the short lower spindle, and the stationary connection from its other end by means of a stiff connecting wire, held between a spring washer and locknuts (Fig. 3 shows the arrangement, but not to scale.)

Wiring up the Set

On the spindle (shown projecting through the hole in the stator) two locknuts are threaded on and screwed up against one another so that they remain fixed firmly in place. The spring washer follows, then the stiff wire, and finally two locknuts that regulate the tension on the washer. The stiff connecting wire may be merely bent round the spindle, or, better still, a spade washer may be soldered to it and slipped between the spring and the locknuts. Note that the stiff wire is held *between* the spring washer and locknuts (not between the two locknuts as might be supposed from Fig. 3.) The photograph on this page makes this perfectly clear.

Wiring may be done with the 24 d.c.c. wire, or with the bare wire sold specially for the purpose. In the photographs it may be seen that tinned square-section wire is used. This is No. 18 gauge, which is very easily bent. As good contact is essential, all the joints should be soldered; but if this cannot possibly be done they should be fastened very firmly.

(*Concluded on page 26.*)

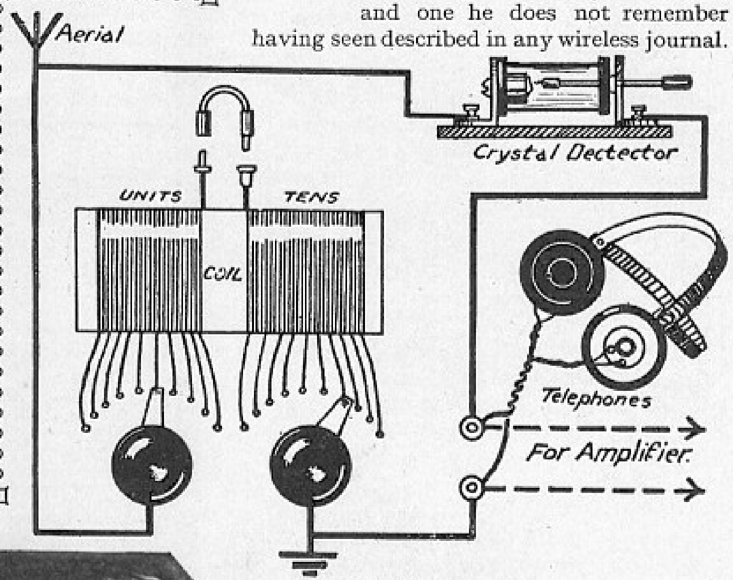
How to Construct

A Reliable Crystal Receiver

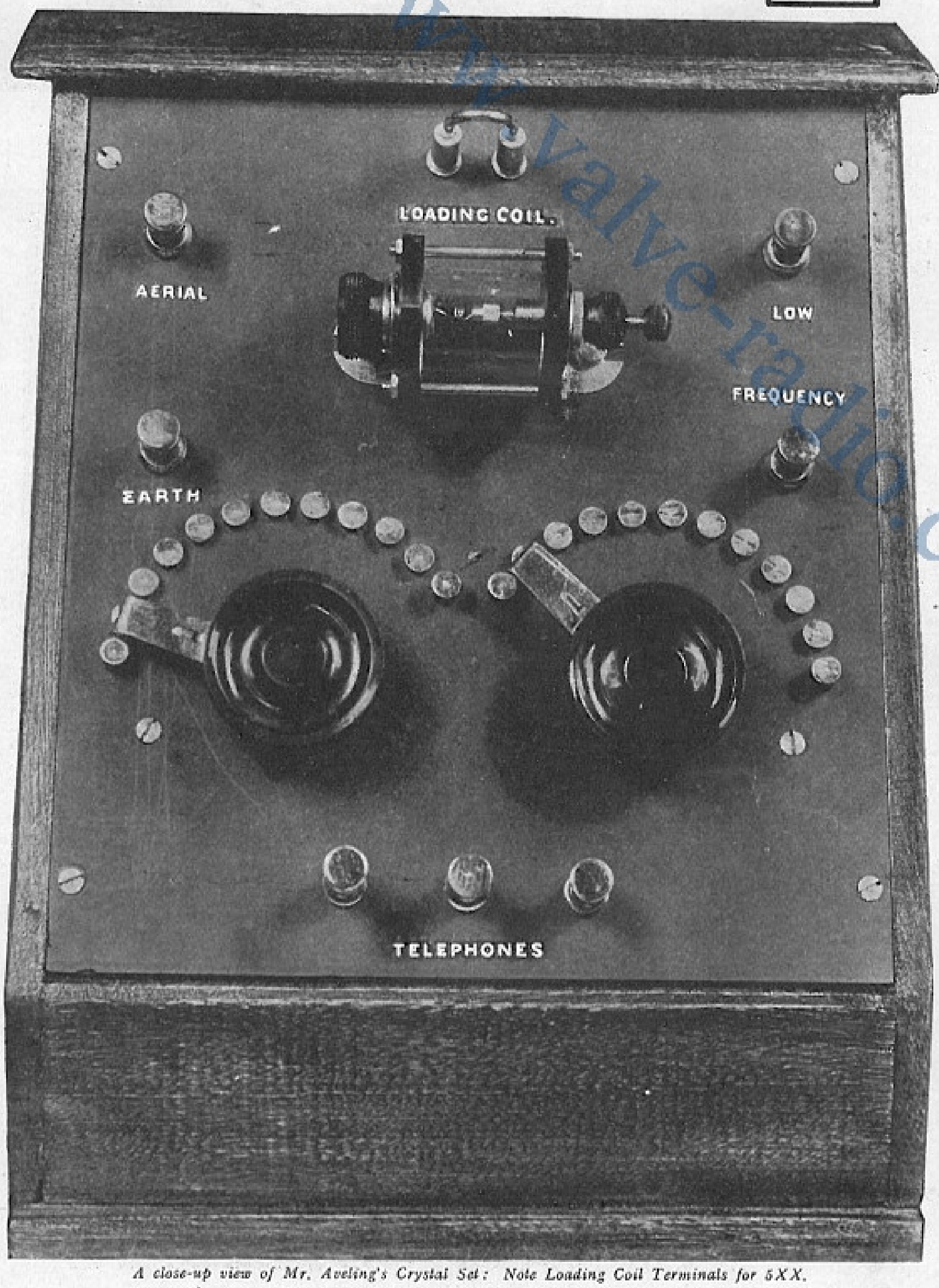
By W. P. AVELING

THIS neat and inexpensive crystal set has given excellent results on test, and if carefully constructed will give every satisfaction to the amateur. 5 X X can easily be heard at a distance of 100 miles when using this receiver with a good aerial.

THE set to be described has been designed with reliability as its watchword. The writer has employed what he considers an easy method of securing the tappings of the coil, and one he does not remember having seen described in any wireless journal.



A Pictorial Drawing of the Crystal Set.



A close-up view of Mr. Aveling's Crystal Set: Note Loading Coil Terminals for 5XX.

LIST OF MATERIALS REQUIRED

1 Cabinet
1 Ebonite Panel, best quality matted 7" × 8" × 3/16"
1 4" Cardboard Former
6 ozs. 22 S.W.G. D.C.C. Wire
2 doz. Studs, ¼" diam. with nuts and washers
2 doz. Nuts and Washers for above (extra)
4 Stops, nuts and washers
2 Switch Arms 1½" radius
7 Telephone Terminals, nuts and washers
6 Nuts and washers (extra) for above
Loading Coil Plug and Socket
Screws ½" or ⅝" × No. 4 or 5 for securing panel and woodblocks for coil
Transfer, "Aerial," etc., etc.
About 24' 18 S.W.G. Square Tinned Copper Wire
"Mic-Met" Detector
1 Piece "Hertzite" Crystal
1 Piece Copper Foil
Shellac
Hardwood ⅜" or ½" thick for blocks

Approximate total cost about £1 if constructor makes his own cabinet

The panel has been purposely made of ample size for easier disposition of the various parts; on the top right-hand side have been added two terminals to which an L.F. amplifier unit can be attached, if more volume is desired, and telephone (holed) terminals have been employed throughout, so that brass connecting bars may be employed to add the above, or a H.F. unit if and when the constructor enters the "valve" class.

Terminals Required

Three terminals have been provided for "'phones"; the two outside ones being used where only one set of headphones is employed, and the middle one where it is desired to use two pairs of headphones, in which case one lead of each of the two pairs of 'phones is screwed down into the middle 'phone terminal (which terminal has no connection underneath the panel, serving simply to connect the two leads of 'phones) and the remaining two leads of 'phones are secured, one to each of the two outer 'phone terminals.

A list of parts required is given, and the intending constructor will do well to obtain the *whole* of them before starting work.

Obtaining True Centres

First of all he had better paste a full-size drilling plan on the top of panel. Place panel on flat folded cloth, carefully marking the points with a fine pointed instrument, pressing same to make a slight hole in the ebonite.

This done, wet and remove drilling pattern and carefully enlarge all the markings with a fine awl; this may be followed up by taking a small twist or diamond drill bit between the finger and thumb and going over all the

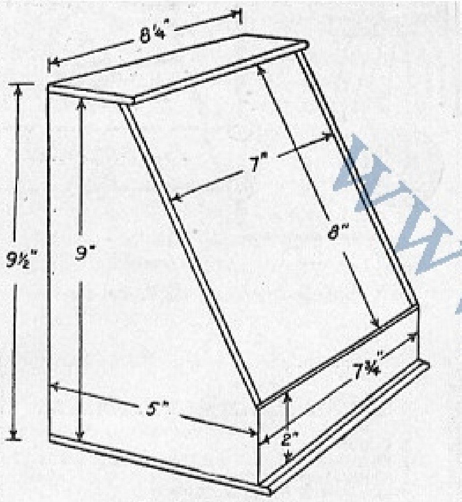


Fig. 1. The Cabinet.

markings again, this time removing the burrs and leaving all ready for insertion of final drill (either Yankee or breast or hand drill).

All this will obviate the danger of the drill "creeping" or slipping, and true centres will result.

Wiring Up

After the holes have been drilled we may very slightly ream top to allow for any little inequalities in shoulder of studs, etc.

Two tongues of copper foil to connect switch arms to stops, two holes being required in each 1½" apart, should then be

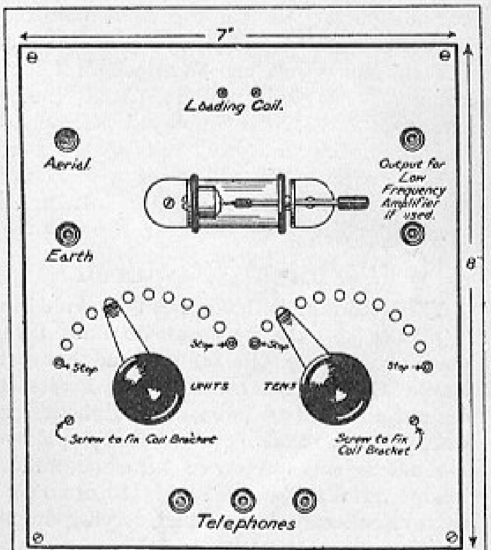
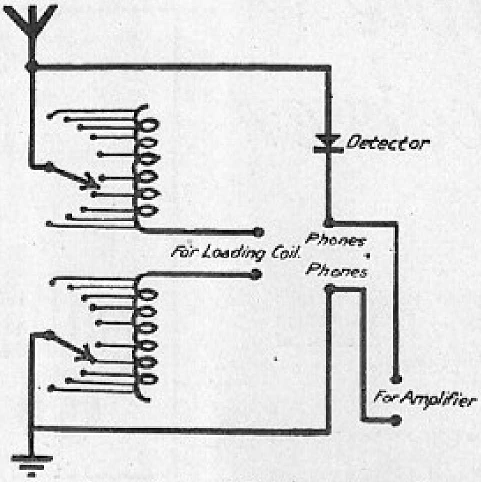


Fig. 2 Layout of Panel

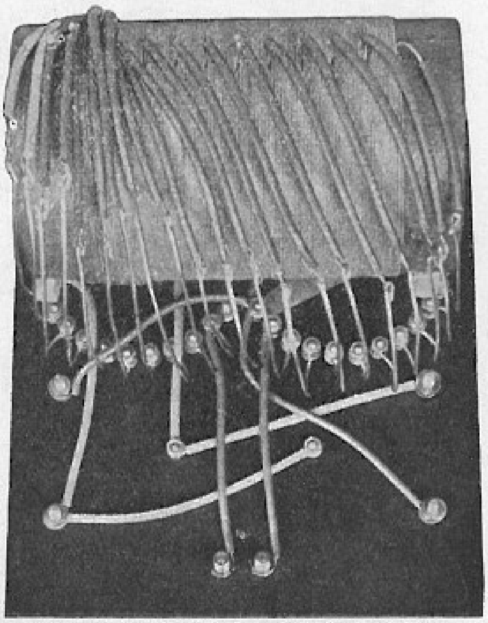
made and fitted over switch arms, spindles, and stops, as shown in photo. The studs, after having the centre "blobs" or pin-points removed with a small file and top edges slightly rubbed off with a piece of fine emery cloth, may then be screwed firmly into position.



Extra diagram showing stud tappings and connections.

This also applies to the stops, terminals, loading coil fitment, and detector, and at this point we might as well do the necessary wiring, using 18 s.w.g. bare (tinned) copper wire, with sistoflex sleeves between the joints, taking care to keep the sleeves from getting between nuts and wire when screwing up. All studs, terminals, etc., now being mounted.

The wiring diagram and photos should give a clear idea, but a point-to-point description may help matters. First of all, the panel having been laid before us, upside down, on a cushion (to prevent damage to


A close-up of the Inductance Coil showing tapping connections to the studs.

Another view of the completed Receiver. Note the neatness and compactness of the whole design.

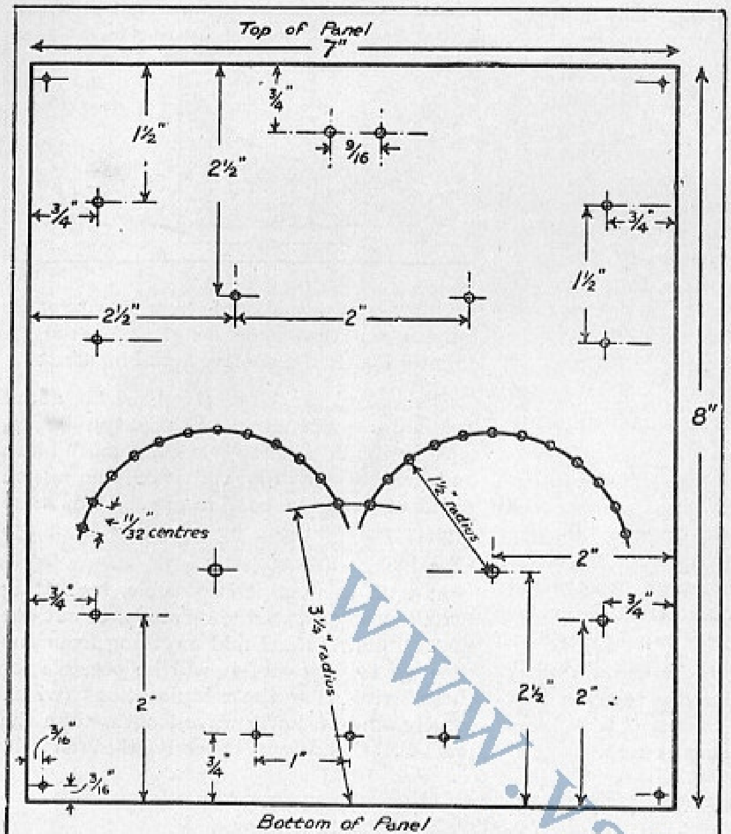


Fig. 3. Drilling Plan

detector), we take a piece of the bare 18 s.w.g. wire, and with round-nosed pliers make a small ring to fit loosely over the "aerial" terminal (top left, as we then view the panel).

Step-by-Step

Next we take the wire to the stop of the "ones" studs, to which is connected, by means of the copper tongue, the switch arm, and cut the wire off about ⅛" past this point; then we cut a piece of sistoflex to span the distance between these two points, slip it over the wire, form a ring to go over the stop, and slip it into position. We place a washer over each little ring and then a nut and tighten. The same procedure is followed with the other connections.

Another connection from "aerial" to cat's-whisker side of detector — one from "earth" to "tens" stop, and hence to 'phone; another connection from "tens" stop to L.F. top terminal. From crystal side of detector to L.F. bottom terminal; one connection from first stud of "tens" studs to loading coil; and another connection from "ones" first stud to the other point of loading coil.

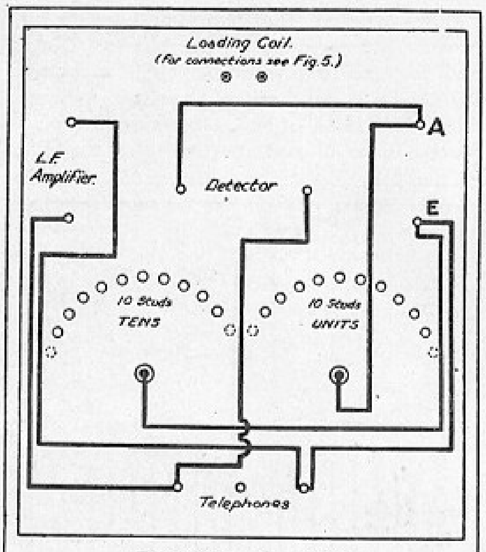


Fig. 4. Under Panel Wiring.

This completes the wiring of the panel.

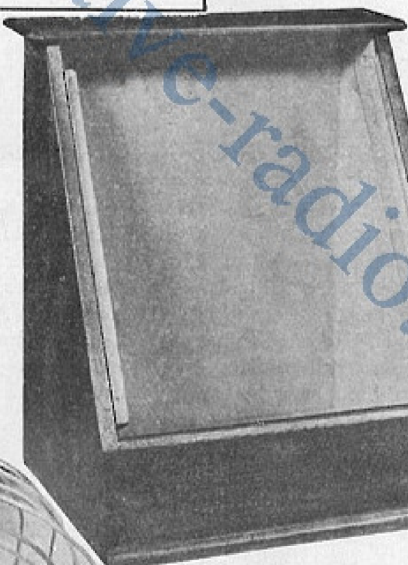
We next take our 4" cardboard former and cut off a 6" length, shellac inside and out, and when quite dry we proceed to wind our 22 s.w.g. d.c.c. wire on. First make two holes in the former in which to anchor the wire, leaving about 6" for connection later on. We then wind on ten turns, tightly, side by side, and not overlapping.

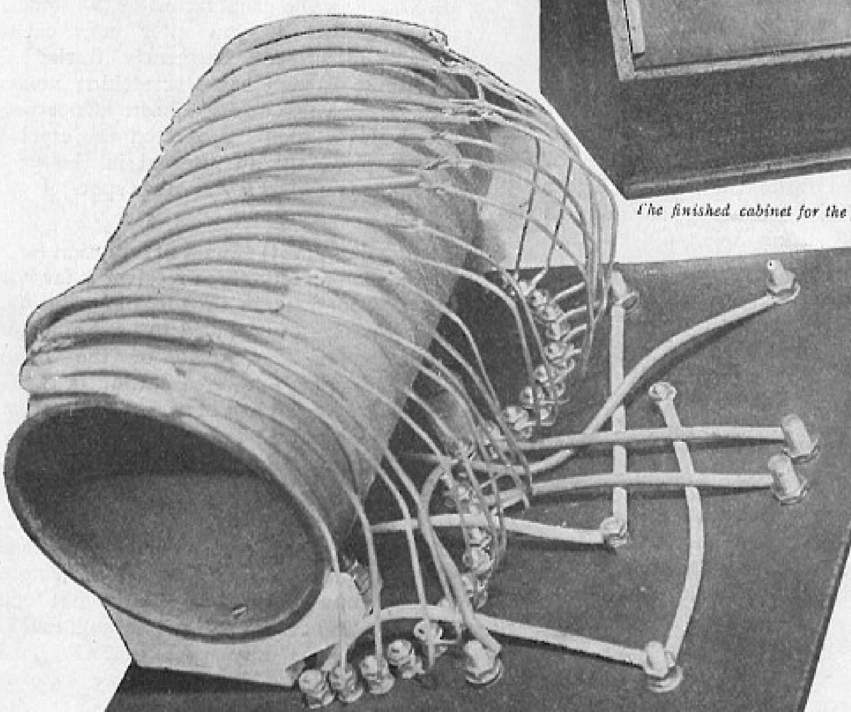
Winding the Coil

At the end of the ten turns we form a loop about 6" in. long, giving the wire one or two twists to keep it in position, and so on each ten turns, until 90 turns have been wound on, when we make another two small holes in the former and anchor the end of the 90th turn, again leaving 6".

Another two holes are made in the former, 6" left as before, and we proceed to wind our simple turns, that is, wind once around, then twist loop 6" long, and so on at each turn until we have wound on nine single turns. These tappings on single turns should be slightly alternated or "staggered" so as to avoid crowding.

We should now have a coil of 99 turns (i.e. 9 tens and 9 ones) and 20 connecting lengths, each about 6" long, for connection to the 20 studs via the bare wire comb arrangement to be described. We may now lightly shellac the coil and allow to dry. Bare the 16 loops and four single wires to within an inch of the former. Twist each loop to the end, and put coil on one side.


The finished cabinet for the Receiver Panel.


An underneath view of the ebonite panel, the wiring completed and showing connections to the studs.

Connecting up the Studs

Now take your square 18 s.w.g. wire, cut off 20 pieces each about 6" long, and with round-nosed pliers form a circle at one end of each (circle about $\frac{3}{16}$" diameter to fit over studs). Commence on one semi-circle of ten *studs* and screw ten of these lengths, each with washer and nut to firmly secure it, each wire being secured in a radiating position. This done, we bend the ten wires close up to studs, roughly at right angles. We do the same with the other semi-circle of ten studs.

The hardwood blocks may then be made and screwed to underside of panel, as shown. Place the coil on these blocks, with the tappings farthest from panel, and secure by screwing (or tacking) to the blocks. Next bend your 20 bare square upright wires towards the coil, cut them off to proper distance and make a hook at end, through which pass the end wire of coil, beginning at outside

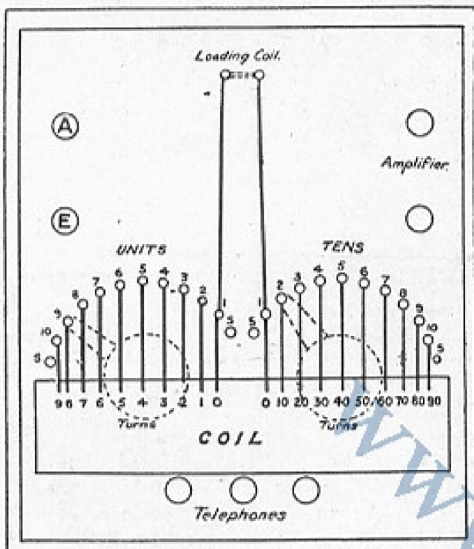


Fig. 5. Details of Tapping Connections.

(either right or left-hand side) and working right across the coil.

This will bring the end of the "tens" to the middle of the coil and the beginning of "ones" (also to middle of coil) to the two centre studs of the two semi-circles (and connected on panel to loading coil). As each hook is made in the top of square wire and corresponding 6″ length of coil tapping passed through it and bent back, the loop is tightly squeezed up in pliers, thus securing the two. If a touch of solder be put on each hook it would be an advantage.

It will be seen in photos that before being passed through its respective hook, each lead or tapping from the coil is sleeved in requisite length of sistoflex.

With the above description and the drawings and photographic reproductions, the construction should present no difficulty to the veriest tyro, and this little set is far in advance of many amateur constructed sets, where the coil is more or less hung (or slung) by a veritable tangle of tappings or flex, often resulting in "shorts" across the studs.

It will be found that London tunes in on a 100′ aerial, on stud 5 of the "tens" = 40 turns, the first switch being at zero.

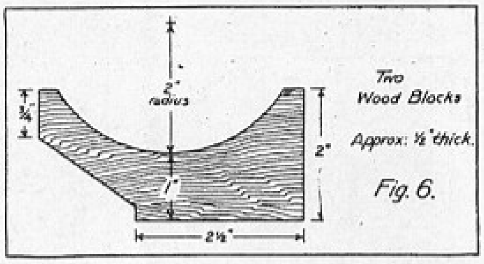


Fig. 6.

Other stations should tune in about as follows on the same length of aerial, or slightly higher if a shorter aerial be used:

Chelmsford can be received, within about 100 miles (depending on locality), by removing the link in the "loading coil" block and inserting a 150 turn coil, tuning on studs to bring in best results. Paris time signals may be got by plugging in a 250 turn coil.

As with this coil it is possible, by setting switch arms on two middle studs, to cut out the coil entirely and add anything from one turn up to 99 turns, it will be possible for those living near the relay stations (which mostly send on lower wave-lengths than the main B.B.C. stations) to receive these as well.

Practical Hints for Amateurs

With regard to aerials you should remember that it is not "length" that counts so much as height. A short high aerial is better for broadcast reception than a long low one. Sixty feet in length should not as a rule be exceeded if efficiency is desired.

* * *

If more than 20′ to 25′ cannot be obtained use a twin-aerial unless the aerial can exceed 30 in height, when the single type should be O.K.

* * *

Of the several types of wire available for the construction of aerials 7/22 enamelled is usually the best at a reasonable figure, while the multi-stranded "Mars" aerial wire can be used if lightness and strength are to be combined with efficiency. Steel wire is not to be recommended.

* * *

To ensure good insulation at least two insulators (china type preferably) should be used at each end of the aerial. The insulation on the wire itself, however thick, should not be relied upon as it may cause loss of signal strength due to capacity leakage if allowed to come into contact with trees, walls, etc.

* * *

Wire supporting halyards for the aerial are quite O.K., and are better than rope if care is taken to insulate the aerial as above.

Remember that the earth lead cannot be too thick or too short. *But* remember also that it is the length of wire or pipe or wire plus pipe that the current has to traverse before reaching the earth that counts. A short wire to a gas pipe or hot water pipe which does not go direct to earth is probably not so good as a longer wire direct to the water main or buried earth plate.

* * *

When the set is not in use the aerial and earth leads should be joined together by means of a switch *outside* the house if possible, this will then make the aerial a lightning protector rather than an *attractor* as is imagined by many people.

* * *

When tuning-in your first set, or a new receiver, go very gently through the operations, for if you twiddle the knobs hurriedly you are likely to miss the signals you search for altogether. Tuning should be done deliberately and slowly, rapid knob-twiddling is a sign of inexperience and inefficiency.

* * *

If a direct earth is used a sheet of galvanised iron makes a good earth, and it should be buried 3 feet down in a slightly slanting position in moist ground. The earth pins sold by various firms also make good earth connections.

* * *

When purchasing an accumulator make sure of its "capacity." Many batteries are marked with ignition or intermittent capacity, which is twice the actual or valve lighting capacity. It is, of course, the latter which counts in wireless reception.

* * *

Though crystal sets do not "radiate" or "oscillate" in the usual senses of the words, remember that if you alter your cat's-whisker adjustment frequently during a programme it may cause scratching noises in a near-by valve or crystal set. Once you have found a good "spot" on the crystal leave it alone till an interval in the programme if you *must* try another spot.

* * *

Remember that the range of reception for a relay station on any given receiver is far less than that for a main broadcasting station. A relay station can be said to have roughly a quarter of the range of the main station. The high-powered station (5 X X, now at Chelmsford) has, of course, the longest range, its crystal range being approximately 100 miles if conditions at the receiving end are good.

* * *

Don't forget to get a wireless licence before building your set, or at least before erecting your aerial if you have not one already. The cost is 10/- per annum, and is obtainable from any post office. This entitles you to build and use any type of *receiving* set.

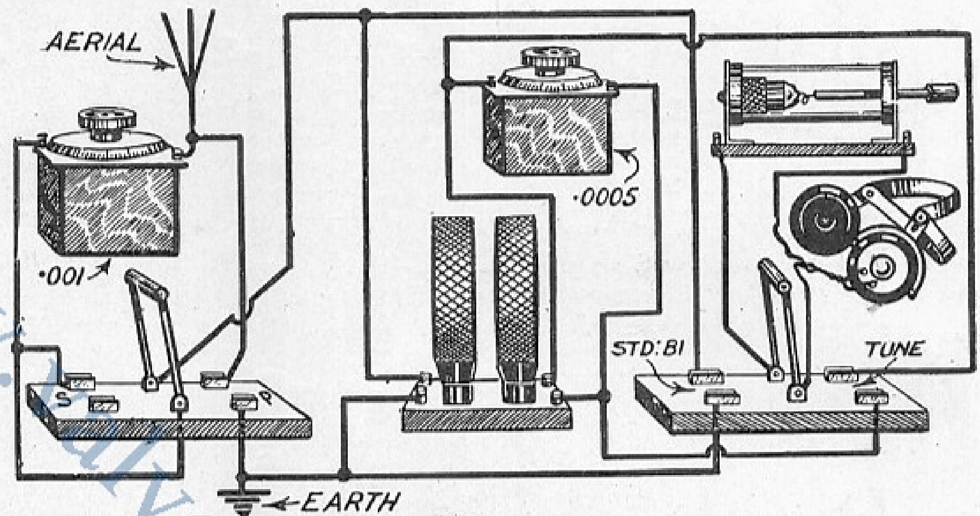
(Continued on page 26)

How to Make

A Two-Circuit Crystal Receiver

Built and Described By LAURENCE J. PRITCHARD.

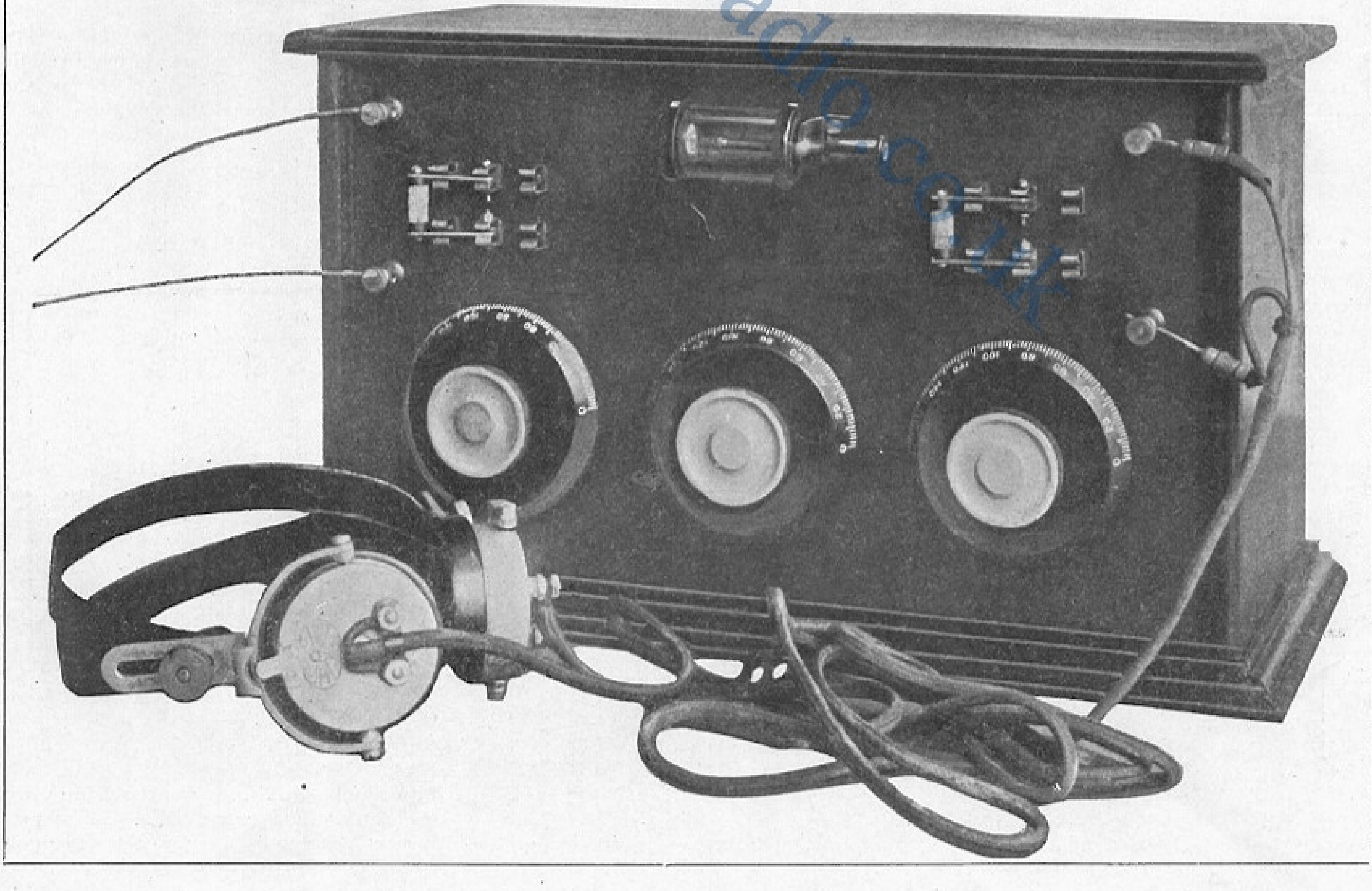
A TWO-CIRCUIT, or loose coupled, tuner is employed in this crystal set and plug-in coils may be used up to a wave-length of 2,600 metres. The constructor will find this receiver extremely selective, and when used in conjunction with a good aerial, capable of receiving 5 X X well over 100 miles away.



A Pictorial Diagram of the Two-Circuit Crystal Set.

THE crystal set illustrated in Fig. 1 is of simple design and may be made by people with little experience in the construction of wireless sets. Home-made plug-in coils are used for aerial tuning. By the method to be described, coils may be made for any wave-length on which it may be desired to receive up to 2,600 metres. The constructor has the knowledge also, that in the event of the home-constructed coils being too difficult or laborious to make, commercial coils such as the " Igranic " can be used in their place. There should be no difficulty in

FIG 1. THE TWO-CIRCUIT CRYSTAL SET CONNECTED UP READY FOR USE.



making the coils described, and by means of a little experimental work in gauging the correct number of turns, extremely good results are obtainable with them.

For receivers which are required to operate over a large band of wave-lengths the plug-in coil is usually the most efficient. Its advantage lies in the fact that all the inductance is used and dead-end effects found in the tapped and sliding forms of inductance are non-existent. A two-circuit, or loose-coupled, tuner is employed, being preferable to the single or open circuit owing to its greater selectivity and freedom from the interference of other transmitting stations working on a neighbouring wave-length. More will be said about the functions and the methods of tuning the two circuits after the construction has been described.

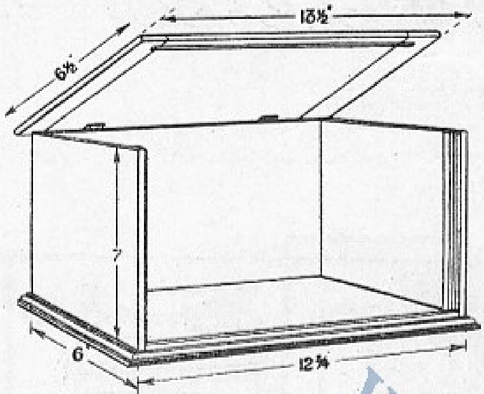


Fig 2. Dimensions for the Wooden Case.

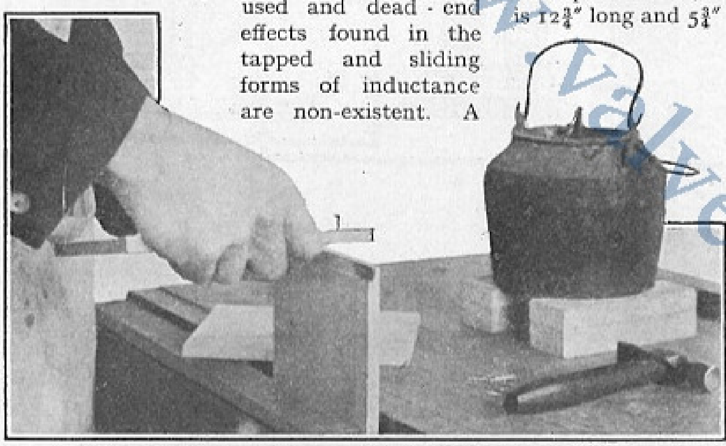


Fig. 3. Pinning and gluing one side of the Cabinet to the bottom.

The case is substantially designed and simple to construct. The main dimensions of the case are given in Fig. 2. It is like a box with hinged lid and moulded base, the latter giving a good appearance to the work. By means of the hinged lid, the coils are instantly accessible when it is desired to change them. As the coils, and indeed all the components, are fitted inside the case, they are rendered dustproof, and thus work under the best conditions.

The top, bottom, and sides of the case are first carefully cut from well-seasoned prepared wood of $\frac{3}{8}$" thickness. Oak, or mahogany, either light or dark polished, looks very well. Very much can be done with common deal if it is carefully selected and stained to bring out the qualities of the grain. The bottom is $12\frac{3}{4}$" long and $5\frac{3}{4}$" wide. If the wood to be used varies in thickness allowances must be made to obtain the correct inside measurements. The latter are the most important, as they represent the size of the ebonite panel and the distance from the panel to the back of the case. The sides are $5\frac{3}{4}$" wide and $7\frac{3}{16}$" high.

In fitting the sides to the bottom, a rebate is cut along the top surface of the latter at each end. This rebate is made by sawing a slot $\frac{3}{8}$" from the end to a depth of $\frac{1}{16}$". A sharp chisel is run along the side of the slot to clear away the wood to form the rebate. This operation is performed at each end of the plank forming the bottom. The width of the rebate allows the ends of the sides to fit flush with it. The sides are now glued and pinned as shown in Fig. 3.

At this stage the sides are quite weak at the joint, and the work should be carefully handled until the back is fixed. This fits on the inside edges of the sides and bottom, so that its outer side comes flush with their ends.

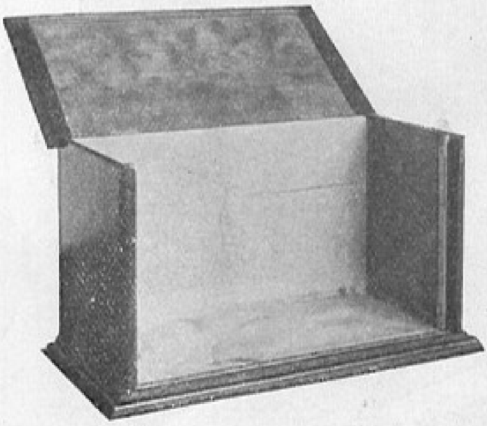


Fig. 4. The Completed Case.

An original feature of the design of the case is the method of fixing the ebonite panel. At a distance of $\frac{3}{16}$" from the inside front edge of each of the side-pieces, a fillet of wood $\frac{1}{4}$" square is tacked and glued to run the full length of the sides. A light rounded beading about $\frac{1}{2}$" wide is tacked on the front edges of the sides so that it projects a little on the inside edges. The fillets and beading thus form a rail or guide into which the panel may be dropped. No difficulty will be found in screwing the panel to the case and lifting the panel vertically. The arrangement of the rails is shown in the illustration of the completed case in Fig. 4.

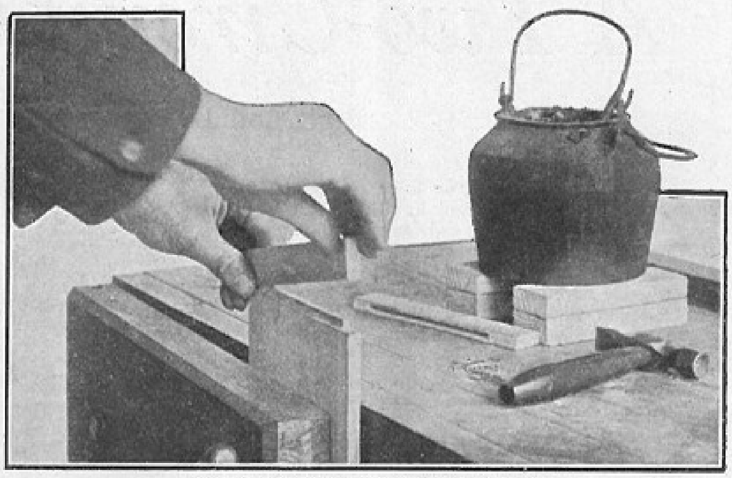


Fig. 5. Gluing the cramped ends of the lid.

Finishing the Case

At the bottom, a similar fillet can be run along the inside; while a small moulding is attached to the front edge at the bottom. This overlaps the panel a little and hides the joint of the ebonite in the same way as the beading does at the sides. In fixing the moulding to the front and side edges, the nails should be driven through the grooves of the moulding where the nail heads will be concealed.

The hinged lid will require some care in construction. As it is not fixed down throughout its width, it would readily warp unless precautions were taken. These precautions consist of cramping the end grain

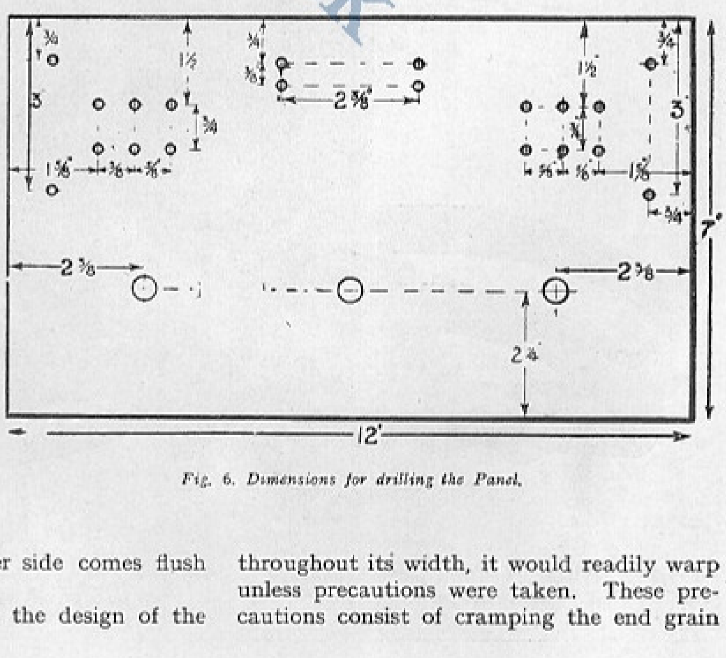


Fig. 6. Dimensions for drilling the Panel.

of the wooden lid with other pieces of wood, securely attached at each end, so that their grain runs at right angles to the grain of the lid itself. The major part of the lid is, therefore, cut rather shorter than the required finished length to allow for the extra pieces to be joined on at its ends.

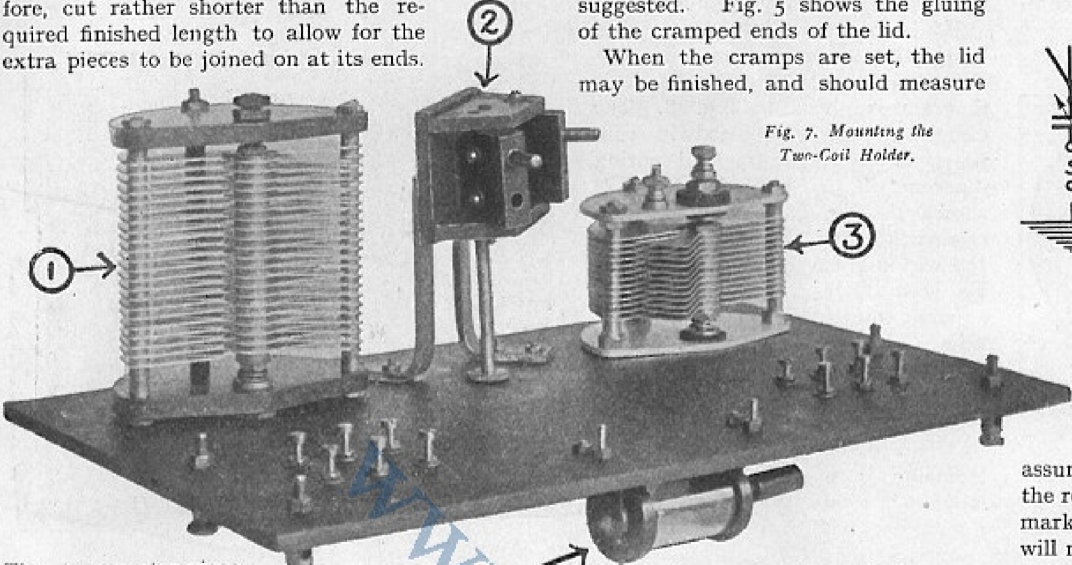


Fig. 7. Mounting the Two-Coil Holder.

The four components numbered are: (1) Aerial Condenser; (2) Coil Holder; (3) Secondary Condenser; (4) Detector.

The top centre-piece measures 11¾" long and 6½" wide. The end-pieces are made from strips of the same wood 6½" long, and 1" wide.

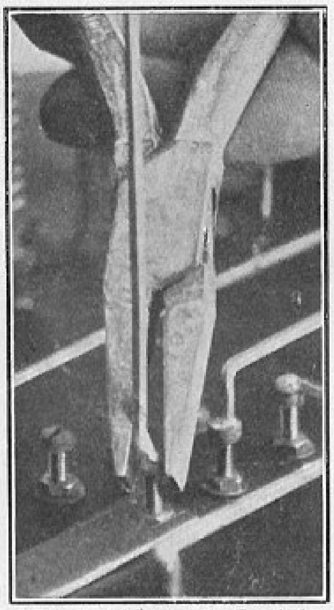


Fig. 11. Tightening the Terminal Nuts (note flat spanner bottom left).

A rebate ⅛" wide and ⅛" deep is cut on each side of the lid to form a tongue ⅛" square. Each tongue is cut off to terminate ½" from each end. A groove corresponding to the tongues is cut in one side of each end-piece. A ⅛" chisel is required for this purpose. It is pressed in vertically at the places where the groove ends, and light chips are then taken out until a depth of ⅛" is obtained. The trough position is carefully marked out, and cut away in the manner suggested. Fig. 5 shows the gluing of the cramped ends of the lid.

When the cramps are set, the lid may be finished, and should measure 13½" long and 6½" wide. The front and side edges are rounded over and the cramps sandpapered flush with the lid. A small beading is tacked to the front edge of the lid to conceal the top edge of the panel when the lid is closed. The remainder of the case can be sandpapered and finished ready for polishing or staining.

Marking the Panel

If it is intended to put this part of the work in the hands of a polisher, the panel may be cut out and the components mounted without delay. The dimensions for the panel are given in Fig. 6. It is cut from good quality matt-surfaced ebonite of 3/16" thickness. It is true that the matting of ebonite can be done at home, but as a general rule the results obtained are not worth the saving of the small difference in price between the glossy and matted surfaced varieties. As a general rule only the best quality ebonite is supplied with a good matt surface on both sides and in this way the purchaser is safeguarded against inferior material.

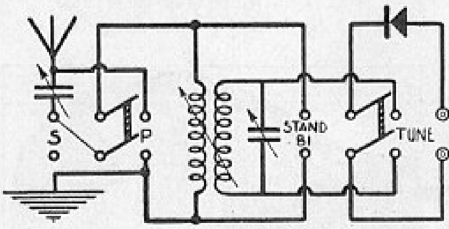


Fig. 8. Theoretical Diagram of the Circuit.

Ebonite is often wasted by marking and cutting the panel without taking certain precautions. The edge of a commercial sheet of ebonite is often far from straight. Should the assumption be made that it is straight, the result will be that when the two sides are marked from the edge with a square they will not be parallel. To make them parallel means filing down both sides, with the result that the panel is then too small. A rule should first be placed against the edge of the ebonite sheet to make certain that it is quite straight. Then, if the panel is cut roughly and oversize, it may finally be trimmed down without waste.

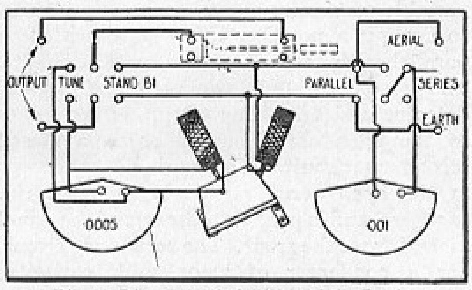


Fig. 9. Diagrammatical wiring of the Receiver.

Pencil should never be used for marking out wireless panels. The best plan is to scratch the surface of the ebonite with a

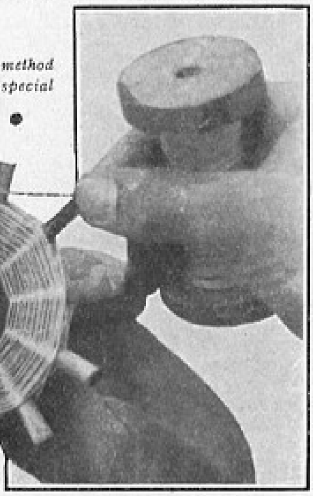


Fig. 12. Showing method of winding the special coils.

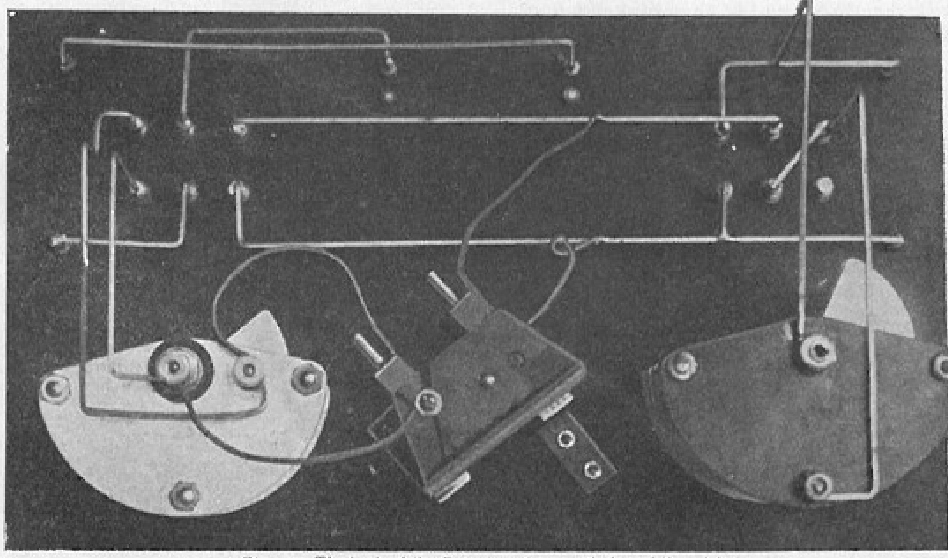


Fig. 10. The back of the Receiver after completion of the wiring.

sharp scriber, and to fill in the scratch with chalk. Panels should be marked out on the rear surface. The position of the holes is given in Fig. 6. At the present time there is no standard method of fixing wireless components, and the holes required for this purpose must be drilled to suit the particular

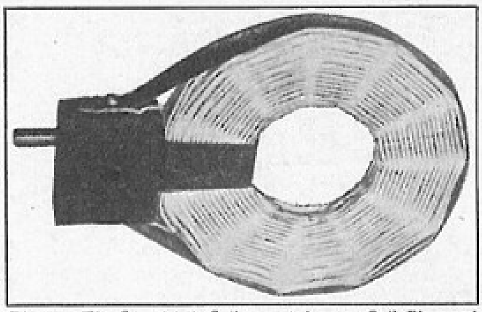


Fig. 13. The Completed Coil mounted on a Coil Plug and fixed by a fibre strap.

apparatus available. The single-hole type of fixing is simplest, in which the outside diameter of the spindle bushing is threaded, and passes through a hole drilled in the panel. A nut is then screwed on the spindle bushing from the outside of the panel.

The Two Switches

Two miniature double-pole double-throw switches are used for controlling the aerial circuits. The switch to the left enables the variable condenser in the open aerial circuit to occupy a position either in series or in parallel with the inductance in that circuit. The second switch connects the crystal detector and telephone circuit either direct to the open aerial circuit or to a closed secondary circuit. The variable condenser in the open aerial circuit is of ·001 mfd. capacity, and is placed to the left of the panel viewed from the front. The secondary circuit has a condenser of ·0005 mfd. capacity, which is operated by the dial and knob at the right of the set. Between these is a third control for varying the coupling between the two coils.

Almost any two-coil holder of good make will be suitable, providing the control spindle of the moving coil extends for a length of $4\frac{1}{4}''$. The coil holder is set some distance back from the panel, and requires a long spindle. If a suitable holder with a long spindle is not obtainable, the cranked spindle must be removed, and replaced with a straight one. The coil holder is supported by brass brackets cut from $\frac{1}{2}'' \times \frac{1}{16}''$ strip brass, and is sufficiently long to make the centre of the holder $3\frac{3}{4}''$ from the back of the panel.

Good Detector Advised

Fig. 7 shows the method of mounting the coil holder. Its position should allow an equal distance between the coils and their respective condensers when the movable coil is at right angles to the fixed coil. The feet of the bracket may be attached by countersunk screws and nuts passing through the panel from the outside. No. 2 B.A. screwed rod will be useful for the movable coil spindle, and is cut off on the outside of the panel to take a condenser dial and knob to match the other controls.

A good make of crystal detector is recommended, and that illustrated is of Burndept manufacture. It is removed from the base on which it is supplied. A feature of the detector is a micrometer adjusting device whereby an accurate setting may be obtained.

Having secured all the components in position, the wiring may be proceeded with. A theoretical circuit diagram is given in Fig. 8. The circuit should be studied in conjunction with the practical wiring diagram of the receiver, which is shown in Fig. 9. This illustration compares with the back view of the wiring given in Fig. 10. It will be seen that square tinned wire is used where a movable connection is not required. Flexible insulated wire is employed for moving connections. After wiring has been carefully checked, terminal and other contacts should be tightened up again with a small spanner made for the purpose, or with a suitable pair of pliers. The effect of soldering is to loosen the terminals slightly, owing to the local softening of the ebonite under heat. The method of tightening the terminals is illustrated in Fig. 11. The pliers hold the work steady while the spanner tightens the nuts.

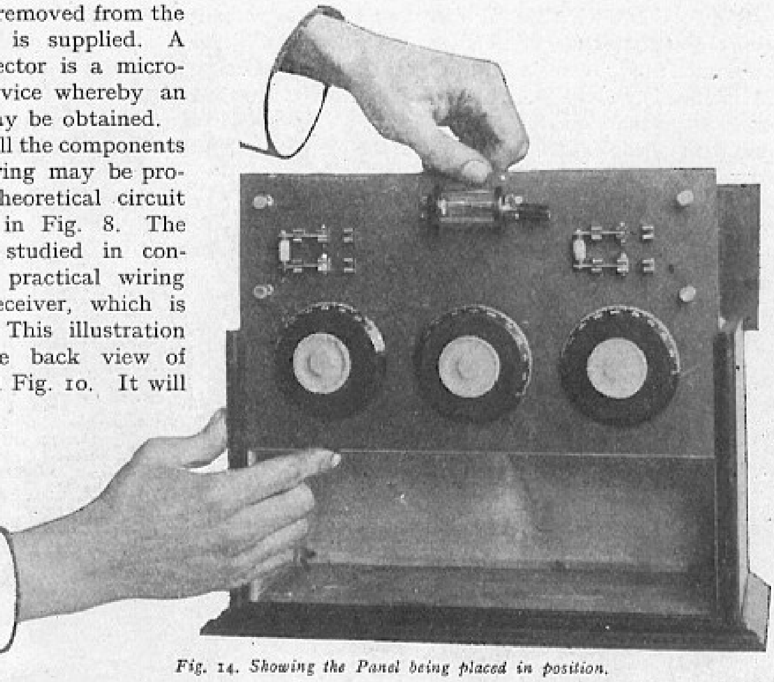


Fig. 14. Showing the Panel being placed in position.

As suggested, the aerial tuning coil may be purchased or home constructed. If the former plan is adopted a No. 35 Igranic duolateral coil will be suitable in the aerial primary circuit, and a No. 50 coil of the same make in the secondary circuit for B.B.C. stations.

For the home-made coils, a special former must be constructed. A disc of beech or other hard wood is turned to a diameter of $1\frac{1}{4}''$, and a thickness of $\frac{1}{2}''$. Round the circumference an odd number of holes are drilled, into which a number of wooden pegs of $\frac{5}{16}''$ diameter are wedged. The pegs should extend about $1\frac{1}{2}''$ from the boss. For ease of winding, a wooden handle is secured to the centre of the boss. In winding the coils proceed as shown in Fig. 12. The wire is passed between any two spokes, and returned to the starting side between the next pair of spokes. In this way the wire passes on the same side of two adjacent spokes, crosses over, and passes the two adjacent spokes on the opposite side. The completed coil is sewn together with stout thread before being removed from the former.

The coil mount with the coil fitted to it is illustrated in Fig. 13. A standard plug and socket fitting is employed, to which the coil is secured by a band of fibre which embraces it. The ends of the bands are held under the contact screws to which the ends of the coil are also connected. For broadcasting wave-lengths 32 turns of No. 22 or 24 s.w.g. d.c.c. is correct on the average aerial.

For reception of Chelmsford and the Paris time signal transmissions, which are sent out on 1,600 and 2,600 metres respectively, a finer wire will be required in order to keep the coils reasonably small. One hundred turns of No. 26 enamelled wire may be used for the Chelmsford transmissions, and the spoked former completely filled with wire for reception of the Paris time signals.

The usefulness of the secondary circuit diminishes as the wave-length range is increased, and on the higher wave-lengths the primary circuit only is needed, as a larger coil can be used than would otherwise be possible.

The panel must be thoroughly cleaned before being fitted into the case. This is easily done, as illustrated in Fig. 14, where the completed panel is seen being placed in position.

Handling the Receiver

To tune the set, the switch to the right is placed in the "stand-by" position, which is towards the left of the case; and the switch to the left is placed in either position. The primary circuit condenser only need be tuned under this arrangement of switches and should be slowly rotated until a signal is heard.

The adjustment of the detector may improve upon this signal, after which the condenser is further rotated to find the station required. It is now possible to use the secondary circuit by switching to the "tune" position. The variable coupling and the secondary condenser only need be adjusted.

The series-parallel switch in the primary circuit is useful for varying the wave-length range of the circuit. When the switch gives the condenser a series position in respect to the coil, a considerably shorter wave-length is obtainable than in the parallel arrangement.

The object of variably coupling the two circuits by means of the two coils is to obtain selectivity. As a general rule the less the coupling, which means the farther apart the coils the fainter will be the signal, yet the less likely will it be interrupted by another transmitting station.

It must be remembered that if the coupling is varied a readjustment of the condenser settings will also be required.

How to Construct

A One-Valve Amplifier

By LAURENCE J. PRITCHARD

THIS one-valve amplifier may be used in conjunction with any crystal set, but it was specially designed to work with the two-circuit crystal receiver described in this book. The use of this one-valve low-frequency amplifier with the crystal set is to increase the signal strength.

THE L.F. amplifier unit is a simple piece of wireless apparatus. The construction of the single stage L.F. amplifier, illustrated in Fig. 1, should present little difficulty, and should have every likelihood of successful operation immediately upon completion.

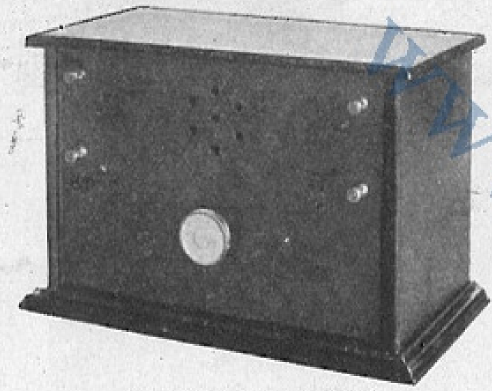


Fig. 1. The Complete Amplifier.

The amplifier may be connected in place of the telephones on any crystal set, but is specially designed to work in conjunction with the two-circuit crystal set described in this book. (Fig. 13.)

Low Running Costs

A feature of this amplifier is its low cost of upkeep. To secure this a dull emitter type of valve is employed, worked from dry batteries placed inside the case. The set is, therefore, entirely self-contained. Two terminals are arranged on the left side of the panel and connected to the "output" or telephone terminals on the right of the crystal set. Peep holes are provided near the top of the panel to allow inspection of the valve from the outside. The filament is regulated by a single variable resistance placed in the centre of the panel towards the bottom.

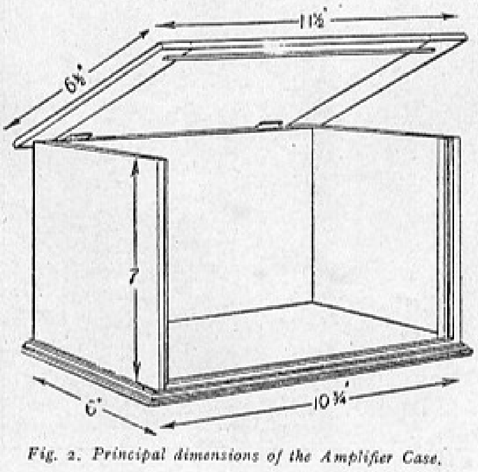


Fig. 2. Principal dimensions of the Amplifier Case.

Dimensions for the construction of the case are given in Fig. 2. Full details on how the case is made are given in the crystal set article. These instructions may be followed in detail as the cases are identical with the exception of the length. The amplifier panel is 3/16" in thickness and 10" long instead of 12", as in the case of the crystal set. It is important that the moulding be of the same depth and secured in relatively the same position, otherwise the terminals of the two units will not register properly.

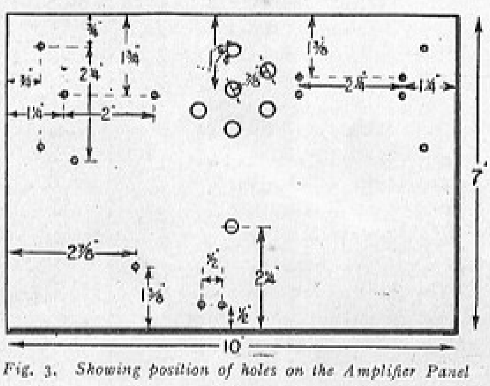


Fig. 3. Showing position of holes on the Amplifier Panel

The lay-out of the panel is given in Fig. 3. All holes are dimensioned. Screwing and tapping operations are reduced to a minimum. Wherever possible, No. 6 B.A. by ½" countersunk brass screws and locknuts are used for bolting the various parts in position. A good supply of these screws and nuts should be obtained.

This method of fixing gives a bad appearance to the finished work unless means are adopted to conceal the many screw heads which appear on the face of the panel. The trouble is overcome by carefully countersinking each hole so that the screw-head lies flush with the panel.

Each screw-head is blackened by a heating process, which almost entirely conceals the screws. This operation is illustrated in Fig. 4. The materials required include an old pair of pliers or other tool to grip the screws while they are being heated, and a small tin of enamel. Brunswick black may be used if available. The screw is heated until it is rather too hot to touch, and then rapidly covered with the enamel, taking care that it is not applied too thickly.

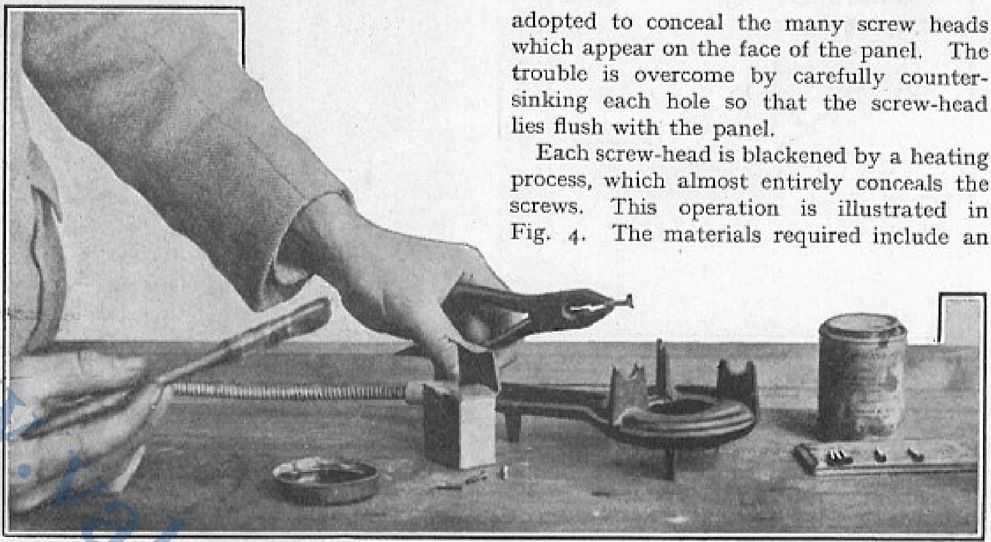


Fig. 4. Showing method of enamelling the Screw Heads.

The Valve Holder

When the head is evenly covered, the screw is warmed again, but over-heating, which would cause the enamel to blister, must be avoided. As the screws are finished they are placed in a row with their heads projecting over a piece of board until the enamel is quite dry. About a dozen screws should be treated like this.

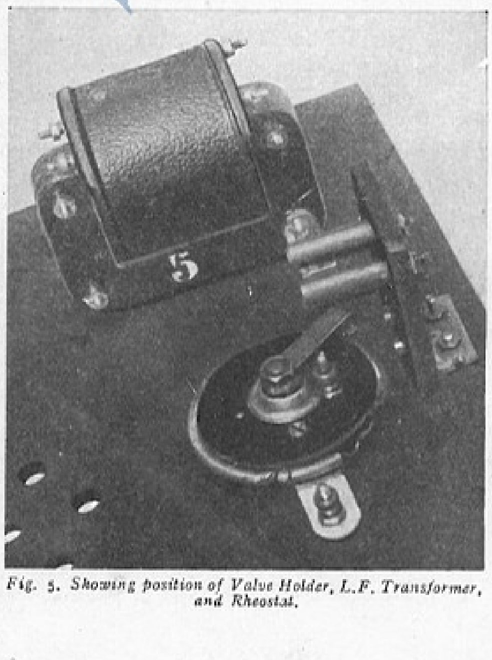


Fig. 5. Showing position of Valve Holder, L.F. Transformer, and Rheostat.

The valve holder itself is made from a piece of $\frac{3}{16}''$ ebonite, 2″ long and $1\frac{1}{2}''$ in width. Four holes are drilled in it, and valve sockets fitted in them. The shelf is bolted to the panel by means of a right angle brass bracket, 1″ long, having sides of $\frac{1}{2}''$ width. Four No. 6 B.A. screws are employed for fixing.

The Filament Resistance

A close-up view of the valve shelf bolted in position is illustrated in Fig. 5. Im-

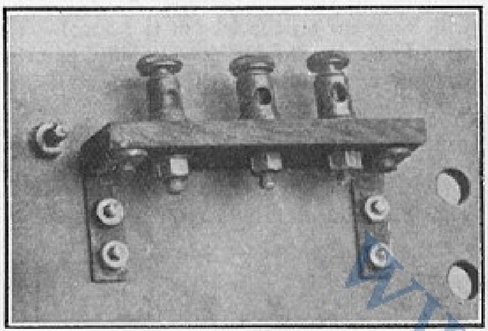


Fig. 6. The Terminal Board is fixed to the corner of the Panel by two brackets as here shown.

mediately above the valve shelf, the filament resistance is fixed. Different types of resistances require different methods of mounting. In the majority of cases two holes are provided on either side of the filament

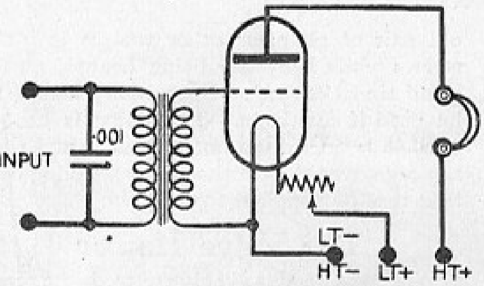


Fig. 7. Theoretical Circuit Diagram.

resistance spindle to enable the base of that component to be bolted to the panel. Care must be taken to see that the control-arm of the resistance clears the valve shelf and the valve socket nearest to the panel.

Mounting the Transformer

A terminal board is attached to the left-hand top side of the panel, as shown in Fig. 6. The wires to the various components are connected to the appropriate terminals on the board; connection to the terminals from the batteries being made with insulated flexible wires. The ebonite strip on which the terminals are mounted measures $2\frac{1}{2}''$

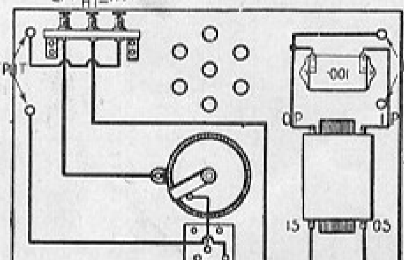


Fig. 8. Diagrammatic wiring for the Amplifier.

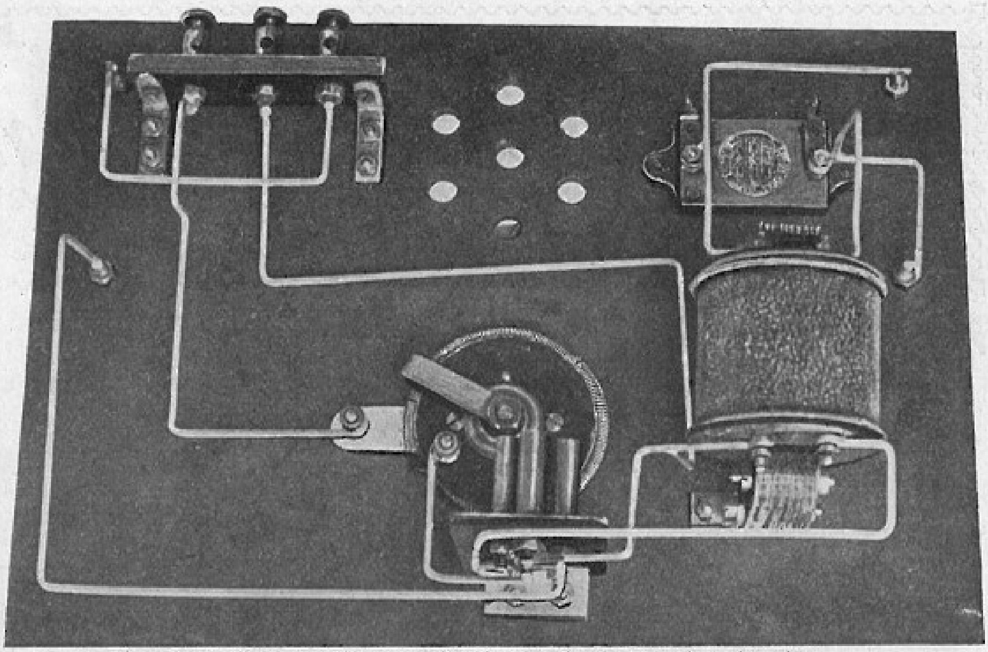


Fig. 9. All the connections are made with square tinned copper wire as here shown.

by $\frac{3}{4}''$. One terminal is bolted exactly in the centre of the board, while the others are $\frac{3}{4}''$ distant, measuring from centre to centre on either side of the middle one. Two brackets made from $\frac{1}{4}''$ strip brass are bolted to the ends of the terminal board, after which the latter may be bolted to the panel in the position indicated in the dimensioned panel lay-out.

Input and output terminals are now fixed, and following them, the L.F. transformer is bolted to the panel. The transformer is placed to the right of the filament resistance and valve shelf when viewed from the back of the panel.

Anti-Capacity Wiring

The theoretical circuit diagram is given in Fig. 7, while a practical diagram is given in Fig. 8, showing the actual wiring of the receiver. As far as possible, connecting wires are drawn as they actually appear in the photograph of the completed wiring. The valve holders are shown in plan view in order that the connections to the different sockets may be easily followed.

The panel viewed from the back with wiring completed is illustrated in Fig. 9. The anti-capacity method of wiring is employed, as in the case of the crystal set,

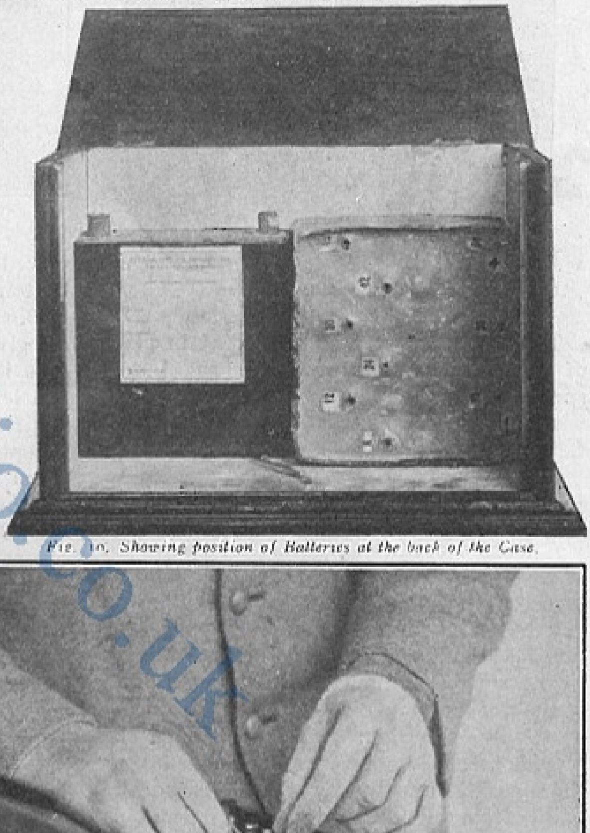


Fig. 10. Showing position of Batteries at the back of the Case.

Fig. 11. The connections to the Terminals are easily made when the lid is raised.

All About Crystal Receivers

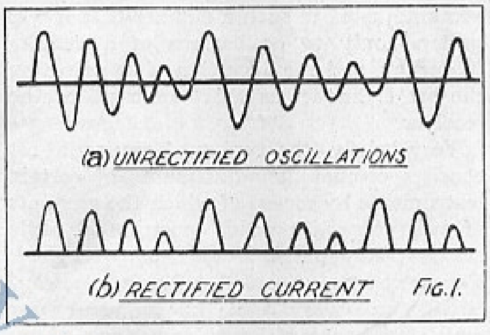
Practical Information for the Constructor

By J. F. CORRIGAN, M.Sc., A.I.C.

BROADCASTING may truly be said to be the cause of the enormous popularity which the crystal receiving set now enjoys. Previous to the introduction of broadcasting, the crystal receiving set had been relegated to the limbo of forgotten things, and commercial and amateur receiving stations alike depended solely upon the use of the valve.

Nowadays the crystal set has come into its very own. This type of receiving apparatus is now, after two years' broadcasting, a very familiar instrument, and the nimble, glittering fragment of crystal, which three or four years ago had been discarded almost completely, now functions nightly in at least half a million of our country's homes.

Why is the crystal set so popular? The answer to this question is not very difficult to discover. The average crystal receiver combines the valuable qualities of extreme



simplicity of construction and operation with low initial cost and practically no expense of upkeep. It is almost fool-proof, and such a receiver can be used by young and old alike.

Crystal sets are not easily damaged, and being fairly portable, they can be carried about from place to place without any harm being done to them. These are the chief reasons which account for the great popularity of the simple crystal set among the many hundreds of thousands of listeners-in who reside within short distances from a broadcasting station. With a well-made crystal set no distortion of vocal or instrumental music is obtained, and in respect of the tonal purity of its reception the simplest crystal set is easily able to hold its own even against the most elaborate of valve receiving instruments.

(Continued on page 18)

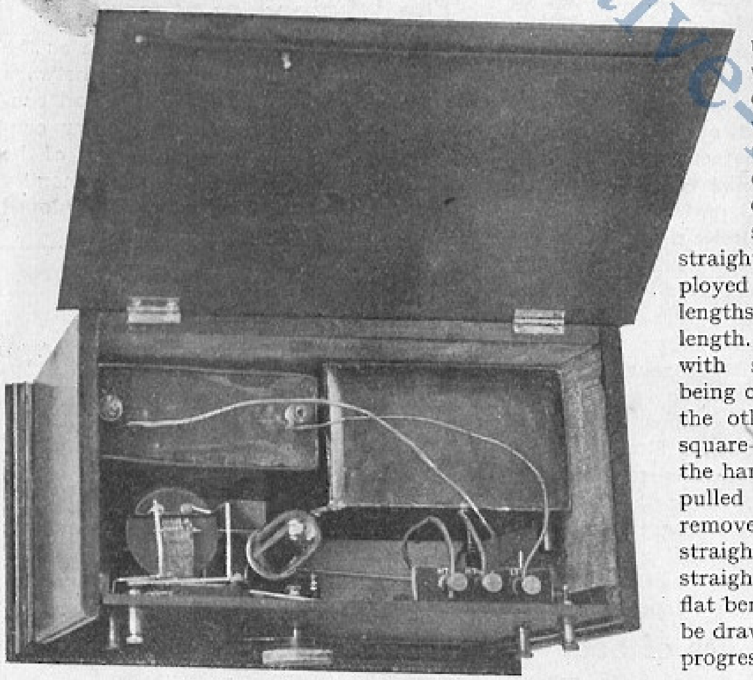


Fig. 12. Showing interior of the completed Amplifier.

using $\frac{1}{16}''$ square tinned wire. A useful tip in connection with the wiring is worth mentioning. The wire is often sold by the reel or hank, and is consequently difficult to straighten. The method employed is to cut off several lengths of wire about 2′ in length. Each piece is dealt with separately, one end being clamped in a vice and the other end in a pair of square-nosed pliers held in the hand. The wire is then pulled until all kinks are removed and it is perfectly straight. The lengths thus straightened are laid on the flat bench to form a stock to be drawn upon as the wiring progresses.

In soldering, acid flux should be avoided, and only a non-corrosive paste, such as "Fluxite" used. Although an acid flux may assist the operation of soldering and indeed appear to be quite satisfactory, traces of the acid remain at the joints, and in time eat away the metal. Corrosion may set up and cause a short circuit. This is particularly true of soldered joints on valve socket stems.

Connecting up the Batteries

The H. T. battery is a Siemens No. 828, which has a total voltage of 54, with tappings at every six volts. The battery is nearly square in shape, having sides of $5\frac{1}{2}''$ by $5''$, and an overall depth of $3''$. Any other make of battery may be used if suitable, providing it conforms to the sizes given. The L.T. battery is of the dry type, a 2-cell, 3-volt Hellesen "Force" battery being used. The batteries used fit the case without any retaining strips. Should they be at all slack, a wedge of thin wood can be pushed between them. The positions of the batteries are shown in Figs. 10 and 12, where it will be seen that the filament battery is placed to the left side of the case, and the H.T. battery wedges in to the right. Both are placed at the back of the case. Method of connecting shown in Fig. 11.

Few Precautions Necessary

The valve employed is a Marconi Osram D.E. 3 type. It should not be put in its holder until the latter has been fitted to the case. In the event of a mistake in wiring or a short circuit caused by two wires accidentally touching, the H.T. current may burn out the filament of the valve. Any possible trouble in this direction can very often be found out before the valve is ruined by taking a few precautions.

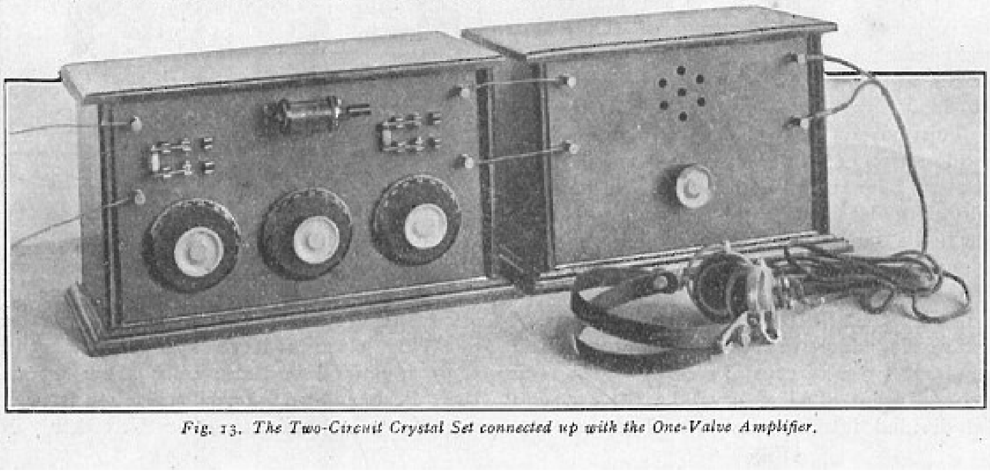


Fig. 13. The Two-Circuit Crystal Set connected up with the One-Valve Amplifier.

Of course, crystal sets have their disadvantages. Briefly, these limitations are due to the fact that the range of reception afforded by a crystal receiver is severely restricted, for, when used under ordinary conditions, the crystal cannot amplify or increase the strength of the incoming signals like a valve is able to do. Thus, crystal sets can only be effectively used within comparatively short distances from a broadcasting station.

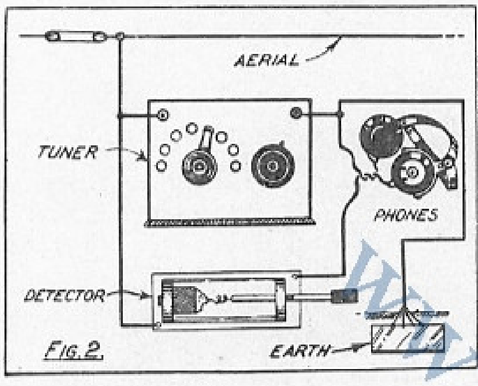


FIG. 2.

Generally speaking, the distance at which a crystal set can be really efficiently operated is about 14 to 16 miles from a main station of the B.B.C., and within a radius of some 4 to 6 miles of a relay station. However, under specially favourable conditions, the range of crystal reception has been very considerably extended, but, nevertheless, it would be advisable for the amateur who resides at greater distances than these from a broadcasting station to purchase or construct a valve-crystal set, preferably of the "reflex" type, rather than invest in a plain crystal receiver and be subsequently disappointed with the results obtained from the latter instrument.

How Receivers Collect Energy

Before we proceed any further it will probably be to the advantage of the very beginner in the art and science of radio

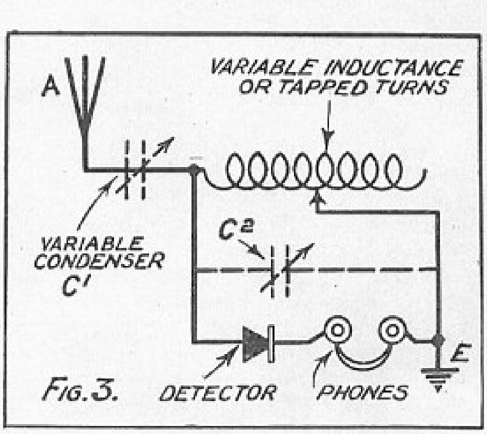


FIG. 3.

reception if we dwell very briefly for a moment or two on the theory of crystal reception, and see if we cannot obtain a grasp of the manner in which the crystal exerts its wonderful function.

In the first place, the beginner will, no doubt, be already aware of the fact that the energy which is set up in the aerial of a set under the influence of the incoming waves of ether takes the form of minute electrical currents which surge backwards and forwards in the aerial with an extremely great rapidity. The currents are thus said to "oscillate," and, because they oscillate or flow backward and forward so very rapidly, they are called "high-frequency oscillatory currents." Which, after all, is not such a very terrifying expression when once its real meaning has been grasped.

How Stations Are "Tuned" In

Well, these currents, oscillating at the rate of something like a million times per second, flow down the lead-in wire of the aerial into the set. Every receiving set is capable of being adjusted in such a manner that it will respond only to oscillations of a definite frequency, and the operation of so adjusting the set is known as the "tuning" of the receiver.

Very briefly, the tuning of any radio set consists of making adjustments of certain instruments by means of which the amounts of two properties which exist in all radio circuits may be increased or decreased. These two properties of all radio and electrical circuits are very well known, and you may already have heard something about them. They are called Inductance and Capacity. The tuning coil of the receiver controls the amount of inductance which is included in the set, whilst the amount of capacity is varied by the condenser.

The illustration *a* in Fig. 1 shows in a diagrammatic fashion the oscillations of the currents which flow into the receiving set. The waves or curves above the middle horizontal line represent current flowing in one direction only, whilst the curves below the line represent that part of the current which flows in the opposite direction.

At *b* in the same illustration is seen the condition of the current after it has passed through the crystal. It is then said to have been "rectified." That is to say, the crystal has only allowed to pass through it those portions of the current which travel in one and the same direction. Thus the crystal has acted as a sort of radio filter or comb, and because it only allows current to pass through it in one direction (or practically so, at any rate) it is said to possess the property of "unilateral conductivity," and it is on this property of all radio-sensitive minerals that their rectifying action depends.

Different Types of Sets

The rectified currents are now passed along to the 'phones of the set, and these, by causing the diaphragms of the latter instruments to vibrate, reproduce the sounds which were transmitted by the broadcasting station.

The above is a very simple and elementary explanation of how the crystal works. *Why* it should function in this manner is another question altogether, and the precise reason for its behaviour is really unknown, although many ingenious theories have been put forward to explain it.

Now let us deal with the main points of difference which are to be found between different types of crystal sets. From a very general point of view, crystal receivers may be divided into expensive and non-expensive instruments. As a rule, the higher-priced set differs from the cheaper outfit not only in appearance and quality of construction, but also in the ease and convenience with which its various adjustments may be made. In some cases, the more costly instrument will give no better results, so far as actual reception goes, than a cheap set, provided the latter is carefully manipulated, for the two receivers may often incorporate exactly the same circuit.

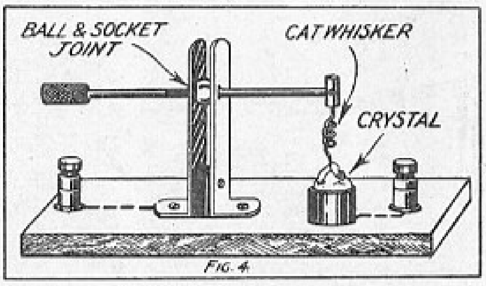
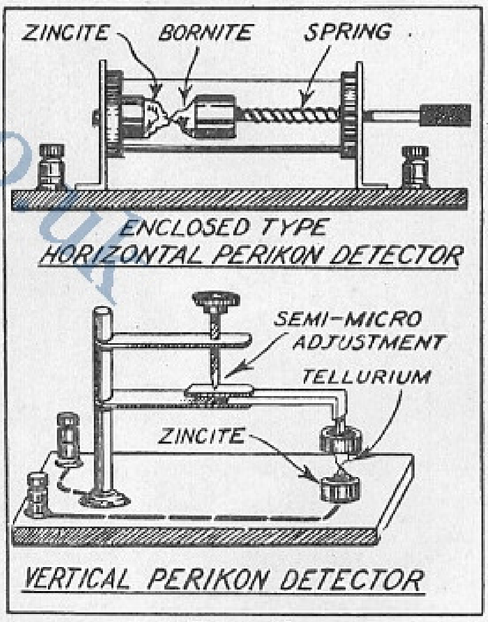


FIG. 4.

On the other hand, however, the more expensive instrument will be found to be a much better built one. Greater care and thought will have been expended on the details of its construction, and therefore such an instrument will give better all-round results in non-expert hands than those afforded by the cheaper receiver.

The "Tripod of Reception"

So much for what may be known as the "general" points of difference between various crystal sets. Technically, and constructionally, crystal sets may differ considerably from one another in respect of the actual circuits which they embody. Generally speaking, the actual circuit which is employed



Figs. 5 and 6.

in the set makes very little difference to the resulting reception of the instrument, provided the set is operated under ordinary conditions, and well within the range of crystal reception. Of course, certain crystal receiving circuits have special points in their favour, but these only show up to their best advantage when the set is used under exceptional conditions, either in conjunction with inefficient aerials, or on the fringe of the range of crystal reception.

All crystal sets contain three fundamental elements or units in their construction. First there is the tuner element or unit, then the detector unit, and finally the headphone, or sound-producing unit. All these are, of course, absolutely essential to any reception. They are as essential to the crystal

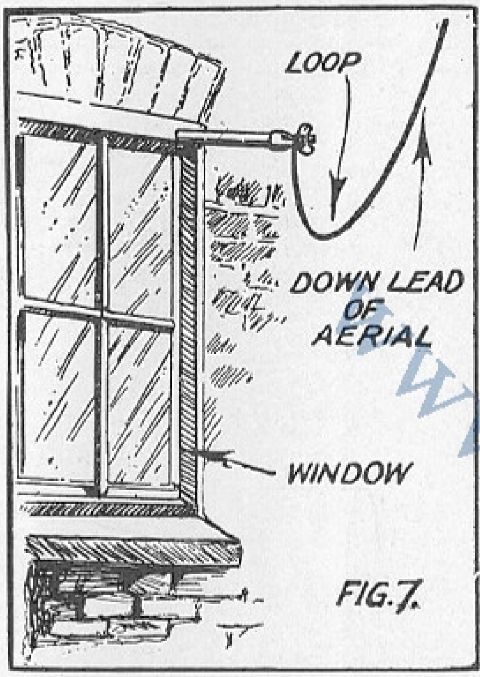


FIG. 7.

receiving set (or to any other set, for that matter) as our brains, hearts, and lungs are to our own bodies. The latter are known as the "tripod of life." And so we may call the tuner, detector, and headphones of a crystal set the "tripod of reception."

Fig. 2 illustrates the arrangement of this "tripod of reception," and in Fig. 3 you will see how these units are illustrated in the conventional symbols of wireless. The coil of wire is the "inductance" of the set, and sometimes, a variable condenser is arranged in either of the positions C^1 and C^2, as indicated by the dotted lines. Each of these arrangements of the condenser affects the tuning capabilities of the receiver.

It is possible to classify all the makes of crystal sets which are at present on the market by means of the tuning systems which they employ. The principle of the detecting units remains the same in all of them.

Methods of Tuning

Thus we have simple coil-tuned sets, coil and condenser tuned sets, receivers which are tuned by a special arrangement of movable coils known as a "variometer," and instruments which are tuned by means of "loose couplers," or systems of two coils of wire which are separated from each other. Each of these systems of tuning has its advantages, and therefore we generally find nowadays that some are used almost to the exclusion of many of the others.

For instance, a set which is tuned by means of a fixed coil of wire, the number of turns in which cannot be varied, will give quite good results provided the number of turns of wire on the coil are carefully adjusted to the wave length of the station which it is desired to receive, but the great disadvantage of this arrangement lies in the fact that the tuning of that set cannot be altered, and therefore it can only be used for receiving one particular station.

Double Circuit Receivers

Again, loose-coupled crystal sets, and sets of the auto-transformer type, although they give excellent results, so far as signal strength of reception is concerned, are bulky. Therefore they are only used in those instances in which extreme selectivity of reception is required, for, as these tuners incorporate two circuits in the receiver, they impart a very high degree of selectivity to the instrument. Therefore they are of the greatest value to those crystal enthusiasts who reside in the neighbourhood of shipping stations, and who wish to get rid of interference from Morse signals.

Long, cylindrical coils, which are provided with a sliding arrangement for varying the number of turns of wire in the tuning circuit are not very efficient, first on account of their great bulk, and secondly because of the fact that the great length of unused turns of wire sets up "dead-end" effects in the circuits, and these effects absorb much of the received energy from the aerial.

The two best types of crystal sets are those which employ variometer or tapped coil tuning. Of the former there are very many excellent types on the market. The well-known P.W. "Ultra" crystal set embodies the latter form of tuning, which is employed in its most effective manner.

Types of Detectors

Crystal sets, which employ cylindrical inductance coils, basket, or plug-in coils which are finely-tuned by means of a variable condenser give good results, but for the most efficient work they are not so satisfactory in use as the crystal sets mentioned above. This is on account of the fact that the inclusion of extra amounts of capacity into a crystal circuit exerts a damping effect upon the resulting signals. In a crystal set it is better to tune by varying the inductance, than by increasing the capacity of the circuit.

If we except the carborundum detector, which necessitates the use of an auxiliary battery and potentiometer, there are two general and distinctive types of detecting units which may be used in crystal circuits. Of these two units, the well-known "cat's-whisker" detector constitutes the one, whilst the less-commonly employed "perikon" detector forms the other. As is well-known, the cat's-whisker detector consists essentially of a fine metallic wire which makes contact with a very light pressure upon the sensitive surface of a suitable crystal. A very simple type of this detector is shown in Fig. 4, whilst of course, there are other more elaborate and efficient forms of the detector which enable the most minute degree of adjustment to be made between the cat's-whisker and the crystal.

Figs. 5 and 6 illustrate two common types of the perikon detector. Here it will be seen that the contact is made between two different varieties of minerals, and not between a fine metallic wire and a crystal. The great advantage of the perikon type of detector lies in its greater stability to shocks and other mechanical disturbances, but this type of rectifying device is not so sensitive as the cat's-whisker detector.

There are very many types of these two detectors advertised nowadays, and the novice in radio reception is often apt to become rather confused when he reads the loving praises which the manufacturers are generally wont to bestow upon their goods. Here, therefore, are a few rules for the guidance of the beginner when making a choice of detectors.

In the first place, a cat's-whisker detector should provide a very easy and thorough means of adjustment. The cat's-whisker should be able to explore almost the entire surface of the crystal, and in addition to this, its pressure of contact should also be able to be minutely adjusted. For this reason, a cat's-whisker detector of the micro-adjustment pattern is to be preferred for really

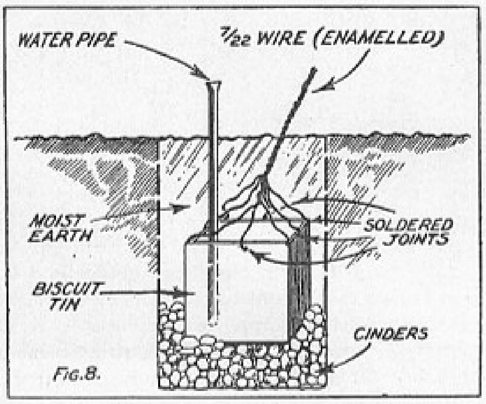


FIG. 8.

efficient and prolonged service, although there is no doubt that many of the much simpler types of detectors function very well indeed. The detector should also be of the enclosed pattern, and, if possible, the crystal should be firmly embedded in its cup by means of Wood's metal rather than merely being clamped in position.

Perikon detectors should have similar points about them, but here there is not so great a need for great delicacy of adjustment between the crystal surfaces.

Operating a Typical Set

Most of the crystals which are employed in cat's-whisker detectors at the present time are composed of galena, either natural or artificial, and the specially selected and graded pieces of this mineral constitute the numerous "ites" of the radio dealer. These are all generally highly sensitive and they are admirably adapted for use with cat's-whisker detectors. As a rule, the novice will find that a galena crystal of a medium-coarse grain will afford the strongest signals. The finer grained material is more suitable for use in crystal-valve sets. Other crystals which can be used in cat's-whisker detectors are silicon, and iron pyrites. These function best with cat's-whiskers of brass or gold.

The usual varieties of crystals which are used in the perikon types of detectors are

ALL ABOUT CRYSTALS

By J. F. Corrigan, M.Sc.

(Continued from Page 19)

zincite and bornite or copper pyrites. Other suitable crystal combinations are zincite and tellurium, zincite and silicon, and sometimes zincite and galena.

The operation of a typical crystal receiving set is simplicity in itself. All the beginner needs to do after making his set and connecting up the aerial and earth leads to it is to bring the cat's-whisker gently into contact with the surface of the crystal. Generally, after this has been accomplished, something will be heard in the 'phones, provided, of course, that broadcasting is in progress from the local station, and a little further adjustment of the detector will result in the signals becoming increased in strength. After this, the tuning of the receiver should be attended to. A little adjustment of the tuning control of the receiver will soon indicate to the radio novice whether he has obtained the "right" degree of tuning or not. Finally, when the set has been properly tuned, the detector should be very carefully adjusted in order to obtain the maximum results from the instrument. What could be simpler than this little sequence of operations?

Obtaining Maximum Results

Although this article does not pretend to deal with the actual construction of crystal receivers, there are nevertheless several points concerning the general principles of crystal set construction which it will be advisable to touch upon.

In order to obtain maximum results from any type of crystal set, the beginner, and also the advanced experimenter, should bear in mind that a crystal receiver is an instrument which is operated solely by the energy which it receives from the aerial. Unlike the valve set, the energy received from the aerial cannot be increased by the application of any local potential. Remembering these facts therefore, it will be ovbious that it would be useless to expect a crystal set to give loud signals when connected up to an inefficient aerial, or to a badly designed earthing system.

Single Wire Aerial Preferable

Therefore, the aerial employed with a crystal receiver should be as long as circumstances and the Postmaster-General's Regulations permit, and, of course, it should be erected as high as possible. Indoor aerials will do very well, perhaps, when the receiver is situated within a mile or two of the broadcasting station, but at greater distances than four miles they begin to give very poor results indeed. The aerial should be well insulated, two or three light porcelain insulators being included in series at each end of the aerial wire.

A single wire aerial is better than a twin wire one for crystal reception. It has less capacity, and, generally speaking, capacity is a thing which is not wanted in crystal work. The aerial downlead should be quite clear of the wall, otherwise capacity effects will be set up, and some of the precious energy absorbed.

The aerial downlead should always enter the room *via* a properly designed lead-in tube; it should not be merely pushed through a hole in the window pane. Make a small loop in the aerial downlead at the point at which it is attached to the lead-in tube, in the manner shown in Fig. 7. This will very greatly help to maintain the efficiency of the aerial in wet weather for it will minimise the leakage of current over the wet surface of the tube.

The Earthing System

The earthing system of a crystal set needs a similar careful consideration. The best earthing arrangement is shown in the diagram, Fig. 8. This consists of an ordinary tin biscuit box, to which are soldered the separate strands of a length of 7-22 wire. This box is buried four or five feet in the ground, and it should rest upon a bed of cinders. It is advisable to have a pipe running down into the middle of the box, through which water can be poured in dry weather, thus maintaining the earth connection in a damp and conductive condition.

The next best earthing arrangement is obtained by soldering the earth lead of the set to a cold-water pipe, and at a point near to that at which the pipe enters the ground. Less efficient results are obtained when the earth connection of the set is made to a hot-water pipe, because, under these conditions, the current from the set will probably have to ramble all over the water system of the house before it finally reaches the ground.

It is not good practice to use a gaspipe for an earth connection, if only for the reason that most gas pipes have composition joints, and these joints offer a very high resistance to the free path of the current. Always keep the aerial and earth leads as short as possible, and never allow them to run parallel to each other for more than 6 inches.

Concerning Coil Construction

So much for the criteria of an efficient aerial and earthing system. If you want to get the very last ounce, so to speak, out of your crystal receiver, you should consider the following points and see how they apply to your set.

As I have remarked before, a crystal set should provide the freest possible passage to the minute currents which flow through it, and very little capacity should be included in the aerial circuit. These conditions are brought about by employing tuning coils, the windings of which are constructed of the thickest possible wire and spaced apart so far as is reasonable and possible. Moreover, don't succumb to the temptation to paint your tuning coils over with paraffin wax or shellac. Coils so treated look very nice, I know, but they have an added amount of self capacity, that radio bugbear which acts detrimentally on the resulting reception. Enamelled or double-cotton covered wires are the best for coil construction for this purpose.

The connecting wires of a crystal set should all be well soldered in their respective places, and they should consist of square sectioned wire, or, if not, of No. 16 or 18 s.w.g. enamelled wire.

Most crystal sets which are sold nowadays are not provided with a fixed condenser placed across the 'phone terminals, yet very often the inclusion of such a condenser in the telephone circuit will be found to materially benefit the reception. This condenser should have a value of about ·0002 mfd. In high-class instruments these condensers are sometimes attached to the set. Be careful, however, if you decide to fix such a condenser to your own set, that the capacity of the article is not too high, otherwise a damping effect on the signals will be the result.

If your crystal set gives trouble, and you are satisfied that there is nothing wrong with the aerial or the earth systems, the fault may be looked for in two other directions—viz., the tuner of the set and the detector. (This is, of course, assuming that the head-phones are known to be in good order.)

Tracing Faults

Seventy-five per cent of crystal set troubles can be traced to faulty detectors, insensitive crystals, and the like. The rest may generally be ascribed to badly designed and faulty tuners, and to loose and dirty connections. If the connections in the set have not been soldered, they will in time become covered with a film of oxide or tarnish, and these, making bad contacts, will increase the total resistance of the path through which the current has to flow. Thus the result will be that when the current gets to the detector or to the 'phones it will be reduced in quantity, and therefore loss of signals strength will follow as a direct consequence.

The tiny currents with which the crystal set deals are precious, and they must be conserved in every possible way. Loose and badly soldered tappings are another cause of current loss in crystal sets, as are also badly adjusted sliding devices, rotating arms, heavily insulated windings, and dirty contact studs.

Other Crystal Set Troubles

If the set be of the panel variety, the panel itself should preferably be composed of well-matted ebonite. Beware of wooden panels. They are often used for crystal set construction, but their employment in this direction is not conducive to the best results. They may function well at first, especially if they have been impregnated beforehand with paraffin wax, but after a time they nearly always absorb a certain amount of moisture from the atmosphere, and this moisture, providing areas of low resistance for the electrical currents, gradually decreases the efficiency of the set's reception. The same remarks apply to sets employing cylindrical inductances of all kinds.

Coming to crystal detector troubles, it may be stated that cat's-whisker troubles are generally due to the use of too thick a wire, or to the wire becoming oxidised. The remedy in these very common instances is to

(Concluded on Page 26)

How to Make a Two-Valve L.F. Amplifier

By LAURENCE J. PRITCHARD

THIS amplifier may be used in conjunction with any crystal set. On test, when connected to the two-circuit crystal set described in this book by Mr. Pritchard, loud speaker signals of good strength were received from 2 L O at a distance of about twenty miles.

WHERE louder reception than that obtained with the crystal set and single-valve amplifier is required, the two-stage low-frequency amplifier illustrated complete in Fig. 1 is suitable. The instrument follows closely the construction of the single-valve amplifier and the crystal set belonging to the series, and fully described in this book.

As a general rule, one stage of low or audio-frequency amplification is not sufficient to give loud speaker results at a distance further than about 10 miles from the broadcasting station. Further distances than this are frequently obtained on the loud speaker, but are above the average.

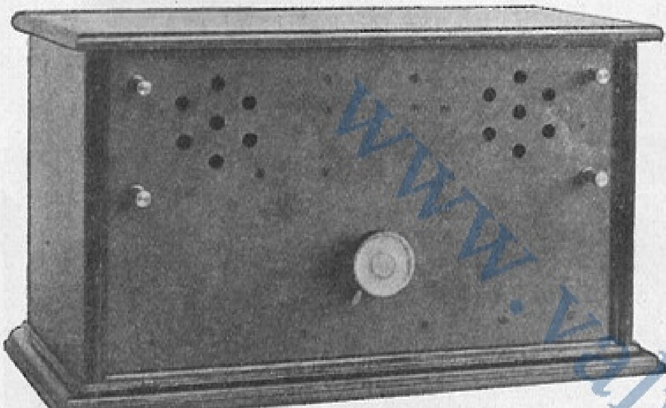


Fig. 1

Fig. 1. The Two-Valve Low-Frequency Amplifier completed. The input terminals are on the left of the panel, while the 'phones are connected to the two right hand terminals.

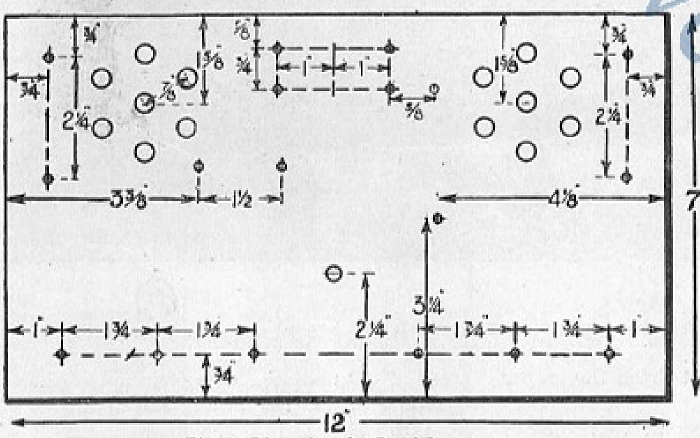


Fig. 2. Dimensions for Panel Lay-out.

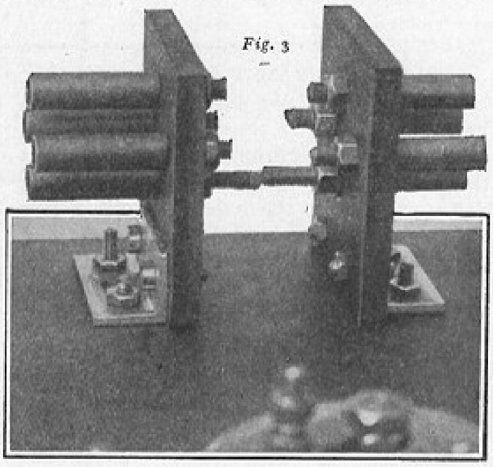


Fig. 3

Fig. 3. Close-up view of Valve Holders.

The figures in Fig. 4 are for reference purposes and denote the following:—(1) 1st L.F. transformer; (2) Grid bias batteries for 2nd valve; (3) Rheostat; (4) Bias for 1st valve; (5) 2nd transformer.

Two valves amplifying at audio-frequency and following a crystal set are usually considered necessary for loud speaker results. With a well-designed and constructed amplifier, with two valves, broadcasting should be heard on the loud speaker, even when amplifying crystal reception alone, up to a distance of about 20 miles or more.

Little need be said of the construction of the case, as in every particular it is identical with that in which the crystal set is housed. For those who are constructing the amplifier apart from the crystal unit, any case 12″ long and 7″ deep, and about 6″ from back to front internally, will be suitable. Under those circumstances the case may be designed to suit the particular receiving set with which it will be used.

The amplifier described in the present article as well as the single-stage amplifier previously described, may be used in conjunction with a valve receiver consisting of a detector and either high or low frequency valves for amplification. There is one important exception to this, however. Care must be taken that the common wires of the high and low tension batteries are the negative wires in each instance. If the valve receiver, for example, has low tension positive connected to high tension negative, the effect of joining up the amplifier will be to short the low tension battery. However, having made certain of this point, a slight alteration to the wiring of the amplifier can be made. This will be described at a later stage, after the wiring has been finished.

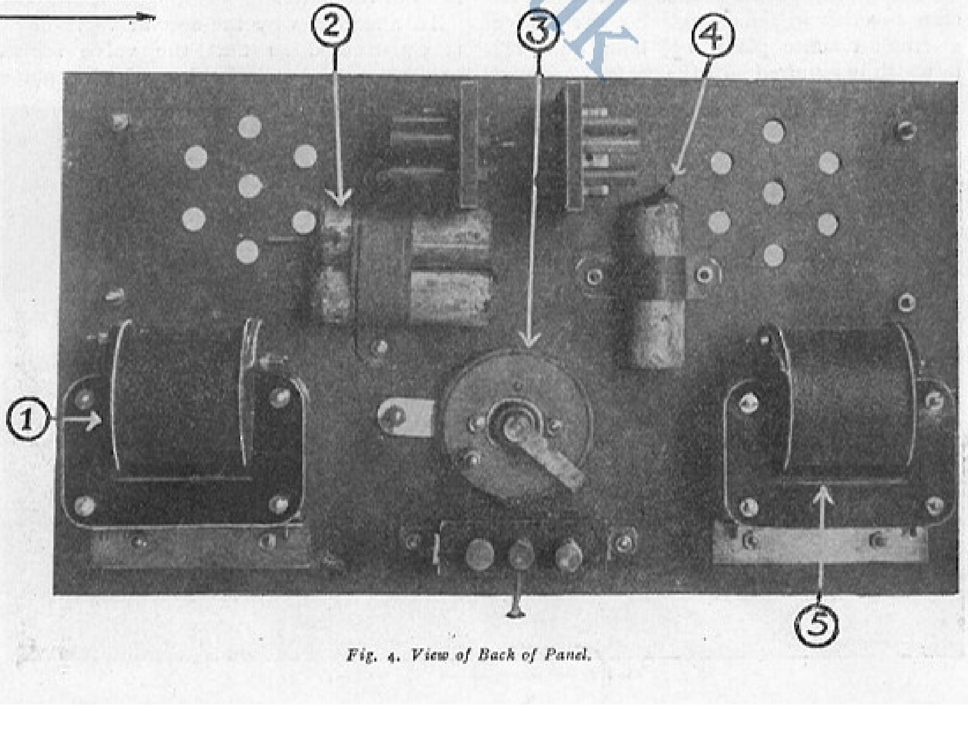


Fig. 4. View of Back of Panel.

A feature of the amplifier is the fitting of suitable grid-biassing batteries to each valve, to obtain louder and purer reception. These batteries are not called upon to take a large discharge, and consequently should last many months.

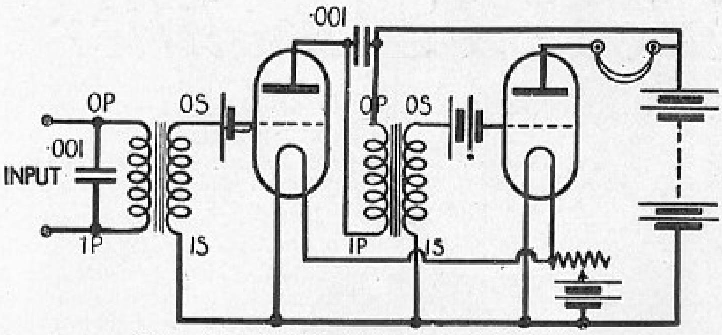


Fig. 5. Theoretical Circuit Diagram of 2 L.F. Amplifier.

A dimensioned panel lay-out is given in Fig. 2. In drilling the peep-holes a small drill is first run through. Following this the hole is enlarged by a drill of the correct size which enters the hole from either side and meets in the middle. This method prevents the panel from chipping.

Mounting the Components

Although there is a considerable amount of work in fixing the components, it is very much simplified by the exclusive use of No. 6 B.A. countersunk brass screws, $\frac{1}{2}''$ long, and lock nuts with which to bolt the various components to the panel. In the single-valve amplifier the method of blacking the screw-heads was described in detail, and therefore only a passing reference is necessary here. The holes in which the screws are passed are carefully countersunk, so that the top of the screw-head lies flush with the surface of the panel, and by blacking the screw-heads an unsightly collection of brass screw-heads is avoided.

The Valve-Holders

The valves, which are of the dull emitter type, are mounted horizontally at the top of the panel, so that their sockets come close together in the centre. For each valve a small ebonite plate $1\frac{3}{4}''$ long and $1\frac{1}{2}''$ in width is required. In the centre of one of the shorter sides a brass right-angle bracket, having sides of about $\frac{1}{2}''$ in width and a length of $1''$, is bolted by means of two No. 6 B.A. screws and nuts. Holes are drilled $\frac{3}{4}''$ apart in the centre of the second side of the bracket for attachment to the panel. Four No. 4 B.A. holes are drilled in each ebonite valve-plate, in which standard valve sockets are fitted to form a valve-holder. The holes of the grid and anode sockets of this valve-holder are in line with the shorter end of the plate, and $\frac{3}{8}''$ from it. The filament socket holes are parallel to and equidistant from the longer sides of the plate.

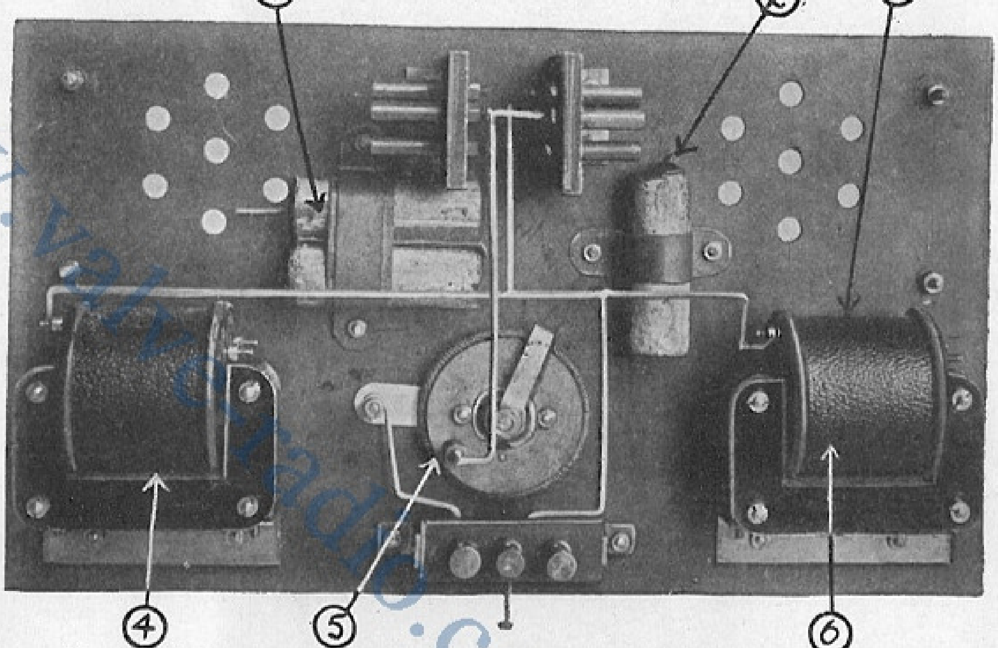
In a similar way the second valve-holder is constructed so that the valve sockets project on opposite sides of the plates. The two filament socket stems nearest the panel are arranged to touch, end to end, while the others are cut off close to their clamping nuts. Details of this part of the construction are given in Fig. 3, which shows a close-up view of the valve plates.

Filament Rheostat

The filament resistance is of the standard disc type, with rotating contact-arm, and is mounted with its spindle projecting through the $\frac{1}{4}''$ diameter central hole shown near the bottom of the panel in Fig. 2. To fix the rheostat to the panel No. 6 B.A. countersunk screws and lock nuts are used. Immediately below the filament resistance is a terminal board on which the three battery terminals are placed.

The terminal board measures $2\frac{1}{4}''$ long and $\frac{5}{8}''$ in width, and is cut from a scrap piece of $\frac{1}{16}''$ ebonite. One terminal is placed centrally, while the others are arranged $\frac{5}{8}''$ on either side of it. The board is raised $\frac{1}{2}''$ from the back of the panel by means of two right-angle brass brackets, screwed to the ends of the board and bolted by No. 6 B.A. screws and nuts to the panel.

Fig. 6. First stage of wiring in the L.T. Circuit.



The numbers indicate the following components:—(1) 2nd Grid Bias Battery; (2) 1st Grid Bias Battery; (3 and 6) 1st Transformer; (4) 2nd Transformer; (5) Rheostat.

Preparing the Transformers

The low-frequency transformers used are "Supra" type, sold by Wates Bros. A slight alteration is necessary to the feet of both transformers before they can be bolted to the panel. As purchased, two brass feet are bolted on diagonally opposite corners of the iron core of the transformer. One of these brackets is removed by unscrewing the slotted circular nut by which it is fixed and replacing it on the same side as the remaining bracket. The feet are required on the same side of the transformer as the O.P. and I.S. terminals.

Two brass brackets, each $3''$ long and with sides of $\frac{3}{4}''$ in length, are cut for mounting the transformers. One side of each bracket is bolted to the feet of the transformer so that the bobbin rests lightly against the back of the panel when the

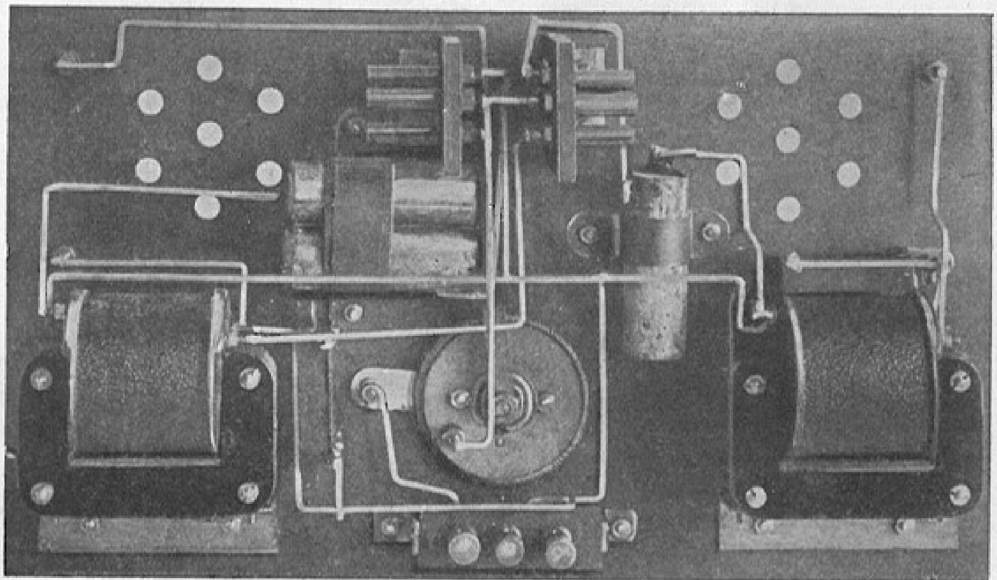


Fig. 7. Showing the wiring of the H.T. and L.T. Circuits.

bracket is flush with the panel. The bolt holes are drilled in the centre of this side of the bracket, and ⅛" from either end. The fixed condensers, which are shunted across the primary of the transformers, are not attached to the panel, but are supported by the stout wires to which they are connected. They may therefore be added during the wiring stages.

Grid and Bias Provided

Four terminals are required on the outside of the panel for input and output connections. The stems of these terminals are tapped 4 B.A. Corresponding holes are drilled and tapped in the ebonite panel and the terminals rigidly fixed in position with lock nuts. These terminals are of the telephone type, and care should be taken that their centre holes are parallel with the length of the panel.

The grid biassing batteries may be taken from a 3-cell 4½-volt pocket flash-lamp battery. To dismantle the battery, the cardboard casing is first stripped off and the pitch at the top of the cells chipped away. It is important in this operation not to break the fine wires concealed in the pitch, which connect the separate cells. One cell is entirely detached from the other two, this being used in connection with the grid of the first valve. It is important that the cardboard strip which separates the zincs of the two connected cells should be kept in position.

Both batteries are bolted to the panel by means of an insulated brass saddle made of ⅝" thin strip brass bent round to the curve of the batteries. The single cell is mounted to the left of the transformer seen on the right of Fig. 4. This illustration shows a back view of the panel with the components mounted, and forms a useful guide for positioning them. The two-cell battery is correspondingly placed to the left of the panel, as seen in this illustration, and is arranged in line with the length of the panel. It is important that a waxed cardboard strip is placed between the two-cell battery and the brass saddle by which it is held to the panel in order that it may not short-circuit the two zincs. The cardboard strip which previously separated the single cell will answer the purpose very well.

Connecting the Components

The components are now ready for wiring. This is carried out according to the theoretical circuit diagram, Fig. 5. By performing the wiring in natural stages it may be more easily accomplished. The first stage includes the low tension circuit illustrated in Fig. 6. As in the case of the crystal and single stage amplifying unit, the wiring is carried out with $\frac{1}{16}$" square tinned wire. A wire from low tension positive, which is the terminal to the left of the terminal board, as seen in Fig. 6, is joined to one end of the filament resistance. The other end of the filament resistance connects to the filament sockets of the valve holders which are the more remote from the panel. In Fig. 6 a wire is shown connected to the inside secondary of both transformers. From about the centre of this wire another is taken at right angles for connection to the filament sockets, which are in contact. To the right of this wire is another which connects to the centre terminal on the terminal board, which is the common high and low tension negative.

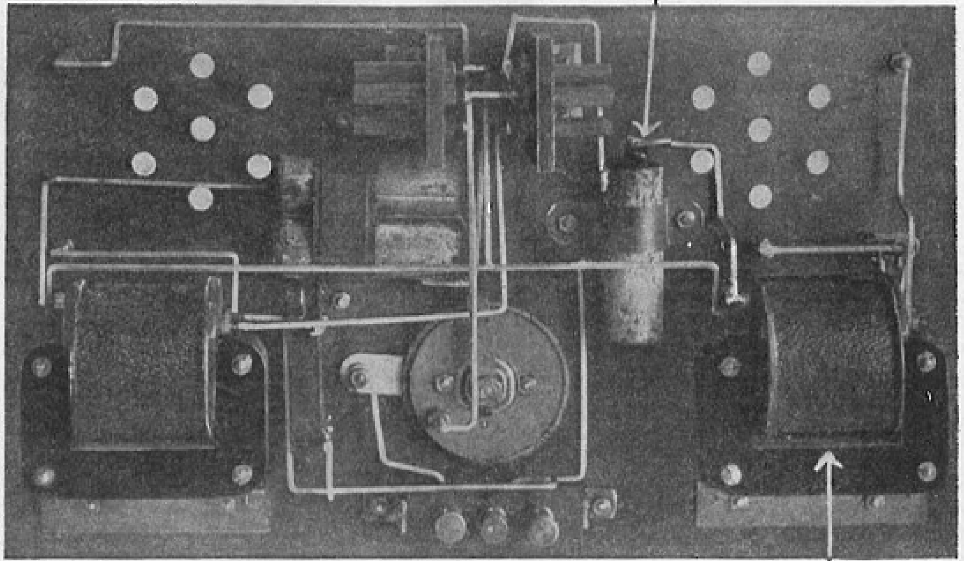


Fig. 8. View of completed wiring at back of Panel. (1) Shows the 1st grid bias battery, and (2) shows the 1st left transformer.

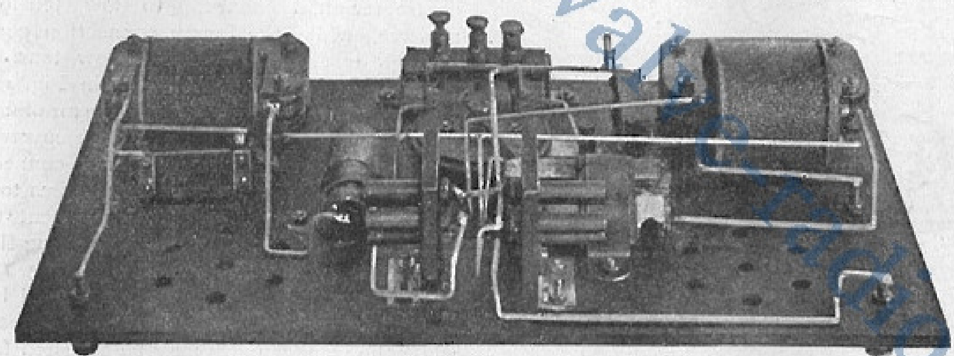


Fig. 9. View of completed wiring as seen from top of Panel.

Wiring up Transformers

A further stage of the wiring shows the completion of the high tension circuit and the primary of the first transformer. This is illustrated in Fig. 7. The remaining terminal, which is high tension positive, connects to the outside primary of the second transformer, and then straight on to the lower of the output terminals. The top output terminal connects directly to the anode of

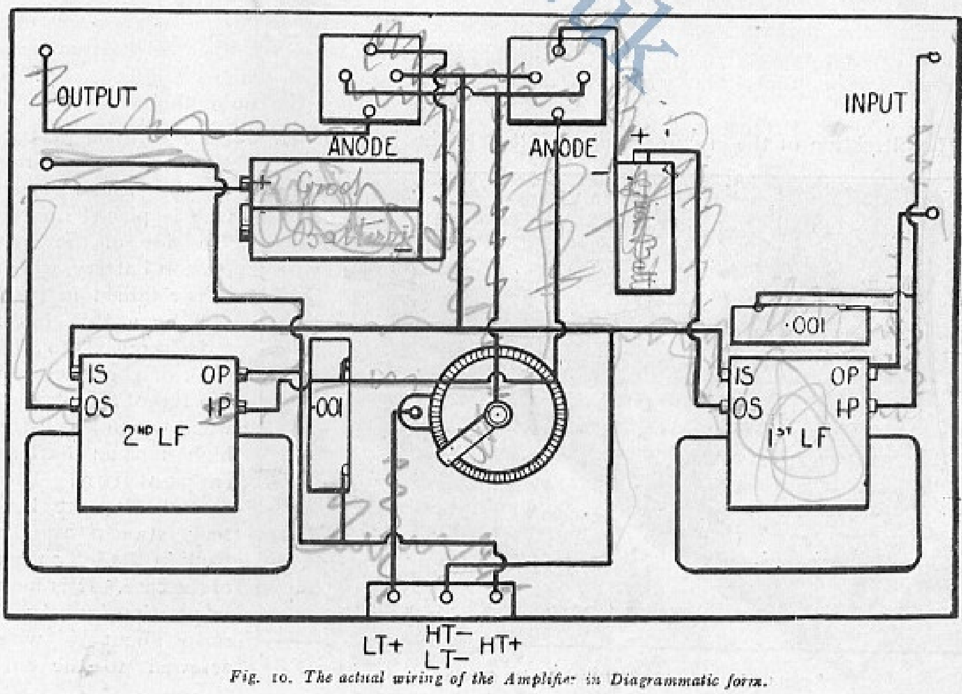


Fig. 10. The actual wiring of the Amplifier in Diagrammatic form.

the second valve. The inside primary, marked I.P., of the second transformer connects to the anode of the first valve. The input terminals on the panel are wired direct to I.P. and O.P. of the first transformer. A fixed condenser of ·001 mfd. capacity is supported on its connections immediately above the first transformer.

Fixing the Batteries

Care should be taken in wiring to see that the space occupied by the valves is kept quite free. This can be done by bending the wires to run close against the panel. The fixed condenser which is shunted across the primary of the second transformer also has a capacity of ·001 mfd., and can be neatly fixed between the filament resistance and the second transformer. The remaining stages of the wiring include the completion of the grid circuits and the grid batteries. A view of the completed wiring as seen from the back is illustrated in Fig. 8. Fig. 9 shows a different view of the completed wiring as seen from the top of the panel. To some constructors the wiring may be facilitated by the diagrammatic representation given in Fig. 10.

In this illustration the valve plates are shown opened out so that a view may be given of the sockets forming the valve holders. As far as possible the wiring of this diagram follows the actual wiring as it is seen in Fig. 8.

The alteration of the circuit, required if it is to be coupled to a valve receiver having a common low tension positive and high tension negative, is carried out in the following manner. Instead of the low tension negative connecting direct to the filaments of the valves, the filament resistance is placed in series with this wire. Low tension positive from which the filament resistance has been removed now connects direct to both valve filaments. The inside secondary of both transformers are still connected to low tension negative.

The high tension battery may be a Siemens No. 829 of 66 volts. It measures $9\frac{1}{8}''$ long, $3\frac{3}{4}''$ wide, and $3''$ in height. Any other battery of suitable dimensions may be used. As shown in Fig. 11, where the batteries are seen fixed in position in the case, the high tension battery occupies the right side of the back of the case, with the taps towards the panel. The battery is fixed in position by a strip of $\frac{3}{8}''$ wood about $2''$ wide, and of a height to reach the top of the battery.

Fig. 11. Showing how the Batteries fit into the Case.

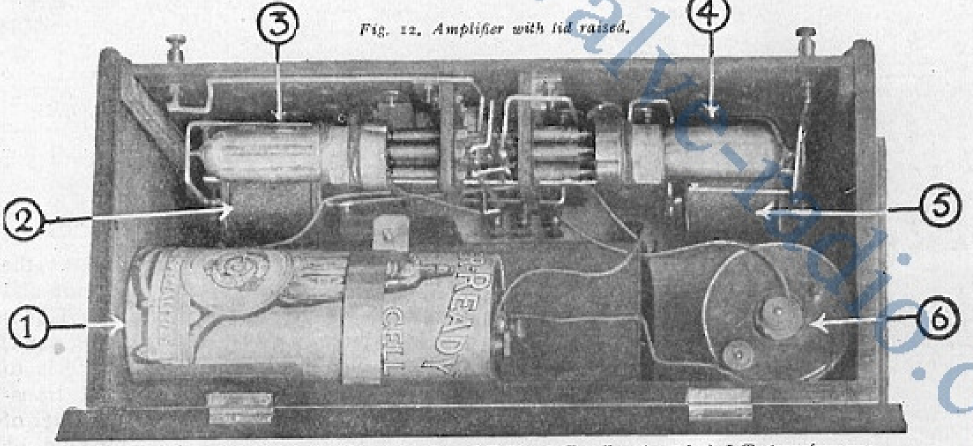


Fig. 12. Amplifier with lid raised.

Components denoted by the numbers are: (1 and 6) Two L.T. cells; (2 and 5) L.T. transformers; (3 and 4) Valves (D.E.3 type).

The low tension battery consists of two standard bell batteries of the round type. One is placed on the top side of the high tension battery, where it is retained in position by a thin brass strip screwed to the back of the case and the top of the strip of wood which keeps the high tension battery in position. The second filament battery stands at the back in the left corner of the case. It is kept in position by a brass strip about $\frac{5}{8}''$ wide screwed to the side and back of the case. In connecting up the batteries the centre terminal of one cell is connected to the zinc, or outside wire of the other battery. The remaining centre terminal connects to low tension positive, while the fourth connection goes to high tension negative and low tension negative terminal. This is seen in Fig. 12, which gives a view of the top of the amplifier with the lid raised. Flexible rubber covered wires are suitable for making these connections. The high tension battery wires terminate in wander plugs for attachment to the battery. An easy method of securing the best high tension tap is illustrated in Fig. 13, where the panel is raised and supported by a pocket knife or other convenient object, while the wander plugs may be adjusted for best reception, or removed when the set is not required.

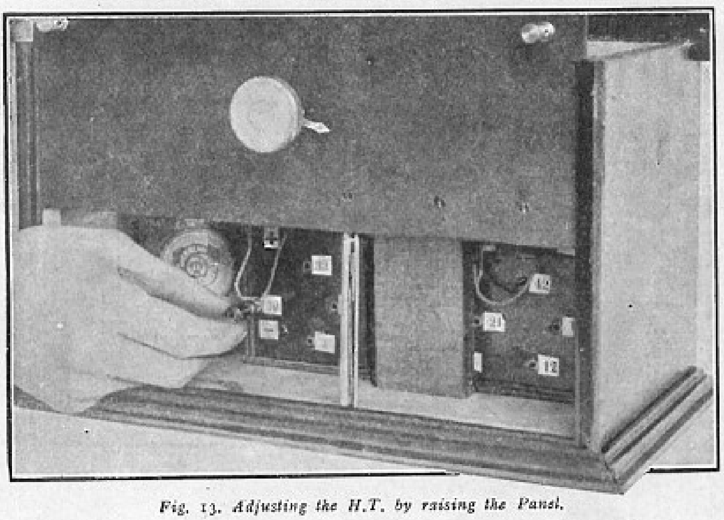


Fig. 13. Adjusting the H.T. by raising the Panel.

The Choice of Valves

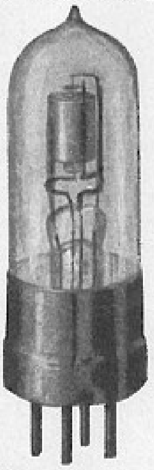
The completed amplifier connected to the crystal set with loud speaker attached is illustrated in Fig. 14. Short connecting wires lead straight across between the output terminals of the crystal set and the input terminals of the amplifier. The loud speaker is connected to the output terminals of the latter. A fixed condenser of a capacity from ·001 to ·005 mfd. may improve the quality of speech and music when shunted across the loud speaker terminals. The same valves can be used as are employed in the single-valve amplifier. In this set shown above two M.O. D.E.3 valves were used.

There is no need, of course, to use this particular type of valve, and any others capable of being run from dry cells can be used instead. A small accumulator could be placed in the case instead of the dry batteries if desired, but it is preferable to use dry cells, as the use of an accumulator not only makes the set heavy, but the acid-laden fumes might result in the corrosion of the wiring of the set. This would have a bad effect, of course, and might be the cause of mysterious noises and other faults that would develop after the set had been used for some time. Other valves suitable for this amplifier are the B5 B.T.H. type, or the A.R.D.E. ·06 type. Though it might result in the batteries running down more rapidly a very good combination of valves is a B5 or D.E.3 in the first stage of the amplifier, i.e. for the first valve, and a B6 power valve for the second. This valve takes more current than the B5 or D.E.3, but only the same voltage, so that it could be used satisfactorily with the same batteries and filament rheostat.

The high-tension battery could remain the same, though a higher voltage, say 80, could be used with advantage if provision is made in the case for the larger battery.

The greatest advantage in using the B6 valve, or one of similar type, is not in obtaining greater signal strength (though this will be one result), but in cutting out any distortion that might be caused by the use of a valve that is not capable of carrying the power delivered to it from the second transformer.

occur, are variation of the positions of the high-tension plugs and the filament control. If this does not help at all, the primary connections of the transformers should be reversed (with the high-tension plug out, of course, to prevent accident), commencing with the second transformer. Find the best connections for these primaries and then, if things are no better, try the effect of a resistance of about 100,000 ohms across the secondary connections of the second transformer. A rough idea as to whether this will help can be obtained by using a match soaked in Indian ink as the resistance. This may cut down the signal strength



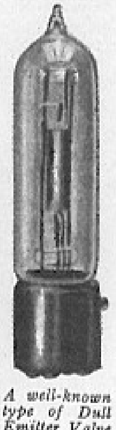
The Ediswan A.R. Bright Emitter valve. The corresponding Dull Emitter of this make (A.R. ·06) can be used in the set described.

Fig. 14. The completed Amplifier connected up to the Two-Circuit Crystal Set described in this book.

This is not to say that the two D.E.3 valves or two B5 valves will not give good results; they probably will, but the constructor who likes to go to the extra expense and trouble of using a larger second valve will be amply repaid by the increased purity and roundness of tone delivered from the receiver.

Possible "Faults"

While discussing purity of tone, it might be just as well to run over the most likely causes of trouble, should faults arise when the set is built. It is not at all likely that trouble *will* be experienced if the directions are carefully carried out, but it is just as well to be prepared for the unexpected, and to be able to deal with it without delay should it eventuate.

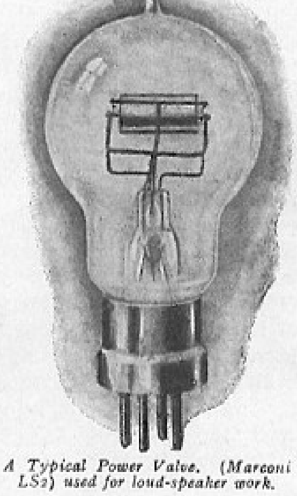


A well-known type of Dull Emitter Valve —The Weco-valve.

Distortion is probably the most likely thing to occur to spoil the constructor's reception, and this is not really a "fault" rather than a matter of adjustment. The first things to be tried, should distortion

somewhat, but it should also have the result of considerably lessening the distortion, if not cutting it out altogether. When it has been found that the resistance has a beneficial effect, it is advisable to remove the match or piece of wood and replace it with a variable leak of, say, 50,000 to 100,000 ohms. Those sold for anode resistances will do quite well, and this should be connected in the place of the wood.

Adjustment of the variable resistance, together with the high - tension and filament voltages, should have the desired effect of removing the distortion. No mention has



A Typical Power Valve. (Marconi LS2) used for loud-speaker work.

been made of the grid bias, for this should only be altered as a last resource, correct bias for the valves mentioned having been given.

The only other fault likely to occur is denoted by extremely noisy reception, and can usually be traced to one or other of the following: Dirty connections, such as valve legs and sockets, and connections to the various plugs and terminals. Run down batteries, accompanied, as a rule, by weaker reception than usual. The batteries should be tested by voltmeters, or taken to a local dealer to be tried if they are suspected.

Noisy Reception

Very noisy reception, which may improve somewhat the longer the set is turned on, is generally due to a faulty transformer. These are difficult for the average listener to test thoroughly, but some indication can be obtained by disconnecting the second transformer primary leads and placing the 'phones in the place of the transformer primary terminals. This enables the constructor to listen on one valve only, and if the noise is cut out—it is sure to be lessened—it is a sign that the trouble is in the last valve circuit.

Next, keeping the two leads off the second transformer, take the leads from the crystal set off the input terminals of the amplifier and place them on the primary terminals of the second transformer. Listen-in again with the 'phones in their proper position—on the 'phone terminals. If the noise is now present, it is practically a sure sign that the trouble is in the second transformer.

In this event it will be necessary to replace the transformer by a new one. If, however, the noise is not present now, the fault must be sought elsewhere. Should the source of the trouble still be elusive, it would probably be best to place the receiver in the hands of a competent wireless man, as he will have the necessary experience and instruments to test the set thoroughly, and remedy the fault.

Choice of Telephones

Before dismissing the subject of crystal sets and amplifiers perhaps a few words about telephone receivers and loud speakers may be of assistance. As regards telephones, the constructor will notice that these are sold according to their "resistances." To classify 'phones by their "resistance" is really a mistake, they should be classified under quite another unit, for it is not their resistance that counts but the number of turns of wire round their magnets.

However, as they *are* known by their resistances we must look upon them from that point of view. For use with the sets described in this book the choice of the 'phones rests between those of 8,000, 4,000 and 2,000 ohms (total resistance), the 120 ohms 'phones being useless for the receivers under consideration.

The 8,000 ohms 'phones are *fairly* good for crystal long-range reception, but as a rule we would advise the 4,000 ohms 'phones for the "crystal only" user. This type of 'phones should suit the crystal and one-valve man as well, but for two valves, used *always*, 2,000 ohm 'phones are best.

In the case of loud speakers, the 2,000 ohm type should be used with the amplifier just described.

Practical Hints for Amateurs

(Continued from page 10)

A set with variometer tuning does not need a variable condenser as well—a false impression that is often present in listener's minds.

* * *

The fixed condenser (usually ·001 mfd.) across the 'phone terminals of a crystal set does not *always* improve reception, and the set should be tried both with and without the condenser.

* * *

Don't get over-enthusiastic in laying out a new set, so that you rush some particular phase of the work or are tempted to put in some kind of make-shift part instead of waiting until you can obtain the correct one.

Go ahead thoroughly and build the set exactly as specified, carefully checking and rechecking your work and being sure of each step as you proceed. In this way you will be sure of success.

* * *

When putting up an aerial do not make the mistake of putting up a small-sized wire to hold the insulators. This only makes the aerial as strong as that bit of wire. Always use the same size wire as in the aerial.

* * *

Don't mark the panel with a pencil when building the set. This may cause a reduction in signal strength owing to the pencil lines causing leakage.

All about Crystals

(Continued from page 20)

provide a thinner wire, and to see that it is composed of some non-oxidisable material.

All crystals become insensitive in time, and if a crystal, after being used with satisfactory results for several months, gradually becomes obstinately insensitive, the best plan is to throw it away and to buy a new one. Of course, many crystals can be renewed in sensitivity by chipping their surfaces with the small blade of a penknife; but crystals are fairly cheap nowadays, and good penknives are dear, and the chipping operation often spells ruin to the blade of the knife, whilst if anything heavier be used for the purpose, the crystal will probably disintegrate altogether.

The Value of Clean Crystals

The cause of the crystal gradually becoming insensitive is one of those many things which scientists know nothing about. Even the best regulated crystals will become insensitive in time.

Lots of amateurs will tell you that grease ruins a crystal. However, before you implicitly believe the words of these well-meaning individuals, try the experiment for yourself. Take a piece of your favourite crystal and rub its surface over with a good, thick layer of vaseline, and then see if you get any worse reception. It is more probable that under these conditions you will get results of increased efficiency, for the layer of grease helps the cat's-whisker to steady its hold on the crystal, and the surface of the crystal will be completely protected from the tarnishing influence of the atmosphere.

Effect of Dirt

Of course, undue handling affects most crystals detrimentally, but that is not due to grease which is deposited upon their surfaces. Probably it is due to the organic acid secretions of the skin more than to anything else.

Crystals should not be heated any more than necessary, and they should be kept as free as possible from dust.

Dust accumulates in every room, and crystal sets seem to offer special attractions to it. Much of the dirt and dust which floats about in the air of industrial cities is of an electrically conducting nature, and this, settling on the panel of the crystal set, provides areas of electrical leakage. It is therefore advisable to keep the set in a box when it is not in use—that is, of course, if the instrument is not already provided with a cabinet having a lid attached to it.

All crystal sets should be kept in dry situations when they are not in use. A warm cupboard offers the most convenient and the safest place of repose for such an instrument during its "off" hours.

In Conclusion

Finally, if you would get consistently good results from your receiver, don't look upon it as a mere toy. A well-designed and a properly constructed crystal set is much more than an amusing toy. It is a wonderfully efficient scientific instrument. Treat it as such, noble reader, and, in the words of a certain William Shakespeare, a gentleman of some international repute (who, incidentally, must have been a bit of a radio enthusiast himself): "You shall have such receiving as shall become your highness."—Winter's Tale iv., 4.

The Home-Constructor's First Crystal Set

(Continued from page 6)

The 24 gauge wire is not, then, as good as square-section, because the latter offers a larger surface area. When the connections shown by the thick black lines in the wiring diagram have been completed, the back of the panel must be cleaned of dust and flux, and it must be placed in position in the case. If it is a tight fit, it will not really need fixing, but it may be screwed down at the corners if desired.

The Loading Coil

All that now remains is to provide a stout wire pin to short between the E1 and E2 terminals, but unless this is done no signals will be received. The purpose of the extra terminal will be seen from Fig. 4, where a loading-coil is shown (dotted) on the extreme right, ready for connecting. If the shorting pin is withdrawn from between E1 and E2, and the ends of the coil inserted instead, the variometer is in effect increased in size according to the number of turns of wire upon the coil.

It is possible in this way to "load" the receiver up as high as 1,600 metres, but a broadcast variometer-tuned set is not so suitable for reception on these high wave-lengths as a receiver tuned with a variable condenser. Such a condenser, of course, involves extra expense, but readers who live more than fifty miles from the high-power station, and who cannot use a short-wave receiver to listen to the ordinary broadcasting stations, would be well advised to use a condenser-tuned set for 5 X X, instead of one employing a variometer. (The variometer possesses certain advantages of its own, but the set here described has been chosen on account of its general utility and cheapness, and it is not intended for a long wave-length long-distance receiver.)

It was, however, thought that readers who live well within the 5 X X range would appreciate the arrangement whereby an extra terminal easily enables the wave-length of the instrument to be raised to 1,600 metres. For this purpose the loading coil should consist of 170 turns of the No. 24 d.c.c. wire wound upon the 4" former. (If it is decided at the outset to make this large coil as well, $\frac{1}{2}$ lb. instead of $\frac{1}{4}$ lb. of wire will be necessary.) It can be made in exactly the same way as that already described, but, of course, the turns will all be as close together as possible, there being no necessity for spacing a gap in the middle of the coil.

Tuning In

The wave-length to which the set will tune partly depends upon the aerial used, but under average conditions the turning of the control knob will tune the receiver from approximately 300 metres to about 600 metres. Thus, if you live near the coast, you will be able to listen to Morse from ships at sea which use a wave-length of about 600 metres. If, however, you are receiving from Sheffield, Stoke-on-Trent, or other station working on about 300 metres, it may be necessary to shorten the tuning range slightly. All that is necessary is a small fixed condenser (·0002) connected in series with the aerial, i.e. at the point X on Fig. 1.

Final Points

The aerial lead is taken to one terminal of this condenser, and the other terminal is connected to A. The same shortening effect could be obtained by using rather less turns on the variometer windings, but the condenser in series gives rather better results.

To use the set, connect the aerial lead to A, the earth lead to E2, and the shorting-plug—a piece of bare wire—between E1 and E2. Connect up the 'phones, and then search the crystal *lightly* with the cat's-whisker until a sensitive spot is found. Meanwhile, with the left hand, turn the variometer knob slowly till signals are at their loudest, and finally readjust the cat's-whisker until the best contact is found.

British and Continental Telephony Stations

Concerts from the following list of stations have been received by thousands of amateurs, and the following table will enable the reader to see at a glance the Call Sign and Wave Length of any British or Continental Broadcaster.

NAME OF RADIO STATION.	CALL SIGN.	WAVE-LENGTH IN METRES.
ABERDEEN	2 B D	495
BELFAST	2 B E	435
BIRMINGHAM	5 I T	475
BOURNEMOUTH	6 M B	385
BRADFORD	2 L S	310
CARDIFF	5 W A	351
CHELMSFORD	5 X X	1,600
CROYDON	G E D	900
DUNDEE	2 D E	331
EDINBURGH	2 E H	328
GLASGOW	5 S C	420
HULL	6 K H	335
LEEDS	2 L S	346–310
LIVERPOOL	6 L V	315
LONDON	2 L O	365
MANCHESTER	2 Z Y	375
NEWCASTLE	5 N O	400
NOTTINGHAM	5 N G	322
PLYMOUTH	5 P Y	335
SHEFFIELD	6 F F	301
STOKE-ON-TRENT	6 S T	306
SWANSEA	—	—
HAMBURG	—	395
MUNSTER	—	410
FRANKFURT	—	470
BERLIN	L P	3,150
LAUSANNE	H B 2	850
EIFFEL TOWER	F L	2,600
AMSTERDAM	P C F F	2,100
BERLIN (VOXHAUS)	—	430
KOMAROV	—	1,800
KBELY	—	1,150
VIENNA	—	530
BRESLAU	—	418
KONIGSBERG	—	463
LYONS	Y N	470
STUTTGART	—	443
LEIPZIG	—	454
STOCKHOLM	—	440
BRESLAU	—	418
ZURICH	—	650
ROME	I C D	3,200
CARTAGENA	E B X	1,200
RYVANG (DENMARK)	—	1,025
BERLIN	—	430
GENEVA	H B I	1,100
MOSCOW	—	3,200
RADIO, PARIS	S F R	1,780
BRUSSELS	B A V	1,100
EBERSWALDE	—	2,930
MUNICH	—	485
ROME (CENTOCELLE)	—	1,800
THE HAGUE	P C G G	1,070
PARIS (SCHOOL OF POSTS)	—	450
LYNGBY	O X E	2,400
BRUSSELS	S B R	265
BARCELONA	E A J 1	325
EIFFEL TOWER	—	2,600
HILVERSUM	—	1,050
SEVILLE	E A J 5	350
GOTHENBURG	—	690
ROME	I R O	425
GENEVA	—	1,100
COPENHAGEN	—	750
LYONS	—	480
YMUIDEN	P C M M	1,050
PARIS (PETIT PARISIEN)	—	345
MADRID (RADIO IBERICA)	—	392
THE HAGUE	—	1,050