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THE "P.W." CONSTRUCTORS' GUIDE

# A Plug-in Crystal & L.F. Amplifier Set

**The Sets Designed and Constructed by the Technical Staff of "P.W."**

## A PLUG-IN CRYSTAL SET.

"Is there a crystal set which is easy to make, easy to operate, and thoroughly dependable in use?"

"Shall I be able to tune into the new B.B.C. stations, and will a set that I make now be suitable if the wave-lengths are altered?"

These, and dozens of similar questions are now being asked on all sides. The set which is described below meets these requirements, and is eminently suitable for crystal-users within range of any British station. It is an easy-change set, adaptable to all wave-lengths, and the constructor who builds it can do so with the confidence that he is using a well-tested circuit that has given satisfaction to thousands of listeners in all parts of the country.

The scheme of the connections is shown by the pictorial diagram. This picture is not intended to convey an idea of the appearance of the set, in any way, but it merely shows in diagrammatic form how the various parts are connected together.

## MARKING THE PANEL.

A very clear idea of the actual appearance can be gained by an inspection of the photographs of the original model (which was constructed and tested by the "P.W." Technical Staff).

These photographs show the receiver being operated, and also a close-up of the finished set, as well as back-of-panel views illustrating the wiring. The whole idea of the set is simplicity, combined with efficiency, so that it is an ideal receiver for the novice who would like to try his hand at a home-made set.

A complete list of the parts necessary to build the set is given below, together with the prices ruling when the parts were bought.

The first step in construction is to make sure that the panel and case fit together nicely, and any little touching up or trimming of the edges with a file should be completed before the panel is marked. When a good fit has been secured, lay the panel flat upon the bench and mark it ready for drilling.

### LIST OF COMPONENTS.

| | s. | d. |
|---|---|---|
| 1 Panel, 5 x 7 x ¼ in., and Box 4 in. deep | 7 | 6 |
| 1 ·0003 Variable Condenser | 9 | 0 |
| 1 Mic.-Met. Crystal Detector | 4 | 6 |
| 1 Single Coil Holder | 1 | 0 |
| 5 Terminals | 0 | 10 |
| Wire, Screws, Transfers, etc. | 1 | 0 |

The position of the different components is shown clearly by the diagram which gives the "Panel Layout." The various positions should be marked lightly in pencil (or scratched with a pin), and then a punch or sharp nail should be used, and these marks will be transferred into the panel itself by a light tap with a hammer. All pencil-marks, etc., should then be carefully removed with a cloth.

Drilling is the next operation, and if a small hand-drill is used this presents no difficulty whatever. If, however, a carpenter's brace is being employed, it may be found that the small wireless drills cannot be securely gripped by it. This little difficulty is easily overcome by winding round the drill a few turns of wire, so that the shank of the drill is in effect thickened, and enlarged sufficiently to allow it to be held firmly.

The sizes for the holes are best found from the components, as these latter vary somewhat, according to the make or type. All the holes should be "clearance," so that the parts just fit in them easily.

Mounting the components in place is the next operation, and here the back of panel photographs will be of service. If the connections are to be soldered—and the full efficiency cannot be gained unless this is done—it is advisable to mount first the terminals and crystal detector. File off the ends to which the wires are to be soldered before the variable condenser is mounted, so that any brass dust can be cleaned from the panel before there is any danger of it getting between the vanes of the condenser.

As is shown in this photograph the completed set is neat and compact and the panel presents an attractive appearance.

Connecting-up should be done as shown by the wiring diagram, and the actual position and spacing of the various wires can be traced from the photographs, though this spacing may have to be varied slightly if different makes of condenser or crystal are employed.

As already stated the connections should be soldered if possible, thus securing perfect contact. If, however, this is not possible, use a fairly soft wire of about 16 or 18 gauge, and make each joint with as large a surface area as possible in good contact. The use of square-section wire facilitates this, and it is therefore recommended.

The description of how to solder properly can hardly be given in this article, but it has so often appeared in "P.W." that this part of the work should prove easy enough, especially if the constructor bears in mind the rules for good soldering—a hot iron, clean flame, as little flux as possible, and scrupulous cleanliness of the work.

Do not forget that each joint should be wiped over with a clean cloth as soon as it is "set," and whilst still warm, to remove the superfluous flux whilst this is liquefied by the heat of the metal.

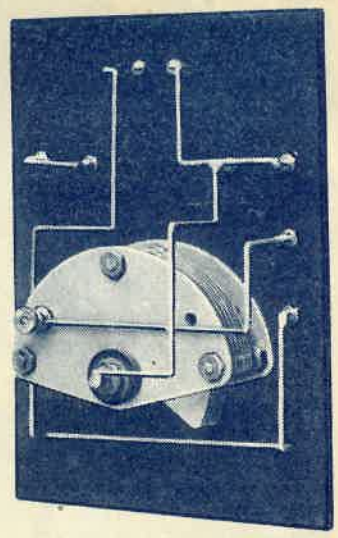
## POINT-TO-POINT CONNECTIONS.

When the connections are finished, check them over from the list of point-to-point connections, which is given separately. The set is now ready for the transfers to be fixed, and if the directions given with these are followed carefully, the appearance of the set should be all that could be desired.

To connect up for test, place the 'phones and earth-lead upon their respective terminals. The aerial lead will be placed upon either the aerial, "parallel," or the aerial "series" terminal, according to the wave-length to be received, and the coil which is plugged into the coil-holder.

For 5 X X, on the long waves, a large coil is necessary and "parallel" tuning is preferable. If your aerial is a long one, a 150 or 200-turn coil will give best results. If it is a short single-wire aerial it is sometimes advantageous to use a 250-turn coil, but as coils vary the safest plan if you are uncertain is to get a 200-turn coil for Daventry, as this is sure to tune in correctly.

Parallel tuning is obtained by placing the aerial lead on the aerial "parallel" terminal, and joining a short strip of bare wire between the "series" and "earth" terminals, so as to join these latter together. (Unless this is done, the condenser is powerless to tune the incoming signals.)



This photograph emphasises the simplicity of the wiring.

For all the B.B.C. main and relay stations a much smaller coil is necessary. The best all-round coil, suitable for all the stations on the lower band of wave-lengths, is a 50-turn coil.

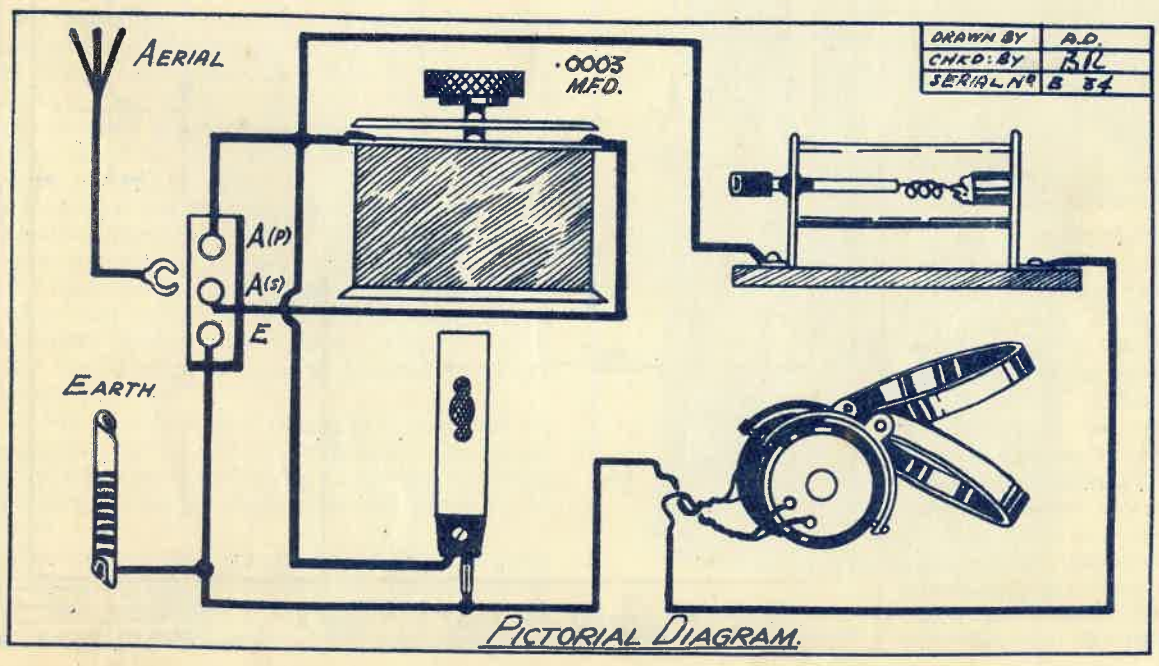
Then if the wave-length to be received is fairly high on the band (say, for instance, 450 metres), the coil is inserted, and the aerial is connected "in parallel," as explained above.

## THE TUNING COIL.

If, however, the wave-length is comparatively short, say 300 metres, the 50-turn coil will still do, but the aerial must be connected "in series." All that is necessary is to disconnect the shorting-strip between the "earth" and "series" terminals, and to place the aerial lead upon the "series" terminal. (The "parallel" terminal will thus be left without external connection.)

The advantage of a receiver like this, that will tune either in series or in parallel, is that it often saves the cost of an extra coil. By the system given here (two-aerial terminal method) the only extra component on the set is one terminal, yet there are all the advantages of a "series-parallel" switching arrangement, without the disadvantage of bad contact, which any form of switch is liable to introduce.

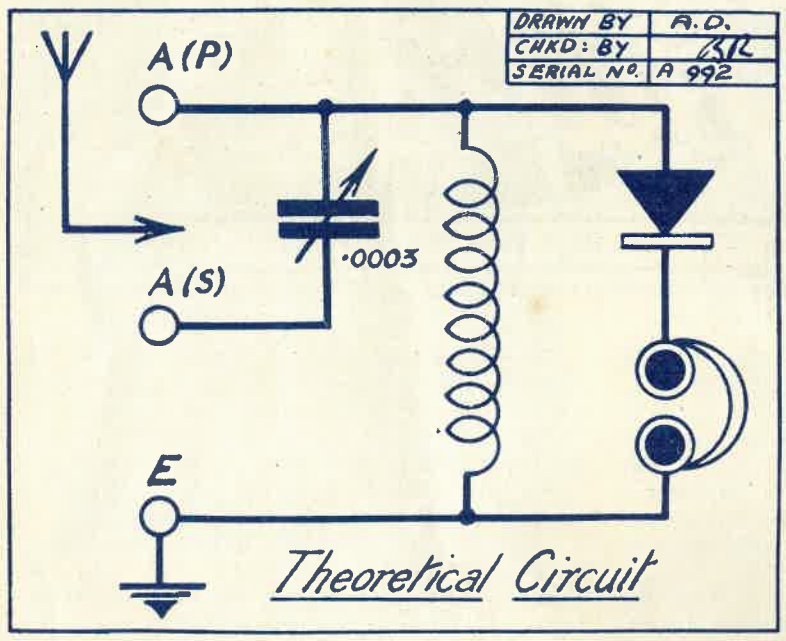
Perhaps a few final hints about components will be of help to those who contemplate making this their first venture in wireless construction. Undoubtedly the most important component on this set is the crystal detector, upon which will depend the ease and certainty of adjustment. The "Mic.-Met." detector will be found to be well worth the extra cost as compared with some of




PICTORIAL DIAGRAM.

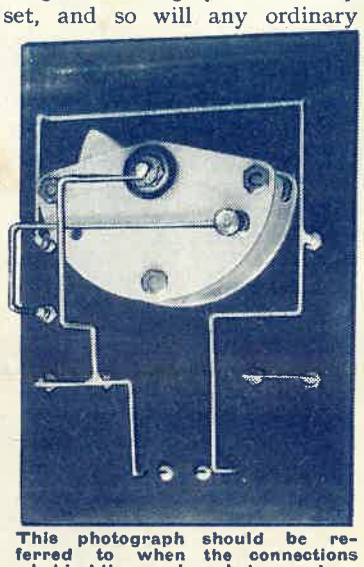
the cheaper detectors upon the market, as it is easily and accurately adjusted, and its design allows of a fine variation of pressure upon the crystal surface, which is conducive to good signals.

If desired a cheaper detector may be used, and those who prefer to try to eliminate crystal-adjustment altogether can employ one of the permanent detectors which are now so popular. To those who do not mind a little trouble to get the last ounce out of the set the type chosen will be found exactly suitable.



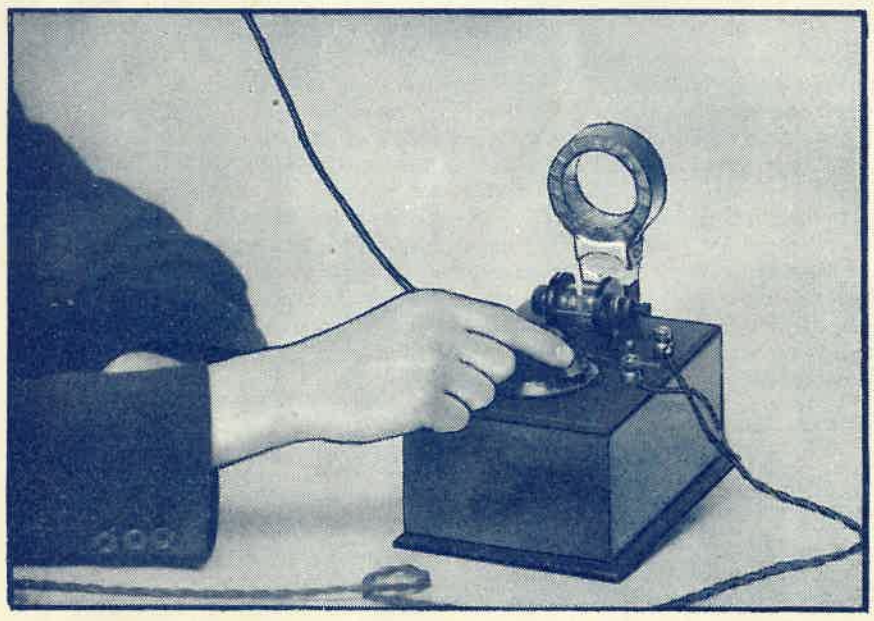

### SUITABLE COILS.

Any of the standard variable condensers of correct capacity will give thoroughly satisfactory results upon this set, and so will any ordinary plug-in coil. This may be of any of the popular varieties, such as basket-coil, honeycomb-type, or the easy-to-make-at-home spider-web coil. Used with a crystal-set there is very little to choose between them for efficiency, and the popular belief that you can't beat a basket coil is probably well supported by common experience.



**This photograph should be referred to when the connections behind the panel are being made.**

If there is a final refinement which might be tried by those who are anxious for the maximum results, it is the inclusion of a .002 or a .001 fixed condenser, to be connected across the telephone terminals. Occasionally this effects an extra tone which is worth while, but as this is not always the case, it has not been provided for in the list of components.



**The finished plug-in Crystal Set being tuned in to Daventry.**

Those who happen to have a suitable condenser should certainly try it as suggested, but as a rule the little set will be found quite capable of holding its own without this extra expense.

**POINT-TO-POINT CONNECTIONS**

**Aerial parallel terminal to moving plates of variable condenser, one side of crystal detector, and one side of coil holder.**

**Aerial series terminal to fixed plates of variable condenser.**

**Earth terminal to other side of coil holder and bottom phone terminal.**

**Top phone terminal to other side of crystal detector.**

For the benefit of those who would like some assistance as to the best type of crystal to employ, the following remarks upon crystal rectification are given :

A very large proportion of the crystals now sold are based on galena, which is used in connection with a cat's-whisker. The average "-ite" crystal is of this type, and it is very sensitive to signals which are weak. If, therefore, this set is to be tried (in conjunction with a good aerial and earth) at a considerable distance from a broadcasting station—say, at 30 miles from a main station, or about 10 miles from a relay station—a detector of this class which employs a cat's-whisker is a very good one to use.

Besides being sensitive to very weak signals, galena has the advantage of being able to deal quite well with strong signals. Listeners who live in cities close to a broadcasting station—for instance, Birmingham, Manchester, Glasgow, or London—will find it excellent for their purpose; but, nevertheless, it is true that other types of crystal detector are quite as good as galena in their ability to handle strong signals.

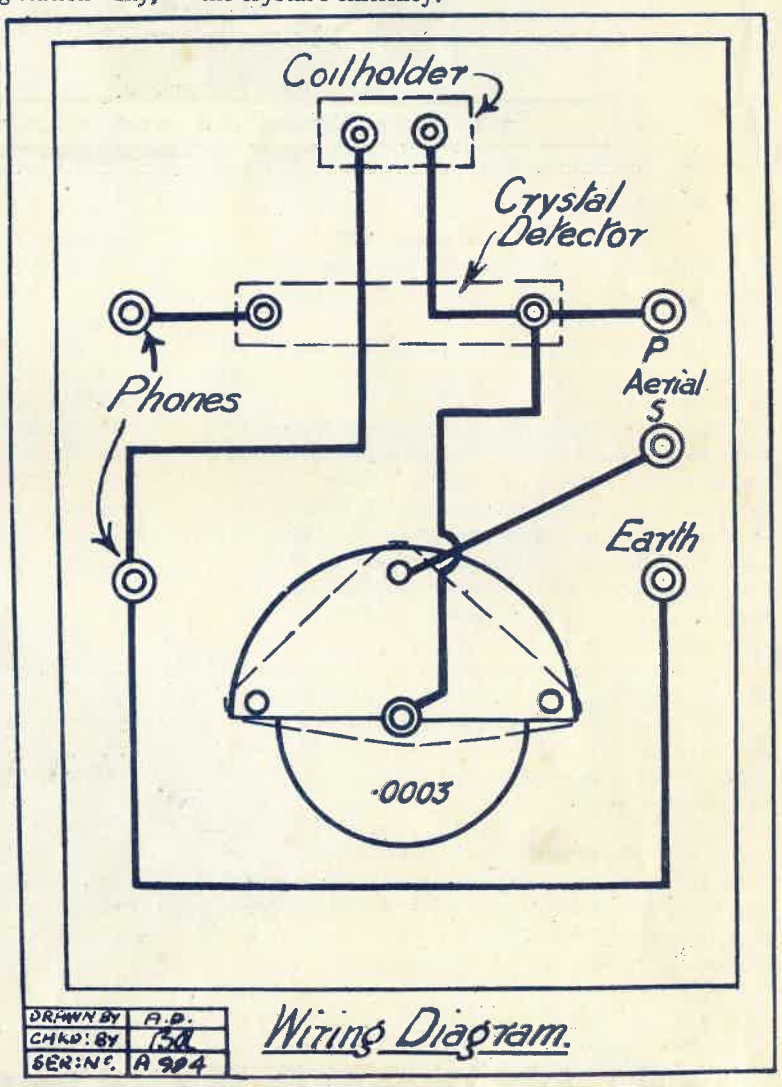
There is, for instance, the Perikon type of detector. This detector is formed by the contact of two dissimilar crystals. It is not so sensitive to weak signals as the galena type, but it is capable of functioning very well indeed with strong signals, such as those obtainable with sets situated within a mile or so of the broadcasting station.

There is another advantage possessed by a Perikon detector which, in some instances, will justify its selection in place of one of the galena detectors. The advantage lies in the fact that a Perikon detector, once it has been adjusted, will maintain its sensitive rectifying contact for several days on end. In fact, it is not uncommon for one of these detectors to require no readjustment for several weeks.

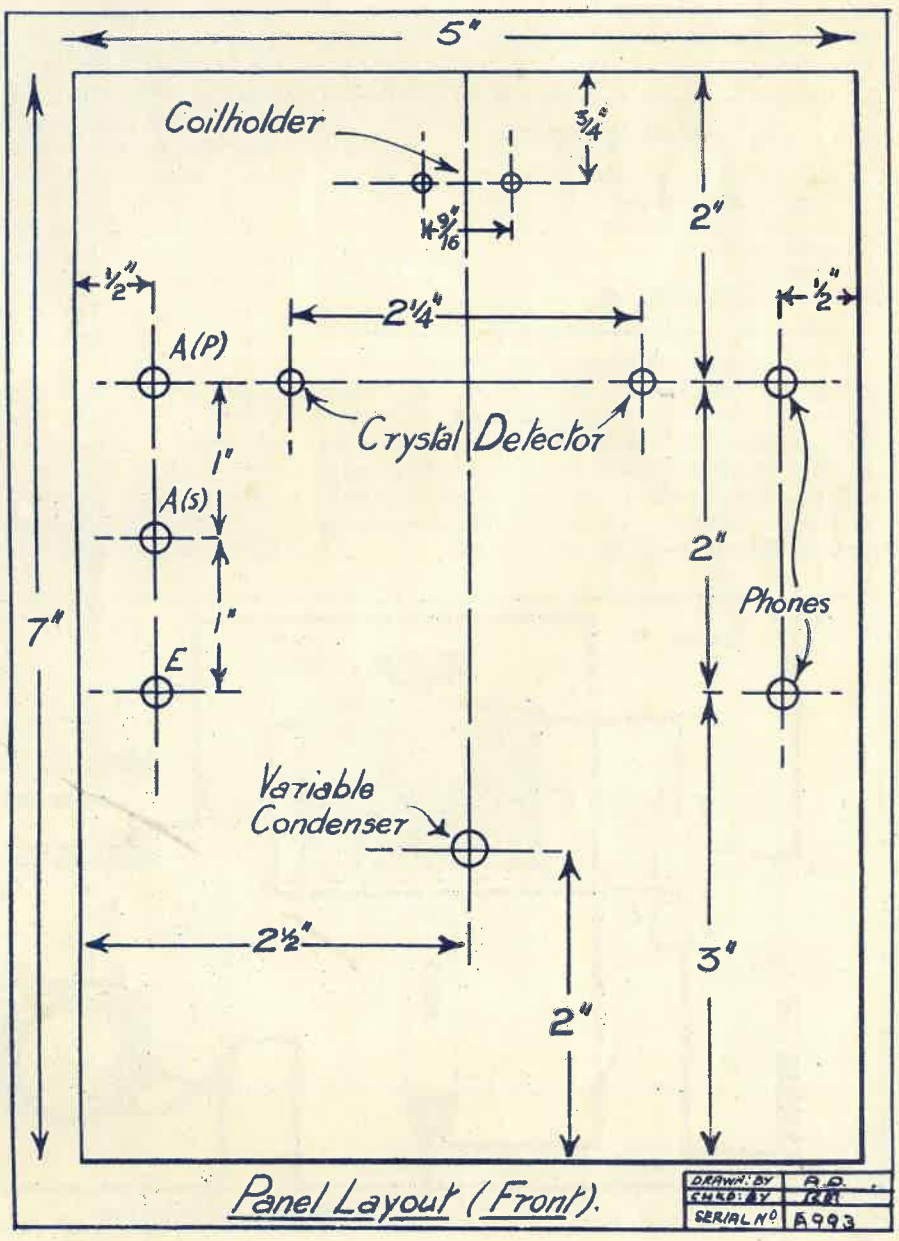
One other advantage is that as the minerals used in this combination are of a far less delicate nature than galena, they do not tend to lose their initial sensitivity as easily as galena does.

Many of the permanent detectors now on sale employ two different crystals, or else a crystal with a cat's-whisker sealed on its surface. In general, therefore, this type of permanent or semi-permanent detector will give thoroughly satisfactory results for those who live quite close to the broadcasting station. In many cases the results will actually be better than if the sensitive galena-cat's-whisker contact were used, because the Perikon detector is able to handle large inputs to better advantage than a crystal which is actually more sensitive but less robust in operation.

Finally, a few hints upon the efficient use of crystals will, perhaps, not be out of place. To maintain galena crystal (and this includes practically any of the 'ite type) in tip-top condition, it should be used in a glass or celluloid-enclosed detector. It is not so much the dust in a room, but the impure atmosphere to which it is generally exposed when employed in an open detector, that operates against the crystal's efficiency.




With an ordinary galena crystal the nature of the wire of which the cat's-whisker is made has very little effect in the resulting reception, provided the wire is made from some non-corrodible metal or alloy. Platinum or gold cat's-whiskers are therefore not absolutely necessary to good reception, when cat's-whiskers made from non-corrodible alloy can be obtained for a fraction of the price.



## A ONE-VALVE TRANSFORMER-COUPLED L.F. AMPLIFIER.

This one-valve amplifier is quite as simple to construct as the plug-in crystal set, and not only can it be used with that receiver, but it can be coupled to practically any type of set, crystal or valve. Moreover, it has been specially designed with this end in view, and certain terminals have been duplicated in order to facilitate its connection to existing valve sets and so that existing batteries can be used.

An L.F. amplifier is employed to increase the loudness of signals and not to increase range of reception, although, incidentally, it will do this as well to some extent. But where the signals received on a crystal set are rather faint this little instrument will bring them up to a very comfortable strength. Generally speakng, two stages of L.F. amplification are necessary in the case of a crystal receiver if it is desired to operate a loud speaker comfortably, even in the case of the local station. However, coupled to a one-valve set this amplifier will work a large loud speaker within moderate ranges of reception.

### THE COMPONENTS REQUIRED.

The circuit employed is quite straightforward, as the theoretical and pictorial diagrams show. The terminals marked "input" are connected to the telephone terminals of a receiver and the energy from that source is passed through the L.F. transformer on to the grid of the valve. The magnified energy is then taken from the plate of the valve to the telephone receivers or loud speaker. Constructors should have no difficulty in following this simple cycle of operations through on both the above-mentioned diagrams.

Very few components indeed are required, although for the purpose of easy reference a complete list is appended in table form. A thirty-ohm filament rheostat is recommended as this will allow greater latitude in respect of valves used. Any good L.F. transformer can be employed; it is not essential that the one specified be used, although it should be noted that the panel drilling diagram gives measurements for the Peto-Scott component. These would have to be modified in the event of the introduction of another make.

The panel drilling should be carried out carefully, for ebonite is a somewhat brittle material. Metal-working drills should be used, and the drill rotated rapidly with a fairly light application of pressure.

**LIST OF COMPONENTS.**

| | s. | d |
|---|---|---|
| 1 Panel and box, 5 x 8 x ¼ in. .. .. | 7 | 6 |
| 1 Max.-amp. L.F. transformer (Peto-Scott.) .. | 19 | 6 |
| 1 Set flush-mounting valve sockets (Peto-Scott.) .. .. .. .. .. .. .. | 0 | 6 |
| 1 Precision rheostat (30 ohms.) .. .. .. .. | 3 | 0 |
| 15 Terminals .. .. .. .. .. .. .. | 1 | 10½ |
| Wire, screws, transfers, etc. .. .. .. .. | 1 | 0 |

Pencil marks are to be avoided, for unless such are very carefully removed they are apt to cause leakages. Marking out can be accomplished with the assistance of some sharp-pointed instrument, the marks taking the form of small crosses to centre the various holes. If the panel is drilled from the front any chips which are caused by "breaking through" will not spoil the appearance of the panel surface.

### DRILLING THE PANEL.

If possible the terminal and valve socket holes should be threaded, or tapping-sized holes drilled and the terminals forced in and made to cut their own thread. This makes for greater permanency than relying on the nuts to hold them in position.

If no drill large enough to bore the filament rheostat mounting hole is on hand it will be necessary to employ the largest one available, and to ream the resultant hole out to the required size with a reamer or the tang of a file.

After the panel has been drilled the various terminals and components can be mounted. Then the wiring can be tackled. Here the constructor will have many things to assist him. He has several back-of-panel photographs which show the actual routes taken by the various leads in the original model, a wiring diagram in addition to theoretical and pictorial diagrams, and, finally, there is the list of point-to-point connections. Square section tinned copper wire should be used, as this material tends to form neater leads. Right-angled bends throughout and no lazy makeshifts is the golden rule. Ample separation between the various connecting wires must be allowed to prevent the possibility of short circuits occurring.

It will be noticed that two pairs of terminals are connected together without being taken to any point in the actual amplifier circuit. These are not errors but serve a definite purpose, as will presently be shown.

Needless to say, we strongly advise the constructor to solder all his connections and not to form loops in the ends of the wires and screw these under the various nuts. Soldering is quite a simple operation and does not take much longer. A hot, clean iron and well-cleaned surfaces on the points to be soldered together are the two main requirements. After the leads have been soldered to the terminals the nuts holding these items in position should be re-tightened, for the application of heat tends to loosen them.


**The One-Valve L.F. Amplifier ready for use.**

Now the Peto-Scott transformer must be connected up so that its OS terminal goes to the grid valve socket, but better results obtain in some makes when the IS terminal goes to the grid point of the valve holder. Unless maker's instructions are provided it may therefore be necessary to experiment with a reversal of the transformer secondary connections should another make be employed. In some instances transformer terminals are marked plainly where they are to go; such as "grid," "G.B." (grid bias), etc.—a typical example being that excellent component, the Ferranti L.F. transformer.

Subsequent to the wiring, every scrap of surplus flux and every trace of metal, ebonite or other dust should be carefully removed, after which panel transfers can be affixed and the instrument is ready for use.

When coupled to a crystal set the following connections are necessary. 'Phone terminals of crystal set to those on the amplifier marked "input." Now, ignoring all the other terminals on the left-hand side of the amplifier, an L.T. battery in the form of an accumulator suitable for the valve which is to be used to the right-hand L.T. terminals. An H.T. battery of about 72 volts should be connected by its positive to the right-hand H.T. plus terminal nearer the output or 'phone terminals, and by its negative to the right-hand H.T. negative terminal. *H.T negative and L.T. negative should be connected together by means of a short piece of wire.*

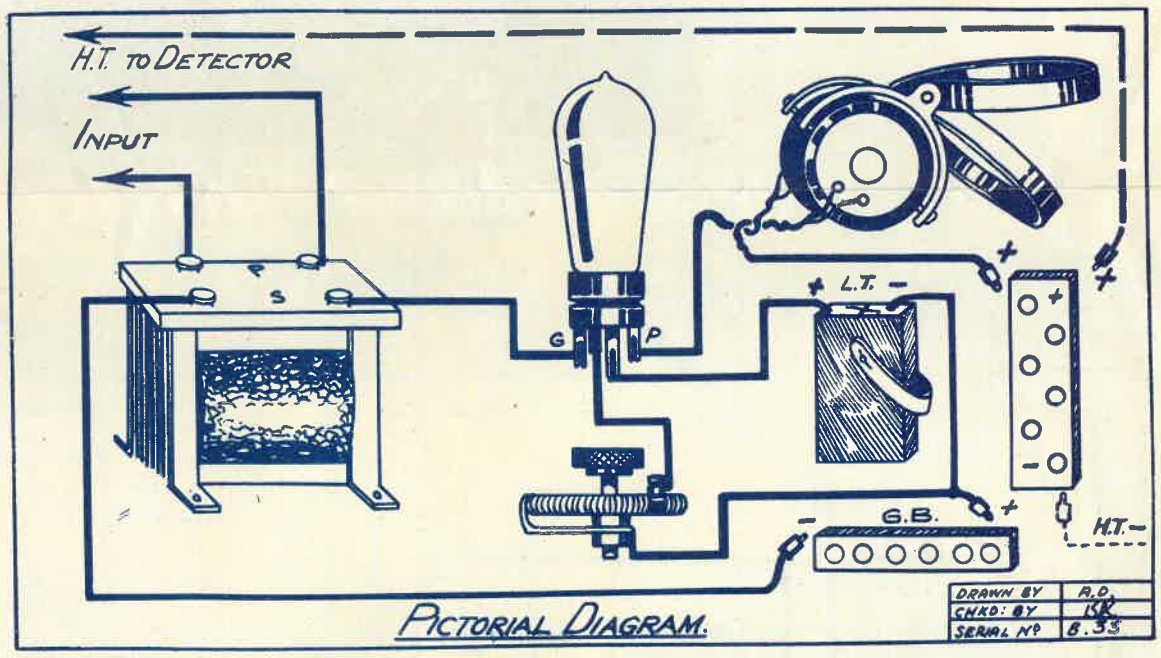
Grid bias will hardly be required, so the G.B. terminals can be shorted by joining them together with a small length of wire.

Sometimes results are improved by connecting one of the input terminals to the earth terminal of the crystal set, an expedient which it is very easy to try. Any type of general purpose or L.F. valve can be used with this amplifier when coupled to a crystal set.

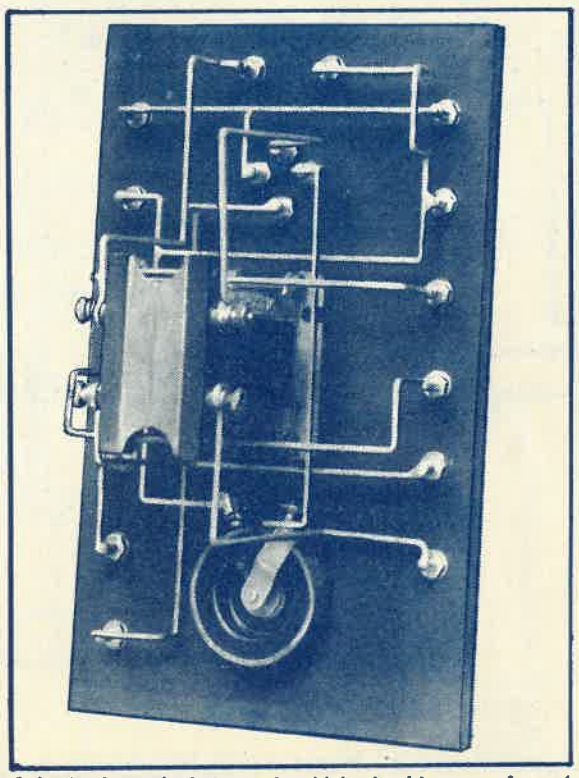
When the instrument is coupled to a valve receiver the following points should be noted. The batteries should be removed from the set and coupled to the right-hand terminals of the amplifier, the battery terminals of the set being joined to the corresponding terminals on the left-hand side of the amplifier. The 'phones of the receiver go to "input" as in the case of the crystal set. No connection between H.T. negative and L.T. negative should be made additionally to that which exists *inside* the receiver. This is a very important point.

### HOW TO USE THE AMPLIFIER.

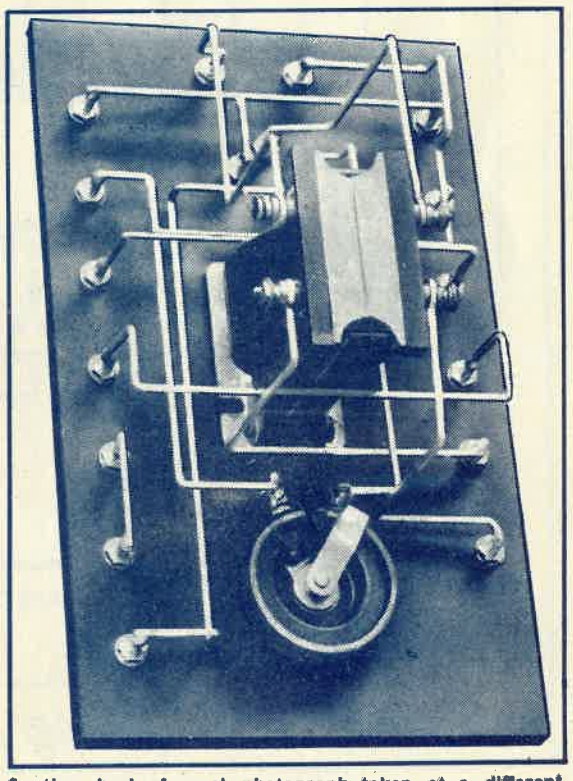
Grid bias up to 4½ volts will be needed if the amplifier is the first stage of L.F. amplification and up to 9 or so if it is the second. Special tapped grid bias batteries can be purchased at any wireless store. They will last for years without renewal. Now we said that the batteries should be connected up to the right-hand amplifier terminals, but constructors will notice that there are two H.T. positive terminals provided. Therefore, two H.T. positive wander plugs will be necessary.




The top H.T. positive terminal serves the receiver and the bottom one the amplifier. Thus different voltages can be applied to the two stages. The amplifier will require a higher voltage than the receiver—it may want anything up to 100 or a few more volts. A small power valve of the Cossor Stentor or Marconi D.E.6 is suitable whether the amplifier is first or second L.F. The 30-ohm filament



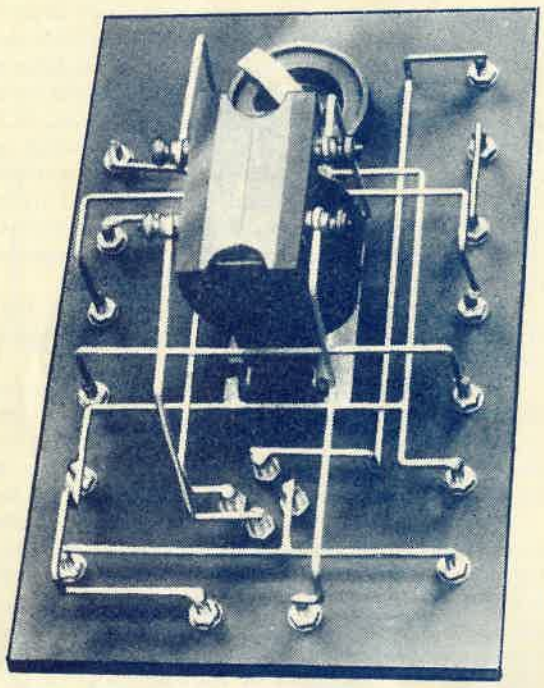
**A back-of-panel photograph which should prove of great assistance during the work of wiring.**



**Another back-of-panel photograph taken at a different angle so that every lead and connection can be seen.**

rheostat will allow ample compensation for slight discrepancies in the voltages of the receiver and amplifier valves.

When the amplifier is used with a valve set it



**This photograph should be studied in conjunction with the wiring diagram given below.**

is always worth while trying the effect of reversing the leads to the input terminals; sometimes a great improvement results. If, perchance, the valve receiver has no telephone condenser, a ·001 or ·002 mfd. fixed condenser connected across these points may also prove of value.

### H.T. AND GRID BIAS.

Two amplifiers, each constructed exactly in accordance with the foregoing instructions, can be used together, as the separate H.T. plus terminals and grid biases provided would enable each to be operated in a perfectly correct manner.

The extra H.T. tapping should always be used when the amplifier is coupled to a valve receiver, and should not be shorted to the other one and one universal H.T. voltage used.

And, by the way, 60 volts H.T. is not really enough for an L.F. amplifying valve. If the constructor already has a good H.T. battery of this voltage in use, another can be placed in series with it. Remember that the resulting voltage when two batteries are placed in series is equal to the individual voltages added together.

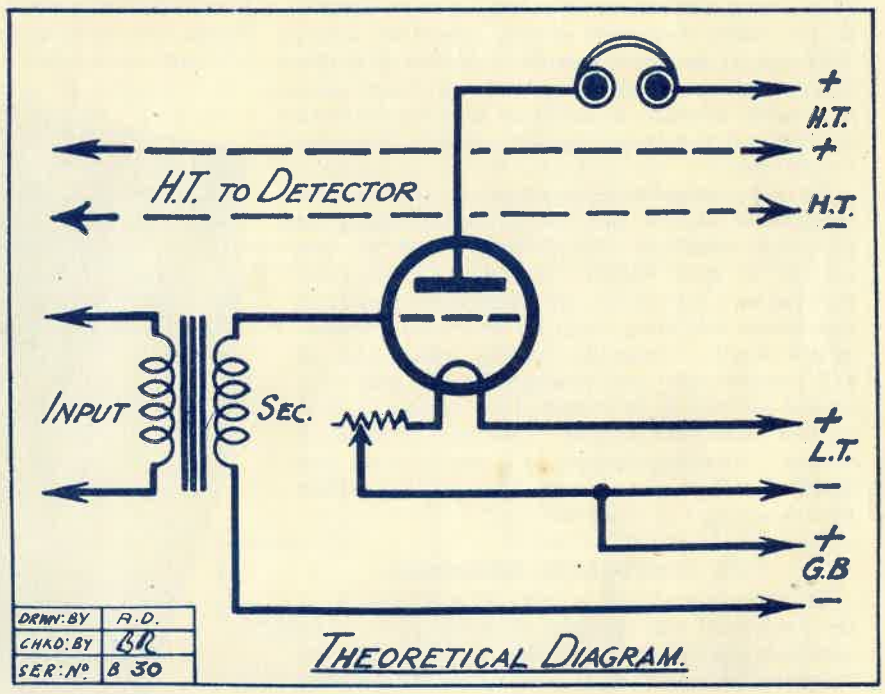
Supposing, for sake of example, the constructor is building this one-valve amplifier to use with a one-valve set, and that he already has a good 60-volt H.T. battery coupled to the latter instrument. He should purchase another H.T. battery of, say, 30 volts and connect this latter by its negative to the positive of the 60 volts. Then there remains one positive and one negative end which can be regarded as the terminals of one single battery. H.T. plus tappings can then be taken from any point on either battery.

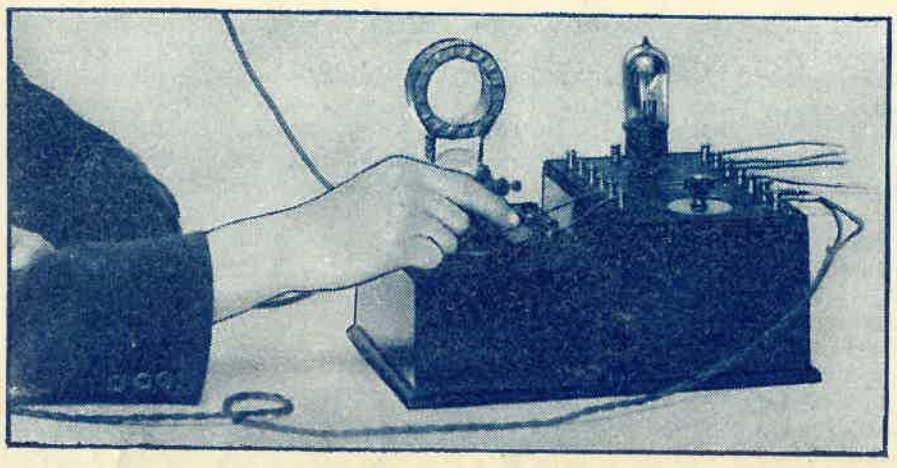
The 1½ volt point on the 30 volts will represent 61½, and the 4½ point 64½, and so on.

An L.F. amplifier, more especially if a small power valve is used, takes a fair amount of H.T. *current*, or at least H.T. consumption goes up rather considerably on the addition of the instrument to a valve set, so that it is advisable to purchase a fairly substantial H.T. battery. One of triple capacity, as sold by Siemens, Ever-Ready, G.E.C., etc., is rather expensive, but it is a good investment. When 2 L.F. are used an accumulator H.T. battery is worth considering, as is also a unit operating from electric light mains.

If this amplifier is followed by another amplifier employing a resistance-capacity coupling, the special resistance coupling valve should be used in the former instrument.

The last valve in a set should always be a power valve.



**The one-valve amplifier coupled up to the plug-in crystal set.**

**POINT-TO-POINT CONNECTIONS.**

**Top and bottom INPUT terminals to the IP and OP respectively of the L.F. transformer. IS of the L.F. transformer to the negative grid bias terminal. OS to the grid socket of the valve holder. Positive grid bias terminal to the two negative L.T. terminals and to one side of the filament rheostat. Other side of the rheostat to one filament socket of the valve holder. Remaining filament socket of the valve holder to the two positive L.T. terminals. The two negative H.T. terminals on the opposite sides of the panel are joined together Similarly, the positive H.T. terminal on the right-hand side and the one exactly facing it on the left are connected together. Plate socket of the valve holder to the bottom loud-speaker terminal. Remaining loud-speaker terminal to the positive H.T. terminal marked " +2."**

Finally, we do not think constructors can fail to obtain anything but satisfaction from this L.F. amplifier, and, once constructed, a stage of amplification is always available for use with almost any set that requires a "boost up" to work a loud speaker properly, or to operate telephone receivers loudly and clearly.