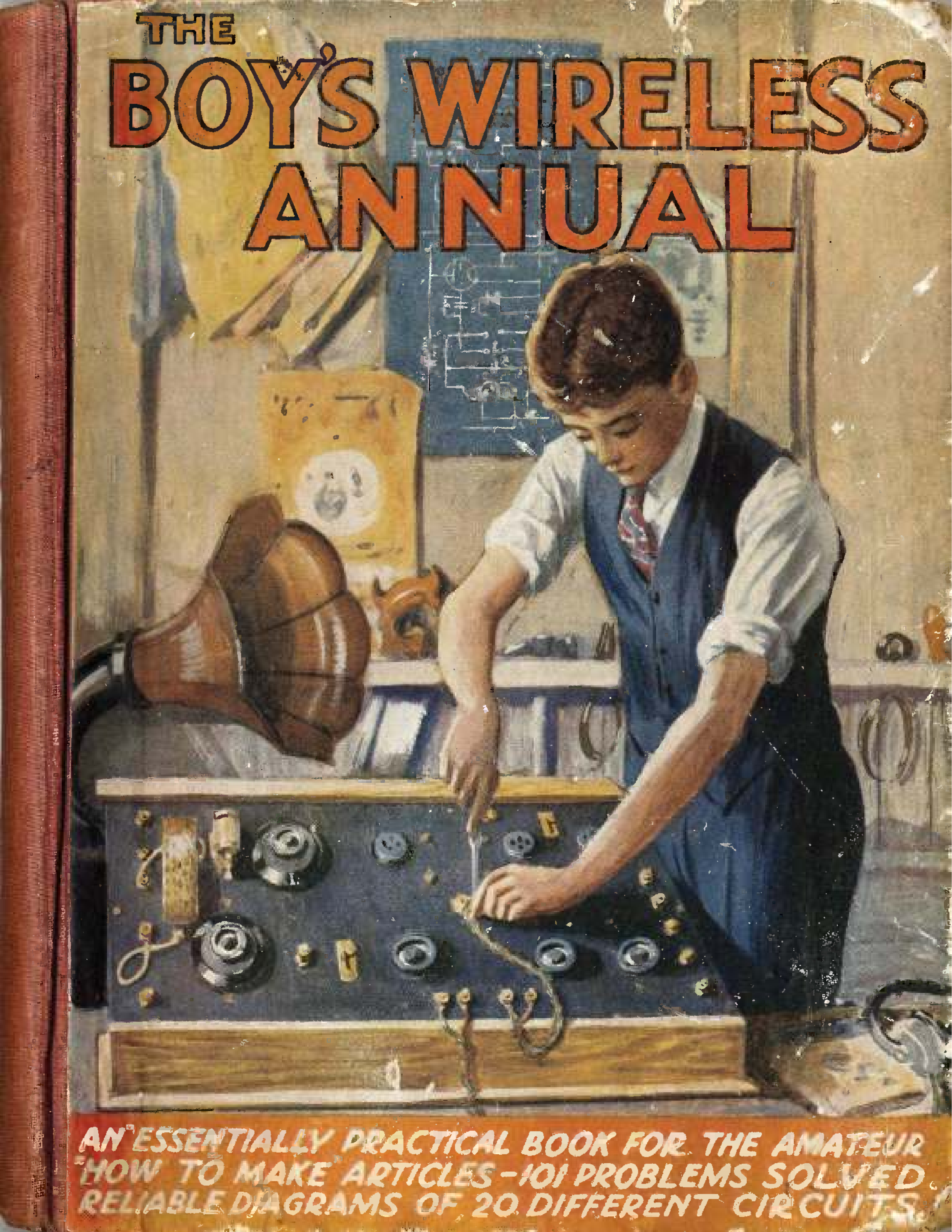
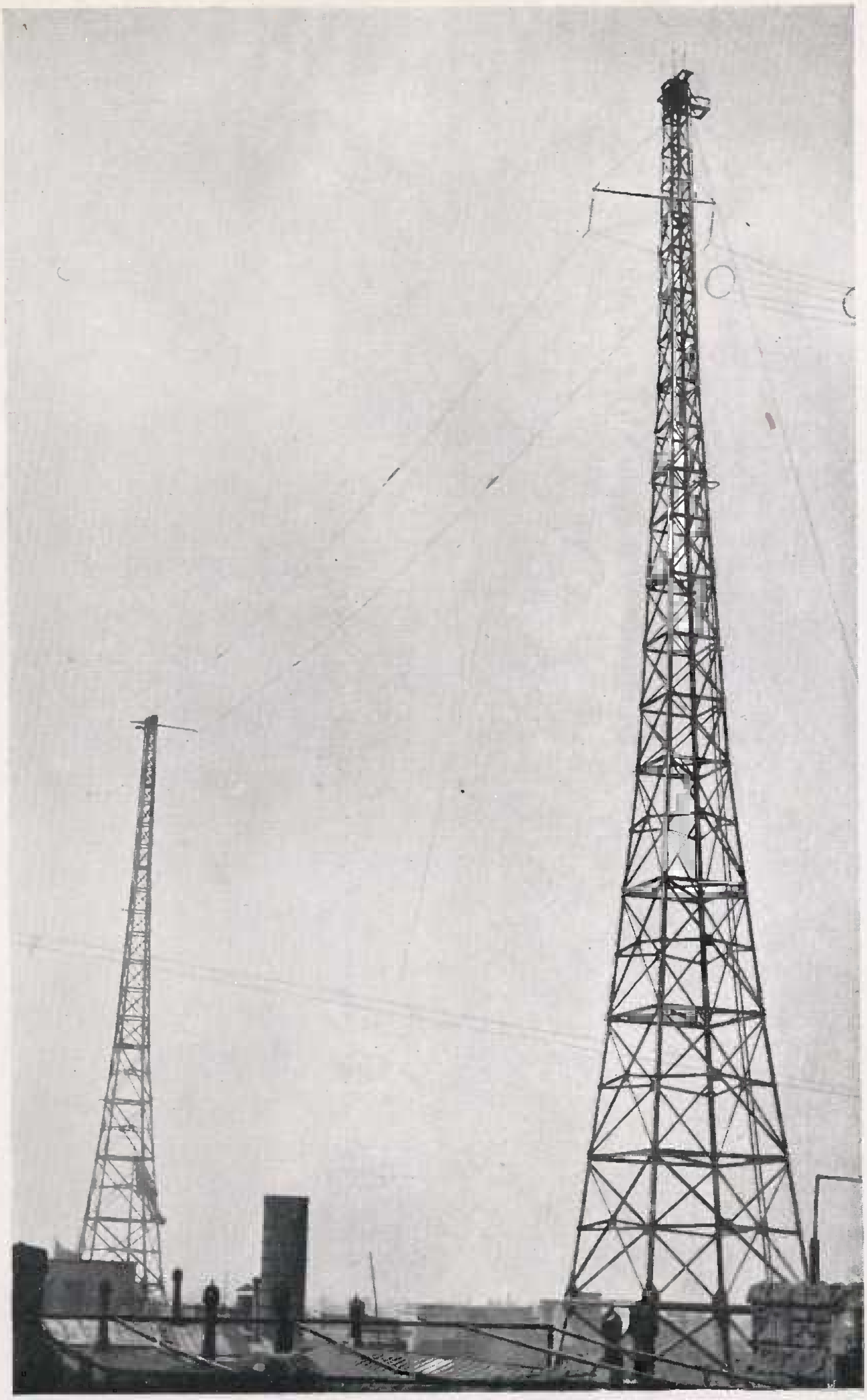

THE BOY'S WIRELESS ANNUAL
AN ESSENTIALLY PRACTICAL BOOK FOR THE AMATEUR
"HOW TO MAKE" ARTICLES—101 PROBLEMS SOLVED
RELIABLE DIAGRAMS OF 20 DIFFERENT CIRCUITS

THE BOYS' WIRELESS ANNUAL



2LO's Aerial.

A good view of 2LO's aerial, situated on the roof of a big store in the centre of London. The tower-shaped masts that support the aerial are 125 feet high, and the transmitting apparatus is connected by special underground cables to the B.B.C. headquarters at Savoy Hill, where the concerts actually take place.

THE BOYS' WIRELESS ANNUAL

Edited by

MICHAEL EGAN

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INTRODUCTION

THREE years ago, when the first British broadcasting tests were carried out from Marconi House, London, the total number of amateurs who listened-in from various parts of the country did not exceed 1,000. To-day the British Broadcasting Company transmits regular daily programmes, from more than twenty stations, to audiences numbering several millions. This swift and wonderful advance in the development of broadcasting gives some indication of the appeal which wireless, as a hobby, makes to all classes of the community. However enjoyable the programmes themselves may be, it is certain that broadcasting could never have achieved such widespread popularity in so brief a period if it were not for the real pleasure that so many amateurs derive from the construction and operation of sets. For hundreds of thousands of amateurs the practical side of wireless constitutes the chief attraction that the subject has to offer.

It will scarcely be denied that wireless as a hobby has no equal. It is the only hobby that can be indulged at any time in any place. There are wireless signals "on tap," as it were, in the ether at every moment of the day and night. During the long winter evenings the practical amateur can spend many a happy hour at his work-bench, increasing the range of his receiver, trying out circuits, repairing old components, or constructing new ones, etc. In the summer time he can take his receiver out of doors, and if it is designed for portable use he can conduct a number of interesting experiments with different types of aerial under different conditions.

Wireless presents a field of activity that is practically limitless in its range. In the first place, there are countless ways in which the component parts of a receiver can be connected together. One circuit will give best results under one set of conditions, while another will be found more suitable under a different set of conditions, and so on. New circuits, moreover, are being devised daily by experts and enterprising amateurs. At the present time there are hundreds of different types of circuit in constant use, and the number increases daily. This aspect of the subject makes a very strong appeal to the average amateur. Secondly, there is literally "no end" to the transmitting stations from which signals can be picked up. Prior to the development of broadcasting the wireless amateur who explored the ether for new stations had to content himself with Morse code telegraphic signals from distant ships at sea; telephonic signals were rare. Nowadays, however, practically every civilised country in the world possesses a number of broadcasting stations which send out regular programmes of music and speech. In addition, there are hundreds of amateur transmitting stations, scattered all over the world, which can be heard chattering away at all hours of the day and night.

From the point of view of variety of reception the British amateur is indeed enviably situated in comparison with his brother amateurs in other lands. Not only is the broadcasting service by the B.B.C. extremely efficient, but Great Britain contains a larger number of broadcasting stations, in proportion to its size, than any other country in the world. The British amateur is also particularly well situated in the geographical sense, with Europe on one side and America on the other. Although the distance between England and America is relatively great, it must not be forgotten that wireless waves travel much more easily over sea than over land. Thousands of amateurs in this country listen-in to American transmissions as regularly as to those sent out from British stations. Many amateurs in fact, make a point of listening-in to stations in Australia, New Zealand, and other distant countries at definite hours each day. Amateurs who possess transmitting licences are constantly making new friends for themselves in foreign lands, *viâ* the ether. It is common practice for "transmitting amateurs" in different countries to exchange greetings with one another at an appointed hour each day. There is nothing to prevent the mere "receiving amateur," of course, from listening to these trans-oceanic chats—provided he equips himself with a suitable apparatus for the purpose.

It must not be imagined that long-distance reception can only be undertaken successfully by those who possess a high degree of technical knowledge. A certain amount of technical knowledge is necessary, of course, but not more than can be acquired by any enthusiast of average intelligence in quite a brief period; of far more importance is *practical day-to-day experience* in the handling of sets and components. It is also wrong to imagine that the construction of a wireless receiver requires exceptional mechanical skill. As a matter of fact, for the purpose of building up a receiver out of component parts the only skill demanded of the would-be constructor is the ability to drill a few straight holes in an ebonite panel. A small drill, with the necessary "bits" for making holes of different sizes can be purchased for about 5*s*. The only other tools required for the construction of any of the receivers described in this book are a screw-driver, a pair of cutting pliers (or pincers) and a soldering outfit. Of this aspect of wireless it may truly be said: "Nothing could be simpler."

FACTS ABOUT AERIALS

The aerial is undoubtedly the most important part of a wireless receiving outfit. A bad aerial renders the best receiver useless. The amateur who wants to get good results will make a point of erecting the best aerial that circumstances permit.

THE simplest form of receiving aerial is a single wire stretching up out of the earth. The waves that flow out from a transmitting station strike this wire and vibrate it. If the waves are long ones, the receiving wire should be long, and if the waves are short ones, the receiving wire should be short. If the receiving wire is either too long or too short for the particular waves that happen to strike it at any moment, a certain amount of energy is consumed in overcoming the resistance it offers to being vibrated, with the result that signals are weakened proportionately. The receiving wire should therefore be neither too long nor too short, if *best* results are to be obtained. The Postmaster-General's regulations limit the total dimensions of amateur aerials to 100 feet, and, for broadcast reception, every inch of this distance should be used if possible.

The single vertical wire, though the simplest, is not the most efficient form of aerial. A bent wire gives much better results than a straight one. Best results are given by a wire which is bent at right angles, the horizontal part being made much longer than the vertical part. Nowadays, it is customary to refer to the horizontal part as "the aerial," the vertical part being regarded merely as a piece of wire for connecting "the aerial" to the receiver. But, viewed in this way, it is difficult to understand why there should be another wire running from the receiver to the earth. In order to appreciate the necessity for having an earth connection, therefore, the aerial should be regarded as consisting of a wire that stretches up from the earth, whether it be a bent wire or a straight one.

In order to tune an aerial to vibrate in sympathy with waves of different lengths, the aerial is connected to a variable coil or a variable condenser, or both. The other essential parts of a receiving equipment are a rectifier (crystal or valve) and telephones. For the sake of convenience, the aerial tuning coil and aerial tuning condenser are usually contained in the same box that contains the detector; the telephones are also connected to two terminals on the outside of this box.

The reason for connecting the aerial to the earth can be explained by comparing the former to a long needle. If you want to produce physical vibrations in a long needle, you can do so best by jamming one end of it into some firm substance, such as a wooden table. The end of the needle must be held *tightly* by the table, moreover, if strong vibrations are to be produced. If the connection is loose, the needle will just move backwards and forwards two or three times and then come to rest. Similarly, a long aerial must be firmly connected to earth before it can be vibrated satisfactorily, and, since the vibrations set up in it are electrical vibrations, the contact it makes with the earth must be a good electrical contact. That is to say, the ground end of the aerial (commonly known as the "earth lead") must be cleaned thoroughly and must be connected firmly to some metal object (also cleaned thoroughly) which is in contact with the solid earth.

The water tap usually offers the most convenient "earth," though it is sometimes more convenient to take the earth lead through the window of the room in which you are receiving to the ground outside. When this is done, the earth lead may be joined to a large sheet of tin, or a length of wire netting, which should be buried about 3 feet in the ground. Suitable earth netting can be obtained from any dealer at a very moderate cost. Whatever kind of "earth" be employed, however, a clean and firm connection *must* be made with the lead from the receiver box. It is advisable to solder the joint—though, in the case of the water tap, a good metallic connection may be effected by means of a strong metal clamp. The earth lead should be kept as short as possible.

A good earth connection is an *essential* factor in receiving wireless messages. If your earth connection is bad, you will hear *nothing*, even if your receiver is connected to the best aerial it is possible to erect. There is, however, another very important factor. Your aerial must be perfectly free to vibrate. You know that if you touch a vibrating string with your finger, or with a pencil or a book, it will cease to vibrate. You will "deaden" the string. The same thing will happen to your aerial if you do not keep it free from houses, trees, walls, etc. It will be deadened. The currents set up in it, instead of flowing to earth *viâ* the receiver box, will flow *direct* to earth *viâ* the object with which the aerial makes contact. Now, ropes and masts, if they touch the aerial wire, are also likely to let the received currents leak away to earth. In the case of an outdoor aerial, therefore, the wire must be prevented from coming into contact with any of the "tackle" used for supporting it. Fortunately, there are certain substances which do not allow electric current to flow through them, such as rubber, glass, porcelain, ebonite, etc. By joining the aerial wire to one end of a strip of rubber, for instance, the aerial may be held in position by a rope that is fixed to the other end of the rubber. In this way the wire and the rope are effectively separated from one another, the rubber preventing any electricity from flowing from the former to the latter. This is known as "insulating" the aerial. It is not sufficient, of course, to insulate the aerial at one point; an insulating block must be inserted at each end, and the down lead must be protected suitably at its lower end.

It is usual to conduct this wire through the window of the room in which the receiver box is situated. Though not essential, it is advisable to make a permanent fixture here. In either case, the wire itself *must* be kept free from contact with the framework of the window or the adjacent wall. As a temporary arrangement this can be effected by joining a short length of rubber-covered wire to the lower end of the down lead, raising the window a fraction of an inch to enable the former to pass in to the receiver. As an alternative to this, the bare aerial wire may be conducted through a hollow glass (or ebonite) tube, the latter being held in position by the weight of the window. Neither of these methods, however, is certain to give permanent satisfaction. Fig. 1 shows how a firm connection can be

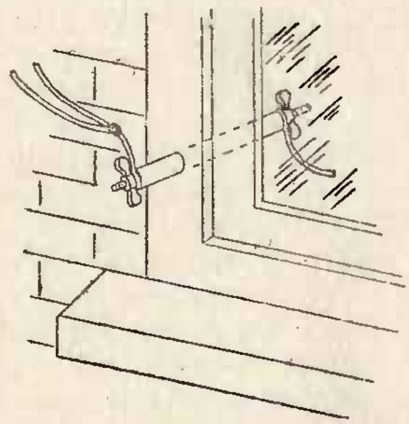


FIG. 1.

secured by means of a brass rod which passes through an ebonite tube; each end of the tube is fitted with a terminal, the inside wire being joined to one and the outside wire to the other. During very wet weather, however, a tube of this kind is liable to give trouble. Water is not an insulator—in fact, it offers a very easy path to electricity—and when the tube and the wall to which it is fitted become damp, they enable the received currents to leak away to earth. This can be prevented by using cowl insulators, patterns of which are shown in Fig. 2.

With regard to the aerial itself, the horizontal wire should be as long and as high as the restrictions of the Postmaster-General and your next-door neighbour allow. If you can obtain a horizontal span of 60 feet, you will be able to erect a fairly satisfactory single-wire aerial, though it will be advisable to use two wires if the space at your disposal is more limited. A double-wire aerial consists of two parallel horizontal wires, each of which is fitted with a separate down lead. The horizontal wires should be spaced at a distance of about 5 feet apart, and the down leads should be joined together at their lower extremities before being conducted through the "leading-in" tube as a single wire.

Whether a single wire or a double wire aerial be used, the down lead (or leads) should be taken from the *centre* or from *either end* of the horizontal wire (or wires), thus giving the aerial the shape of a "T," or an "inverted L," respectively. Of these two types of aerial, the latter is the more popular among amateurs, partly because of its convenient shape, and partly because of its "directional" characteristic. The horizontal part of the aerial is slung from the roof of the house to a mast at the end of the garden, so that the down lead dangles conveniently in front of the window of the room in which the receiving instrument is kept. Moreover, if the garden is sufficiently large to allow a choice of site for the mast, it may be possible to erect the aerial in a position which makes it particularly sensitive to signals coming from a certain transmitting station—the nearest broadcasting station, for instance. This is due to a special characteristic of the "inverted L" aerial.

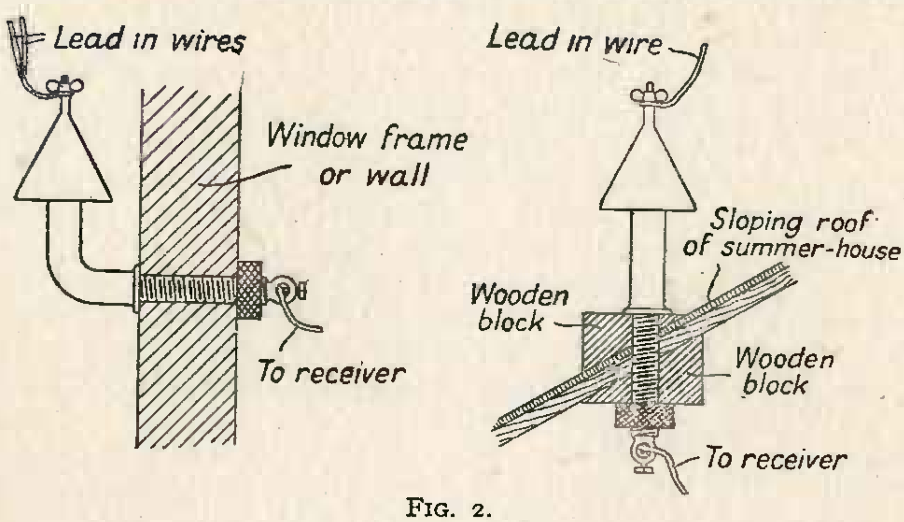


FIG. 2.

Instead of a single-wire aerial, a double-wire aerial may be used (see Fig. 3). This will be slightly more efficient than the single-wire aerial for long wave reception, though it will not offer any advantages over the latter for the reception of broadcast signals. Assuming that you have unlimited space at your disposal for the erection of an aerial, the problem that confronts you may be expressed in the question: Do you wish to receive broadcast signals only, or do you wish to receive long wave signals as well? Remember that long wave signals are nearly all Morse code signals. You will certainly be able to hear the high-power stations of the world flashing messages from continent to continent, and you will hear battleships of practically every navy in the world talking to their home bases from the high seas. But these messages will be sent in the Morse code, and in many cases their texts will be transposed into some secret code, so that even though you know the Morse code, you would still be unable to

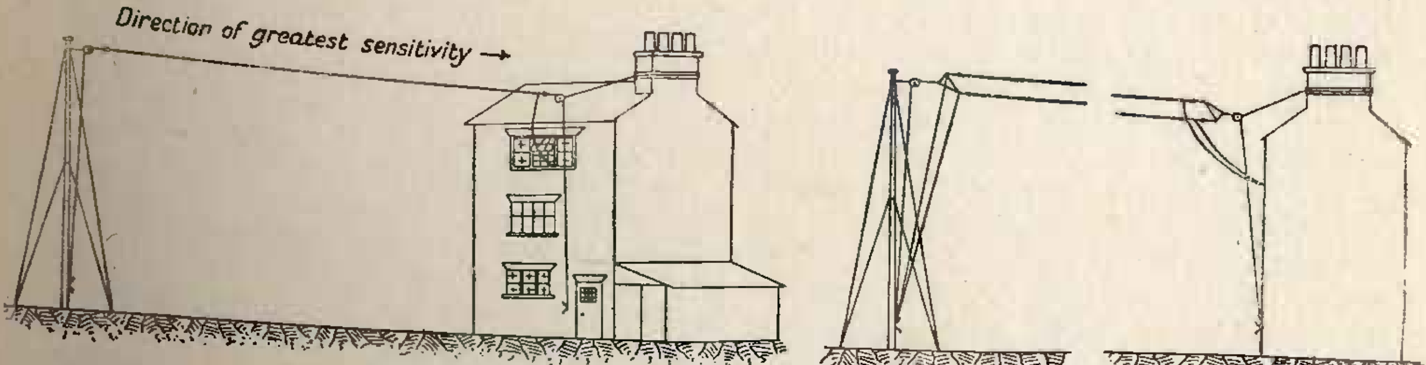


FIG. 3.—Showing methods of erecting single- and double-wire aerials.

unravel them. This does not mean that you will hear no long wave signals on a single-wire aerial, or that you will be able to hear unlimited long wave signals on a double-wire aerial. The difference is not so great as all that, but if you really want to get long wave messages, you will be likely to find the double-wire aerial more suitable to your purpose. For ordinary broadcast signals alone, I would advise you to choose a single-wire aerial—if you can put up a good one. If you have not got a long stretch of space at your disposal, it will probably be not only necessary, but essential, to erect a double-wire aerial for the reception of broadcast signals.

To sum up, single-wire aerial consists of a horizontal length of wire, connected by a vertical " down lead " to the receiver at one end, and left " free " at the other end. This is the most popular type of amateur aerial, and is usually known as the " inverted L " aerial, owing to its shape. Instead of the down lead being connected to the *end* of the horizontal wire, it can be joined to the *centre* of the latter, both ends of which are thus left " free." An aerial of this kind is called a " T " aerial. Whether a " T " or an " L " aerial be used, the horizontal part should be at least 45 feet long, if satisfactory results are to be expected. If this space is not available, it will certainly be advisable to use a double-wire aerial, which consists of two parallel horizontal wires, each with a separate down lead. The horizontal wires should be spaced not less than 5 feet apart, and the two down leads should be joined together at their lower extremities before being brought in to the receiving instrument as a single lead, as shown in Fig. 4.

The main difference between these two types of aerial lies in the fact that one exhibits a slight " directional effect." An " inverted L " aerial is directional in the direction opposite to that in which the disconnected end points. Suppose you had such an aerial erected in the garden at the *back* of your house. You would probably take the down lead from the house end of the horizontal wire, and the free end would therefore be at the farther end of the garden. This aerial would exhibit a directional effect in the direction towards which the *front* of the house faced. That is to say, it would be more sensitive to signals coming from that direction than to signals coming from any other direction. An inverted " L " aerial is therefore a suitable kind of aerial to use if your house faces, but is a long distance from, the broadcasting station whose signals you want to receive. If you are very far from the broadcasting station, signals will naturally tend to be weak owing to the distance they have already travelled, and it is therefore desirable to make your aerial as sensitive as possible to them.

Although it is advisable, wherever possible, to erect your aerial out of doors, this is not essential. If you can put up a *good* outdoor aerial, do so, by all means. But if you find that you cannot erect an outdoor aerial without trespassing on your neighbour's property, there is no need to despair. You will probably be able to instal some kind of indoor aerial. On the whole, indoor aerials are not so efficient as outdoor ones, and therefore require more sensitive receivers if the same results are to be obtained with them

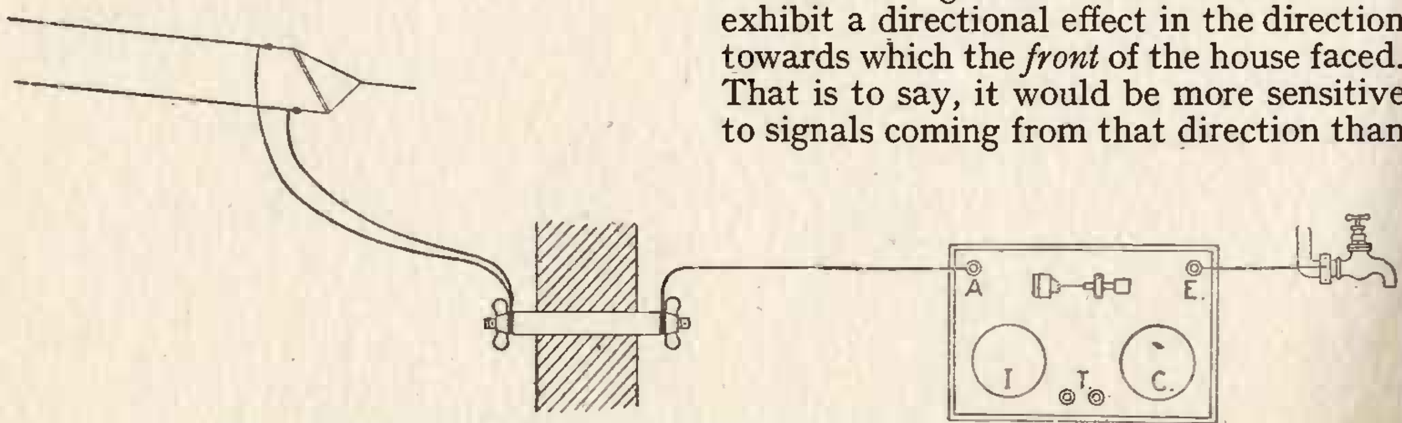
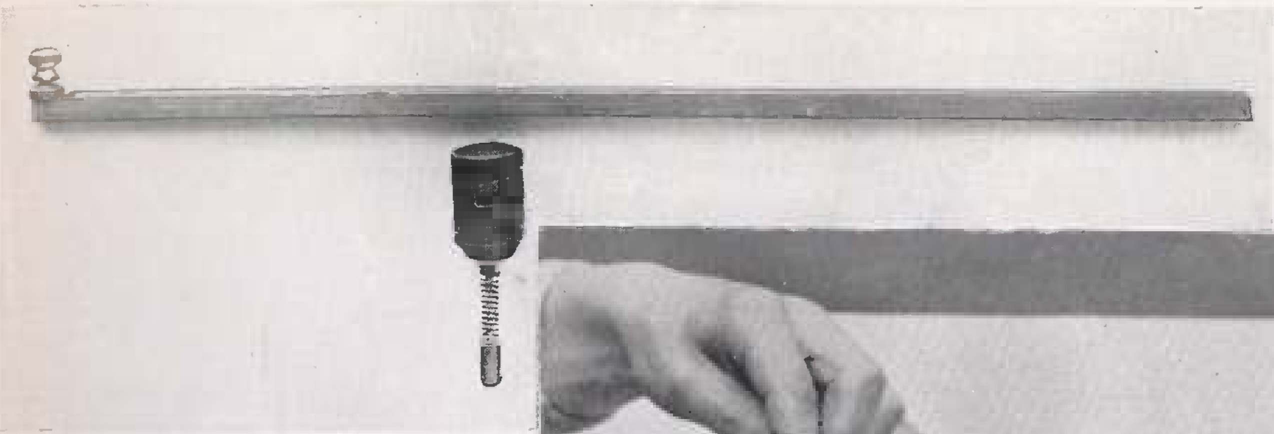
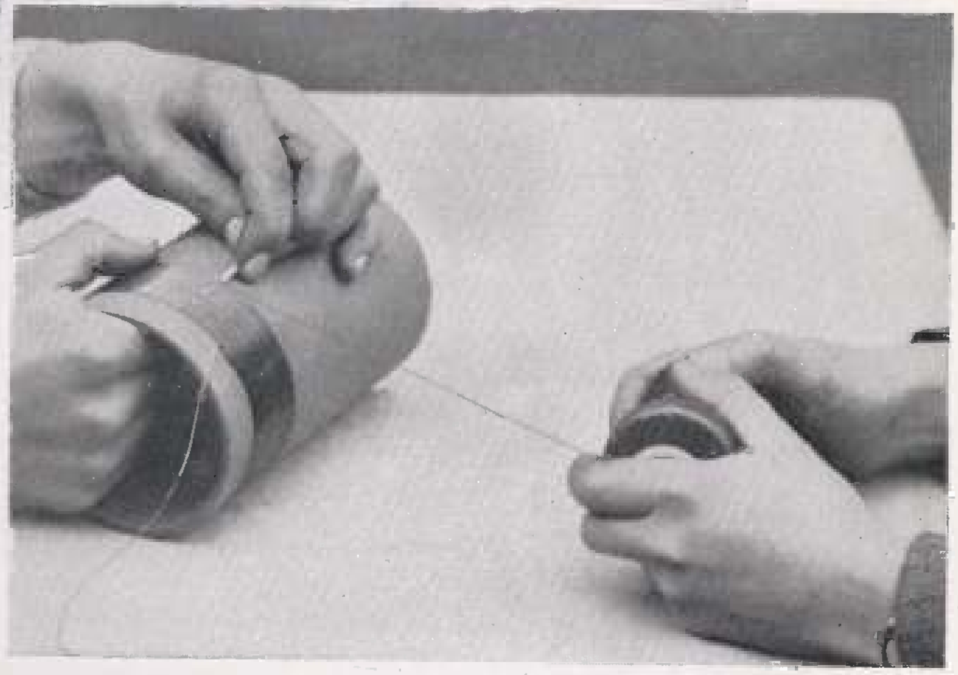


FIG. 4.—Showing method of connecting-up aerial, receiver, and " earth."

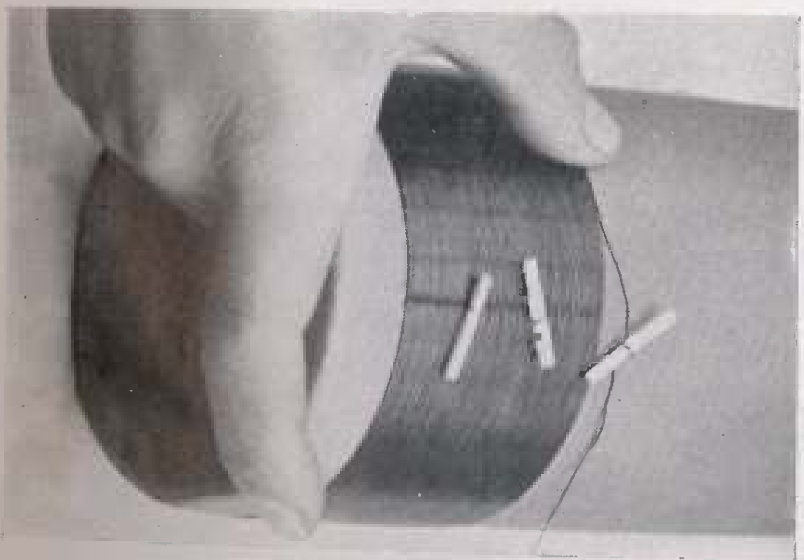
VARIABLE TUNING COILS



Brass bar and slider. Note small spring which enables firm contact to be made with coil.



Packing the turns of wire closely together with a match.

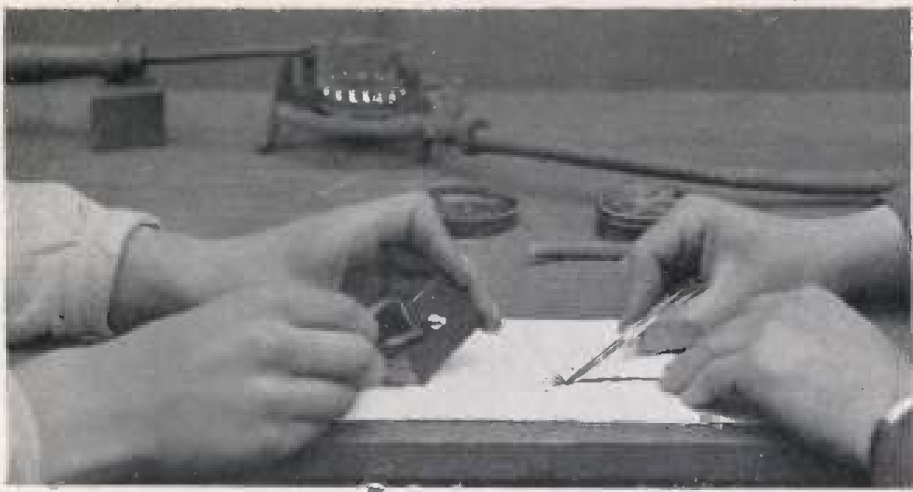


Method of marking the tapping points by means of matches, a single turn of wire being taken round each match.

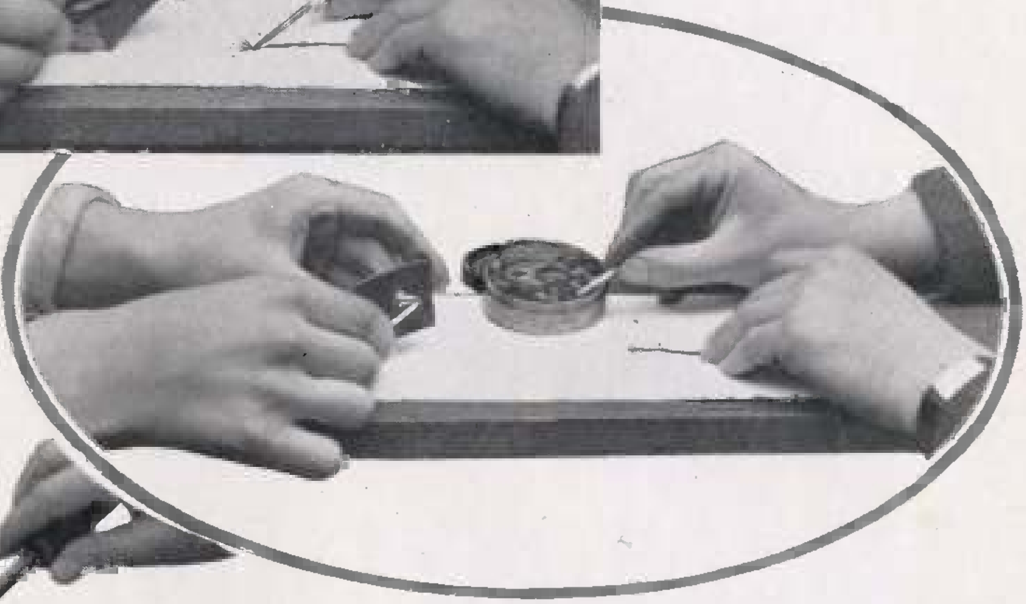
Passing the wire through binding holes.

Base board and supports for coil.

(*See page* 39.)



1. Clean each part thoroughly.



2. Smear a little fluxite on each part.

3. Dip the heated iron swiftly in the fluxite.

HINTS ON SOLDERING

(*See page* 6.)

4. Take a drop of solder on the head of the iron.

5. Guide the molten solder over the joint with the tip of the iron.

as can be obtained with the latter. But the cost of receivers increases with their sensitivity—which is another very good reason for putting up an outdoor aerial if it is at all possible to do so.

Indoor aerials can be erected on the same lines as those we have just been considering with reference to outdoor aerials, though, because of their reduced sensitivity, it will usually be advisable to employ the inverted "L" type. In the case of outdoor aerials, it frequently happens that the shape of the aerial is governed by the local surroundings. If the garden happens to run south from the house, it will rarely be convenient to erect an aerial which gives a southward directional effect, unless you wish to receive in a summer-house at the end of the garden. (I might mention here that you must not try to bend back a down lead from one end of the aerial so as to be able to connect it to a receiver which is situated beneath the other end.) Insulated wire should be used for indoor aerials, because of the increased likelihood of the wires coming in contact with their surroundings. If you are erecting an aerial in a room, you will, of course, get the greatest span by running the horizontal wire between opposite corners. If you can obtain a still greater span by running the wire across a room and along a corridor—all the better. Sometimes you will get better results with an indoor aerial by bending the wire and taking it along two adjacent sides of the room. As a matter of fact there is a great deal of good fun to be got by experimenting with indoor aerials. The best thing to do is to try a number of ways, until you find the way that gives best results in your own particular case.

When an aerial is picking up signals, the received electric currents are flowing up and down between the aerial and earth *through the receiver*. If the aerial were to touch against a water pipe (for example) whilst this is happening, the currents, instead of flowing to earth *viâ* the receiver, would flow to earth *viâ* the water pipe, with the result that no signals would be heard in the telephones. In erecting an aerial, therefore, the wire must either be slung quite clear of all surrounding objects, or else it must be covered with some insulating material which will effectively prevent it from making metallic contact with the latter. Bare wire is usually employed for outdoor aerials, whilst insulated (rubber-covered, or cotton-covered, or enamelled) wire is generally regarded as being more suitable for indoor aerials

HAND CAPACITY EFFECTS

ONE frequently finds, when tuning a receiver, that the movement of one's hand towards, or away from, the controls has the effect of altering the strength of signals. This is due to the fact that one's hand provides a capacity path to earth, so that the tuning of the circuit is altered at each movement. This effect is most frequently experienced when handling condensers in high-frequency circuits, and different means are employed for eliminating it. Long extension handles are available which enable condensers to be operated from a distance, thus minimising the effect of hand capacity. These will not be necessary, however, if a thin sheet of metal be fixed at the back of the panel so as to "screen" the condenser from the operator's hand. This metal screen should be connected to the earth terminal of the receiver. If the end plates of the aerial condenser are made of metal the fixed vanes should be connected to earth and the movable vanes to the aerial, but when the end plates are made of ebonite or some other insulating material better results are usually obtained by connecting the movable vanes to earth. Hand capacity effects do not, as a rule, give much trouble in connection with ordinary broadcast reception, but when receiving on short waves their elimination calls for a good deal of care and attention, particularly in the operation of "heterodyne" instruments for the reception of continuous wave signals.

HINTS ON SOLDERING

EVERY amateur should know how to solder. It is often quite an easy matter to make a good metallic connection between two wires by twisting the ends of the wires around each other firmly. The trouble about a connection of this kind, however, is that it is likely to work loose in time, especially in the case of instruments which are used for home experimental work, and which are, therefore, moved about a good deal during reception.

The necessary instruments for doing a soldering job are: a soldering iron, a small tin of some good soldering paste, such as *fluxite*, and a stick of solder. The whole outfit can be purchased for a few shillings. A soldering iron is really an iron rod, fitted with a copper head and a wooden handle. These instruments are made in different sizes. A small light iron, with a head that terminates in a point, is the most suitable for wireless work. Besides taking longer to heat, large irons are difficult to control when dealing with small wire connections. A small light iron can be heated quickly and handled conveniently, whilst the pointed head enables neat work to be done. On the other hand, if the iron is *too* small it will also lose its heat quickly. However, this is partly a matter of individual taste. Some people find that they can do better work with a heavy instrument, while others prefer a light one.

We will suppose that the job in hand consists in soldering the end of a piece of wire to the base of a terminal. The first thing to be done is to clean thoroughly both the wire and the terminal base. *This is most important.* The great majority of soldering failures arise from trying to solder two dirty pieces of metal. The cleaning of a piece of wire can usually be effected by scraping it with a knife. If necessary, emery paper may be used to clean the parts concerned, after which the abrasive particles should be removed by wiping with a dry cloth. The beginner is advised to make this the first step in the process of soldering a joint, to be followed by the heating of the iron. With a little experience, of course, quicker work can be performed by doing both jobs simultaneously. The reason why the beginner is recommended to carry out each operation separately is because it is such an easy matter to forget all about the iron whilst engrossed in cleaning the items to be soldered, and it is important that the iron should not be overheated.

An ordinary iron can be heated quite effectively by placing the head in the flame of a gas ring. The moment at which it has acquired the proper degree of heat can be judged by the changing colour of that part of the head which is just outside the flame. The iron will then be approaching the red-hot stage, and it should be whipped out of the flame and dipped into the tin of fluxite quickly before being applied to the solder.

Having cleaned the wire and the terminal base, these should be smeared over with a thin coating of the fluxite, which can be applied with the aid of a match. As this takes only a second or two, it may safely be performed whilst the iron is heating. (When dealing with stranded wire, it is advisable to splay the ends of the wire slightly before applying the fluxite.) If working alone, the instrument should now be propped in a convenient position, so as to allow the wire and the terminal base to be placed in contact with each other. If you have an assistant on the job, he or she can facilitate matters by holding these in position.

Everything is now ready for the actual soldering. Take the stick of solder in the left hand, holding one end of it about an inch above the joint that is about to be soldered. Then, whip the iron out of the flame, dip it quickly in the fluxite, and apply the hot tip to the end of the solder-stick, causing a small drop of molten solder to adhere to the copper tip. Finally, just touch the joint lightly with the iron, using the tip to guide the molten solder. On removing the iron, the joint will cool and harden rapidly.

A VARIOMETER CRYSTAL RECEIVER

This little receiver is both simple to construct and simple to operate. When used with a good aerial it will be found extremely efficient for the reception of any of the B.B.C. stations at a range of 25–30 miles, whilst 5XX can be received on it at a range of 100 miles.

IN spite of the marvellous advance that has been made in the science of wireless during the past few years, crystal receivers are more popular to-day than they ever have been in the past. Nothing can beat the crystal receiver for simplicity, and certainly no other type of receiver can compete with it in the matter of cost. As far as its efficiency is concerned it is sufficient to point out that 5XX, the high-power broadcasting station, can be picked up on a crystal at a distance of 100 miles or more. Further evidence of its efficiency is provided by the fact that the majority of valve users to-day equip themselves with crystal sets "for emergency purposes." When the valve set breaks down the crystal comes to the rescue.

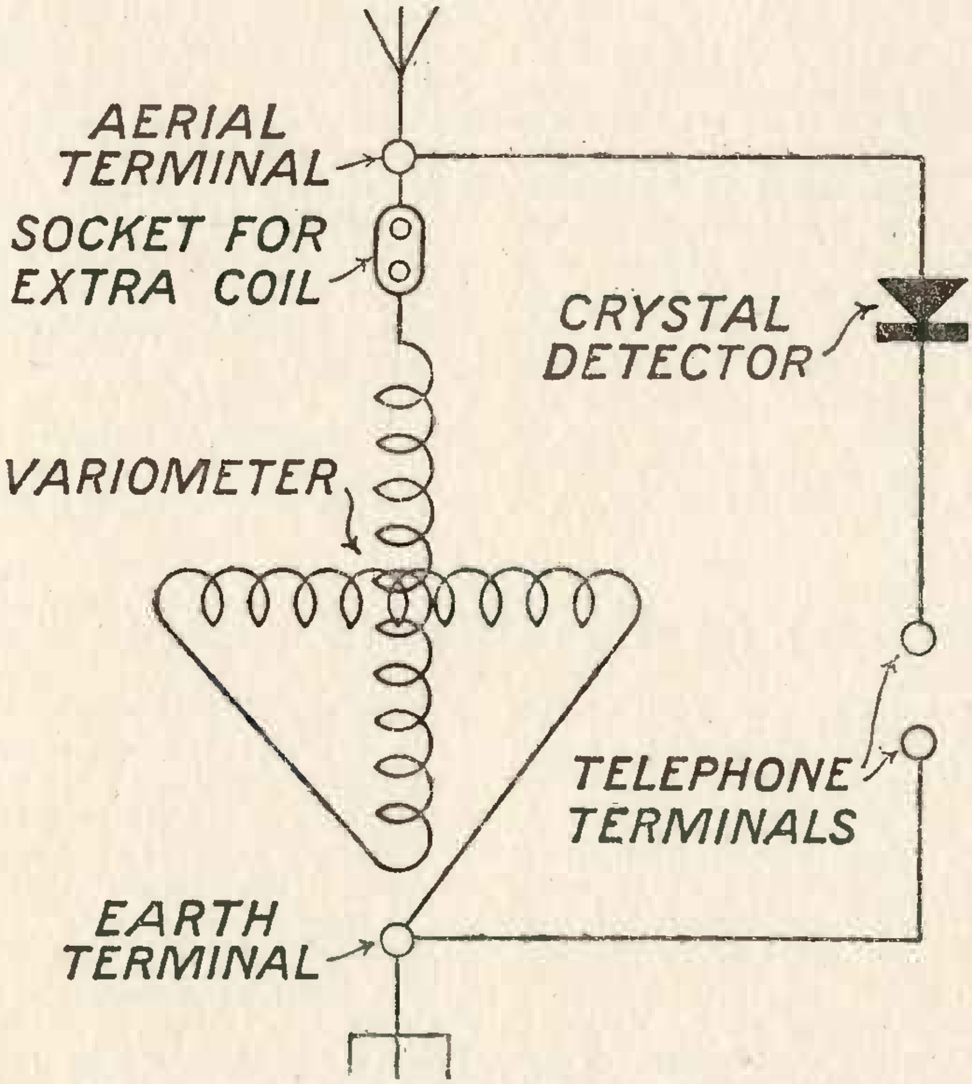


FIG. 1.—Diagram of connections of the variometer Crystal Set.

The receiver described below is, without doubt, one of the simplest and most efficient types of crystal set that can be made—or bought. The receiver itself contains only two items, a variometer and a crystal. In order to receive signals, of course, telephones are also necessary, as well as an aerial and a good earth connection. The chief advantages offered by a variometer over other forms of tuning coil are: (1) no condenser is required, and (2) no "dead end" effects are produced. If a coil of fixed inductance is used (*e.g.*, a plug-in coil), a condenser is necessary for the purpose of varying the tuning, and with coils that operate on the "slider" or "tapped" principle, losses due to "dead end" effects are inevitable.

In order to enable signals to be received from 5XX (the high-power station at Daventry, which works on a 1,600 metre wavelength), provision is made in this receiver for the addition of "loading" coil for the purpose. A socket, for holding a plug-in coil, is connected in series with the variometer. In order to tune in to 5XX, therefore, it is only necessary to plug in a coil of suitable value (for instance, an Igranic coil, No. 200) and adjust the variometer. When the loading coil is removed for the purpose of tuning in to the local broadcasting station, the "dummy" plug, shown in photograph, should be inserted in the socket. A diagram of connections is shown in Fig. 1.

The construction of the receiver, which is illustrated on the previous page, is simplicity itself. A small panel, measuring about 6 inches square, affords ample space for mounting the variometer, coil socket and crystal. A hole of $\frac{1}{4}$-inch diameter is drilled in the panel at a distance of about 1 inch below the centre point. This takes the spindle of the variometer. The crystal is mounted on the outside of the panel, a clearance of at least $\frac{1}{2}$ inch being left between it and the variometer dial. The position of the terminals is a matter for individual choice, of course; the positions shown in the illustration will be found as convenient as any. Unless the variometer is of unusually large dimensions the container box need not be more than 5 inches deep.

The components used in this receiver are an Edison-Bell variometer and an R.I. detector. Excellent results were obtained with the completed instrument—loud signals on three pairs of 'phones on an indoor aerial at a distance of three miles from 2LO, and signals of the same strength on an outdoor aerial at a distance of twenty-five miles.

"FADING" SIGNALS

THE phenomenon known as "fading" is one which has exercised the minds of scientists and amateurs considerably during the past few years. Certain physical conditions, as yet only dimly understood by those who have given most attention to the phenomenon, cause signals from distant stations to diminish unexpectedly in strength. Sometimes, in fact, signals appear to "fade out" completely for a definite interval. There is evidence to show that "fading" is conditioned to a large extent by atmospheric changes, as well as by the geological structure of the section of the earth over which the waves are travelling. Long wave signals are more prone to "fading" than short wave signals. It is also fairly well established that genuine "fading" is rarely experienced at close distances from a transmitting station; it is almost invariably experienced with long-distance signals. An amateur will sometimes think that signals are "fading" when, in reality, his receiver is faulty. In a valve receiver, for instance, if the resistance of the grid leak is too high, signals will decrease in strength intermittently. If the contact between a crystal and a catwhisker is very light and critical, moreover, minute vibrations, imperceptible to the listener, may throw it out of adjustment *temporarily*, giving the impression that signals have faded away completely for several seconds. False "fading" of this kind can be just as troublesome as the genuine variety.

A SINGLE-VALVE RECEIVER

As a general rule, crystal sets are only suitable for receiving broadcast programmes within a range of twenty-five miles or so. For greater distances it becomes necessary to depend upon valves, except in the case of 5XX.

The great merit of the valve lies in the fact that it amplifies or strengthens the energy picked up by the aerial, in addition to detecting or making it audible in the phones. With a crystal, the strength of current passing through the 'phones is always something less than that actually picked up by the aerial. In a valve set, on the other hand, this limitation does not hold. One is able to multiply the received energy many times so that it becomes possible to receive signals from very distant places.

Naturally the extra energy which is, so to speak, added by the valve to the received signals must be supplied locally. Accordingly a valve set involves the use of two batteries, or sources of electric power, one called the "high tension" for applying an electric pressure to the "plate" of the valve, and the other an accumulator or "low-tension" battery for "lighting" the valve filament. Otherwise, with one or two minor additions, which will be referred to later, the circuit elements of a valve set are the same as those used with a crystal receiver.

Many people are inclined to fight shy of the valve. So much highbrow literature has been written on the "magic lamp" of wireless that the amateur is inclined to regard it as being too involved and technical. This is a mistake. It is quite easy to build and use a valve receiver without troubling in the slightest degree about the technical principle on which it works. The main thing is to get results. The why and wherefore can follow as one's enthusiasm grows. When it reaches the point of attempting to pick up, say, American broadcast programmes, then a certain amount of theory becomes essential. The single-valve circuit about to be described will not perform miracles. In practice it will be found about 50 per cent. better than a crystal circuit.

There are many shapes and sizes of valve on the market, but all the modern types are alike in their essential features. Outwardly the appliance looks very much like an ordinary incandescent lamp. At the base, however, one observes four outstanding prongs, and a close examination will show that each of these is connected to the "inside" parts in a certain definite fashion. The prongs themselves are not symmetrical in plan, three being grouped together in a small triangle, whilst the fourth stands somewhat apart from the rest. This peculiar spacing is for the deliberate purpose of ensuring that the valve, when inserted in its socket, will always connect the inside elements or "electrodes" (as they are called) with the appropriate outside parts of the complete circuit. A wrong connection of the electrodes with the external circuit may result in the valve being burnt out. This is an expensive mistake to make. Apart from the cost of a new valve, however, there is no danger whatever in making a false connection. Nothing will explode or give rise to unpleasant electric shocks. There need be no misapprehension on this point.

The isolated prong is usually marked with the letter P, and is connected inside the valve to a cylindrical metal piece, called the "plate" (or "sheath"), which surrounds the two other electrodes. One of the latter, called the "grid," consists of a thin spiral wire which is connected to the prong opposite to that marked P, *i.e.*, it forms the apex of the triangle previously referred to. The two remaining prongs are connected inside the bulb to each end of a straight piece of wire, called the filament, which lies along the centre of the spiral grid.

When the valve is in use, the two prongs forming the ends of the filament are connected to the two terminals of the accumulator, so that the current from the latter causes the filament to become red hot; the prong joined to the "plate" is connected to the positive pole of the high-

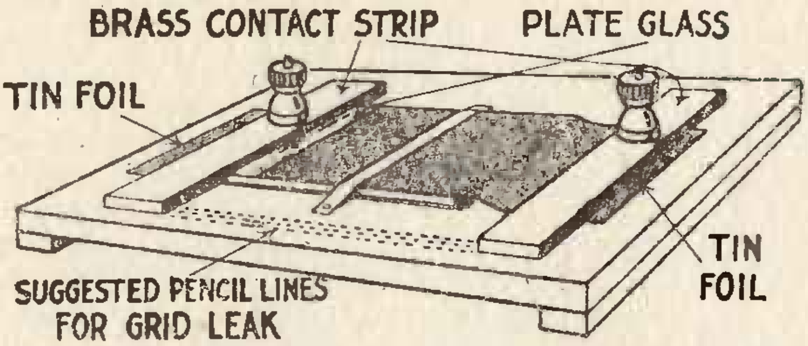


FIG. 1.—A simple type of grid condenser, with "grid leak" consisting of graphite or lead pencil lines.

tension battery; and the "grid" prong is fed with the currents from the aerial in much the same way as a crystal is fed from the aerial.

There is this difference however. In order to utilise the "detecting" property of the valve it is necessary to interpose a grid condenser and "grid leak," between the aerial proper and the grid of the valve, as shown in Fig. 3.

The grid condenser is a simple affair to make, or it can be bought for two or three shillings. In the latter case a *fixed* condenser of ·0003 microfarad should be asked for.

A home-constructed grid condenser is shown in Fig. 1. A strip of ebonite is screwed to each end of a piece of ¼-inch sheet ebonite, 4 inches by 3 inches in plan, so as to raise it slightly above the table. Two pieces of tinfoil are next cut out, 3 inches long by 1½ inches wide. One sheet of tinfoil is laid on to the ebonite base board and clamped down at one end by a thin brass contact-strip with a central terminal as shown. Over this is placed a thin plate of glass, or sheet ebonite, or a thick sheet of waxed paper, measuring 2½ inches by 1½ inches. Finally, a second sheet of tinfoil is laid over the glass, etc., and is secured at one end by a brass contact-strip and terminal in a similar manner to the first. The parts are held together by a transverse strip of tape secured at each end by drawing-pins as shown.

The next accessory, the grid leak, is still more simple to make. It consists merely of a very high resistance which can be connected either across the two end terminals of the grid condenser, or between one terminal of the condenser and the negative end of the low-tension battery. If the former method is employed, an efficient grid leak can be made by the simple expedient of drawing a number of lead-pencil lines across the ebonite base board of the grid condenser, between the ends of the two brass contact-strips. Graphite or lead pencil is an electric conductor of high resistance, and by making a fairly thick pencil marking in the manner described a "leak resistance" of the necessary value is created between the two plates of the condenser.

Alternatively a special "grid leak" graphite resistance can be mounted on a base board with two end terminals, as shown in Fig. 2, or a special composite resistance can be purchased for two or three shillings.

The next piece of apparatus required is a valve holder. This can also be purchased for a couple of shillings, or four separate hollow screw sockets can be bought for a few pence and screwed directly into a base board to take the four prongs of the valve and hold it in position.

Finally, a rheostat or controlling resistance for the filament current is necessary. This instrument is not easy to make, and by far the wisest policy is to buy one. A

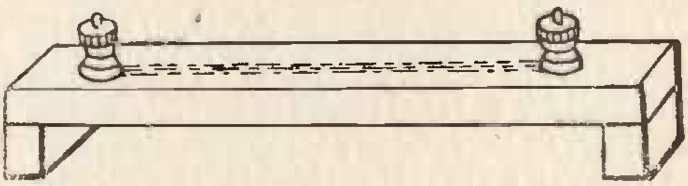


FIG. 2.—A home-made grid leak for use with a detecting (or rectifying) valve.

good rheostat can be obtained for a few shillings.

The valve socket and the rheostat should be mounted on a single panel of ¼-inch ebonite, 7 inches long by 4 inches wide. Strips of hardwood, ½ inch wide by

1 inch deep, are screwed along the short ends of the panel in the way described in connection with the grid condenser. This lifts the panel slightly above the supporting surface and leaves room for the wiring connections underneath.

If a valve socket has been purchased, this is screwed down on to the panel at one end; or the four separate screw sockets, previously referred to, can be screwed directly into the ebonite, care being taken to space them properly apart so that they will readily take the prongs of the valve. The rheostat is next mounted, terminal. The other end of the rheostat winding is left alone to form a "dead end." This completes the filament circuit.

The grid prong of the valve, marked G in the drawing (*i.e.*, the apex of the smaller triangle on the valve socket), is connected straight across to the grid condenser terminal, the adjacent terminal on the panel being connected by a short length of wire to a bared portion of the negative filament lead which has just been inserted. The remaining connections are readily completed. The plate prong of the valve is joined to one of the telephone terminals,

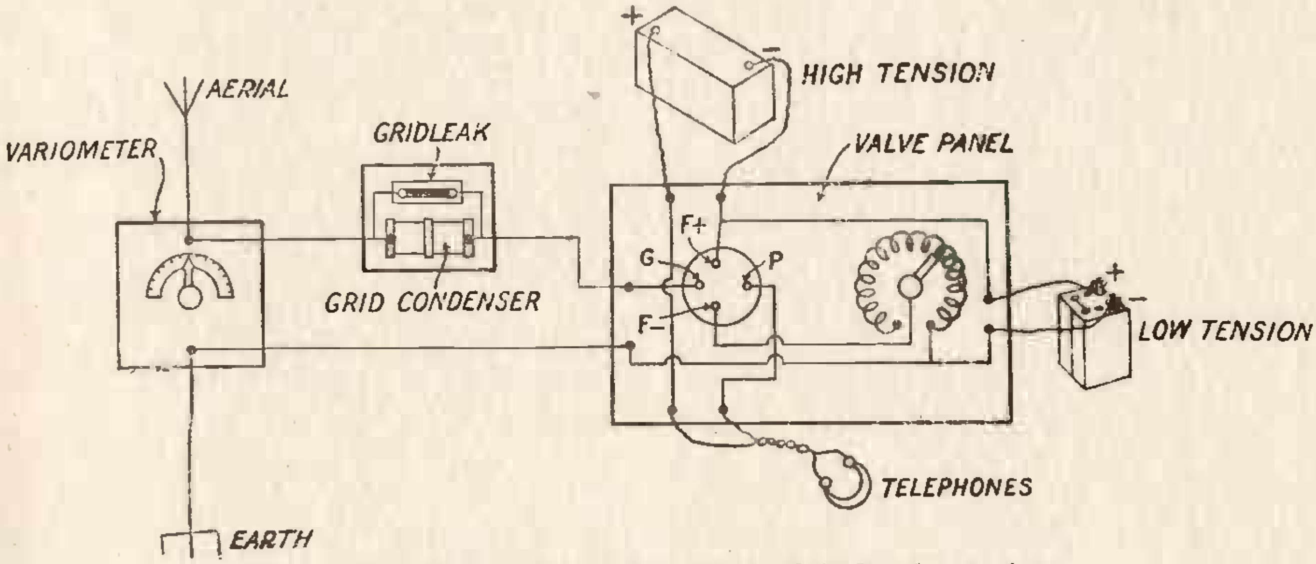


Fig. 3.—Showing lay-out and connections of single-valve receiver.

in the manner just described, at the other end of the panel.

The final step is to wire the panel. In the first place eight terminal screws are mounted at the sides of the panel in the positions shown in Fig. 3, two for the telephones, two for the high tension, two for the accumulator or low tension, and the remaining two for connection to the grid condenser and earth respectively.

Taking the filament circuit first, it will be seen that a wire goes from the valve prong, marked F –, to the rheostat arm. A length of insulated wire should therefore be connected between these two points by soldering in the manner already described. Next, the prong marked F + should be similarly connected to the low-tension positive terminal. One end of the wire on the rheostat winding should then be joined to the low-tension negative the other telephone terminal being taken across to the high-tension positive. The high-tension negative is connected by a separate wire to a bared portion of the positive filament lead as shown. The panel is now ready for wiring up to the other component parts of the complete receiving circuit.

The rheostat handle is first turned so that the contact arm is completely off the resistance wire. This breaks the filament circuit. The accumulator is then connected up by insulated wire to the terminals at the right-hand side of the panel, and the negative lead of the high tension is joined to the right-hand terminal at the top of the panel. The corresponding positive lead is joined to the left-hand terminal. (The positive plug should not be inserted into the battery until you are actually ready to receive signals.) The telephones are joined across the lower pair of terminals. The upper terminal on the left-hand side of the panel is connected to one side of the grid condenser, the other side of which is then joined to the aerial terminal on the variometer. The lower left-hand terminal on the panel is taken straight across to the earth terminal of the variometer. Finally, the grid leak is connected across the two terminals on the grid condenser as shown.

The circuit just described utilises a variometer inserted directly between the lead-in and earth ends of the aerial. Any of the types of variometer previously described will do equally well. The more convenient instrument is the rotary type, in which the two coils are wound upon two cylindrical formers, one being fixed to a central spindle, so as to rotate within the other. The tuning of the aerial circuit will be somewhat "coarse," but at the same time it will be found quite efficient for the reception of broadcasted telephony.

If desired, the tuning of the aerial circuit can be improved by the addition of a 0·0005 variable condenser. For a long aerial of, say, 100 feet, this should be put in series with the variometer. For shorter aerials it will be better to insert the condenser in parallel with the variometer. This is done by connecting the two terminals of the condenser directly across the two terminals of the variometer.

When the set has been connected up, the high-tension plug is inserted in the battery and the rheostat handle is turned until the filament lights up. The variometer handle should then be swept slowly around, and if all is as it should be the thrill of success will come in *viâ* the phones.

It is important that the correct amount of high tension should be used. Different types of valve require different quantities of high tension for their successful operation, and the extent to which this may be varied in practice is usually marked on the label which is affixed to a valve when purchased. The instructions given should be carefully followed, because their infringement is liable to result in damaging the valve seriously. Even when the valve itself is not actually damaged by an excess of high tension, its efficiency as a detector or amplifier may be considerably impaired. Any indication of a blue glow within a valve is a sign that too much high tension is being applied.

The filament current should also be reduced to a minimum, consistent with satisfactory signals. Once signals have been picked up, the filament current and plate voltage (high tension) should be reduced as much as possible without weakening the sounds in the telephones.

AN EFFICIENT TWO-VALVE NOTE AMPLIFIER

The amplifier described below can be used with any type of crystal or valve receiver to operate a full-sized loud speaker. It is capable of amplifying signals without the slightest trace of distortion

WHEN a wireless amateur first entertains the idea of changing over from crystal to valve work the question arises: What is the best kind of valve receiver to begin with? To this there are four possible solutions, and the "correct solution," as the text-books say, depends upon the ambitions of the individual in each case. First of all there is the high-frequency amplifying valve, which can be hooked up in front of a crystal with the object of increasing the range of reception. This will appeal particularly to those who want to frolic in "fresh fields and pastures new" in the domain of ether. Then there is the single-valve detector, which can be used in place of the crystal. Thirdly, there is the low-frequency amplifier, which can be hooked up behind a crystal, with the object of rendering signals from the local station suitable for reproduction by a loud speaker. And lastly, any combination of these three uses of the valve can be employed.

The third of these alternative methods of using valves (*i.e.*, for low-frequency amplification) is the one which is likely to give most satisfaction (and most value for money) to amateurs whose radio activities have previously been confined entirely to crystal reception. The relative efficiency of telephones and loud speakers is, of course, a debatable matter; yet few amateurs who have heard *good* loud-speaker reproduction will deny that this is, after all, the only really satisfactory way to hear wireless transmissions—particularly *musical* items. It is largely because good loud-speaker reproduction is so rare that the relative efficiency of telephones and loud speakers continues to be a matter for debate. The two-valve low-frequency amplifier described below can be used with any kind of crystal detector. It is capable of amplifying quite weak telephone signals to sufficient strength to fill a large room with loud-speaker signals.

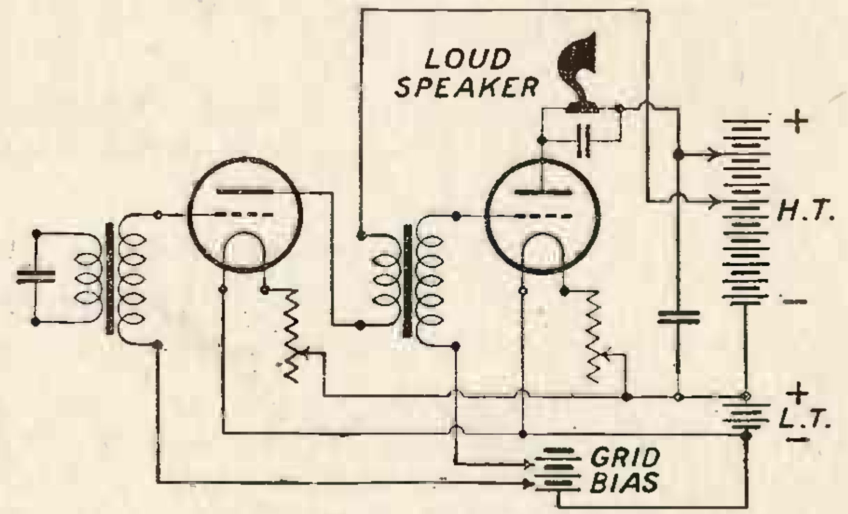


FIG. 1.—Diagram of connections of the amplifier.

The chief characteristic of this amplifier is that it enables one to get the best out of *any type of valve.* The rheostats are of the dual kind, suitable for both dull-emitter and bright valves; and each valve is provided with a variable grid bias and a variable anode voltage. In other respects the circuit, which is shown in Fig. 1, is the ordinary transformer-coupled one. It will be seen that the use of variable anode and grid potentials necessitates twelve external connections. In the first place there are the two input, two output, and two low-tension connections; then there are three leads to the high-tension battery and three more to the grid bias battery. The amplifier must therefore be fitted with twelve terminals. This seems a formidable proposition at first sight, but as a matter of fact it is quite a simple matter to accommodate even this number of terminals without detracting from the appearance of the instrument in any way.

The purpose of the various terminals is shown more clearly in Fig. 2. The two input terminals are on the left-hand side, and the remaining ten terminals are on the right-hand side. Counting from the top, the second and third terminals are suitable for this two-valve amplifier. It will be seen from the photographs of the instrument that the two rheostat handles are the only items that need appear on the panel, a feature which helps to make the general appearance of the amplifier both simple and pleasing. The base of the cabinet measures 10 inches by 7 inches, and the maximum height is 10 inches.

The rear view of the cabinet shows all twelve terminals mounted on a narrow strip of "Radion" insulation, which sits on two wooden blocks fixed to the floor of the cabinet. The front panel of the amplifier is a "Radion" panel. The rheostats employed are the well-known McMichael

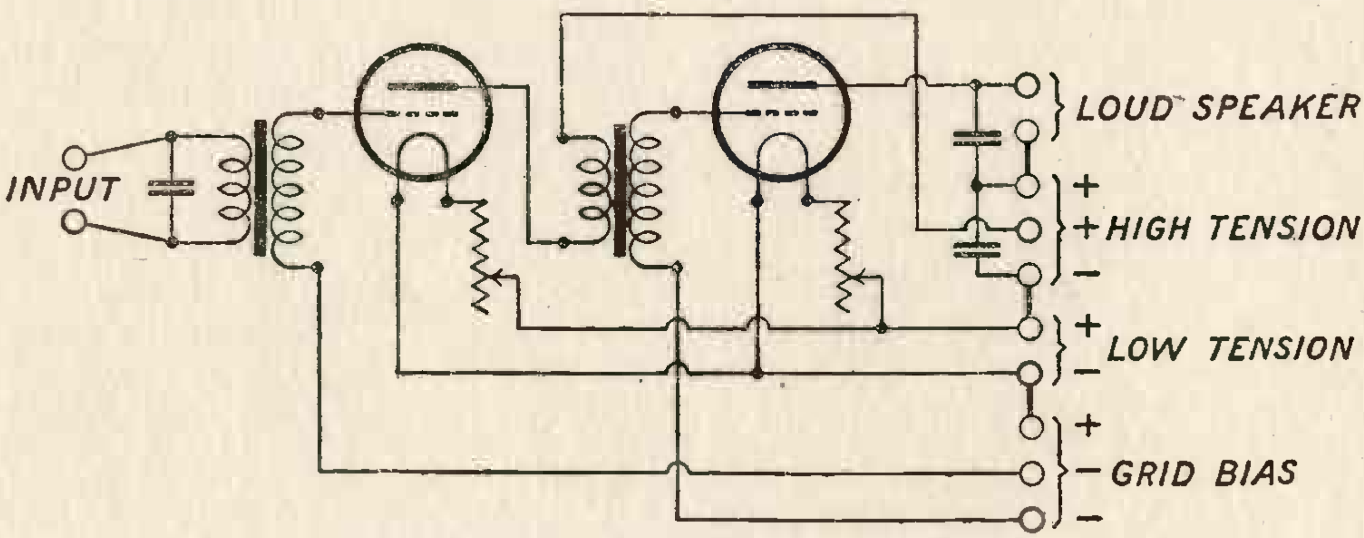


Fig. 2.—Showing the positions of the twelve terminals.

connected together by a short wire; so are the fifth and sixth, and the seventh and eighth. One could, of course, by using common terminals in these three positions, reduce the total number of terminals to nine; but this economy is scarcely worth while effecting; it will be found much more convenient in practice to have a separate terminal for each lead, and thus avoid the confusion that is apt to occur at times when double connections are taken from the same terminal.

The choice of a cabinet for any kind of receiver is, of course, a matter of individual taste—at any rate, so far as shape is concerned. (A cabinet must, of course, afford sufficient accommodation to enable the various components to be housed and wired efficiently.) A small cabinet of the "sloping panel" type will be found quite double-filament type. The first transformer is a Ferranti, and the second a Marconi "Ideal."

The advantages of mounting the terminals at the back of the cabinet will be apparent to amateurs who follow the practice of keeping all batteries out of sight in a separate compartment. One sometimes sees batteries installed on the floor underneath the table on which the receiver stands. This is not the best way of doing things. Apart from the inconvenience of altering connections when the batteries are in this position, and the length of the leads needed for connecting the latter to the receiver, batteries used for wireless reception should be kept at some little distance above the floor in order to eliminate "capacity effects" to earth. In this connection an ordinary packing-case can be made to render good service. If the lid be removed, and the case "stood on end," a battery shelf can be fitted inside the case at a distance of about 18 inches from the top. The wires from the terminals can then be taken to the batteries through small holes drilled in the top, on which the amplifier stands. (The packing case can be draped with some material in keeping with the colour scheme of the room in which it is installed.)

The two high-tension positive leads and the two grid bias negative leads should, of course, be fitted with wander plugs. In the majority of cases a 6-volt battery (comprising four dry cells) will be found quite suitable for the purpose of biasing the grids of both valves. As certain "power" valves require as much as —7 or —8 volts on the grid in order to yield maximum amplification, however, it may be advisable to use a battery consisting of half a dozen dry cells, giving a voltage of about —9. Incidentally, it is sometimes a good plan to use a portion of the high-tension battery for this purpose. One rarely has occasion to use every available cell in a high-tension battery; several cells at the positive end of the battery are nearly always on the unemployed list. Some of these can be used for the purpose of grid bias, though they must, of course, be disconnected from the main part of the battery (*i.e.*, the part that is supplying anode potential) before being so employed. This can be done by scraping away the surface insulation between, say, the sixth and seventh cell (counting from the positive end) and breaking the wire that unites them. These cells, when thus cut off from the main battery, can be used quite satisfactorily as a grid bias battery.

Three fixed condensers are shown in the diagram: one across the primary of the first transformer, another across the loud-speaker terminals, and a third across the high-tension battery. The actual condensers used in the amplifier are T.C.C. (Mansbridge). The function of the first of these condensers is, of course, to prevent radio-frequency impulses from penetrating to the first transformer: its value should be about ·002 microfarad. A suitable value for the by-pass condenser across the loud speaker is usually between ·04 and ·07 microfarad. The "reservoir" condenser across the high-tension battery serves the double function of smoothing out voltage variations in this battery, and of preventing "stray" reaction coupling between the valves; the capacity of this condenser may be as much as 1 or 2 microfarads.

CRYSTAL HINTS

DUST is the greatest enemy of crystals. A thin layer of dust on the surface of a crystal may be sufficient to prevent reception. For this reason crystals of the enclosed type, mounted in a glass container, are to be recommended. As glass containers cannot be made perfectly airtight, however, there are few crystals that do not benefit by a periodical cleaning. A very little vaseline, applied with a soft cloth and rubbed gently over the surface of the crystal, will remove all traces of dust. The film of vaseline should afterwards be removed with a clean dry cloth. Of the numerous kinds of crystal on the market to-day it is impossible to say which is the best; many of them are really excellent, and the amateur who is fortunate enough to get hold of a good one will have no cause to complain. A crystal should not be over-sensitive, otherwise there may be a tendency for very loud signals to throw it out of adjustment. Galena crystals are particularly good for dealing with loud signals; they also enjoy the advantage of being usable with practically any kind of catswhisker. The sensitivity of a crystal can sometimes be improved by snipping a bit off the end of the catswhisker, thus providing a new contact point. Crystal detectors should always be kept in a dry place, whether in use or not, because dampness is almost as injurious as dust and dirt.

A FOUR-VALVE ALL STATION RECEIVER

THE ideal set for the amateur is one which can receive not only all the British broadcasting stations, but a goodly number of the continental stations as well—on telephones or loud speaker, as required. There are certain stunt circuits which enable this to be done with the aid of three, or even two valves, but such circuits can only be operated satisfactorily by highly skilled operators with a good deal of experience behind them. The amateur who wants to get good results with a minimum of worry requires a "straight" circuit, a simple, reliable circuit that can always be relied upon to bring in signals and that can be operated with ease by the "inexperienced" members of the household. The circuit employed in the construction of this four-valve receiver fulfils these requirements. It is perfectly simple and straightforward, in addition to which it embodies the latest improvements of modern amateur practice.

The receiver contains one high-frequency valve, by means of which long-range signals can be picked up when desired; one detector valve, for the rectification of signals; and two low-frequency valves, to provide sufficiently strong signals to operate the biggest loud speaker. Three "double-pole double-throw" switches are provided. One of these enables the aerial tuning condenser to be connected in series or parallel with the aerial tuning coil, thus providing the widest possible range of tuning. With a standard P.M.G. aerial this switch should be put in the series position when receiving any of the B.B.C. stations, and in the parallel position when receiving longer wavelengths. The second switch, in one position, enables the detector valve to be used alone, and, when placed in its alternative position, brings the high-frequency valve into action as well. Thus, when the switch is pressed up the detector valve is the only valve that is functioning, but when the switch is pressed down, both the high-frequency and detector valves are in circuit. The two positions of the third switch are marked "PHONES" and "LOUD SPEAKER." When this switch is placed in the latter position, the last two valves are brought into circuit. When the loud speaker is not being used, this switch must be put in the position marked "PHONES." These two switches operate quite independently of one another, so that signals can be received on either telephones or loud speaker whether the detector valve is being assisted by the high-frequency valve or not. The combinations obtainable with these switches in different positions are explained quite clearly in Fig. 5. The action of the series-parallel switch in no way affects the valve combinations of course, the sole function of this switch being to provide the maximum tuning range.

Another valuable characteristic of this receiver consists in the provision of a separate H.T. tapping to each of the four valves. Although signals *can* be obtained with receivers in which all the valves are given the same amount of high tension, such receivers never really do themselves justice. No two valves in any receiver require the same amount of high tension; the first valve may only need 30 volts, whilst the last valve often needs 130 volts. The effect of compromising between the two demands—giving, say, 80 volts to each valve through a common high-tension lead—is to reduce the efficiency of both valves. By providing each valve in a receiver with a separate lead to the high-tension battery—as we have done in the case of this receiver—signal strength is increased very considerably. Yet another feature of this receiver is the facility it affords for applying a separate "negative bias" to the grids of the two low-frequency valves. Practically every experimenter uses "negative grid bias" to-day; it is no exaggeration to say that this device increases the efficiency of a receiver by at least 50 per cent., by making signals louder and eliminating distortion.

Fig. 1 is a complete diagram of connections. The first valve is for high-frequency amplification when searching for long-range signals. It is tuned by means of a plug-in coil and a variable condenser of 0·0005 microfarad capacity. A No. 50 or 75 coil will be found suitable when receiving British broadcasting stations. The aerial circuit is also tuned by means of a plug-in coil and a variable condenser. The latter instrument, which has a capacity of 0·001 microfarad, can be put in series or parallel with the former by the operation of the first "double-pole" switch. The series position will be found to give the best results with some aerials, and the parallel position with others. When the condenser is in series the coil should be a No. 50 or 75 for the reception of broadcast signals, but when the condenser is in parallel the most suitable coil may be a No. 25, 35 or 50. The best combination for each individual aerial can only be found by experiment. The reaction coil (for broadcast reception) should be a No. 50 or 75.

All three coils may, if desired, be mounted on the same coil holder. In this case the anode coil would also act as a reaction, and the circuit would be a "double reaction" one. As it is difficult, however, to prevent a circuit of this kind from "oscillating" when the anode coil is used as a reaction, it is advisable to mount this coil away from the others, and at right angles to them, as shown in one of the accompanying photographs.

The following components have been used in the construction of this receiver:

4 Igranic rheostats, 8 ohms resistance each.
1 Vernilor variable condenser (square-law vernier), 0·001 microfarad.
1 Ditto, 0·0005 microfarad.
4 Decko valve holders.

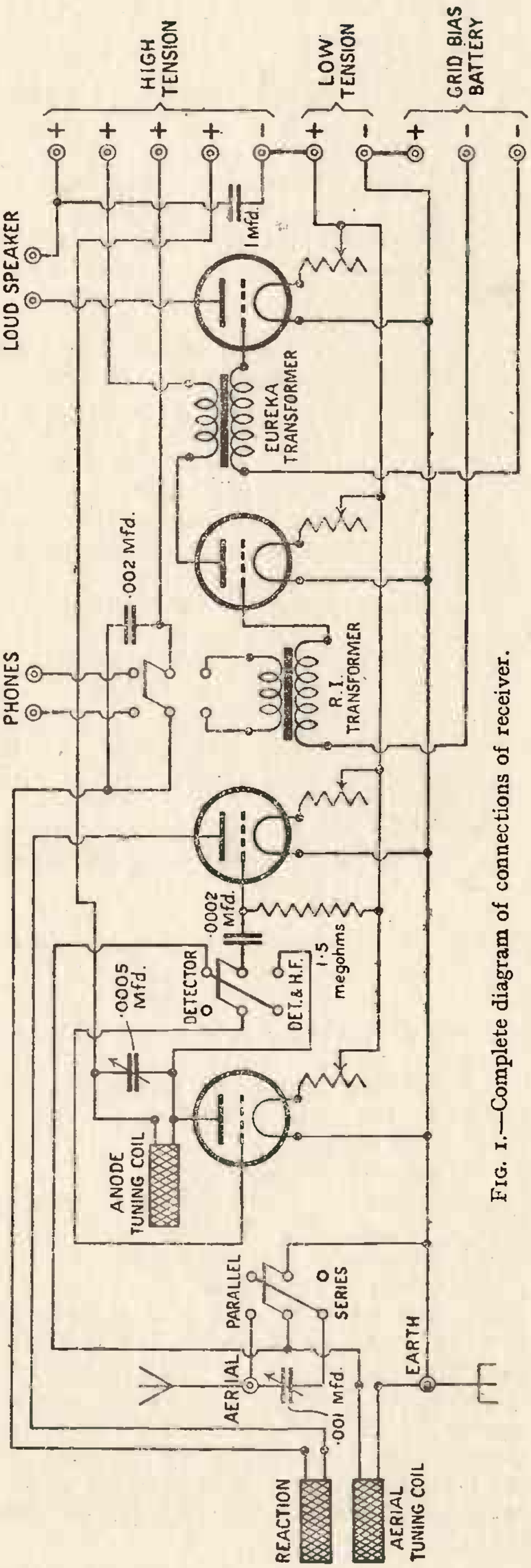


FIG. 1.—Complete diagram of connections of receiver.

1 Peto-Scott double coil holder, back-of-panel type.
1 Single coil holder.
1 Dubilier fixed condenser, 0·002 microfarad.
1 Ditto, 0·0003 microfarad.
1 Dubilier grid leak, 1·5 megohms.
1 T.C.C. condenser, 1 microfarad.
3 Dewar switches, double-pole, double-throw.

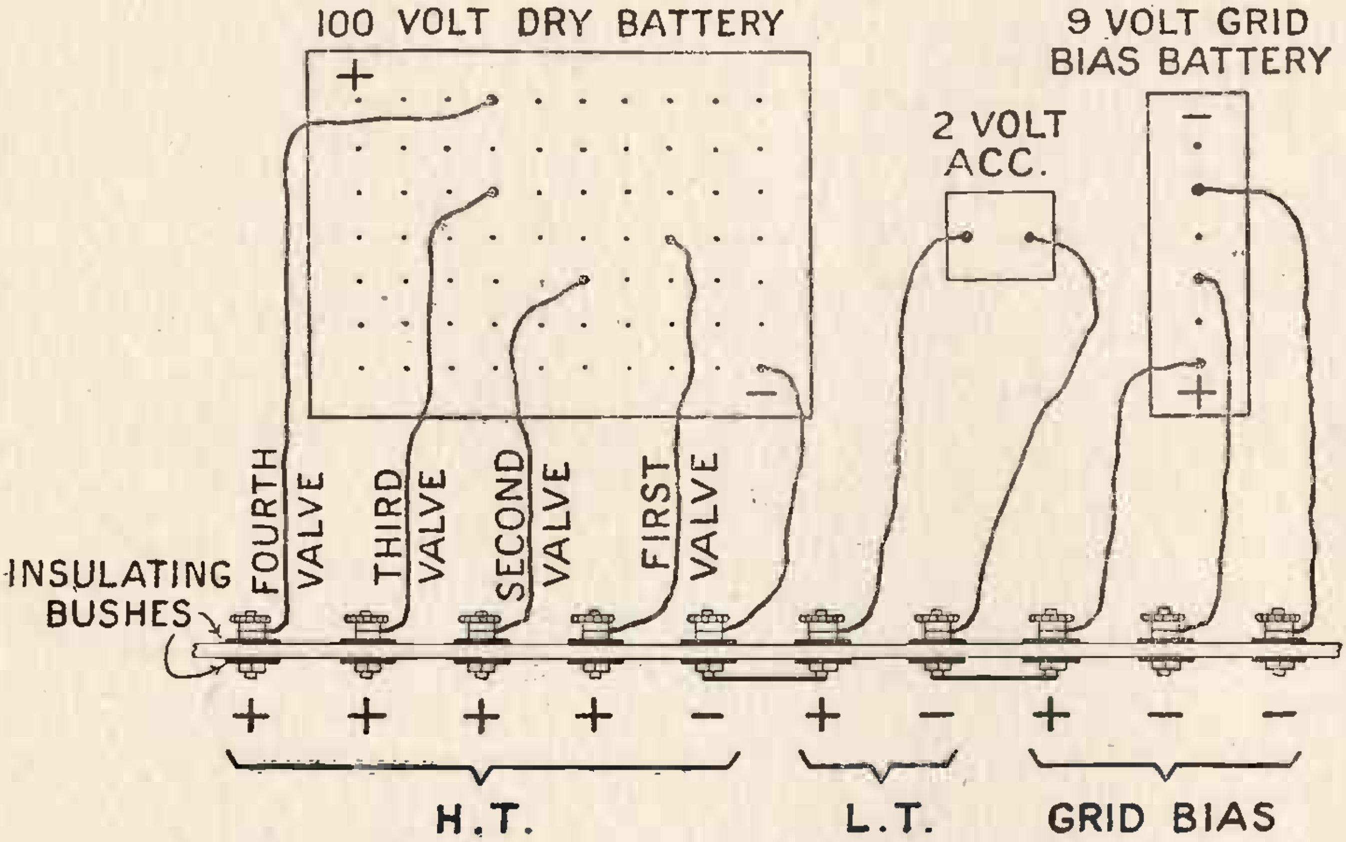


FIG. 2.—Showing connections from the three batteries to the terminals in back wall of cabinet.

1 R.I. low-frequency transformer.
1 Eureka "Concert Grand" transformer.
1 Peto-Scott cabinet.
1 Peto-Scott "Red-Triangle" ebonite panel, 16 by 8 inches.
16 Terminals. (J. Cann, Ltd.)
10 Clix insulating bushes.

It will be seen that the double-coil holder is mounted inside the receiver, being controlled by the knob at the left-hand side. This practice need not necessarily be followed, of course; the coil holder may be mounted on the outside: in fact, the latter course is to be recommended to the amateur who has not had much experience in the construction of sets, as it provides extra space for the accommodation of the other components and thereby facilitates the work of wiring up the receiver.

The receiver contains sixteen terminals in all. These include five H.T., two L.T., and three grid bias terminals, and it will be found convenient to mount these ten battery terminals on the back wall of the cabinet, as shown in the accompanying photographs. The other six terminals (for aerial and earth, 'phones and loud speaker) should be mounted on the panel. The ten battery terminals are shown on the right-hand side of Fig. 1. Fig. 2 is a plan drawing of the back wall of the cabinet, showing the terminals connected up to the various batteries. The four positive leads to the high-tension battery, and the two negative leads to the grid bias battery, should be fitted with "wander" plugs, of course. All the battery terminals, moreover, should be mounted with insulating bushes.

The following procedure will be found

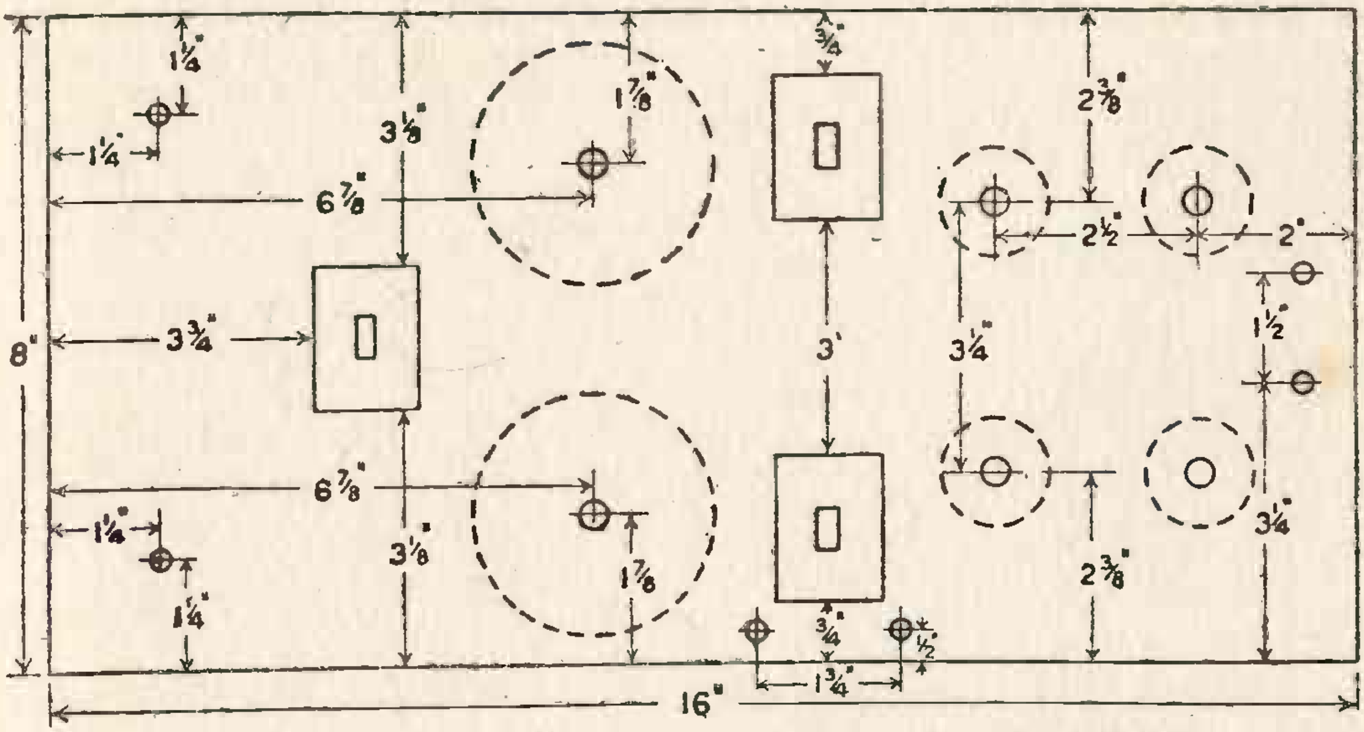


FIG. 3.—Diagram showing positions of various components on panel.

convenient in the construction of the receiver. First of all, drill the panel (as per instructions given in Fig. 3) and mount the rheostats, condensers and switches on it. (The upper condenser is the 0·0005 microfarad, and the lower one the 0·001 microfarad.) Next mount the valve holders on the back and right-hand walls of cabinet. (It should be noted that the cabinet has two floors, the upper one being removable. Allow this " false " floor to remain where it is for the present.) The positions of the three valve holders and ten terminals in the back wall of cabinet are given in Fig. 4. The fourth valve holder should be mounted in the centre of the

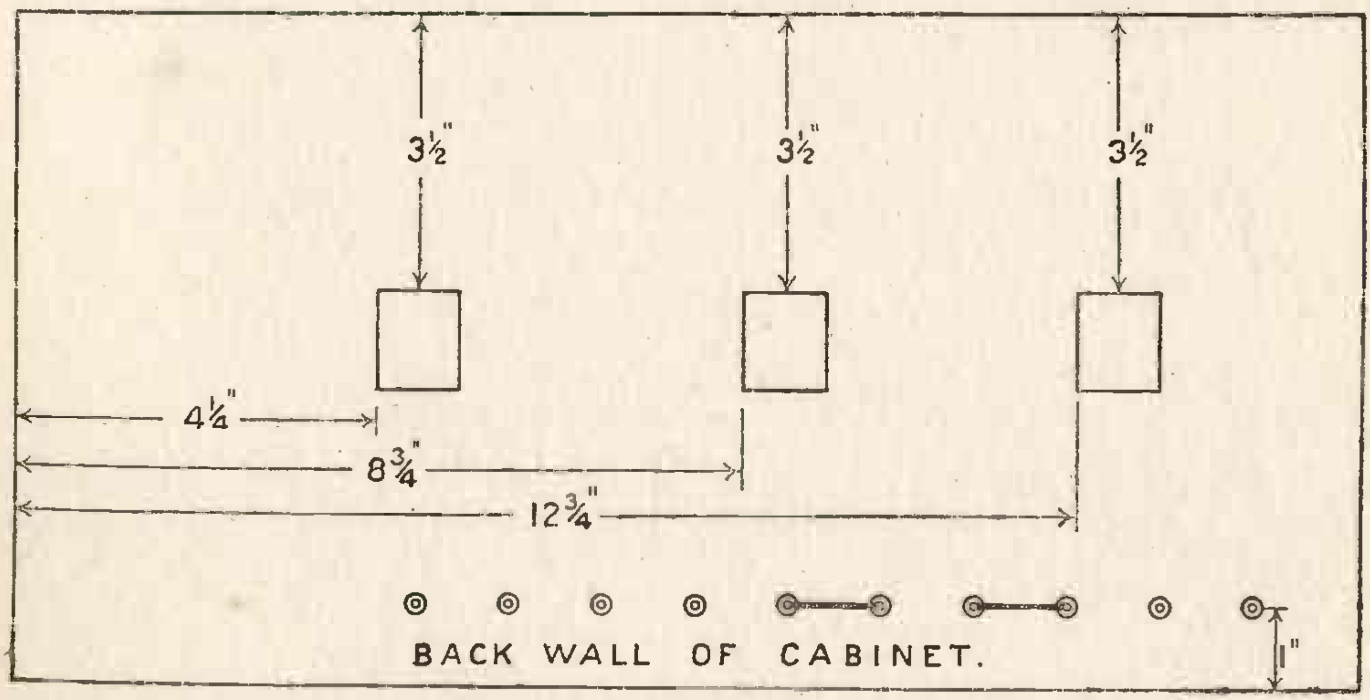


FIG. 4.—The small squares indicate the position of the valve holders.

right-hand wall, at the same height as the others from the " false " floor. Next drill the left-hand wall of cabinet and mount the coil holder. This item should be mounted at a height of about ½ inch from the " false " floor, so as to permit of the latter being removed when necessary. The coil holder should also be as close as these latter items so as to leave the maximum amount of space between each component. Remove the panel again and screw the low-frequency transformers, etc., to the " false " floor. Then replace the panel once more and fix it (by means of two screws in its lower edge) to the " false " floor.

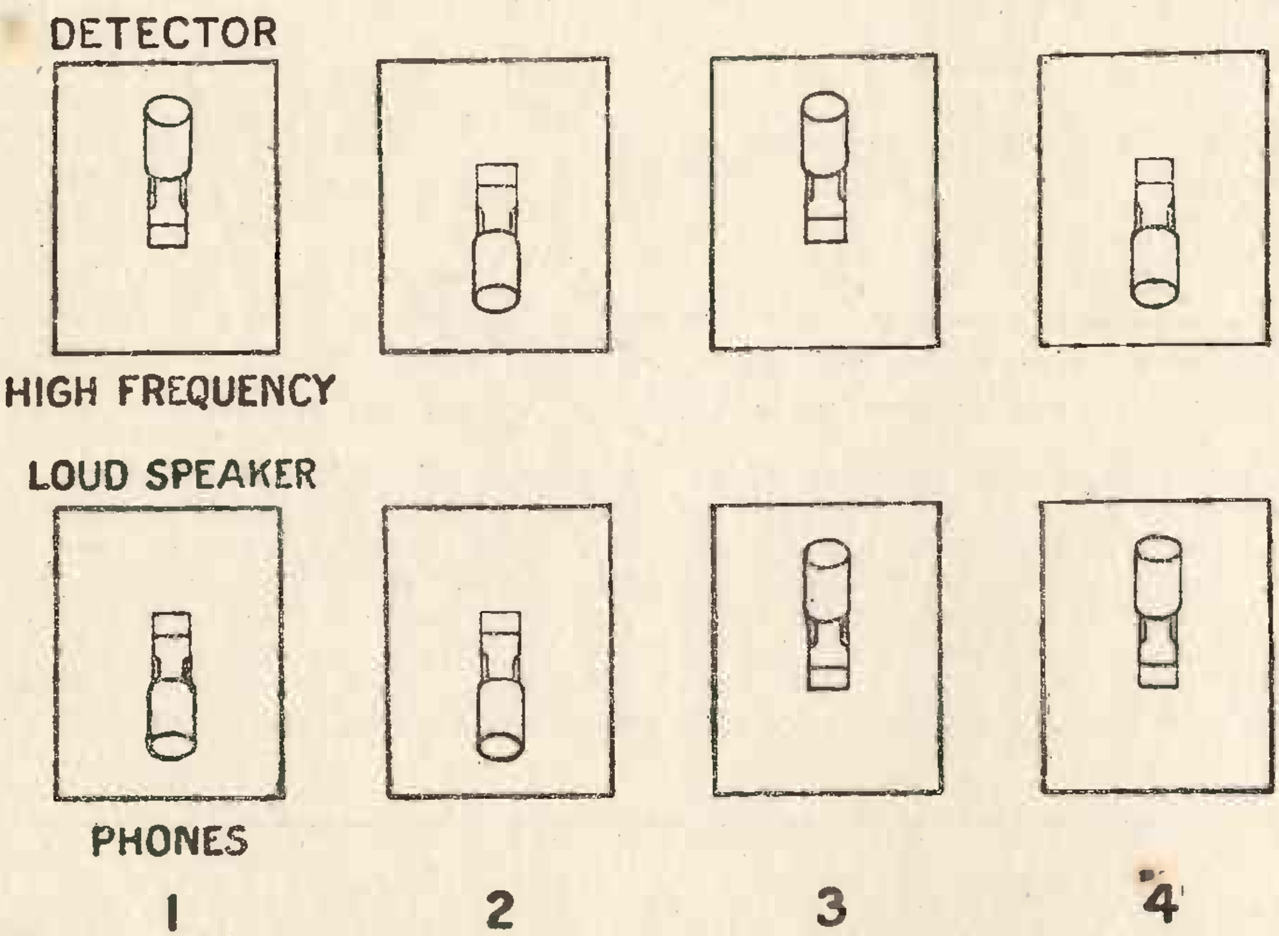


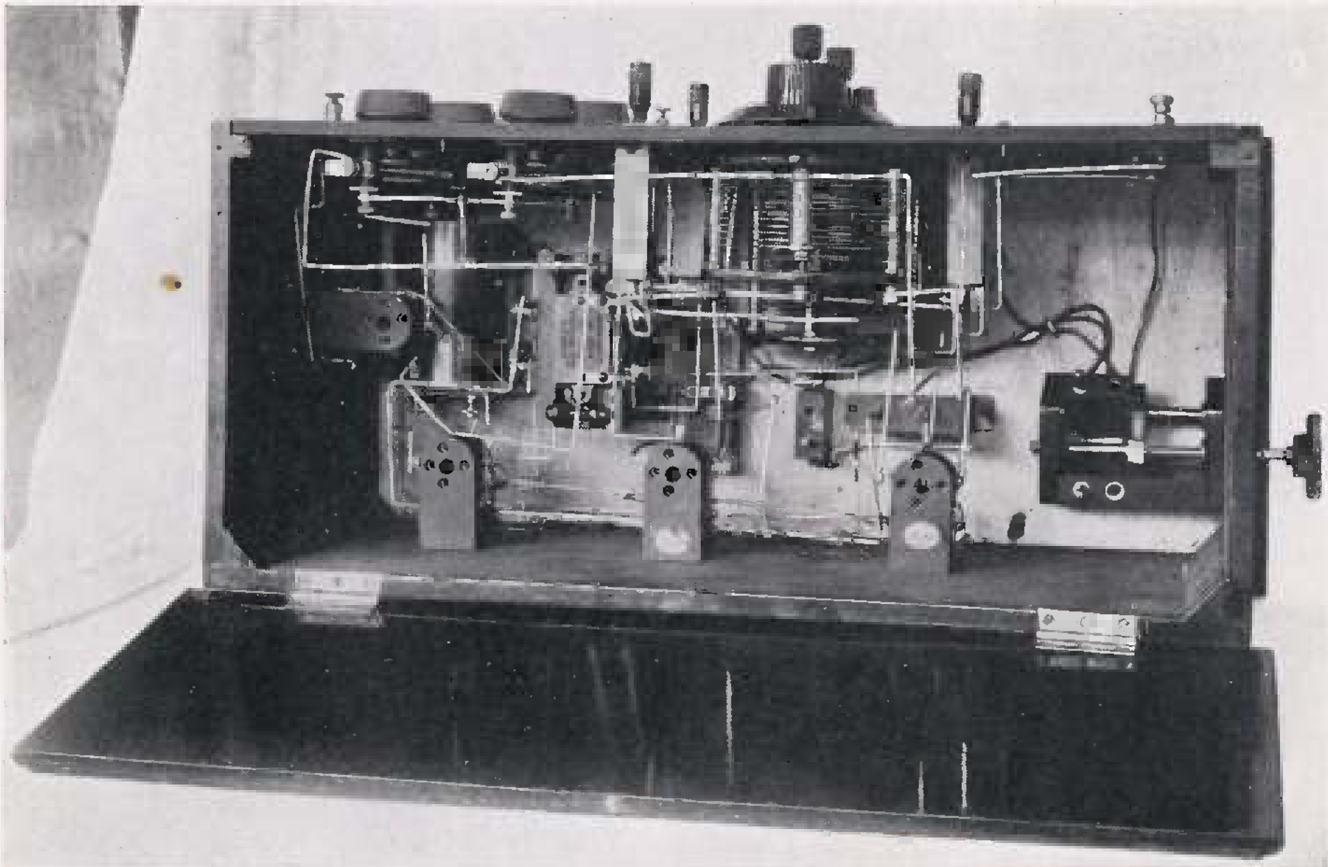
FIG. 5.—This diagram shows four alternative combinations of the valve switches. In the first position the detector valve alone is in use, in conjunction with the telephones; in the second position the high frequency valve is added to the detector valve, for the reception of long distance signals in the telephones; in the third position the detector and the two low-frequency valves are in circuit, for loud speaker reproduction; and in the fourth position all four valves are in circuit, also for loud speaker reproduction.

possible to the back wall of the cabinet, to allow plenty of space for the operation of the reaction coil. Next mount the ten battery terminals along the back wall at a height of 1 inch from the " false " floor.

The single coil holder, the grid leak and condenser, the two low-frequency transformers, and the two fixed condensers can now be fitted into position on the " false " floor. Replace the panel on the front of the cabinet, and adjust the positions of

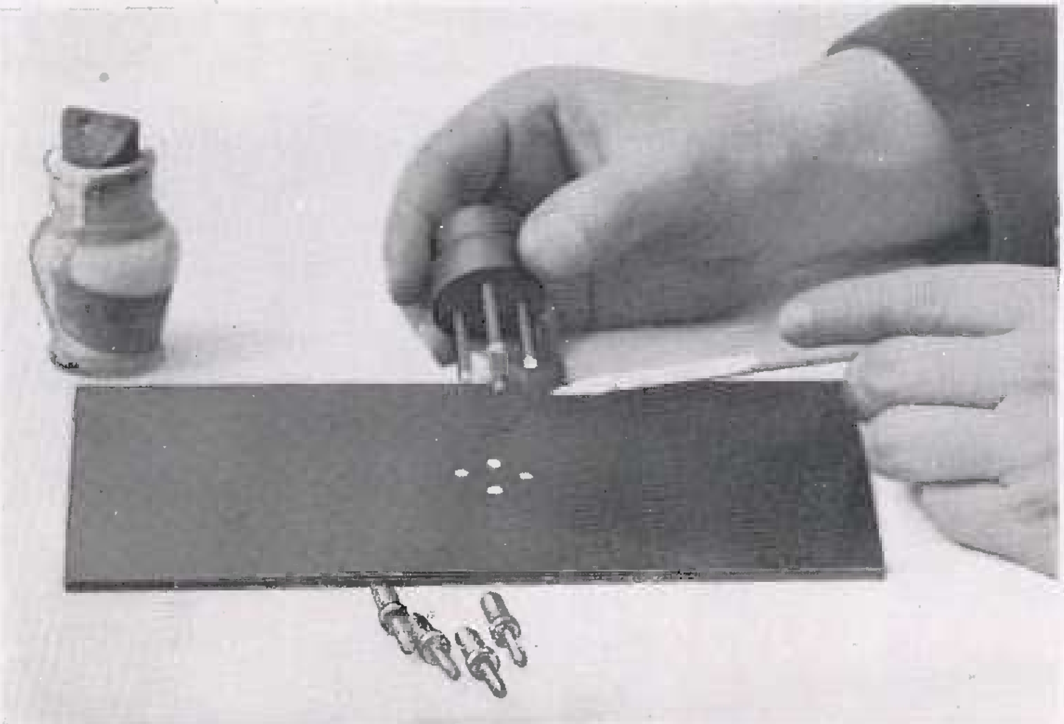
The panel and floor can now be withdrawn together, and a good deal of the wiring can be done before replacing this combined unit. It is recommended that the wiring be carried out with square " bus bar " wire. This can be obtained from any wireless dealer ($\frac{1}{16}$ inch square). It is strong and pliable, and enables neat " right-angled bends " to be made at all the awkward corners. All connections, except those to the double coil holder

Front view of the Four-Valve All-station Receiver.



Interior view of Four-Valve All-station Receiver.

(*See page* 16.)



In order to ensure that the holes in the ebonite are drilled at the correct distances apart, the prongs of the holder, or of the valve itself, may be marked with white paint or chalk, and an impression of the latter reproduced on the ebonite, by contact. All traces of paint or chalk should afterwards be removed.

A manufactured rheostat, or variable resistance, for regulating the flow of current through the filament of the valve.

(*See page* 9.)

and the L.F. transformers, should be soldered.

Having done as much as possible of the wiring on the floor and panel unit, replace the latter, and measure off the various wires that go to the battery terminals and valve holders. This is the trickiest part of the job, and care should be taken not to solder any connection that will prevent the floor-and-panel unit from being removed until *all* the connecting wires have been cut and bent to the required length and shape. It will be found necessary to remove the floor-and-panel unit several times to facilitate this part of the work. It may also be found convenient to remove the two low-frequency valve holders ; this can be done in a moment, of course. Some connections may safely be left to the end of the job (*e.g.*, the filament connections) as they are easily accessible after the floor-and-panel unit has been finally replaced. Work with a medium-sized soldering iron ; a big iron is clumsy, and a small one does not retain sufficient heat to enable the job to be done quickly. Go over each connection carefully with the aid of the diagram, and see that none are forgotten.

The designer of this receiver tested the instrument on a none too efficient aerial five minutes after the last connection had been made. Four Cossor " Wuncell " valves were used ; a W1 in the high-frequency position, a W2 for detector, another W2 in the first low-frequency stage, and a W3 power valve in the second low-frequency stage. All four valves were worked from an Oldham 2-volt accumulator. Within another five minutes three B.B.C. stations were tuned-in at loud-speaker strength, and, on tuning up to 600 metres, innumerable British and continental coast stations—not to mention a dozen or more ships—were immediately picked up. The anode voltages used were : 45 on the first valve, 30 on the second, 70 on the third, and 100 on the fourth. The first low-frequency valve had a grid bias of – 3, and the last valve – 6 volts.

SELF-OSCILLATION

WHEN a receiver oscillates spontaneously, without the assistance of a special energiser, it is said to be in a state of self-oscillation. This condition of spontaneous oscillation, or self-oscillation, should be rigorously avoided by the amateur when operating his receiver, because it constitutes a very annoying form of interference. An oscillating receiver is a miniature transmitter, which sends out a steady stream of continuous waves. These waves, though relatively weak, are capable of actuating the aerials of other listeners within a definite radius. It is quite a simple matter for a single oscillating receiver to put a hundred other receivers in its vicinity out of action for the time being. None but the most selfish and careless amateurs, therefore, will fail to take the necessary steps to prevent their receivers from oscillating. If the freedom of the ether is to be preserved for all, each individual must play the game. In receivers which employ reaction coupling on the aerial the coupling should always be kept as loose as possible. That is to say, the distance between the reaction coil and the aerial coil should be as great as may be consistent with satisfactory reception. If, in spite of this precaution, it is found difficult or impossible to prevent self-oscillation, the reaction coil should be reversed. Self-oscillation can also be prevented by " stabilising " the high-frequency valve, or valves, by means of a potentiometer. The function of this instrument, which should be connected across the filament battery, is to control the potential of the grid of the high-frequency valve. Special potentiometers for this purpose can be purchased from any wireless dealer.

THE STORY OF WIRELESS

A simple, non-technical explanation of how wireless signals are transmitted and received

WIRELESS, like any other branch of science, can present itself to the beginner either as an intensely interesting subject or as a deadly dull one, depending largely upon the amount of common-sense that is applied to it from the outset. The important thing for the beginner to remember is that the whole subject cannot be understood "straight off."

The novice must also guard against the error of taking analogies too literally. In order to explain an unfamiliar technical process, it is often not only helpful but necessary to make use of some analogy from everyday life. For instance, we compare the process of sending out a wireless message from a transmitting aerial with that of sending out a musical note from a violin string. There is a certain similarity between these two processes, *but they are not even nearly identical*, and it is from a failure to realise this latter fact that the beginner's troubles frequently arise. Analogies are taken too seriously, instead of being taken "with a pinch of salt," as it were. When it is stated that a transmitting aerial sends out a wireless message in much the same way that a violin string sends out a musical note, it must not be imagined that anything more than a similarity between the two processes is suggested; the analogy must not be pushed too far.

Analogies are merely intended to serve as stepping stones, by means of which the imagination of the reader can pick its way through realms of doubt. When one analogy has served its purpose to carry the reader a little bit towards enlightenment, it must be abandoned in favour of the next one.

The easiest and best analogy with which to introduce the subject of wireless is that of human conversation. In many important respects the processes involved in the transmission and reception of wireless messages are similar to those which take place when two human beings converse. Human conversation, in fact, may be described as nature's own system of wireless communication.

When two people are engaged in conversation they are, in the strictest sense of the phrase, communicating by wireless —*i.e.*, without the aid of wires. One speaks; the other listens. That is to say, one transmits and the other receives, and the transmitted or spoken message reaches the receiver (or listener) without the aid of any intervening wire. At any particular moment in the conversation the speaker and listener are functioning as miniature transmitting and receiving stations respectively. And when the speaker "closes down" and begins to listen, and the listener begins to speak, they simply reverse their functions, as do wireless stations that are engaged in communication with one another. Again, a speaker can broadcast his signals to a number of listeners at the same moment. When he speaks he radiates his message in all directions, just as each of the big wireless broadcasting stations radiates its signals every night in all directions. A street orator or singer comprises a small human broadcasting station, sending out signals that can be "picked up" by any small human receiving station (or listener) within range.

This brings us to another important point of similarity between these two systems of wireless. When I speak, my voice can be heard over a certain distance, and this distance depends primarily upon two factors: (1) the amount of strength or energy I use in speaking, and (2) the quality of hearing possessed by my listener. If I speak with average strength, and if my listener has average hearing, I shall be intelligible to him at a distance of, say, twenty yards. If I speak softly, my listener will probably have to reduce the distance between us to ten yards, in order to be able to hear me. Or, if I suddenly shout, he will probably still be able to hear me if he moves away to a distance of forty yards. Again, if my listener's hearing is not good—*i.e.*, if he is slightly deaf—the above distances will have to be reduced by at least a few yards before he can hear me, whilst if his hearing is unusually sharp, he will be able to catch my words at still greater distances. Again, if he is very deaf he will scarcely be able to hear me over more than a few inches, even though I shout my loudest. We can therefore say that the distance over which speech can be received depends upon the amount of energy used by the speaker *and* upon the sensitivity of the listener's hearing; or, to state the same conclusion in a different way, the loudness of "signals" received from a speaker depends upon the amount of energy used by the speaker *and* upon the distance between speaker and listener.

The same conditions obtain in connection with the wonderful system of wireless communication devised by man. The London Broadcasting Station, for instance, uses a certain amount of energy to send out its programmes each evening. The amateur who possesses a sensitive valve receiving outfit (representing the man with sharp hearing in the foregoing analogy) can pick up these programmes over hundreds of miles, whilst the amateur who can only boast a (comparatively insensitive) crystal outfit (representing the rather deaf listener) will not be likely to receive the programmes outside a range of thirty to forty miles. If the London Broadcasting Station were to increase its energy and, as it were, shout, its signals could be received over proportionately greater distances by both valve and crystal outfits. Unfortunately for listeners-in, however, the Government restricts the amount of energy that may be used for broadcast transmission.

No matter how much energy is employed by a broadcasting station, the distance over which its signals can be received depends upon the sensitivity of the receiving equipment. With a very insensitive receiver one might fail to get intelligible signals at a distance of five miles from a high-powered transmitting station which is capable of producing clear signals in a sensitive receiver 5,000 miles away. This would be comparable to what takes place when, by shouting at the top of my voice, I can make myself clearly intelligible to a friend who listens from a distance of 100 yards, whilst a very deaf person at my elbow can only hear a faint, confused rumble. Finally, then, the distance over which signals can be received from any wireless station depends upon the amount of energy or power used by the station *and* upon the sensitivity of the receiving apparatus; or, again, the loudness of the signals received from any transmitting station depends upon the sensitivity of the receiver *and* upon the distance between the receiver and transmitter. If one were to travel away from London in a motor car fitted with a portable wireless receiver, one would find that signals from the London Broadcasting Station gradually decreased in strength and finally died away altogether when the range became too great for the receiver—just as, if a person walks away from a speaker, the sound of the latter's voice gets weaker and weaker, finally dying away completely as the listener gets "out of earshot."

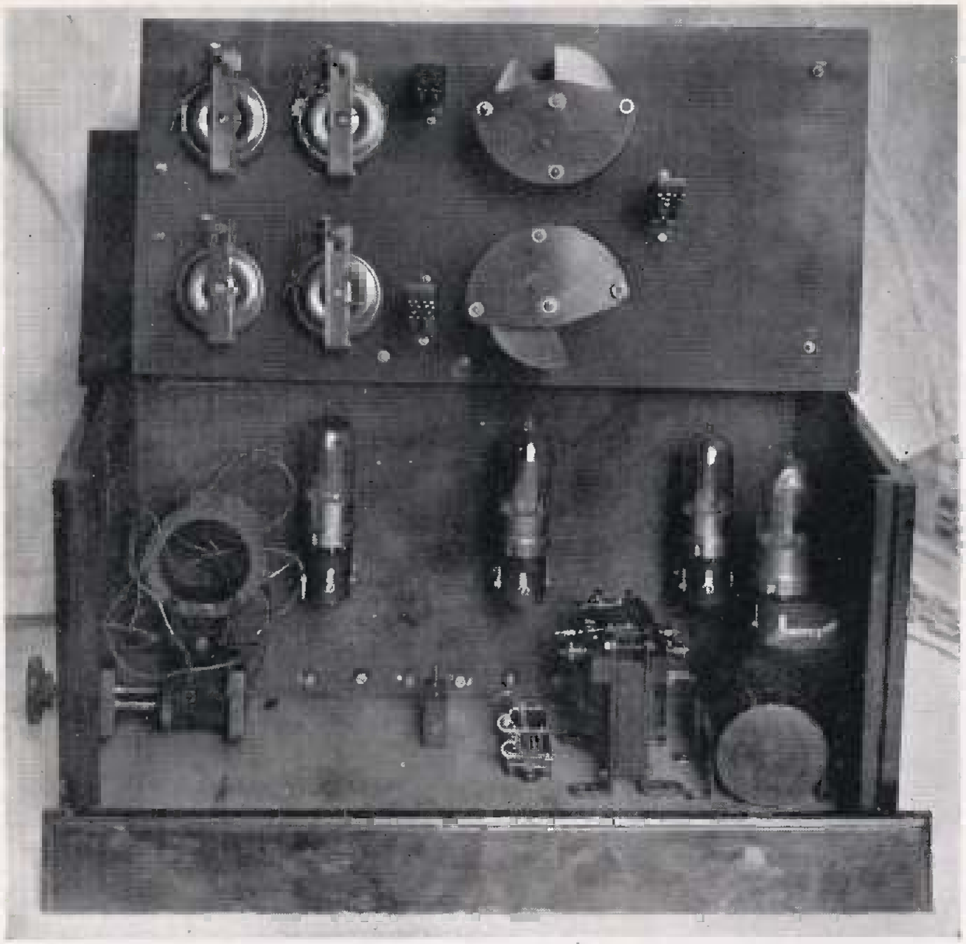
Let us examine a little more closely the method adopted by nature in the miniature system of wireless which we employ in ordinary conversation. Out of what material does nature construct her wireless transmitters and receivers? What is it that enables a message to be "radiated" by one person and "picked up" by another? These questions are really quite simple, provided we do not try to investigate them in too much detail. Each of us is provided by nature with two small membranes, or "vocal chords," situated in the throat. In the act of speaking these chords are shaken, or vibrated, and the vibrations thus produced give rise to waves of energy in the surrounding air. The energy which causes the vibrations in the first place is, of course, drawn from the general store of vital energy that animates the speaker's body—life energy. In the act of speaking some of that energy is "tapped" and utilised for the purpose of vibrating the vocal chords, and these vibrations, in turn, impart energy to the surrounding air in the form of waves. The more energy is used for the purpose, the more "energetically" do the chords vibrate and the greater is the amount of energy in the resulting waves; and if the waves are strong they travel a comparatively long distance, and if they are weak they travel only a short distance. A certain amount of energy is lost by the waves in overcoming the resistance of the air as they move outwards, and if they are already weak when they leave the speaker they soon die out altogether. The two essentials for speech, therefore, are (1) a supply of energy, and (2) chords which are capable of being vibrated by that energy. These are also the essentials of a wireless transmitting station; the energy, however, is in a particular form (*i.e.*, *electrical* energy), and the chords are composed of wire (generally known as an "aerial").

Nature also provides us with a miniature receiving apparatus in our ears. This also comprises small delicate membranes which can be acted upon and vibrated by waves of energy in the surrounding air. The waves of energy that radiate from a speaker's throat strike upon the delicate membranes in a listener's ears and cause them to vibrate; the mechanism of the listener's brain then converts these vibrations into "sound." The miniature receiving equipment of nature's wireless thus comprises two essentials, also, viz.: (1) membranes that are capable of being vibrated by passing waves and (2) a mechanism for converting these vibrations into sound. And the same essentials are met with in a receiving equipment of the wireless system devised by man, known respectively as the "receiving aerial" and the "receiver."

Each of us is thus fitted with a miniature "transmitter" and "transmitting aerial" and a miniature "receiver" and "receiving aerial." The transmitter utilises a certain amount of energy to vibrate the transmitting aerial. The vibrations of the latter cause waves of energy to radiate in all directions—the distance over which the waves travel in any direction depending upon the amount of energy used in the first instance. These waves are capable of producing sympathetic vibrations in the "receiving aerial" of any listener within range, and the vibrations thus picked up are converted into sound by the "receiver" in the listener's head. A similar series of operations takes place when a wireless message is sent out from the London Broadcasting Station and picked up by a receiving station at, say, Eastbourne. The transmitting aerial at the London Broadcasting Station is vibrated by the power derived from an electric motor. These vibrations cause waves of energy to spread out, or radiate, in all directions. Some of the waves strike the receiving aerial at Eastbourne and are converted into sound by the receiver to which that aerial is connected.

From what has been said it will now be clear that no direct answer can be given to such questions as: "What is the range of your receiving station?" "How far can a broadcasting station send?" The answers to such questions depend on the power of the transmitting station from which signals are to be received and the sensitivity of the receiver used for picking up the broadcasted signals. The first question is equivalent to asking: "What is the greatest distance over which you can hear sound?" The obvious answer to which is: "It depends upon the amount of energy used in producing the sound." Similarly, the second question is equivalent to asking: "Over what distance can your voice be heard?" A correct answer to which would be: "It depends largely upon the quality of hearing possessed by whoever is listening to me." Finally, then, as with human conversation so with wireless communication: the distance over which a receiver can pick up messages depends upon the amount of energy used by the transmitter, and the distance over which a transmitter can send intelligently depends upon the sensitivity of the receiver.

There is yet another important process involved in ordinary conversation which is closely analogous to a basic process in



Showing positions of various components in Four-Valve Receiver before wiring up. The ebonite panel (back view) is balanced on top of cabinet. Note the battery terminals in back wall of cabinet.

(*See page* 16.)

"CRYSTAVOX" LOUD SPEAKER.

This "Crystavox" Loud Speaker can be used with a crystal receiver. If signals are clearly audible when the 'phones are held twelve inches from the ear they are quite loud enough to operate a "Crystavox."

(*See page* 50.)

wireless communication. The "transmitting" mechanism in my throat enables me to vibrate my vocal chords at different rates. If I produce rapid vibrations, the energy waves set up in the air will follow each other rapidly, and on striking the receiving membranes in a listener's ears will produce rapid vibrations in them. And if I vibrate my vocal chords slowly, the resulting energy waves in the air will follow each other slowly and produce slow vibrations in the receiving membranes of a listener's ears. The first thing to note about this is that the vibrations at the receiving end are a reproduction of those at the transmitting end. In fact, except that they are weaker—some of the energy of the waves having been expended *en route*—they are an *exact* reproduction. Now, the mechanism of the brain converts the received vibrations into sound, and the "pitch" of the sound depends upon the rapidity of the vibrations. If the vibrations occur rapidly the pitch of the sound is high, and if they occur slowly the pitch of the sound is low, vibrations of intermediate rapidity producing sounds of intermediate pitch. Thus, if I vibrate my vocal chords at a certain rate my listener will hear, say, the note "doh" on the tonic sol-fa scale. If I now increase the rate of vibration by definite amounts, he will hear the notes "ray," "me," "fah," "soh," etc. The quicker the rate of vibration, the higher the pitch of the note.

As stated above, a similar process is met with in wireless communication. Transmitting aerials can be vibrated at widely different rates. When an aerial is vibrated quickly the "wireless waves" set up by its vibrations follow each other quickly through space and set up rapid vibrations in any receiving aerial within range; similarly, when a transmitting aerial is vibrated slowly it produces slow vibrations in a receiving aerial. In other words, a receiving aerial always vibrates in sympathy with the transmitting aerial whose signals it is picking up; both aerials vibrate at exactly the same rate or "frequency." We will return to this question of frequency again.

To sum up, then, the fundamental process by which wireless messages are transmitted and received is closely analogous to that involved in ordinary conversation. The transmitting aerial is vibrated by means of a quantity of electrical energy, the rate at which the vibrations take place being controlled by a special mechanism known as a "transmitter." These vibrations cause waves of energy to flow out through space in all directions, and the waves get weaker and weaker as they travel further and further. If these waves strike a receiving aerial they set up sympathetic vibrations in the latter, causing it to vibrate at the same rate as the transmitting aerial. The strength of the received vibrations depends upon the amount of electrical energy originally used in the transmitter *and* upon the distance between the transmitting and receiving aerials. If the received vibrations are sufficiently strong they can be converted into sound by means of a special mechanism known as a "receiver." The complete operation of sending and receiving a wireless message is therefore as follows: A special mechanism vibrates the transmitting aerial; as the result of these vibrations wireless waves are sent out through space in all directions; some of these strike the receiving aerial and cause it to vibrate in sympathy with the transmitting aerial; the received vibrations are then converted into intelligible sounds by the "receiver."

We now come to an important point at which our analogy breaks down—or, rather, at which we see that our analogy is *only* an analogy. The vibrations produced in our vocal chords in the act of speaking are *physical* vibrations, similar to the vibrations produced by "plucking" a violin string. When a violin string is vibrated by being plucked it can be *seen* to vibrate. The string actually moves backwards and forwards, causing waves of energy to flow through the air in the manner already described. But the vibrations produced in a transmitting aerial are *electrical* vibrations. These vibrations cannot be seen. The aerial remains perfectly steady, even when it is vibrating most fiercely; there is no outward movement whatever.

The beginner may be confused at first by the idea of invisible vibrations, but a little reflection will soon get rid of any confusion that may be experienced on this score. If one were able to heat and cool a rod of metal alternately at short intervals, one would, on gripping the rod, get the impression that it was vibrating with heat. The easiest way to describe the alternate sensations of hot and cold would be by saying that the rod was "vibrating with heat." Yet the rod would evince no movement; it would not "shake" like the violin string. Or, again, if, instead of heating and cooling the rod, one were to pass a current of electricity through it, switching the current "on" and "off" alternately, one would, on touching the rod, get the impression that it was vibrating with electricity. Provided the current was not too strong, one would get a series of tolerable electric "shocks," separated from each other by periods of no-shock. The stationary rod would be vibrating electrically.

This is actually how a wireless transmitting aerial is vibrated. A current of electricity is passed up and down it very rapidly, with the result that it vibrates electrically. Each complete vibration sends a wave of electrical energy out from the aerial. On striking a receiving aerial the waves thus produced cause the latter to vibrate electrically, in sympathy with the transmitting aerial. In other words, the receiving aerial also vibrates *electrically*—a current of electricity flows up and down it at exactly the same rate as the current in the transmitting aerial. The *only* difference between the vibrating currents in the two aerials is that the transmitting current is much stronger than the received current, owing to the loss of energy from the waves in their passage from one to the other. The greater the distance between the two aerials, of course, the greater the loss of energy from the waves and the greater the difference between the current strength.

The main problem of reception is that of converting this comparatively weak received current into sound. It will be obvious that if this current is *very* weak it will have some difficulty in "making the wheels go round" in the receiver; hence the advisability of picking up as much current as possible from the waves.

We must now consider another important point of dissimilarity between wireless and conversation. When we speak we send out waves of energy through the surrounding air. The same thing happens when we play a violin or a piano or any other musical instrument, or when we bang the table, or cough or whistle, etc. In each case we cause waves of energy to flow out through the air in all directions from the "source of disturbance." Now, the air is an essential factor in this process; it is the medium through which the sound waves (as they are usually called) flow. If there were no air there could be no sound; there could be neither "speaking" nor "hearing." If all the air were exhausted from the room in which the reader is now sitting, he or she would be unable to hear the slightest sound of any description. There would be complete silence, which could not be broken by the discharge of a gun a few feet away. In short, air is the substance which conveys the "sound" of a speaker's voice to a listener's ears, and if there were no air there could be no conversation.

Now, wireless waves are quite different from sound waves in this respect. Air is *not* the medium through which wireless waves move from a transmitting station to a receiving station. Wireless waves are totally independent of air. They can pass through an air-filled room as easily as they can pass through a room from which all the air has been exhausted. But they do pass through something—or so it is assumed, at any rate. Scientists find it difficult to imagine that energy can pass from one place to another without the assistance of a conveying medium of some kind or other. As pointed out above, this view is supported by the fact that the energy of sound waves cannot be conveyed from one point to another without the assistance of the air—a fact which can easily be demonstrated in practice. The view is generally held, therefore, that there actually exists an invisible and intangible substance through which wireless waves flow—a mysterious substance which we are utterly incapable of detecting with any of our physical senses. To this substance is given the name of "ether." Ether is the medium through which wireless waves flow.

This mysterious medium pervades the whole of the physical universe. It permeates all matter. It exists wherever there is matter, and it also exists wherever there is no matter—*i.e.*, in a vacuum. In other words, it exists throughout space. Wherever there is space there is ether. Ether is the stuff that space is made of. This is important to remember. When a wireless message is sent from, say, London to Manchester, it is through the ether that the wireless waves flow. They do not flow through the air. If there was no air between London and Manchester the waves would accomplish their journey just as easily and just as quickly. Also, if the message was received on an indoor aerial at Manchester, the waves would flow through the ether that permeates the walls of the house in which the receiving aerial was installed, and thus reach the aerial. Ether underlies the bricks in the walls of the house. They are like so many sponges soaked with ether. The whole universe swims in a sea of ether, as it were.

We have now noted a fundamental difference between sound waves and wireless waves. The former flow through air, and the latter flow through ether, for which reason they are sometimes distinguished from each other as "air waves" and "ether waves." Now wireless waves are not the only waves that flow through the ether. The light waves that come to the earth from the sun and the stars also travel through the ether. Also the waves of radiant heat that come from the sun travel through the ether. In fact, these light and radiant heat waves *are* wireless waves. They are manufactured by nature, however, and they differ from the wireless waves manufactured by man in one respect: they are much *shorter* than the latter.

We have now referred to sound waves, wireless waves, light waves and heat waves, and we have seen that sound waves are in a class apart from the others. Air is the medium through which they are conveyed, whilst all the others act through ether.

Ether waves therefore include light waves, radiant heat waves, and what we ordinarily call wireless waves; and these waves only differ from each other in the matter of *length*—just as the waves of the ocean only differ from each other in the matter of length. Out in mid-ocean the huge "rollers" may be hundreds of feet long: closer in to the shore the waves are usually much shorter—a matter of 20 feet, perhaps—and the tiny "ripples" that race along the beach may be only a few inches in length. In the same way the waves of the ether differ from each other in length. Light waves are the "ripples" of the ether, and wireless waves are the "rollers," and between these are the waves of radiant heat.

Very short ether ripples produce the sensation of *violet* colour when they strike our eyes; slightly longer ripples produce the sensation of *blue*, and so on through the colour scale until we reach the longest of the ether ripples, which produces the sensation of *red*—these being the longest ether waves that we are capable of detecting with our eyes.

The next longest ether waves are incapable of affecting any of our physical senses, and are usually referred to as "infra-red" waves. Following these in the order of length come the waves of radiant heat, and after these, finally, are wireless waves—the longest of all ether waves. There are ether ripples even shorter than those which produce the sensation of violet colour (the famous X-rays), but they are also outside our range of physical detection. The longest light waves are only the tiniest fraction of an inch in length, and radiant heat waves are only very slightly longer. In fact, the whole range of light and radiant heat waves are encompassed in a very small fraction of an inch! Wireless waves, however, extend over a much wider range. The smallest wireless waves that have been produced so far are about half an inch in length, whilst the longest wireless waves are in the neighbourhood of twenty miles.

RADIO TRANSMISSION

The essential differences between radio-telegraphy and radio-telephony are explained below in simple language

WHEN a wireless message is sent out from a transmitting station, the transmitting aerial has to be vibrated electrically in order to produce waves of electrical energy in the "ether." The waves thus set up radiate from the transmitting aerial *in all directions.*

The analogy of a stone dropped into a pond is often used to illustrate this idea of waves being radiated in all directions. As the result of the impact of the stone and the water the latter is caused to rise and fall in "rings," which gradually spread out further and further through the water from the point of impact. Moreover, should these circular waves reach to a block of wood floating on the surface of the water at the other side of the pond, the block of wood will "bob up and down" as each wave passes it, thus illustrating one way in which water waves might be "received." These water waves, however, do not radiate in all directions; they are confined to the surface of the pond. Wireless waves on the other hand, in addition to travelling horizontally (like the water waves), travel upwards and downwards and, literally, in all directions.

Let us imagine now that we have at our disposal a transmitting aerial and the necessary mechanism and energy for vibrating it. And let us imagine further that the aerial is connected to the transmitting mechanism through a switch, by means of which we can connect these two items together or disconnect them from one another at will. (The action of this switch will be similar to that of the familiar "tumbler" switch, by means of which an electric light bulb is switched "on" or "off.")

When the switch is placed in one position the aerial is connected up to the electric supply and, as the result of the vibrations thus set up in the former, wireless waves are sent out in all directions. And when the switch is placed in the other position the aerial is disconnected from the electric supply, thus putting an end to the aerial vibrations and the emission of wireless waves. Now when the switch is placed in the former position the waves radiated from the aerial can produce sympathetic vibrations in a distant aerial, and these vibrations can, by means of a special apparatus, be converted into sound. So long as the switch at the transmitting station is "on" a buzzing sound will be heard at the receiving station, and when the switch is put "off" (*i.e.*, disconnected) the buzzing sound will cease. By putting the switch "on" for long or short intervals, therefore, long or short buzzes can be produced at the receiving station.

This is the method employed in wireless *telegraphic* communication. The operator at the transmitting station controls a switch, by means of which he can vibrate his aerial for long or short intervals, thus producing long or short buzzing sounds in the telephones of the operator at the receiving station. Certain combinations of long and short buzzes are used to denote definite letters of the alphabet, and each word is spelt out letter by letter. Thus, the letter *a* is represented by a short buzz followed by a long buzz, the letter *b* by a long buzz followed by three short buzzes, the letter *c* by the following series: long buzz, short buzz, long buzz, short buzz—and so on for all the other letters of the alphabet. Any pre-arranged combinations would serve the purpose of communicating by this method, of course, but the combinations invariably employed to-day are those which were evolved by a gentleman named Morse during the last century, and are therefore known collectively to-day as the Morse code.

In practice, it is usual to refer to short and long buzzes as "dots" and "dashes," respectively. Thus the Morse equivalent for *a* is "dot-dash," for *b* "dash-dot-dot-dot," for *c* "dash-dot-dash-dot," etc. The switch controlled by the operator at a transmitting station does not resemble an ordinary electric light switch in appearance, of course, although both switches function in the same way. A transmitting switch—or "operating key," as it is usually called—takes the form of a short horizontal bar which can be "rocked" up and down on a pivot. When the key is pressed down the aerial becomes connected to the transmitting mechanism (thus causing the former to vibrate) and the wireless waves are sent out. On removing the pressure of the hand, a special device causes the key to spring back to its former position, automatically disconnecting the aerial from the transmitting mechanism again.

Needless to say, a wireless *telephony* transmitter operates on a somewhat different principle from that described above. In wireless telegraphy (*i.e.*, Morse communication) the vibrating electric current that flows into the transmitting aerial is controlled by the action of the operating key. In wireless telephony, however, the current that flows into the transmitting aerial is controlled by the sound waves that flow from the speaker's or singer's throat. This is effected by means of an instrument called a "microphone," which is in all important respects similar to the little black "mouthpiece" with which every post office telephone is fitted. In wireless telephony, therefore, the microphone may be said to take the place of the operating key which forms such an important item in a telegraph transmitter. The operating key is pressed down and released by the action of the hand, whilst the microphone is compressed or released by the action of the sound waves which strike upon it.

A microphone consists essentially of two small discs, which contain, between them, a quantity of powdered carbon. When the discs are pressed together the minute particles of the carbon are also packed closely together, and when the distance between the discs is *increased* the little carbon particles become loosened. (This is quite obvious, of course; the effect of pressing the discs together is similar to that of pressing the sides of, say, a bag of sugar together.) Now the current that flows into the transmitting aerial depends upon the amount of current that can flow through this powdered carbon; when a strong current flows through the carbon a strong current flows into the aerial, and *vice versâ*. Moreover—and this is the important point—the strength of the current that can flow through the carbon depends upon the compactness of the carbon particles. The more tightly they are packed together the stronger the current that can flow through them, and hence the stronger the current that can flow into the transmitting aerial. In other words, when the carbon powder is compressed, its resistance to the passage of electricity decreases, with the result that a comparatively large current can flow through it. Similarly, when the pressure exercised upon the carbon is reduced the resistance of the latter to electricity is increased, with the result that it will only allow a comparatively small current to pass through it. Big pressure means big current.

As stated above, the current that flows through the microphone (*i.e.*, through the powdered carbon) is controlled by the action of the sound waves that strike upon it. When the sound waves that emanate from a speaker's voice are strong (*i.e.*, if the voice is "loud") the discs are compressed rather a lot, and a fairly big current flows through. Again, when the sound waves are weak (*i.e.*, when the voice is "soft") the discs are only slightly compressed, and a comparatively small current flows through. Similarly, if the sound waves follow each other at a fairly rapid rate (*i.e.*, if the pitch of the voice is "high") the rate at which the pulses of vibrating current follow each other through the carbon (and, consequently, into the aerial) will be equally rapid; and if the sound waves follow each other at a slow rate (*i.e.*, if the pitch of the voice is "low") the rate at which the pulses of current flow into the aerial will be equally slow. Every variation that occurs in the *strength* and *pitch* of the "transmitting voice" thus effects a variation in the current that flows into the aerial.

The character of the voice is thus, as it were, stamped upon the current that vibrates the aerial. It is also, therefore, borne along by the wireless waves which the aerial vibrations set up, and, since the waves produce vibrations in the receiving aerial which are reproductions of those in the transmitting aerial, the vibrations in the receiving aerial will also be stamped with the character of the voice. (It must not be forgotten that, except that they are proportionately weaker, the vibrations set up in a receiving aerial are identical with those which occurred in the transmitting aerial. The vibrations in the transmitting aerial are reproduced in miniature in the receiving aerial.) In wireless telephonic transmission, therefore, sound waves are, as it were, converted into variations in wireless waves. The problem of reception is to re-convert these back into sound waves.

We may here consider the factors that affect the *length* of wireless waves and the *rate* at which they follow each other from a transmitting aerial. Wireless waves may vary in length from a fraction of an inch to about twenty miles. The length of the waves sent out by commercial transmitting stations, however, usually ranges from hundreds to tens of thousands of feet, though these limits are sometimes exceeded. The average length of the waves sent out by the various broadcasting stations is in the neighbourhood of 400 metres.

The length of a wireless wave is taken to be the distance between the crests of the two adjacent waves. When we speak of the length of the wave sent out by any particular transmitting station, therefore, we mean that the crest of each wave is distant from the crest of the wave immediately before and behind it by a definite amount. And this distance is commonly known as the "*wavelength.*" There is another important factor to be considered at this point, viz., the rate at which the waves follow each other through space. This, of course, will depend upon the rate at which vibrations are produced in the transmitting aerial. If the latter is vibrated rapidly the waves will follow each other at short intervals, and if it is vibrated slowly the waves will follow each other at long intervals. This rate at which the waves follow each other is known as the *frequency* of the waves. These two definitions should be kept clearly in mind. The wavelength is the distance between the crests, or tops, of two adjacent waves. And the frequency is the rate at which waves follow each other. Now there is a fundamental relationship between these two factors of wavelength and frequency, and it may be expressed as follows: the greater the wavelength the smaller the frequency, and the greater the frequency the smaller the wavelength. This will need a little further explanation.

The reader must try to get a clear idea of what is meant by the *frequency* of wireless waves. There is nothing complicated about it. When used in reference to wireless waves the word "frequency" is used in its ordinary everyday sense. When we speak of the frequency with which accidents occur in the city of London we refer to the *number* of accidents that occur in the city of London *in a certain time*—per day, or per week, or per month. Now let us take a simple example to illustrate the law which states that the wavelength and the frequency vary inversely, *i.e.*, that when the wavelength increases the frequency decreases, and when the wavelength decreases the frequency increases.

Suppose that there is a straight railway line running from, say, London to Manchester, and that there is a straight road running alongside it. And suppose, further, that there is an unlimited supply of trains at the London terminus and an unlimited supply of motor cars at a neighbouring garage. At a stated time an exodus of trains from London commences, each train following *immediately behind* the one in front of it, and all moving at a uniform speed. At the same time a similar exodus of motor cars commences (from the adjacent garage), each car following *immediately behind* the one in front of it, and all travelling at the same speed as the trains.

Now the length of each train is 84 feet, and the length of each motor car is 7 feet.

By the time the first train has drawn out of the station, therefore, the twelfth motor car will have drawn out of the garage.

As the second train begins to leave the station the thirteenth motor car also begins to leave the garage, and by the time the second train has drawn clear of the station the twenty-fourth motor car will also have drawn clear of the garage, and so on. For every train that leaves the station twelve motor cars will leave the garage. The frequency of the motor cars from the garage may thus be said to be twelve times that of the trains from the station. Each train, however, is twelve times as long as each motor-car. The frequency and the length of the vehicles are therefore in inverse proportion.

The parallel lines of trains and motor cars race on towards Manchester, the front of the first train level with the front of the first motor car. On reaching Manchester, the first train will take a certain time to enter the station, and during that time twelve motor cars will enter the neighbouring garage. Twelve more motor cars will enter the garage in the time taken by the second train to enter the station, and so on. The relation between the frequency and length of the vehicles is thus the same at the receiving station (Manchester) as it was at the dispatching, or transmitting station (London).

Now let us alter one factor in the example we have taken; let us suppose that the length of each train is 168 feet, instead of 84 feet, *i.e.*, twice as long as in the original example. If in the first instance each train took half a minute to draw out of (or into) a station, it will now take a full minute. That is, the frequency with which the trains arrive at a station will now be halved. Only one will arrive each minute, whereas in the former instance two of them arrived each minute. In other words, by doubling the length of the trains their frequency is halved. Similarly, if we were to treble the length of the trains (or motor cars) their frequency would be reduced to one-third of its former value, and so on.

By substituting wireless waves for trains and motor cars in the above analogy the reader should have little difficulty in grasping clearly this important relationship between wavelength and frequency. *As the wavelength increases the frequency decreases, and as the wavelength decreases the frequency increases.* On looking into the matter carefully it will be seen that this law held in the above analogy of trains and motor cars because all the vehicles moved *at the same speed.* Had the trains travelled more slowly or more rapidly than the motor cars, the whole analogy would have been thrown out of joint. If waves of different length travelled at different velocities the above relationship between wavelength and frequency would not exist. But they do not. All wireless waves, whatever their length, travel at the same velocity. That velocity, moreover, is extremely high, being in the neighbourhood of 186,000 miles per second. (Light waves and waves of radiant heat travel at the same enormous speed.) It is quite impossible to imagine anything moving at 186,000 miles per second, of course. We must, nevertheless, be content to accept it as a fact that wireless waves do actually move through the ether at this colossal speed, which, when reduced to metres, is 300,000,000 metres per second.

Now, suppose we were to vibrate an aerial at a frequency of one million vibrations per second. (Also a difficult process to imagine; yet far higher frequencies can be attained!) At the end of the first second a million waves will have spread themselves over a distance of 300,000,000 metres. Each single wave will, therefore, be 300 metres in length. (If a million waves occupy 300,000,000 metres, one wave must occupy 300 metres. The wavelength is thus obtained by dividing the velocity by the frequency.) Again, suppose we were to vibrate an aerial at a frequency of 500,000 per second, *i.e.*, half the former frequency. In this case 500,000 waves will have spread themselves over a distance of 300,000,000 metres at the end of the first second, since the velocity remains the same. Each wave will, therefore, be 600 metres in length. Similarly, it will also be seen that when the frequency is doubled the wavelength is halved.

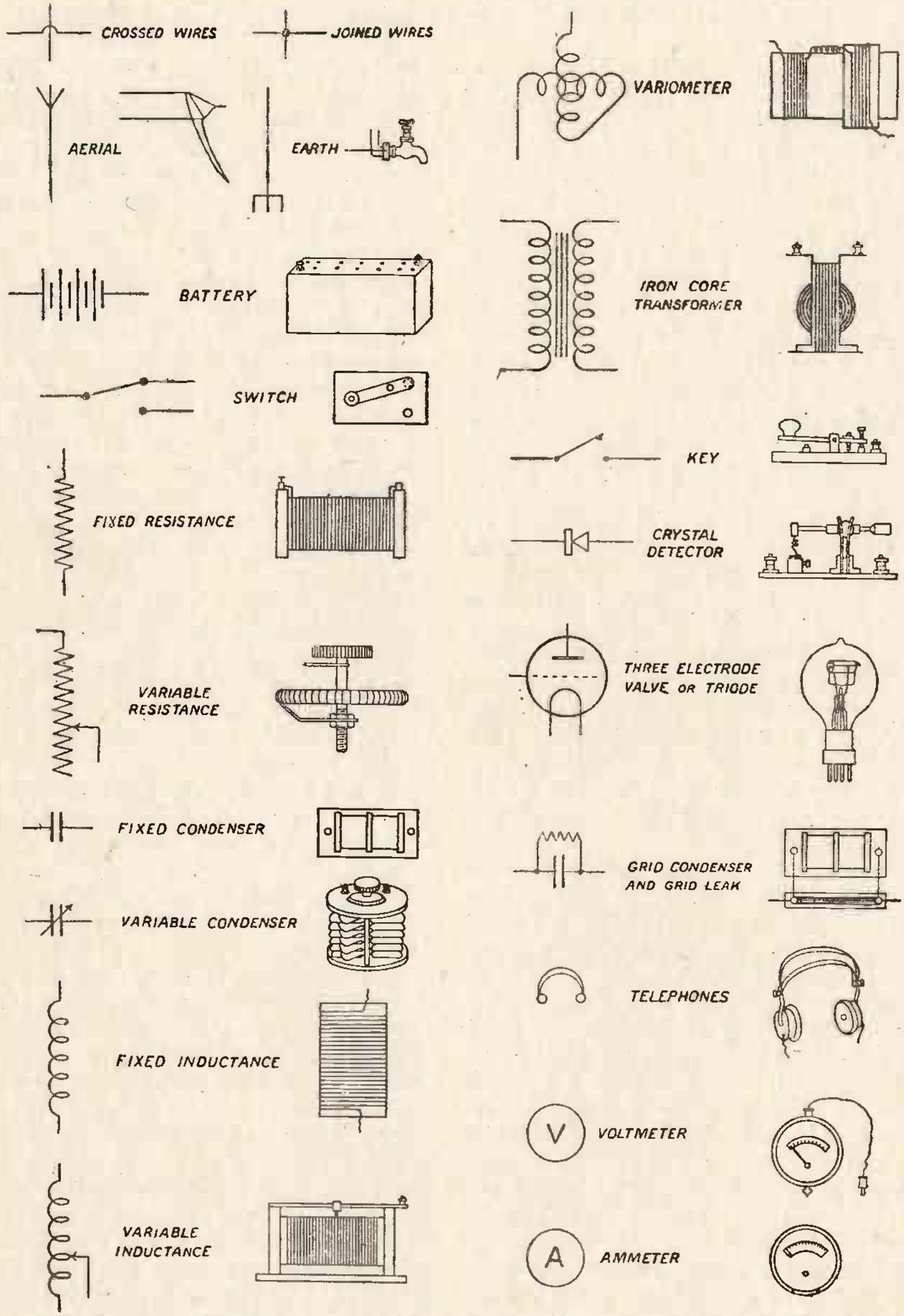
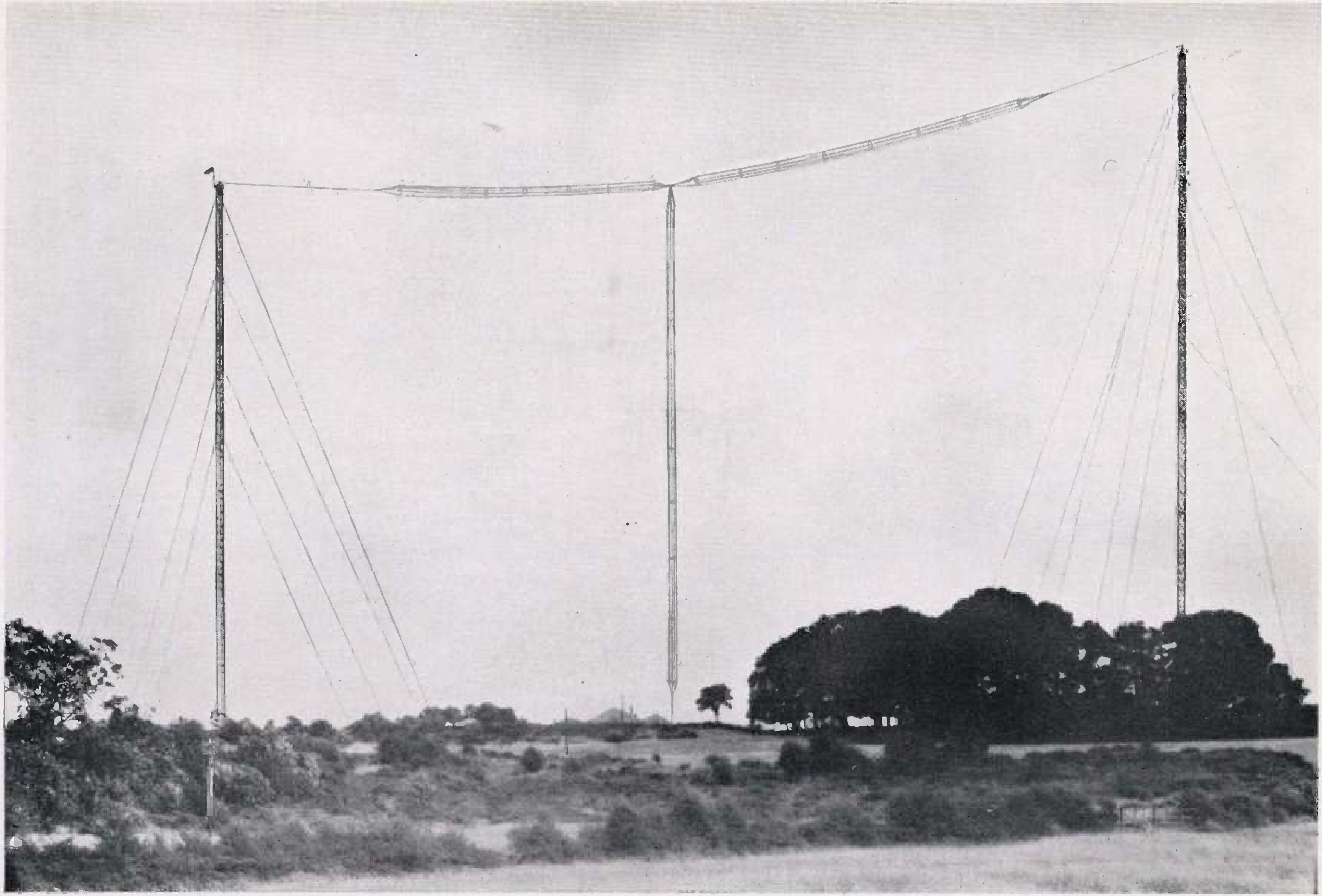


Table of symbols used to denote familiar instruments.



Daventry Station.

This photograph gives a clear view of the masts and aerial system of 5XX, the high-power broadcasting station at Daventry, in the centre of England. The masts are 500 feet high, and the aerial, which is of the "sausage" type, has a horizontal span of 600 feet. The power of this station is 25 kilowatts, and it can be picked up within a radius of 100 miles on a crystal receiver.

SOME USEFUL OPERATING TIPS

THE majority of wireless amateurs are guilty of the fault of burning their valves too brightly. This should be rigorously avoided, because no other fault is likely to prove so expensive in the long run. Not only are signals weakened by burning a valve too brightly, but the life of the valve itself is thereby shortened considerably. It should always be remembered that the light given off by a valve is really *waste energy*. It serves no useful purpose. It is a by-product, as it were. The primary object in passing a current of electricity through the filament is to *heat* the filament, so as to make the latter shoot off electrons. But it so happens that when a filament is heated to a certain temperature it begins to glow (*i.e.*, to emit light waves), just as a poker that is heated in a fire begins to glow as soon as it has acquired a certain degree of heat.

There is, however, a correspondence between the heat developed in, and the light liberated from, a particular filament. Roughly speaking, the hotter a filament is, the brighter it also is. For practical purposes, therefore, varying degrees of brightness may be taken as indicating varying degrees of heat. One soon learns, when dealing with a particular valve, approximately what degree of brightness it should exhibit when working at its best. But the thing to remember is that there is nothing to be gained—on the contrary, there is much to be *lost*—by exceeding this value. Not only does undue brightness mean that the life of the valve is being shortened, and its efficiency impaired, but it also means that filament current is being wasted. The amateur who knows his job will always aim at making his valves emit *as little light as possible*. The golden rule is: A valve should burn as dully as is consistent with good results. This applies with special emphasis to dull-emitter valves.

Another common fault among amateurs, particularly among beginners, is the use of too much high tension. Precisely the same thing applies here. *Use as little high tension as possible.* A valve will often work far better with 40 volts high tension than with 50, or 80, or 100 volts. For some reason or other, the first thing a beginner thinks of when he wants to increase signal strength, is to "bung on more high tension." Or it may be that his first brain wave is to "give the filament more juice." In either case the chances are that he is going the best way to work to *reduce* signal strength. Now and again, of course, it may happen that a valve *does* need a little extra filament current or high tension, in order to get the best results from it, but this does not alter the fact that the vast majority of amateurs tend to "overload" their valves in these two respects.

Valves are used for three distinct purposes: (1) for high-frequency amplification, (2) for rectification, or detection, and (3) for low-frequency amplification. There are certain valves, usually called "general purpose" valves, which can be used to perform any of these three functions. In the early days of broadcasting practically all valves were of this kind. Nowadays, however, most manufacturers produce what may be called "specialised" valves; that is, valves which are intended for use in one only of these three ways. One type of specialised valve is intended for high-frequency amplification, another for detection, and a third for low-frequency amplification. Each of these types of valve, moreover, requires a *special method of treatment* as regards the amounts of filament current and high-tension voltage necessary for its proper functioning. For example, many detector valves work best with 30 volts high tension, whereas many low-frequency amplifying valves require as much as 120 volts. Even a "general purpose" valve, of which there still are many good types on the market, needs different current and voltage values when used for different purposes.

It will be obvious from this that the best results can only be obtained from a receiver when the connections of the latter are such that the filament current and high-tension voltage of *each* valve can be varied independently of the other valve or valves that the receiver may contain. This means that each valve must be provided with a separate filament rheostat, as well as with a separate "wander" plug by means of which its high tension may be varied. The amateur who possesses an old-fashioned receiver, in which a single rheostat controls the supply of filament current to all the valves, will therefore be well advised to modify his set so as to provide each valve with its own rheostat. The accompanying diagrams show how the different rheostats should be connected together. Fig. 1 shows a three-valve receiver, in which all valves are "fed" through the same rheostat, whilst in Fig. 2 each valve has its own rheostat.

The diagrams also show the alterations that are necessary in order to permit of a different high-tension voltage being applied to each valve. The receiver in Fig. 1 has only a single wander plug (marked with an arrow). The plate of each valve, it will be seen, is connected to the lead on which the wander plug is fitted. This means that whatever voltage is applied to the plate of the first valve (when the plug is inserted in one of the sockets on the high-tension battery) is also applied to the plates of the other two valves. The inefficiency of this method will be appreciated when we reflect that the first valve may have been designed to operate with 40 volts high tension, the second with 30 volts and the third with 80 volts. Fig. 2 shows how each valve can be provided with a separate lead and wander plug. Fig. 2 also shows how the third valve (*i.e.*, the low-frequency amplifying valve) of such a receiver could be fitted with "grid bias," but as this subject is treated in a special article elsewhere further comment will not be necessary here (see p. 37).

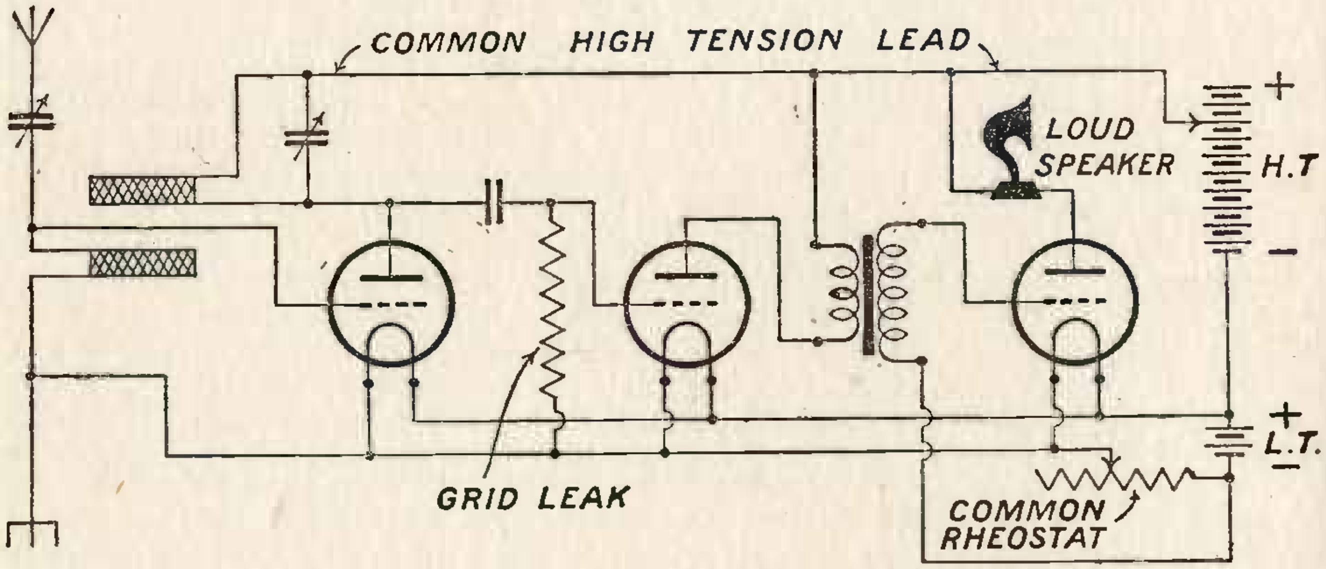


FIG. 1.—A three-valve receiver in which all filaments are controlled by the same rheostat.

The leads that connect a receiver to its batteries should not be unnecessarily long. Apart from the untidy appearance that they usually present, straggling leads are likely to lead to bad reception. Moreover, if several long leads are allowed to get mixed up together in a higgledy-piggledy fashion, the danger of making "wrong connections" is increased considerably. (And special attention should be given to this danger when dealing with batteries. A wrong connection on a battery may mean that the battery becomes "shorted," and when this happens the odds are that the battery will not be fit for use again.) Battery leads should therefore be kept as short as possible. It is a good plan, when circumstances permit, to install the batteries beneath the receiver, about midway between the latter and the floor. The usual practice, when the receiver stands on a table, is to let the batteries rest on the floor, except, of course, in the case of receivers of the cabinet type, which usually contain a special compartment for batteries. It is better practice, however, to lift the batteries off the floor and stand them on some support (a wooden box, or shelf, for instance) under the table on which the receiver stands.

The majority of valve receivers nowadays are tuned by means of "plug-in" coils. These coils can be used in a number of different positions—*e.g.*, in the aerial circuit, the secondary circuit and the anode (or plate) circuit of a receiver. Energy can be transferred from one circuit to another by coupling two coils together; in some cases three coils are coupled together. Moreover, plug-in coils are sometimes used for variometer tuning. (A variometer consists of two coils connected in series, the total inductance of both coils together depending upon the coupling between them.) When working with plug-in coils, therefore, it may be necessary to *reverse* them at times. Unless a special coil-holder is employed this involves changing over the connections that go to the latter from the receiver. A popular type of reversible coil-holder is shown in Fig. 3.

One sometimes sees circuit diagrams in which the negative pole of the high-tension battery is connected to the negative pole of the filament accumulator (the latter being connected in the ordinary way to the grid of the valve). There is nothing to be gained by this, however. As a matter of fact, by connecting up in this way the voltage of the high-tension battery is reduced by an amount equivalent to the voltage of the accumulator. When the high-tension negative is connected to the low tension (*i.e.*, accumulator) positive, the voltage of the latter is added to the former. Sometimes, also, the practice of connecting the grid of the valve to the positive of the accumulator—instead of to the negative—is recommended. In certain circumstances this is worth trying, although most valves work better when connected to the accumulator negative.

The importance of the "grid leak," which is almost invariably used with rectifying valves, is not always realised. This item consists of a small fixed condenser and a high resistance, and there

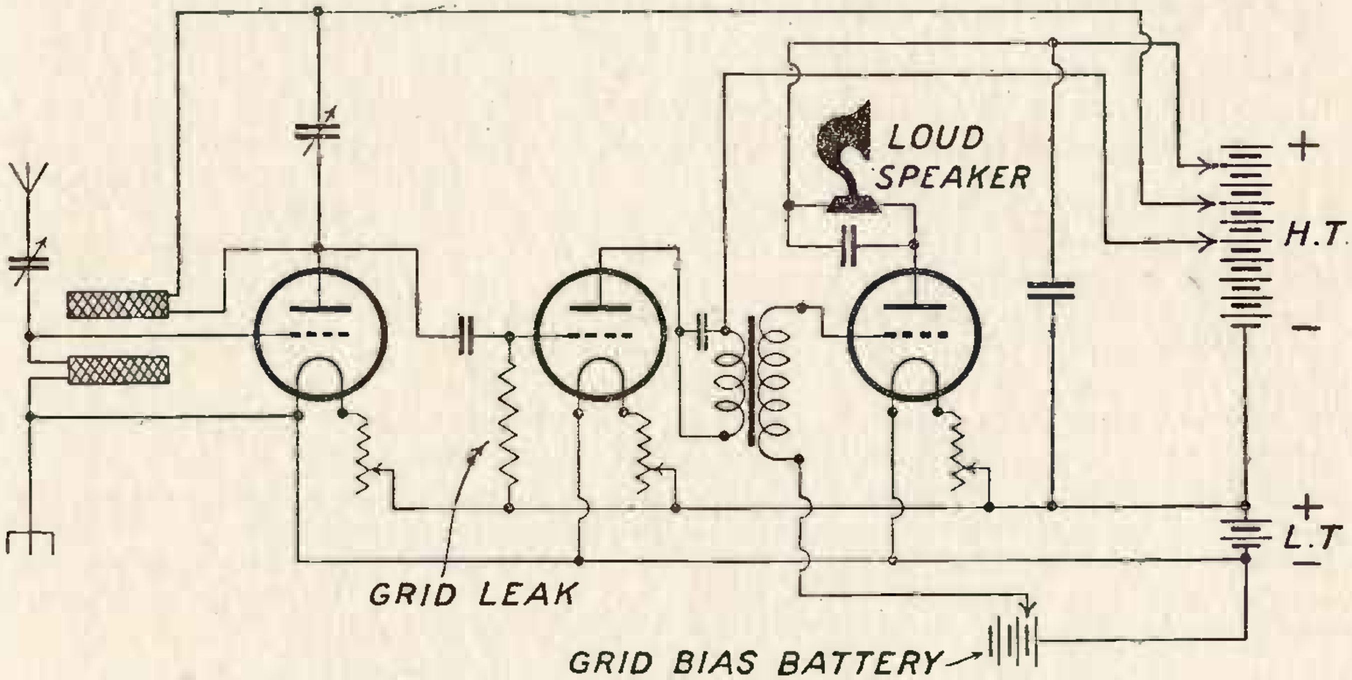


Fig. 2.—Showing how a variable grid bias can be applied to a low frequency valve.

are different ways in which they may be connected in a circuit. In Fig. 1 the lower end of the leak is connected to the negative lead of the low-tension battery. In Fig. 2 it is shown connected to the positive lead of this battery. The latter,

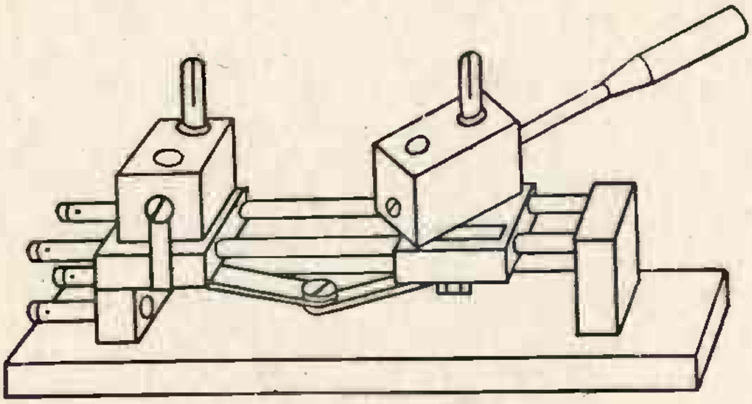


FIG. 3.—A reversible coil-holder.

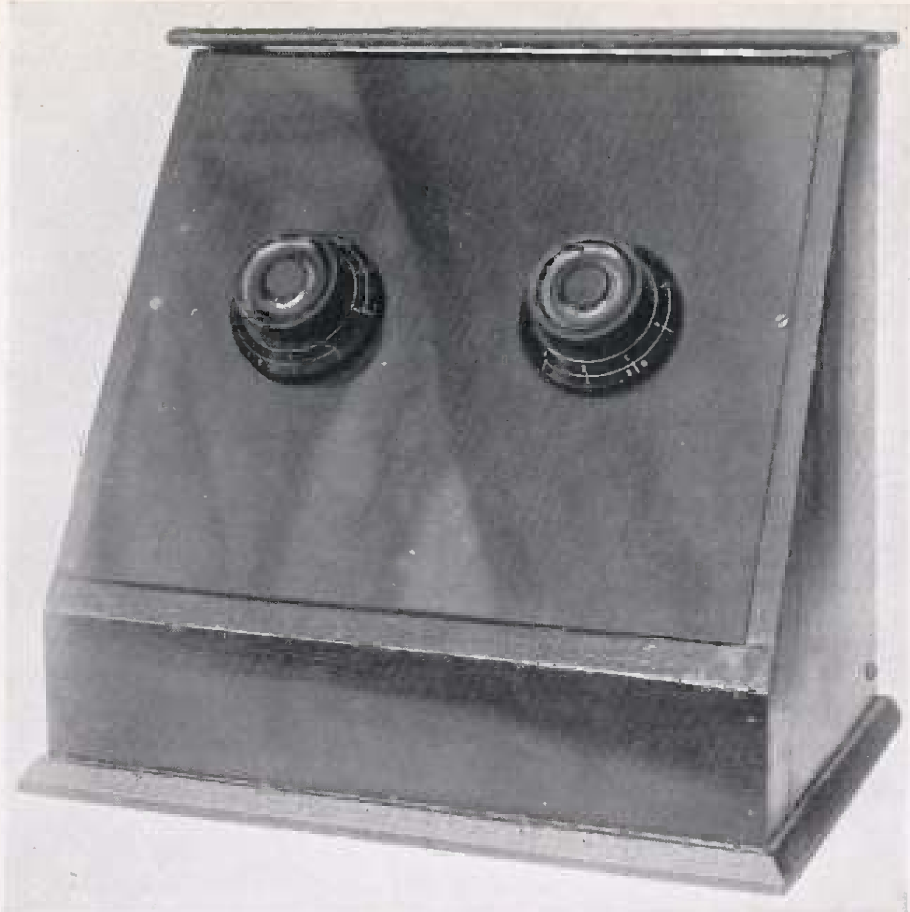
it should be noted, is usually the better way. When the high-frequency valve is coupled to the detector valve by means of a transformer, the grid leak may be connected directly across the grid condenser. It is not possible to say what are the best values for these two parts, because different valves require leaks and condensers of different values. A good average value for the condenser is 0·00025 microfarad, and a good average value for the leak is 2 megohms. It is well worth while, however, to ascertain by experiment the best values for a particular valve. By doing so the efficiency of a receiver can often be increased by 20 to 30 per cent.

Signals can also be improved in many cases by connecting a small fixed condenser across the primary terminals of the first low-frequency transformer. The value of this condenser should not be more than about 0·002 microfarad. Another position in which a fixed condenser can be employed with advantage is across the high-tension battery. A suitable value for this condenser, which is usually called a "reservoir" condenser, is 2 microfarads. As its main function is to prevent voltage variations in the battery, it helps to eliminate "rustling" noises from the telephones or loud speaker. The "tone" of a loud speaker can often be improved by shunting it with a fixed condenser of about ·05 microfarad capacity. The positions of these three condensers are shown in Fig. 2.

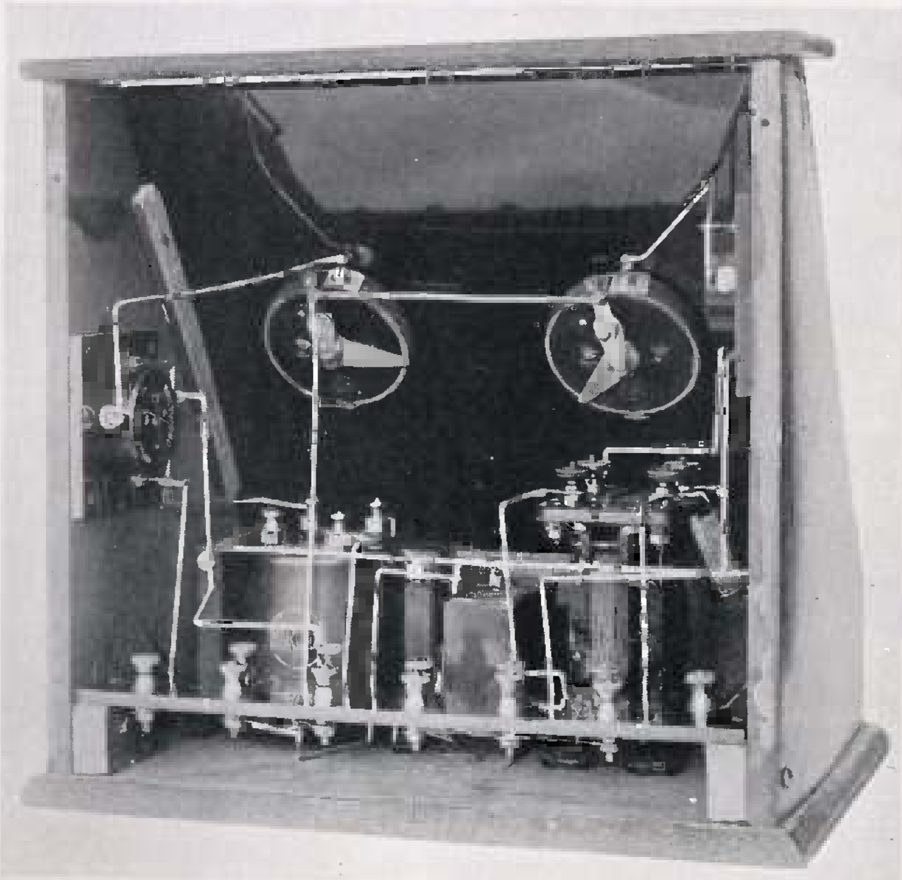
A wireless receiver should at all times be handled as gently as possible. An accidental knock or jolt *may* give rise to a fault which cannot be traced without a good deal of trouble. The wise amateur will train himself to handle his instruments as carefully as possible.

EUROPEAN BROADCASTING STATIONS

	Station	Call sign	Wavelength	Power
PARIS	Eiffel Tower	FL	2,650 M.	5 kw.
PARIS	Radio-Paris	SFR	1,750 M.	6 kw.
BERLIN	Koenigswusterhausen	LP	1,300 M.	10 kw.
BERLIN	Voxhaus	b (in morse)	505 M.	4·5 kw.
HAMBURG	Norag	ha (in morse)	395 M.	1·5 kw.
HILVERSUM	Hilversumsche Draadlooze, Omroep.	NSF	1,050 M.	1·5 kw.
ROME	Unione Radiofonica Italiana.	IRO	425 M.	3 kw.
OSLO	Kringkastingselskapet	—	382 M.	1 kw.
BARCELONA	Radio-Catalana	EAJ13	460 M.	1 kw.
BILBAO	Radio Club de Vizcaya	EAJ8.	420 M.	1 kw.
BRUSSELS	Radio Belgique	SBR	265 M.	1·5 kw.
SWEDEN	Stockholm	SASA	427 M.	1 kw.



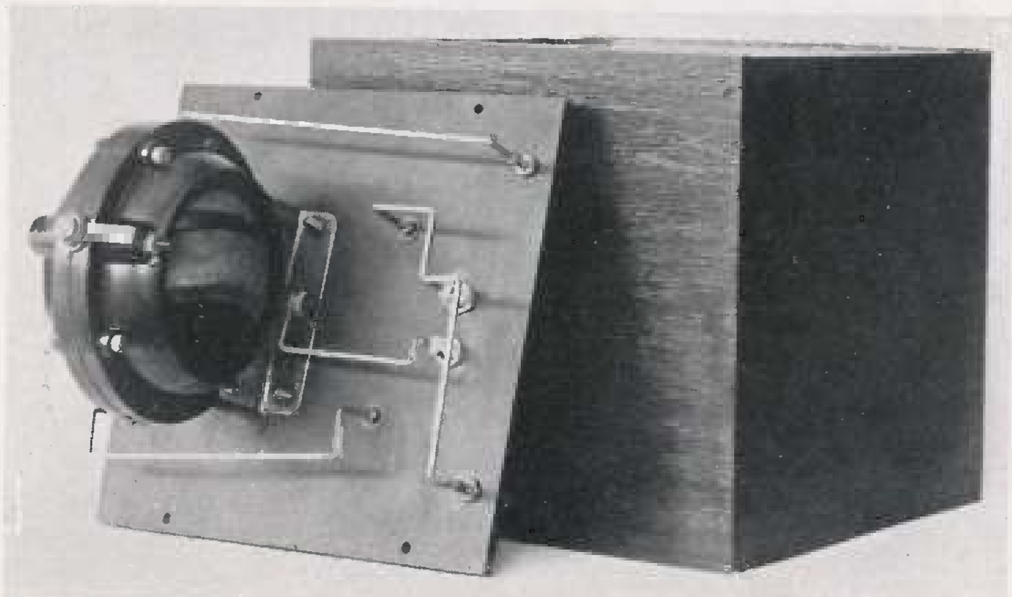
Front view of the Two-Valve Amplifier.



Rear view of the Two-Valve Amplifier.

(*See page* 13.)

Front view of Variometer Crystal Set.



Showing internal wiring of Variometer Crystal Set.

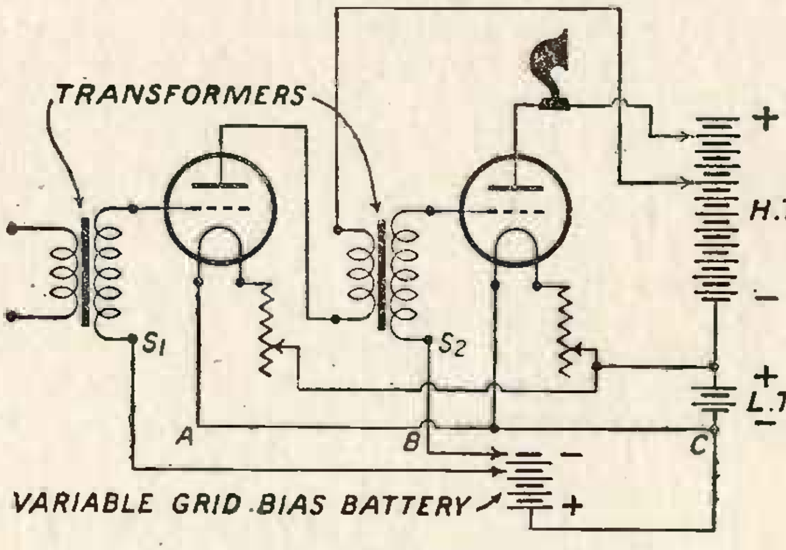
(See page 7.)

"GRID BIAS"

What it means—And how to apply it

PRACTICALLY every experimenter in the country uses *grid bias* in his receiver. Mere " listeners - in," however, rarely do so. The reason for this appears to be because listeners-in, as a rule, know so little about the technicalities of wireless that they are afraid to attempt any alteration of the wiring of their receivers. To many non-technical amateurs, indeed, the very fact that experimenters employ grid bias suggests that this must be a difficult and complicated method of reception. Yet the truth is that there is no difficulty whatever in using grid bias in an ordinary receiver. One or two slight alterations in the wiring are necessary, of course, but in view of the increased efficiency that this device secures in nearly every case, the small amount of trouble involved in making the necessary wiring alterations is negligible.

Without going too deeply into the theory of the valve it may be pointed out that the way in which any particular valve functions depends to some extent upon the purpose for which it is used in the receiver. This does not mean that the basic principle on which a valve operates is changed each time the valve is shifted from one position to another in a circuit. It merely means that its *mechanism* becomes modified in certain respects. For example: when a valve is used as a detector (whether it be a " general purpose " or a " specialised " valve) a " grid current " is necessary. That is to say, there must always be a stream of electrons flowing from the filament to the grid. If there is not a grid current the valve will not detect; and, generally speaking, the larger the grid current the more efficiently does the valve carry out its work of detection. Every one knows that when the filament of a valve is heated it shoots off electrons towards the grid and anode of the valve. Some of these electrons penetrate the meshes of the grid and reach the anode; others settle on the grid itself. If the grid has a positive charge on it, it will attract a good many electrons—which are, of course, negative. Therefore, one way of increasing the grid current is by giving the grid a positive charge, as, for instance, by connecting it to the positive pole of the filament accumulator. Again,



The correct way to apply "negative grid bias" to low frequency valves.

if there is a big voltage (*i.e.*, high tension) on the anode, the latter will attract most of the electrons to itself, and the grid current will be correspondingly small. A second way of increasing the grid current, therefore, is by *reducing* the high tension on the anode. This is the method that is usually employed in practice. That is why detector valves require much less high tension than any other valves.

Now, when a valve is used for low-frequency amplification the presence of grid current is a nuisance. In order to get a maximum of signal strength with a minimum of distortion, grid current must be eliminated from the low-frequency valves of a receiver. This, in effect, means that the grids of the valves must not be allowed to become positive (as they have a tendency to do), and the best way to guard against this is to give them a definite "negative bias" by connecting them to the negative terminal of a small battery of dry cells. Different valves require different degrees of biasing. With some valves a bias of —3 volts is sufficient, while others need as much as —9 volts. When two low-frequency valves are employed in the same receiver it will generally be found that the second valve requires a stronger negative bias than the first. It is therefore necessary to arrange matters so that the amount of bias applied to one valve can be varied independently of the other.

The accompanying diagram shows how *any* receiver that contains two low-frequency valves can be modified to permit of a variable grid bias being applied to each valve. It will be seen that the positive side of the biasing battery is connected to the negative side of the filament accumulator, whilst the lower end of the secondary winding of each transformer is connected to a negative terminal on the biasing battery. (The arrowheads indicate that these connections are variable.) Normally, if the receiver was originally intended to work without grid bias, these secondaries would be connected to the negative side of the filament accumulator. S_1 would probably be connected to the point A, and S_2 to the point B; and, since the wire AB is continued to C, the two secondaries would thus be connected to the negative side of the accumulator. When altering a receiver for the purpose of including grid bias, therefore, all that is necessary is to disconnect these leads and take them direct to the grid battery, the positive pole of the latter being connected to the negative pole of the accumulator.

The grid battery should consist of a number of dry cells connected in series. Ordinary "flash lamp" cells will do. As suggested above, the actual number of cells required will vary with different types of valves. The voltage of each cell is approximately 1·5 volts, so that if six cells be used the total voltage will be 9 volts. For all ordinary purposes a battery of this size should be ample. The above diagram also shows how separate high-tension voltages may be applied to the two valves. It is only by applying a variable grid bias and a variable anode voltage in this way to each valve that the maximum efficiency can be obtained from a receiver.

PLUG-IN COILS

PLUG-IN coils are made in standard sizes, each size being accorded a special number. Thus, most manufacturers produce coils numbered 25, 35, 50, 75, 100, and so on up to about 300. For the purpose of ordinary broadcast reception the four smallest coils (25 to 75 inclusive) will be found suitable. For aerial tuning a No. 25, 35 or 50 is generally used, depending upon the size of the aerial and the manner in which the aerial tuning condenser is connected (*i.e.*, in series or parallel). Some firms also produce coils of intermediate sizes (*e.g.*, Nos. 30 and 40), and these may also be used, of course. For secondary tuning, and for purposes of reaction, a No. 50 or 75 coil is usually employed. Nos. 50 and 75 are also commonly used in tuned-anode circuits. If a receiver exhibits an undue tendency to oscillate the smaller coil should be used for anode tuning because this involves the use of extra capacity, which, of course, introduces damping and prevents self-oscillation. When the aerial tuning condenser is connected in parallel a No. 25 or 35 usually gives best results, but when connected in series a No. 50 (or sometimes a No. 75) can be used advantageously. For the reception of Daventry (5XX) the following coils should be used with a standard aerial: a No. 150 in the aerial circuit (with condenser in parallel), a No. 200 in secondary circuit, a No. 250 in tuned-anode circuit, a No. 100 for reaction (when this is on the aerial), and a No. 200 when the reaction is on the tuned-anode.

VARIABLE TUNING COILS

Containing full instructions on how to make a number of reliable crystal sets

ONE of the best known types of tuning coil employs a " slider " for varying the wavelength. This is illustrated in Fig. 1. A coil of wire is held between two wooden supports, which are mounted on a wooden base board. Above the coil, a brass rod joins the wooden supports. A sliding contact, or " slider," rides on this brass rod, and makes contact, as it moves, with the wire on the coil. This instrument can be made as follows :—

First of all, get some hardwood, of about $\frac{1}{4}$ inch thickness, and saw off two pieces, each measuring 6 inches by 6 inches. These are the supports for the coil. For the base board, slightly thicker wood (about $\frac{3}{8}$ or $\frac{1}{2}$ inch) is more suitable. A convenient size for the base board is 10 inches by 14 inches ; this will allow space for mounting the crystal beside the

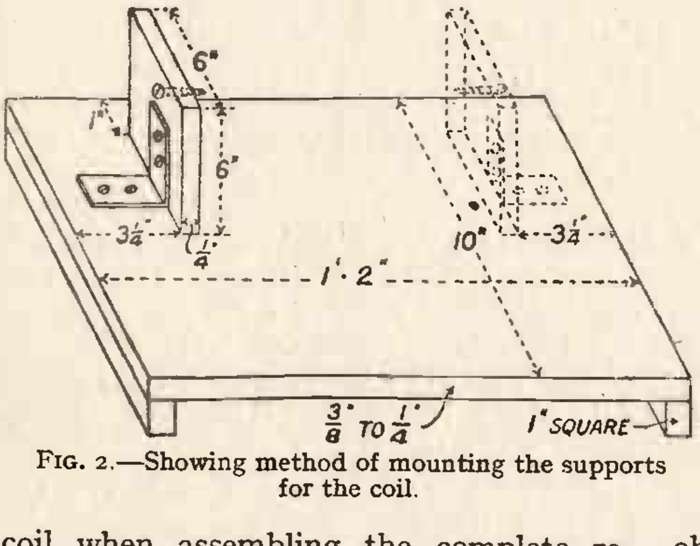


FIG. 2.—Showing method of mounting the supports for the coil.

coil when assembling the complete receiver. Screw two strips of wood, of about 1 inch square section, along the 10-inch sides of the base board, so as to raise the latter from the operating table and permit of the connecting wires being brought *underneath.* Next, mount one of the side supports as shown in Fig. 2, by means of a small metal bracket. The dotted lines show the position to be taken up by the second support when the coil is ready for mounting. A long screw,

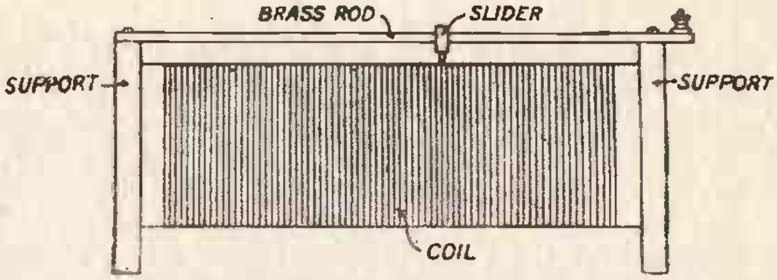


FIG. 1.—Illustrating the principle on which a " slider " coil operates.

driven through each support at a distance of $\frac{3}{4}$ inch from the top, will serve as pegs on which to hang the coil. When the coil is mounted, however, the second support should be pressed tightly against it before screwing the metal bracket to the base board.

Winding the Coil

Tuning coils may be wound with different kinds of wire on tubes of different sizes. The wavelengths that can be

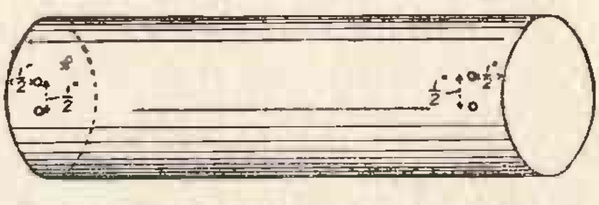


FIG. 3.—Holes bored at each end of cardboard tube, for fastening the ends of the wire.

obtained with a particular coil, however, depend upon the thickness of the wire and the diameter of the tube on which it is wound. The dimensions of the coil which is now to be described will enable signals to be heard from all broadcasting stations, merchant ships and commercial aircraft, on an average amateur aerial. You will need a cardboard tube of 4 inches diameter, and ½ lb. of No. 24 S.W.G. enamelled wire. The cardboard tube should be approximately 7 inches in length.

First of all bore two small holes, about ½ inch apart, at each end of the cardboard steadily. As the wire winds on to the tube, take care that each turn lies as close as possible to the next. This can be facilitated by holding the tube at a slight angle. The friend who holds the wire should be careful not to let it go slack suddenly; it should be taut, though not too taut, throughout the whole process of winding the coil. In order to ensure close

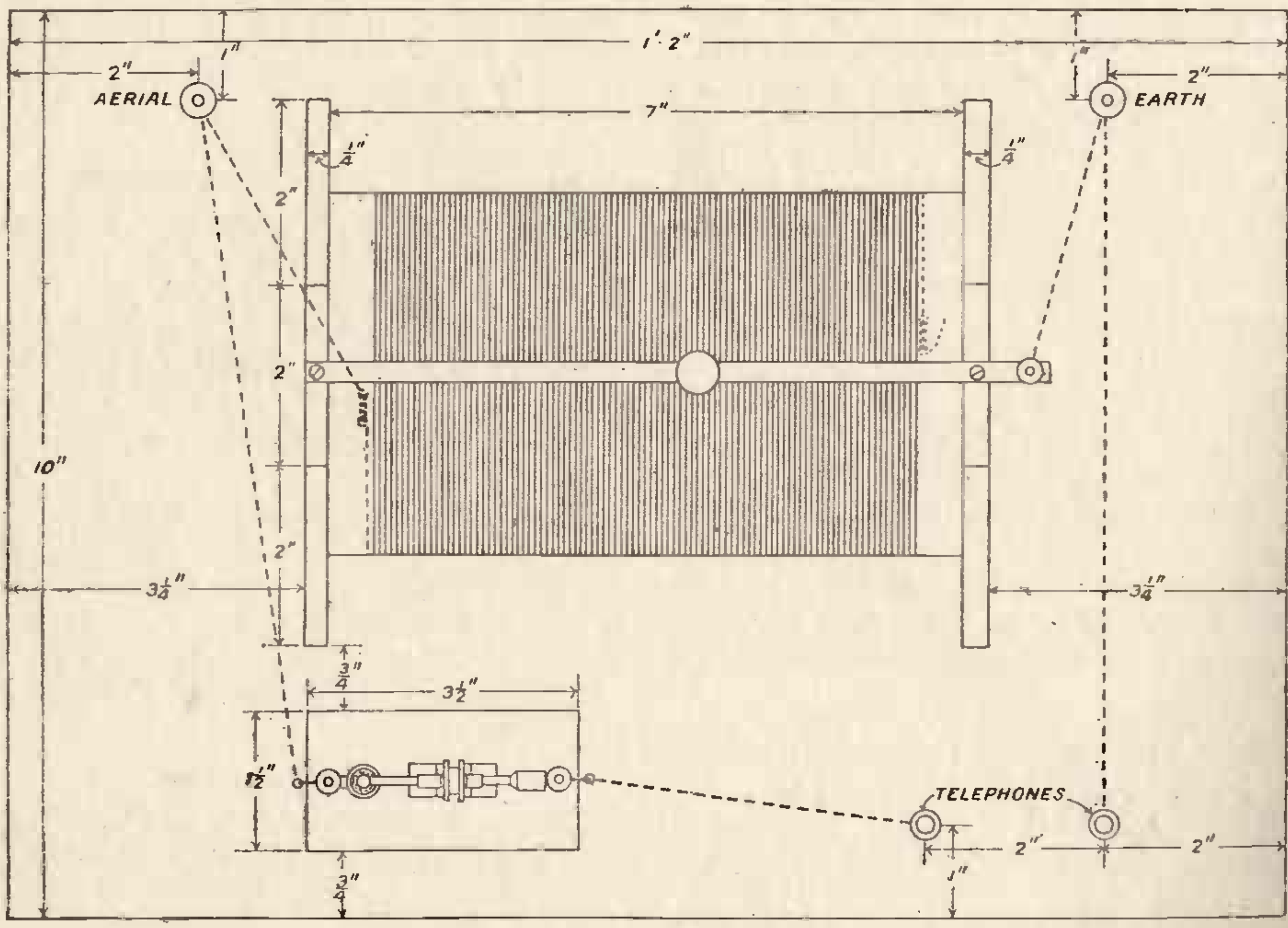


Fig. 4.—Showing lay-out and connections of crystal receiver, Model A.

tube, as shown in Fig. 3. Take one end of the wire and pass it in and out through either pair of holes a few times. This will be sufficient to keep the wire from slipping during the process of winding. Leave about 12 inches of the end of the wire protruding from one hole. Now commence winding the coil. This can be done most easily by getting a friend to "pay out" the wire from the reel on which it is wound, whilst you do the actual winding. Hold the cardboard tube at both ends and revolve it slowly and winding, it is a good plan to pack the turns up tightly together, after every ½ inch or so has been wound, by means of a pencil or a match. Continue winding until the holes at the other end of the tube are reached; then finish off by passing the wire in and out through the holes as before, leaving this end of the wire *inside* the tube. The coil is now ready for mounting.

Before mounting the coil bore a small hole in the base board just in front of the support that has already been fixed in position. Draw the 12-inch end of the wire on the tube through this hole, and slide the tube over the screw.

Fix the second support in position. The next step is to screw the brass rod, having previously slipped the slider over it, to each of the supports, the end which carries the terminal being placed on the second support. The coil is now complete, and the crystal and terminals may be mounted on the base board.

These items may be placed in any position, of course, but they must be connected to each other exactly as shown. Fig. 4 showing crystal receiver, Model A, suggests a convenient way of arranging them. The aerial and earth terminals are placed at either corner at the back of the base board. In front, the crystal is fixed at the left-hand side, and the telephone terminals at the right. All the wiring is done underneath the board, as shown by the dotted lines. The free end of the coil wire, which has been drawn underneath the base board, is connected to the aerial terminal. From the small terminal on the end of the brass rod a wire is taken, through a hole in the base board behind the second support, to the earth terminal. Another wire goes from the earth terminal to one of the telephone terminals, a third from the other telephone

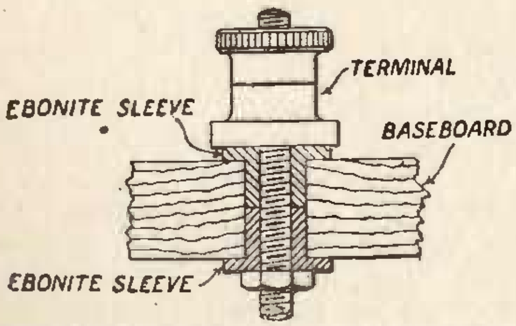


FIG. 6.—Showing how a terminal may be insulated from the base board by an ebonite sleeve.

terminal to the right-hand side of the crystal, and a fourth from the left-hand side of the crystal to the aerial terminal. Fig. 5 shows the completed receiver.

The enamel insulation must be removed from the coil along the path followed by the brass contact of the slider. It is usually found that the action of moving the slider up and down the rod will effect this. The contact of the slider should

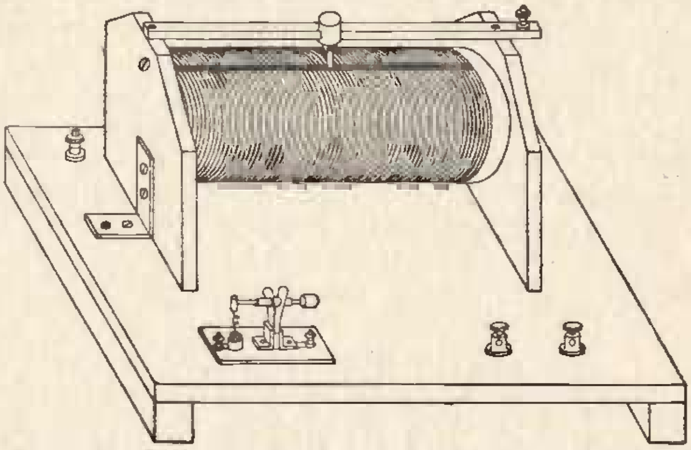


FIG. 5.—Showing slider coil and crystal mounted ready for reception. All connections are made underneath the base board.

exercise a fair pressure on the rod. This can be secured by stretching or compressing the small spring inside the slider to whatever extent is necessary.

It is advisable to make temporary connections underneath the base board whilst testing the receiver. Each terminal is held in position by a locking screw. These screws may be utilised for the purpose of connecting the wires to the terminals. Leakage effects can be reduced to a minimum by using small ebonite sleeves (which can be procured through any dealer) to insulate terminals from the base board, as shown in Fig. 6. When you have satisfied yourself that the instrument is capable of receiving signals you can, if you wish, make permanent connections by soldering the wires to the terminals.

The Tapped Coil

A second type of variable tuning coil can be made by taking short tapping leads from various points on the coil to a row of brass studs on the base board. As the arm of a circular switch moves over these studs, varying quantities of wire can be included in the circuit, thereby enabling signals of different wavelength to be picked up. Fig. 7 illustrates the principle on which this kind of coil operates. The coil can be mounted between two wooden supports similar to those used in connection with the slider coil. The brass rod and slider are not needed, however, as the connections to this coil are effected by means of the studs. A small piece of wire connects each stud to a point on the coil. When the arm of the switch is placed on the first stud the whole of the coil is inserted between the aerial and earth terminals, and as the switch arm is moved over the remaining studs, larger and larger "chunks" of the coil are cut out of the circuit, until, when the last stud is reached, all the coil is cut out. The necessary studs and switch arm can be purchased quite cheaply. This kind of coil does not permit of such "fine" tuning as can be obtained with the slider coil. The latter enables single turns of the coil to be added to, or subtracted from, the circuit by moving the slider through a small fraction of an inch, but with the tapped coil several turns of the coil are brought into, or excluded from, the circuit at each movement of the rotary switch. Of course, the greater the number of studs (and tapping wires) used with the coil, the finer the adjustments that can be obtained with it.

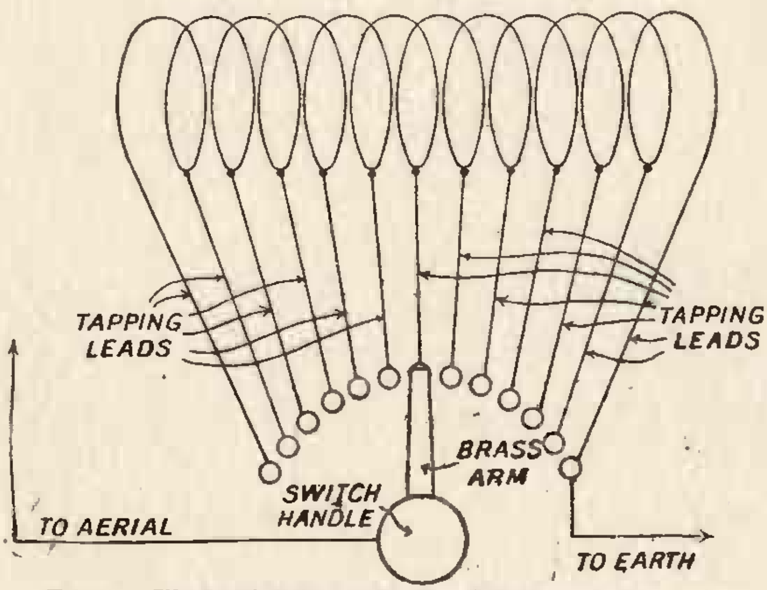


FIG. 7.—Illustrating the principle of the tapped coil, and one method of connecting it up.

When preparing to wind a tapped coil, binding holes should be made at each end of the cardboard as before. Commence winding in the manner already described. When you have covered ½ inch of the tube with wire, bind the wire round a match in a single turn, and continue wiring as before. Repeat this as each ½ inch of the tube becomes covered, and finish off the last ½ inch by passing the end of the wire in and out of the holes at the end of the tube. Leave about 12 inches of wire at this end also. The matches mark the points at which the tapping wires are to be fixed to the coil. Remove the first match carefully (so as to avoid loosening that particular turn of wire), and scrape the enamel from the small loop formed by bending the wire round the match. The first tapping lead may now be joined to this loop, either by passing the wire through and round the loop, or (preferably) by making a soldered joint. The insulation should also be removed from the tapping lead, of course. In fact, it cannot be insisted upon too often that all the metallic connections of a wireless receiver should be thoroughly cleaned before being made.

When completed, the coil may be mounted in the manner already shown, thirteen holes being bored in the base board to allow the eleven tapping wires and the two end wires of the coil to pass underneath. These wires are now connected to the thirteen contact studs, as illustrated in Fig. 8, which shows the complete lay-out and all connections of crystal receiver, Model B. The studs, which can be obtained for a few pence, are screwed through the base board, the spindle which carries the handle of the rotary switch being fitted in a similar manner. Approximately the same amount of wire will be required for each of the two models, A and B. Although the coil in Fig. 8 is divided into twelve parts, finer adjustments can be obtained by dividing it into a still greater number of parts. Again, fine tuning can also be obtained by winding twelve turns of wire (distinct from the main coil) on the left-hand side of the same tube, *each* turn being joined by a tapping lead to the studs

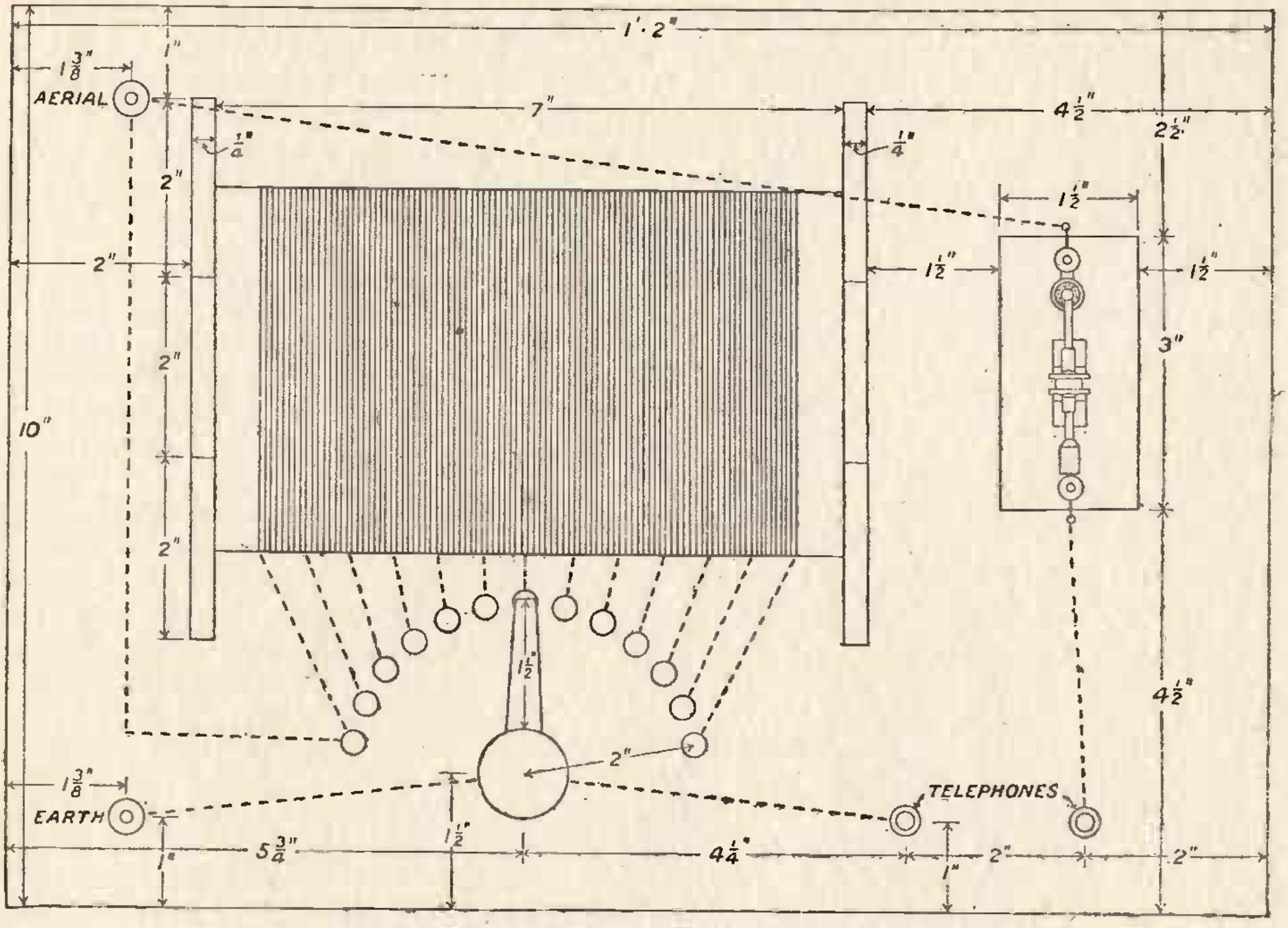


FIG. 8.—Showing lay-out and connections of crystal receiver, Model B.

of a second rotary switch. In this case, the aerial terminal of the receiver should be connected to the first stud of the *auxiliary* switch, the arm of the latter being connected to the first stud of the main switch. Again, a slider coil and a tapped coil could be mounted on the same base board, the aerial terminal of the receiver being connected to one end of the slider coil, and the brass rod of the latter to the first stud of the rotary switch. By using the two coils together in this way, rough adjustments can be obtained on the one and fine adjustments on the other.

The Sliding Variometer

A third form of variable tuning coil is known as a "sliding variometer." This really consists of two separate coils of wire which are connected to one another in series. One end of one coil is connected to one end of the other, thus leaving a single free end from each coil for connecting up to the aerial and earth terminals of the receiver. as shown in Fig. 9. The tuning is varied by sliding one coil over

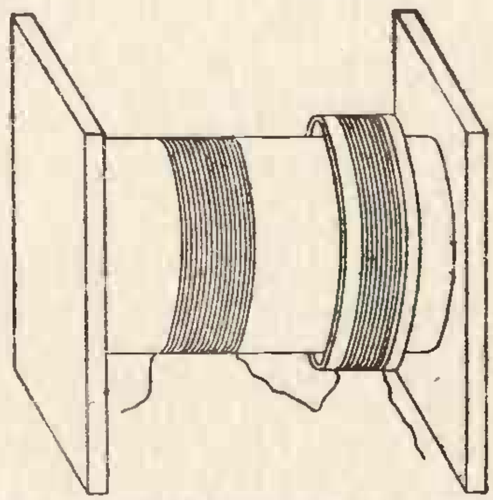


FIG. 9.—Illustrating the principle of the sliding variometer.

the other. Double cotton-covered wire is more suitable than enamelled wire for coils of this type. The dimensions of the sliding variometer shown in receiver, Model C (Fig. 10), are as follows:—

The longer of the two cardboard tubes is 3 inches in diameter and 5 inches in length, and carries forty turns of No. 26 S.W.G. double cotton-covered wire. The outer tube is 3¼ inches in diameter and 1½ inches in length, and carries thirty turns of the same kind of wire. The relative positions of the two coils is an important factor in tuning. If signals are not heard when the coil of larger diameter is first moved over the other, it will be necessary to withdraw the former coil, reverse it, and then replace it in the reversed position. This will be understood by reference to Fig. 10, in which the letters A and B are marked on either side of the movable coil. If signals are not heard with the coil in the position shown, it should be withdrawn and replaced with the side B nearest to the left-hand wooden support. For this reason the correct direction of the movable coil should be ascertained by experiment before finally fixing the second support.

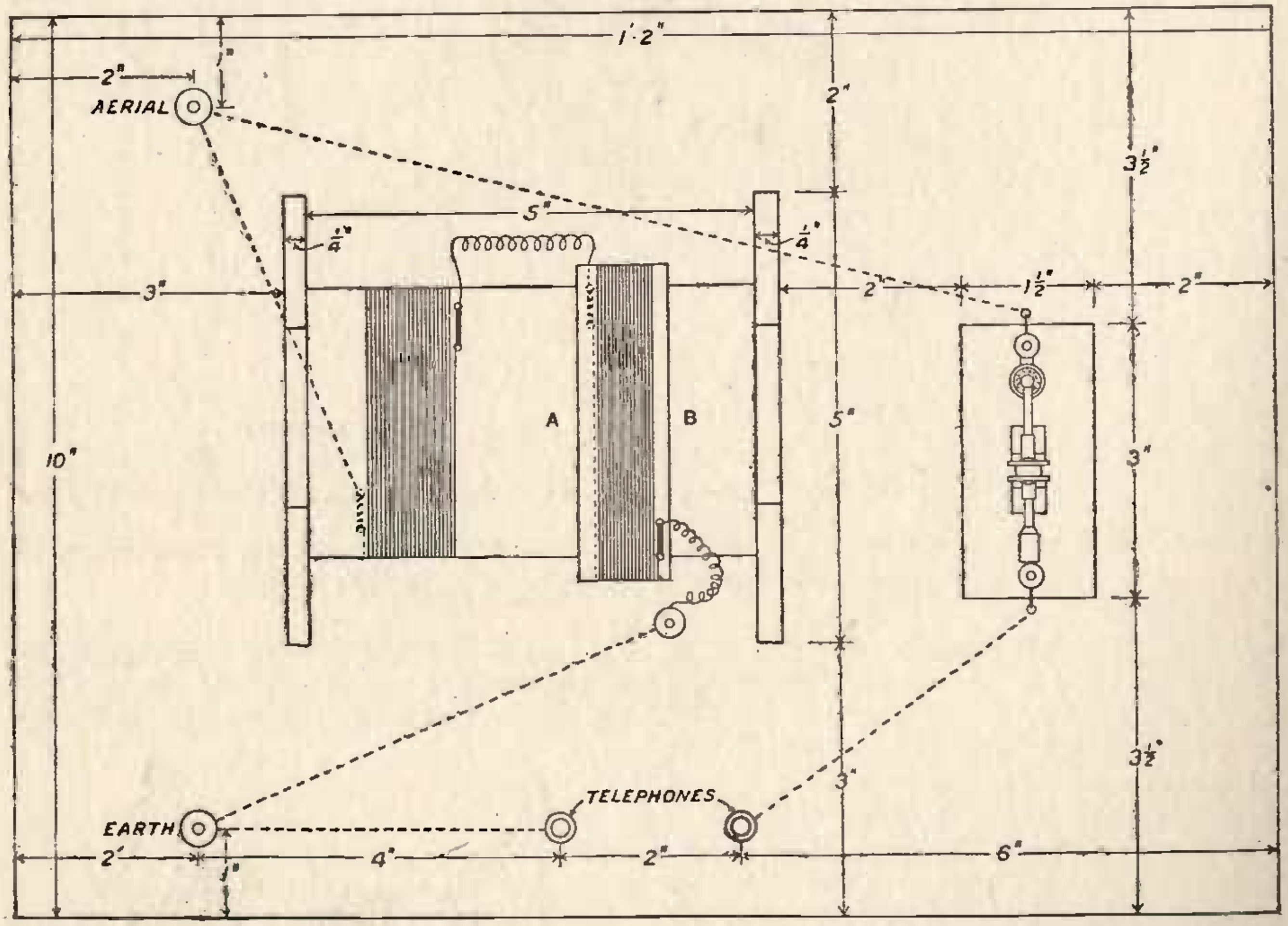


FIG. 10.—Showing lay-out and complete connections of crystal receiver, Model C.

The Rotary Variometer

Another popular form of variometers is shown in the accompanying photograph, the details of mounting being given in Fig. 11. Each tube should be wound continuously in two sections, a space of about ¼ inch being left between the sections in order to allow the two short spindles, by means of which the coils are joined together, to be inserted without coming into contact with the wires. Convenient dimensions for a variometer of this kind would be as follows: An outer tube of 4 inches diameter and 3 inches length, carrying thirty turns of No. 26 double cotton-covered wire, and an inner tube of 3½ inches diameter and 1½ inches length, carrying twenty turns of the same kind of wire. One spindle, to which the ebonite handle is fixed, passes loosely through a hole in the outer tube, and is made fast to the inner tube by means of locking nuts. The lower spindle may either be fixed as shown in Fig. 11 (*i.e.*, locked to the inner tube and passing freely through the outer tube), or it may be locked to the outer tube and allowed to pass freely through the inner tube. In either case, a thick washer will preserve the spacing between the two tubes. As in the case of the sliding variometer, one end of each coil must be joined together. This can be done conveniently by joining one end of each coil to one of the spindles by extra nuts. Sufficient " play " should be allowed, however, to permit of the inner coil being rotated. The variometer may either be enclosed in a box or mounted on a base board. When the latter method is adopted, the lower spindle should be locked to the outer tube. The variometer can then be mounted by fixing this spindle to the base board as with an ordinary terminal. The connections for this instrument are exactly the same as those for the sliding variometer.

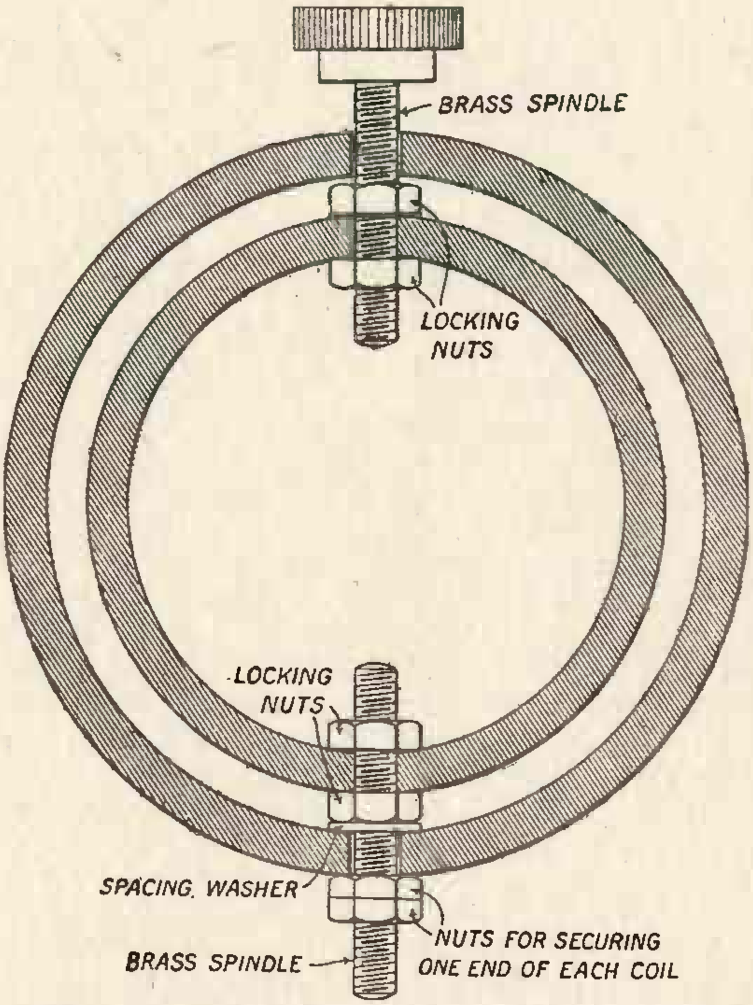


FIG. 11.—Arrangement of tubes for rotary variometer.

THE RIGHT CONDENSER IN THE RIGHT PLACE

FEW aspects of wireless are more confusing to the average non-technical amateur than that which concerns the use of condensers in a receiver. At the outset of his career the amateur is informed that the function of a condenser is to " tune in " signals. The condenser is probably the first instrument to which he is introduced by the dealer who sells him his two-valve, three-valve, or four-valve receiver. " This little black knob is the knob of the tuning condenser. All you have to do is to turn it slowly from side to side—so !—until signals fill the room." Marvelling at the simplicity of it all, he takes the prize home, twiddles the black knob delightedly, and—all being well—fills the room with signals. Then, one day, something goes wrong, and signals are replaced by ominous " crackling " noises. He consults a knowing friend—an " experimenter," perhaps—and the well-meaning advice that is showered upon him contains numerous unintelligible references to anode condensers, grid condensers, inter-valve coupling condensers, transformer by-pass condensers, high-tension reservoir condensers, telephone by-pass condensers, etc., etc. Every amateur, sooner or later has to go through this period of disillusionment with regard to the functioning of condensers. These instruments are not so simple as the persuasive, knob-twiddling salesman would have us believe. They are, in fact, capable of performing a number of very clever tricks, quite apart from the comparatively simple one of tuning an aerial.

Maximum efficiency in a receiver can only be obtained by the amateur who studies the condenser's repertoire of tricks. In particular, clear, distortionless reproduction can only be secured by the judicious use of condensers at different points in a receiver. One of the commonest causes of distortion is the presence of unwanted currents that find their way into the windings of the transformers and tuning coils which are a necessary part of every receiver. If these unwanted " stray " currents succeed in working their way as far as the loud speaker, they inevitably produce distortion ; they can, however, be sidetracked and trapped by means of condensers of suitable value.

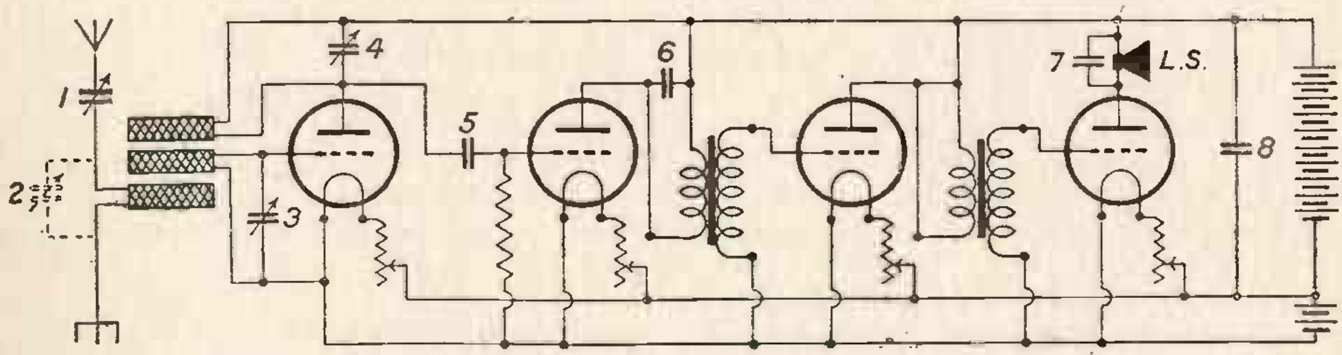
The accompanying diagram shows eight different condensers in a four-valve receiver, containing one high-frequency valve, one detector and two low-frequency valves. It is not suggested that this circuit represents the most efficient type of four-valve receiver ; it is only used here for the purpose of illustrating the various positions in which condensers can be used advantageously. Condenser No. 1 is an aerial tuning condenser, connected in series with the aerial. This is always a *variable* condenser, and when employed in this position its maximum value should lie somewhere between 0·0007 and 0·001 microfarad. It is sometimes advisable, however, to work with the aerial tuning condenser in the parallel position (No. 2), particularly if the aerial itself happens to be rather short. When in this position a suitable maximum capacity is 0·0005 microfarad. If the receiver is fitted with a " change over " switch for putting the condenser in the series or parallel position as required, it will be advisible to use a ·001 microfarad condenser.

In this circuit the aerial is coupled " inductively " to the grid of the first valve, a device that is frequently used for the purpose of securing " selectivity." A separate condenser must therefore be used for tuning the grid circuit of the high-frequency valve. The best maximum value for this condenser (No. 3) is about 0·0005 microfarad. It will be seen that the plate, or anode, circuit of this valve is also tuned. That is to say, the valve operates on the "tuned anode" principle, and the tuning is done by means of a plug-in coil and a condenser. The value of this condenser (No. 4) is generally between ·0003 and ·0005 microfarad. (Incidentally there is "reaction" coupling between this valve and the aerial, all three coils being mounted on the same coil holder.) Condensers Nos. 1, 2, 3 and 4 are, of course, variable.

Condenser No. 5 is known as the "grid" condenser. It is one of the most important items in the whole receiver, as on it depends the functioning of the detector valve. (It is also sometimes called a "leaky" condenser, because of the leaking action of the resistance that is connected to it. The two items work hand in glove, as it were.) The best value of the grid condenser can only be found by experiment; it usually lies in the neighbourhood of 0·00025 or 0·0003 microfarad. Although the majority of amateurs use a fixed condenser in this position, some amateurs prefer to use a variable condenser, with the object of obtaining the most critical adjustment possible.

The first valve amplifies the high-frequency currents that flow down from the aerial, and then passes these high-frequency currents on to the second valve for "rectification." Now the process of rectification virtually involves changing the high-frequency currents into low-frequency currents—*i.e.*, currents of audible frequency. The detector (or rectifying) valve should therefore pass *only* low-frequency currents to the third valve. It happens, however, that a certain number of high-frequency currents frequently force their way through the detector valve and try to flow through the primary of the transformer that is situated between this valve and the third valve. These currents are sidetracked, or by-passed, by means of a small condenser connected as shown (No. 6). It will be seen that the by-pass condenser is connected across the primary of the transformer. If no condenser were employed the currents would *have* to pass through the transformer, as this would be the only path available for them. The condenser offers them an alternative path which, for *high-frequency* currents, is a much easier one than the path offered by the transformer primary. This alternative path, however, *if the condenser is the correct value*, is a difficult one for the low-frequency currents to follow. Thus currents of high- and low-frequency are separated from each other when they leave the plate of the second valve. The low-frequencies pass through the transformer, but the high-frequencies travel through the condenser, and find their way back into the reaction coil. The best value for this condenser is about 0·002 microfarad.

Condenser No. 7 is also a by-pass condenser, and in the great majority of cases it improves the tone of signals considerably. The most suitable capacity is usually found to lie between 0·003 and 0·006 microfarad. Condenser No. 8 is a "reservoir" condenser, connected across the high-tension battery. Its purpose is



This diagram shows eight different positions in which condensers can be used with advantage in a multi-valve receiver.

to smooth out any variations that may occur in the voltage output of this battery; it acts as a kind of "buffer" to the latter, and steadies the voltage applied to the plates of the valves. It also helps to prevent "stray" reaction effects between the valves, the tendency to such effects being due to the fact that all the valves draw their high-tension supply from the same battery. A fixed condenser of 1 or 2 microfarads capacity is usually employed in this position.

BRITISH BROADCASTING STATIONS

	Wavelength	Call Sign
Aberdeen	495 M.	2BD
Belfast	439 M.	2BE
Birmingham	479 M.	5IT
Bournemouth	386 M.	6BM
Cardiff	353 M.	5WA
Daventry	1,600 M.	5XX
Dundee	331 M.	2DE
Edinburgh	328 M.	2EH
Glasgow	422 M.	5SC
Hull	335 M.	6KH
Leeds-Bradford	346 M. / 310 M.	2LS
Liverpool	315 M.	6LV
London	365 M.	2LO
Manchester	378 M.	2ZY
Newcastle	403 M.	5NO
Nottingham	326 M.	5NG
Plymouth	338 M.	5PY
Stoke-on-Trent	306 M.	6ST
Sheffield	301 M.	6FL
Swansea	482 M	5SX

ON CHOOSING COMPONENTS

THERE are so many different types of wireless instruments on the market to-day that the beginner is apt to be confused by the variety that confronts him when he goes to make a purchase. It was only natural that, with the development of broadcasting, receiving instruments should become more efficient than they ever were before. Moreover, owing to the wide appeal that broadcasting makes to all classes, thousands of new instruments have been evolved in the course of the past two or three years to meet the varied requirements of the vast army of listeners-in and experimenters that has gradually come into existence. Although most of these new instruments are designed on principles of practical utility, and are therefore " well worth the money " required to purchase them, some are little more than " stunt " instruments which are rarely capable of fulfilling the claims put forward for them. The amateur who contemplates buying new instruments, therefore, should be quite sure that he knows what he wants before he makes a purchase.

Probably the most important component in any receiver is the tuning coil. This is even more important than the condenser, because, although it is possible to receive signals without a condenser, some kind of tuning coil is practically essential. Nowadays the great majority of wireless amateurs use either " plug-in " coils or variometers for tuning purposes, illustrations of which are shown in connection with the constructional articles in this book. Variometers are frequently used in crystal receivers, or in valve receivers which employ high-frequency " tuned anode " circuits. " Tapped " coils and " slider " coils are still used, of course, for crystal reception, but variometers are undoubtedly more efficient for this purpose, as well as being simpler to operate.

Another component which has become very popular recently is the " vernier square law " condenser. This instrument embodies two improvements on the ordinary type of condenser. Every variable condenser has a number of moving vanes, or plates. These are mounted on a common spindle, and when the spindle is rotated (by turning the control knob of the condenser) all the moving vanes rotate simultaneously. For this reason it is not possible to get very minute adjustments. By adding an extra vane, however, *which can be rotated independently of the other moving vanes*, very sensitive adjustments can be obtained. This extra vane is called a " vernier " vane, and instruments which possess it are called " vernier " condensers.

The " square law " effect, which some condensers give, is usually obtained by making the vanes " cam-shaped," instead of semi-circular. It was found that with the usual type of condenser (employing semi-circular vanes) there was a tendency for several of the broadcasting stations to " bunch " closely at one point on the graduated dial. That is to say, the tuning positions for the various broadcasting stations were crowded together. By making the vanes cam-shaped, however, the tuning points were spread out more or less evenly over the whole dial. This effect is known as the " square law " effect. It will be seen, therefore, that the vernier square law condenser has definite advantages to offer over its earlier rival.

Modern valves can be divided into two classes: Bright emitters and dull emitters. A bright-emitter valve consumes, on an average, about 0·7 ampere filament current at a pressure of 4 or 6 volts. Dull emitters, on the other hand, usually operate on 2 or 4 volts, and have an extremely small current consumption, varying from 0·35 ampere to 0·06 ampere. Strictly speaking, the term " dull-emitter " is usually applied only to valves of the 0·06 class. Valves which consume between 0·1 and 0·35 ampere are commonly described as " low temperature " valves;

these form an intermediate class between bright emitters and dull emitters. So many factors are liable to affect one's choice of valves that it is not easy to offer advice on the matter. For one thing, valves vary a good deal in price, from 4*s*. to 30*s*., or more. Perhaps the best advice is: Buy the best valve you can afford, and be sure to deal only with firms of repute. Valves of the 0·06 class can be operated entirely with dry cells. The more expensive valves are usually "power" valves, specially designed to deal with large currents. In receivers which contain two stages of low-frequency amplification the second low-frequency valve should always be a power valve. A power valve is sometimes used in receivers employing only one low-frequency stage. Valves can also be subdivided into "general purpose" valves and "specialised" valves. The former can be used in any position in a receiver, while the latter (which are becoming increasingly popular among amateurs) are specially designed to operate in either low-frequency, detector, or high-frequency circuits. It is important to remember that different types of valve require filament rheostats of different resistance value. A rheostat that is suitable for use with a bright-emitter valve may be responsible for destroying a dull emitter. Manufacturers usually supply full instructions on this subject with their valves, and careful attention should be given to these. Some wireless firms produce what may be called "all purpose" rheostats for use with any type of valve—*e.g.*, the McMichael double rheostat and the Mullard universal rheostat.

The choice of a suitable rheostat is necessarily dependent upon the voltage of the battery used for heating the valve, or valves. As a rule it is not wise to operate a valve at a higher voltage than that specified by the maker. By using a rheostat of suitable value, however, this rule can sometimes be broken without danger. The market to-day contains some excellent 2-volt "non-spillable" accumulator cells which are particularly suitable for use in portable outfits. A few of the better-known makes of dry cell are also quite satisfactory for this purpose. When buying dry cells for filament heating it is advisable to ask specially for large cells. The voltage of a dry cell, irrespective of its size, is about 1·5 volts. Many valves of the 0·06 class are designed to operate at about 3 volts: two dry cells are therefore necessary. But, although two small dry cells will give 3 volts, they cannot sustain this voltage for any length of time. Large cells are slightly more expensive than small ones, of course, but the difference in cost is not nearly as great as the difference in efficiency.

Although it is quite impracticable to work a loud speaker from a crystal set in the ordinary way, there is a special type of loud speaker—known as the brown "Crystavox"—which, under suitable conditions, can be operated with very satisfactory and efficient results from a crystal. In order to ascertain whether your crystal receiver is capable of operating a "Crystavox," carry out the following test: Hold your headphones at a distance of 12 inches from your ear while signals are being received; if signals can still be heard distinctly at this distance, your receiver is sufficiently sensitive to operate a "Crystavox" satisfactorily.

REPAIRING A H.T. BATTERY

Eliminating a dud cell

IN addition to the accumulator which lights the filament of the valve, a valve receiver requires a second battery for its operation. This is usually called a "high-tension battery," its function being

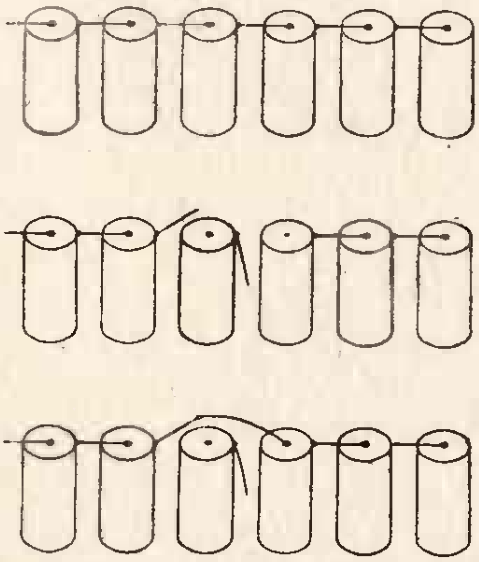


FIG. 1.—Showing the stages involved in excluding a dud cell from a battery.

to apply a high tension (or pressure), to the sheath (or plate) of the valve. These batteries are usually composed of a number of "dry" cells (unlike the acid-filled cells of the accumulator). They cannot be recharged, and must therefore be replaced by new ones when discharged. Owing to the very minute currents taken from them, however, they can be made to last a number of months with ordinary usage and care. (High-tension batteries of the accumulator type can also be obtained. These are recharged in the ordinary way when they become run down. They possess a certain advantage over the ordinary dry cell type, and are becoming increasingly popular among experienced amateurs who work with multi-valve sets.

A dry high-tension battery may consist of some dozens of small cells, and the most likely fault to be encountered arises from one of the cells becoming "dud." This may be due to deterioration, or to a loose internal connection, etc. Whatever the cause, however, one bad cell may be sufficient to render the whole battery useless, and the best way to repair the fault is to cut that particular cell completely out of the circuit. Each cell contains two terminals, and, though these terminals are sometimes easily accessible, it is more usual to find that all the cells have been sealed into the containing-box by means of some insulating material, through which small metal sockets, which make the contact with the terminals, protrude. In the former case, it is a comparatively simple matter to disconnect the bad cell and connect up the two adjacent ones on either side of it. In the latter case, the only remedy is to "short" the faulty cell on the outside of the sealing surface, by connecting a small piece of wire to the two metal sockets which make contact with the terminals of the bad cell.

Fig. 1 shows how a faulty cell should be cut out of the circuit. In the top row, the cells are seen connected together, the

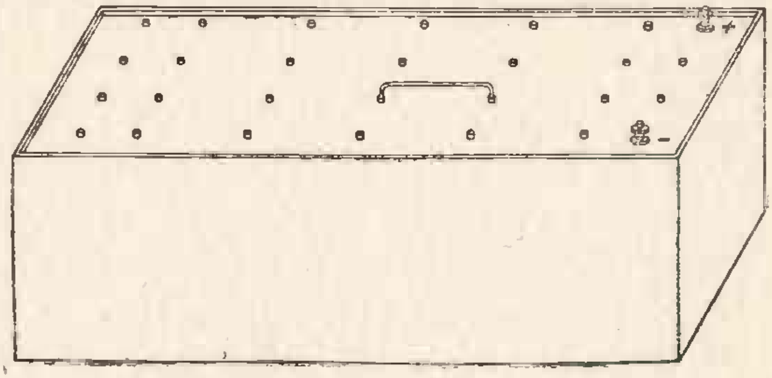


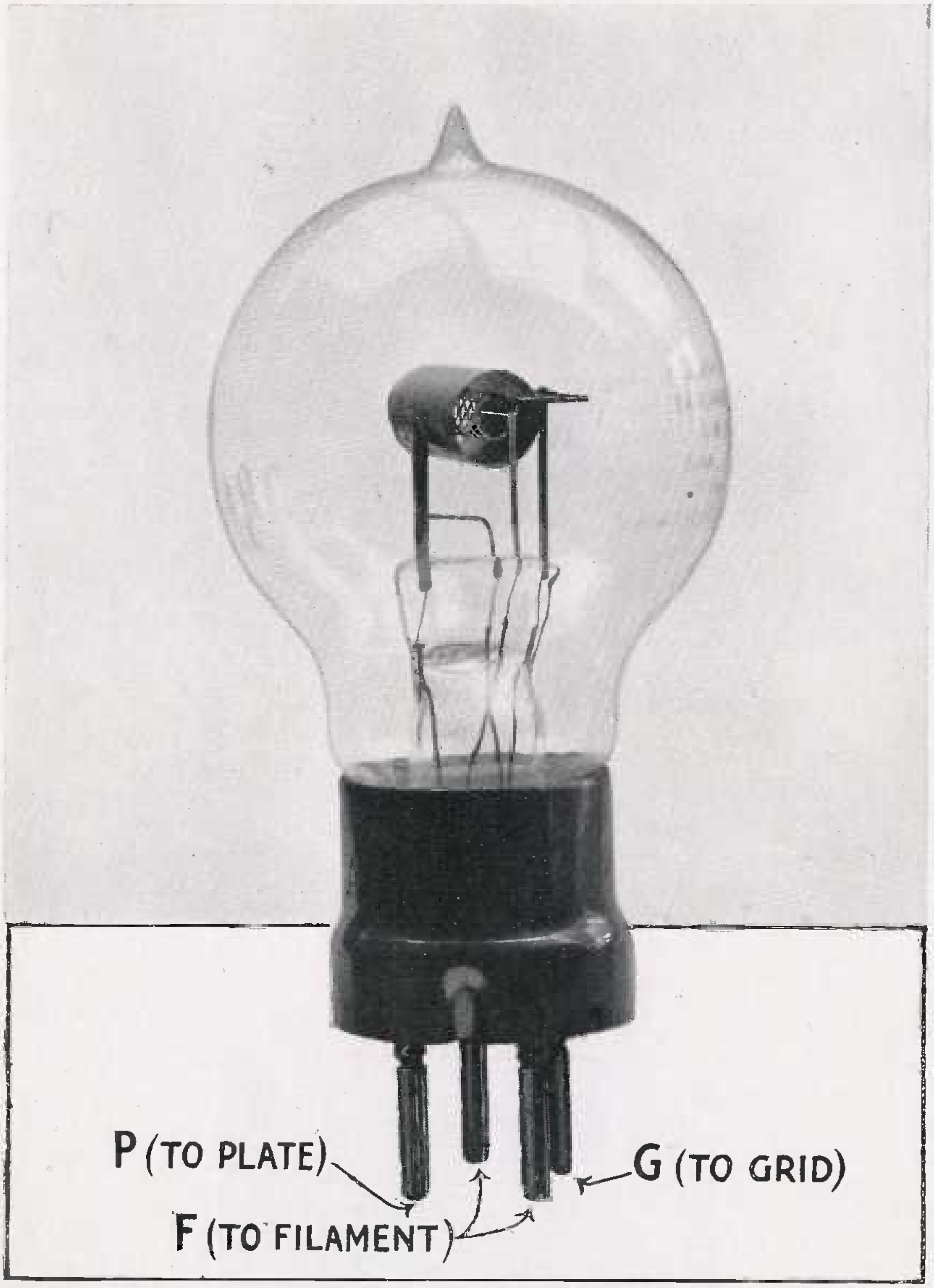
FIG. 2.—Method of "shorting" a dud cell.

third cell from the left being the faulty one. By applying a hot soldering iron to the centre poles of the faulty cell and the cell on the right of it, the former can be released from the series of cells. This is shown completed in the middle row of cells, whilst the bottom row shows how the cells 2 and 4 should be joined together, in order to reconnect the series. The wire which joins cells 2 and 4 should not be allowed to touch against the terminals of the faulty cell; rubber-covered wire is most suitable for the purpose. It will be necessary to use an extra piece of wire, of course, because the wire terminal which comes from the side of cell 2 will not be long enough to reach to the centre terminal of cell 4. The connections should be soldered carefully. Fig. 2 shows how a faulty cell can be "shorted" in a battery which only exposes terminal sockets to view. The ends of a small piece of wire are inserted firmly in the sockets which have betrayed the position of the faulty cell.

A small voltmeter, similar to that already recommended for use with an accumulator, will enable you to detect a faulty cell in either type of dry battery. Each cell must be tested separately, of course. If a cell fails to give a reading on the voltmeter it should be removed at once, or "shorted." Should it give only a slightly smaller reading than its companion cells, there is no need to treat it as a "defaulter."

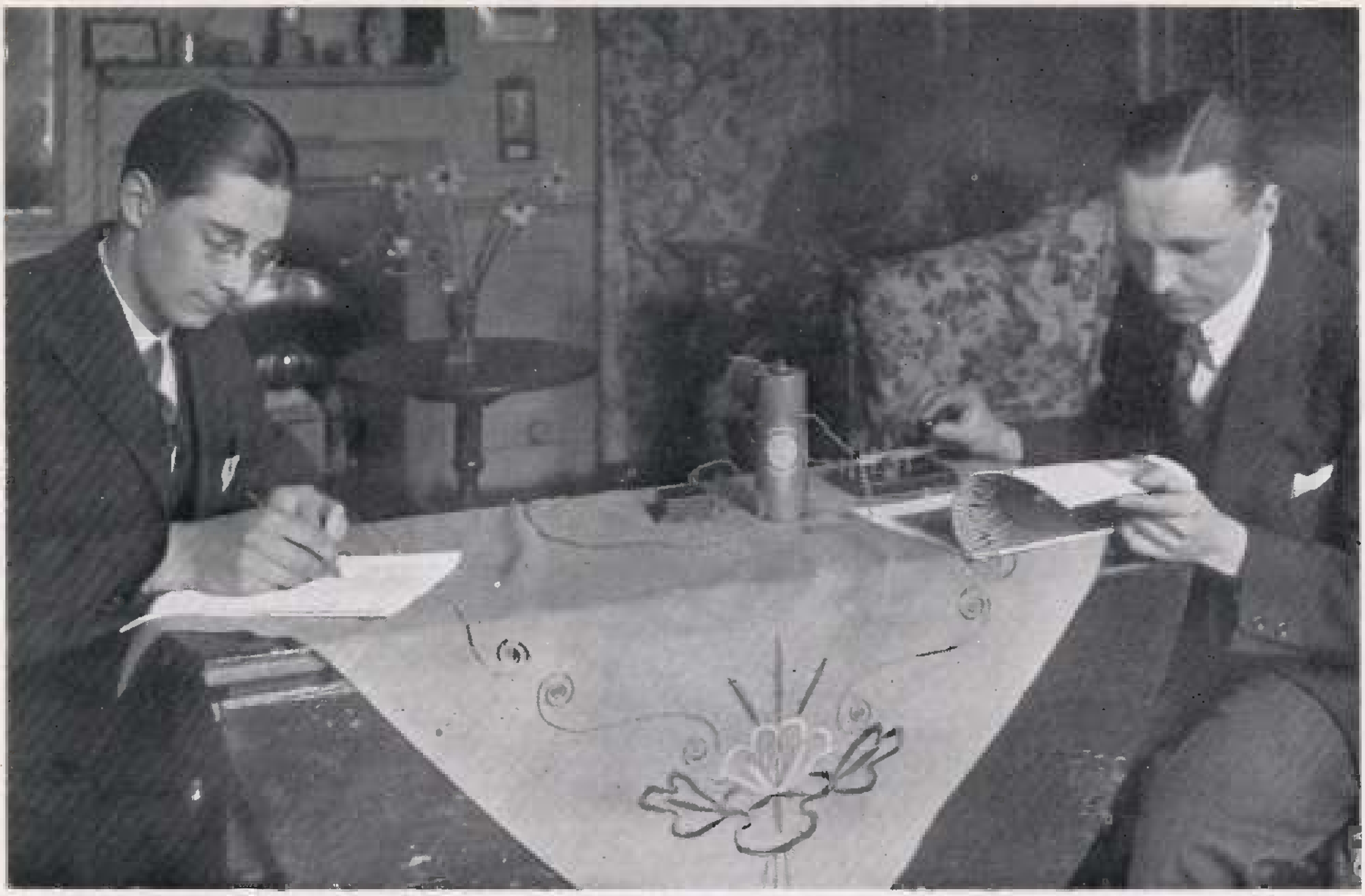
HOW TO TUNE YOUR RECEIVER

THE tuning of a receiver is such a simple matter that amateurs are apt to give less thought to it than it deserves. When it is merely a matter of getting signals there are several ways of tuning a receiver. The various controls can be adjusted indiscriminately until signals are heard, and then readjusted more carefully to bring signals to their loudest strength. This haphazard method of tuning is all right, of course, in the case of a small, simple receiver, but when dealing with multi-valve instruments maximum efficiency can only be obtained by tuning systematically. A multi-valve receiver containing a tuned anode circuit with reaction on the aerial should be tuned as follows. First of all, loosen the coupling between the reaction coil and the aerial tuning coil to a maximum by setting the coils at right angles to one another. Then turn the aerial tuning condenser slowly until weak signals are picked up, and bring signals to their maximum strength by adjusting the anode tuning condenser. Move the aerial condenser a few degrees to either side of its present position and bring signals to their maximum strength once more by means of the anode condenser. If this second maximum is louder than the first maximum repeat the process; if it is weaker it means that the aerial condenser has been moved to the wrong side of its original position; correct this by moving it in the opposite direction, and bring signals to their maximum strength once more with the anode condenser. Repeat this process until the positions of the condensers are such that no further adjustment of either can increase signal strength. At this stage the coupling between the aerial coil and the reaction may be "tightened" a little bit, care being taken not to make it so tight as to cause the receiver to oscillate. This alteration in the coupling will, of course, throw the receiver out of tune, and it will be necessary to adjust the condensers again. By tightening the coupling in stages, adjusting the condensers at each stage, signals can be brought to their absolute maximum strength. The whole operation of tuning by this method can, with a little practice, be performed in less than half a minute.

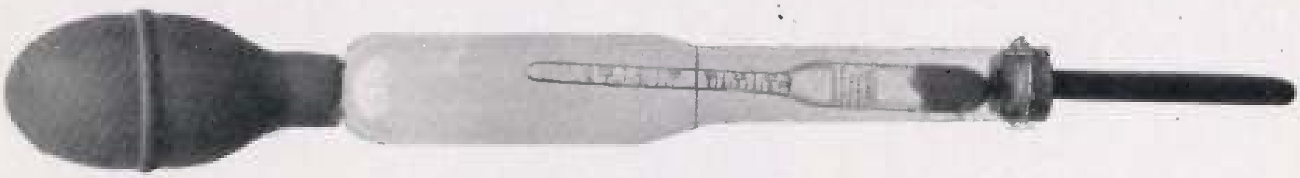


A well-known type of thermionic valve. Note that the prong P is at a greater distance than the prong G from either of the prongs which connect up the filament. This prevents the valve from being inserted wrongly in its socket.

(*See page* 9.)



Practising the reception of Morse code wireless messages by means of a simple buzzer equipment, which forms a miniature transmitting apparatus. (*See page* 57.)



A " hydrometer," by means of which the specific gravity of accumulator acid can be determined in a few seconds. (*See page* 53.)

The " Exide " accumulator: widely used throughout the wireless world. (*See page* 53.)

THE CARE OF ACCUMULATORS

Points on using, testing and charging accumulators

THE batteries used with a valve receiver must be kept in thorough working order if consistently good results are to be obtained. An accumulator battery is used for lighting the filament of the valve. This is a fairly expensive item, but with proper care it can be made to last a long time. It consists of a number of metal plates in a vessel which contains sulphuric acid. The container which holds the plates and the acid is usually composed of some transparent substance, which enables the interior condition of the accumulator to be inspected easily. As its name implies, this instrument is used for the purpose of storing up electricity. In fact, it is also called a storage battery. Before it can be of any use, it must be stored, or charged, with electricity from some source of supply—a dynamo, for instance. The charge that is thus given to it can be saved up and drawn off in small quantities when required. Each time you use your valve receiver, you actually draw off and consume a small quantity of the electricity which your accumulator contains.

If you order your accumulator by post, it will be sent to you without the acid; this must therefore be added by whoever is going to be responsible for the charging of the accumulator. Ordinary commercial sulphuric acid must not be used for this purpose, as it contains certain impurities which are injurious to the accumulator. A special kind of sulphuric acid, suitable for accumulators, can be procured through any chemist. The acid should be diluted with water (preferably *distilled* water) until it is brought to the proper specific gravity. When an accumulator has been in use for some time, the volume of the liquid decreases appreciably. This is due mainly to the evaporation of the water. It is also due, to a much smaller extent, to the loss of some of the acid, owing to the "spraying" effect that takes place after charging. It will not do, therefore, to go on adding water to increase the volume of the liquid to its former value. Water should only be added to replace the water that is lost by evaporation, and acid should be added to replace any acid that is lost by spraying. Unless this is done the diluted acid cannot be kept at the correct specific gravity.

Unless you are fully qualified to undertake the charging of your own accumulators, you will leave this matter to whoever is responsible for the charging, of course. Nevertheless, it is desirable that you should be able to check the efficiency with which the job is being carried out from time to time. If your accumulator is left to the care of your local dealer for recharging every time it gets "run down," it may not be given the attention it requires. A careless assistant may forget all about adding acid and go on adding water, without troubling to test the specific gravity. You can guard against this—and it is highly important that you should do so—by using a hydrometer to test the specific gravity yourself. The simplest type of hydrometer to use for this purpose consists of a glass cylinder with a rubber bulb at one end, and a rubber tube at the other. After squeezing the bulb, the rubber tube is inserted in the acid; then, by releasing the bulb, a quantity of the acid is sucked up into the glass cylinder. The instrument looks just like a large fountain-pen filler, with a short piece of rubber tubing attached to the end through which the acid is sucked up. The glass contains a small float, and when the hydrometer is filled with acid the float rises to a certain height—depending upon the specific gravity of the acid. The specific gravity may be read from a graduated scale on the face of the glass. The correct reading should be about 1·250. Other types of hydrometer contain a number of floats, and their relative positions in the glass indicates the specific gravity of the acid. You should certainly possess one of these inexpensive instruments if you wish to keep an eye on the charging of your accumulators.

You should also possess a voltmeter. This is an instrument for measuring the *voltage* of an accumulator. Valve accumulators may contain one, two or three cells, and the voltage of each cell decreases slowly when the accumulator is in use. *The voltage should never be allowed to drop below* 1·8 *volts per cell.* An accumulator can be seriously damaged by allowing the voltage of the cells to drop below this value. Unless you have had considerable practical experience of accumulators you will not be able to tell, without the use of a voltmeter, when your accumulator needs recharging. So long as you allow this state of affairs to continue you will have no one but yourself to blame for the consequences. The moment the voltage drops to 1·8 volts per cell, the accumulator should be disconnected from your receiver and sent to be recharged *at once.* You should never leave a discharged accumulator standing about idle for longer than you can help.

Quite a small voltmeter, such as can be obtained at any electrical store, will enable you to test an accumulator. Each accumulator cell has two terminals on the outside, and a voltmeter also has two terminals. In order to test the voltage of the cell, all that is necessary is to touch the cell terminals with the voltmeter terminals. A moving needle, which passes over a graduated scale on the voltmeter, indicates the voltage. *This reading should be taken whilst the cells are in use, i.e., whilst the current is actually flowing from the accumulator through the valve.* The voltage of a cell does not drop at a uniform rate. When it reaches the 1·8 mark it begins to drop more rapidly than formerly. The rate at which it is dropping is indicated by the diminishing brightness of the valve. Sometimes, in the course of about an hour's working, a considerable decrease in the brightness of the valve is noticeable. When this happens, the accumulator should be disconnected immediately, because it means that the 1·8 mark has been passed, and the voltage has begun to drop rapidly. This danger, as I have already explained, can be averted by means of a small voltmeter.

Even when an accumulator is not used regularly it is a good plan to charge it regularly. It would benefit by being charged up about once a week, or once a fortnight. When it is not in use at all, an accumulator should not be allowed to go uncharged for more than about six weeks, or at most two months. If you are going away for a long holiday, therefore, don't leave your accumulator lying idle at home. Take it to whoever looks after the charging of it for you, and don't omit to mention that you will not be using it again for some time. Of course, if you are going away for a very long period, and do not wish others to use the accumulator in your absence, you can prevent any deterioration by draining off the acid from the cells. After doing this, the cells should be rinsed out several times with clean water and then left to dry. On reassembling the accumulator for use again it is only necessary to fill it with sulphuric acid of the correct specific gravity. It is essential that the accumulator should be fully charged on both occasions, *i.e.*, before the acid is removed, and immediately after it has been restored to the cells at the end of the period of non-usage.

When diluting concentrated acid to the proper specific gravity it is advisable to use distilled water. This can be obtained from any chemist. But the water must *not* be added to the acid. *The acid must be added to the water.* The best kind of vessel to use for diluting the acid is one made of lead. Vessels made of other metals must *not* be used. A glass vessel may also be used for the purpose. Should any of the acid be spilled, it should be wiped up at once, as it is capable of destroying the object with which it comes into contact. A coating of vaseline on the terminals will preserve them from the corrosive action of the acid.

TRANSFORMERS FOR VALVE SETS

THE action of the transformer depends upon Faraday's discovery that a part of the energy of an electric current spreads outward through the space surrounding the metallic conductor in the form of a magnetic " field." This magnetic field is in turn capable of producing sympathetic or induced electric currents in any adjacent conductor. Such induced currents, which, of course, represent a transfer of energy from one conductor to the other, are, however, only created when the value of the spreading field of force changes, which only occurs in the case of an oscillating or varying current. In other words, no transfer of energy can take place from a circuit or conductor carrying a steady current.

A Transfer of Energy from one Circuit to Another

A transformer, then, is an instrument for transferring *alternating* electric energy from one circuit to another. Essentially it comprises two separate coils, one called the " primary " and the other the " secondary." The primary coil is included in the " input " circuit, whilst the secondary forms part of a separate, or " output," circuit. The two coils are wound together about a common axis, so that the varying magnetic field from a rising and falling current in the primary coil cuts through, or " threads," the windings of the secondary coil. This linking of the varying magnetic field set up by the current in the primary coil causes corresponding currents to flow in the secondary coil, and so effects a transfer of energy from the input to the output circuit.

The amount of energy that can be taken from the secondary coil is always rather less than the amount of energy applied to the primary, the difference being due to small losses caused by eddy currents and hysteresis effects (if an iron core is used), or to leakage of the magnetic field in other cases. But this difference is quite small.

Although the *amount* of energy transferred from the primary to the secondary winding is approximately the same, however, the actual *form* in which the energy appears in the secondary is in most cases very different from that in which it is applied to the primary. Hence the name *transformer*. If, for example—ignoring the factor of " losses " for the moment—there are ten times more turns in the secondary winding than in the primary, the *voltage* taken off across the secondary will be ten times greater than that applied to the primary terminals, and the current will, of course, be ten times less, in order to keep the total energy constant. A transformer designed on these lines is called a *step-up* transformer.

On the other hand, if there is only one-tenth the number of turns in the secondary coil, as compared with the primary, then the voltage appearing across the secondary will be only one-tenth the strength of the primary voltage. In this case, however, the *current* in the secondary will be ten times more than in the primary, so that the product of volts and amperes (*i.e.*, total energy) will be the same in both cases. A transformer of this kind, in which voltage is lost, but current is gained, across the secondary, is called a *step-down* transformer.

With and Without Iron Cores

Sometimes both primary and secondary coils are wound round an iron core. This greatly increases the extent of the magnetic flux, and the instrument accordingly acts with greater efficiency than when no iron core is used. At the same time an ordinary iron-cored transformer cannot be inserted in a circuit containing high-frequency currents, because the impedance or opposition set up by the extensive changes in magnetic flux is sufficient to choke back or prevent such currents from flowing through the coils.

Accordingly, when it is a question of

transferring *high-frequency* currents from one circuit to another (as in a transformer-coupled high-frequency amplifying valve circuit), *air-cored*, or "open" transformers are used.

Now if the current flowing in the primary winding of a transformer consists of a direct current, upon which is superposed an alternating current, only the alternating current is transferred to the secondary. As previously stated, no energy transfer takes place in respect of the direct current. For this reason, when working with a valve receiver, it is a perfectly sound plan to use a 1 to 1 transformer even with high-resistance telephones, because the transformer serves to keep out the steady or direct current (flowing in the circuit of the last valve) from the telephone windings. It is bad practice to allow a steady flow of current to pass through the telephone earpieces, as this may demagnetise the pole pieces, and so render the telephones insensitive. In any case, the *direct* current serves no useful purpose since the *variable* current constitutes the only effective supply of energy so far as the operation of the telephones is concerned.

A telephone transformer of the step-down type is always employed when low-resistance telephones of, say, 60 or 120 ohms are used. It should be remembered that, in general, the output impedance (not resistance) of the transformer should equal the impedance of the telephone windings. Similarly the output impedance of the plate circuit of the last valve should be approximately equal to the input impedance of the primary winding of the telephone transformer.

The ordinary transformers used between low-frequency valves or note magnifiers are of the step-up voltage type. The total number of windings in both primary and secondary windings should not be less than 30,000. The ratio of the primary and secondary turns usually varies according to the particular stage of low-frequency amplification concerned. It may be as high as 4 to 1 and as low as 1 to 1. The metal core is generally formed of E-shaped stampings of stalloy metal to minimise eddy currents and hysteresis losses.

HOW TO STOP "HOWLING"

LOW-frequency amplifiers are often responsible for the production of unpleasant noises which are commonly referred to as "howling." This is due to the fact that every low-frequency amplifier has a tendency to oscillate at audible frequencies, particularly when two or more stages of amplification are used. A low-frequency transformer has a "natural" frequency of its own, at which frequency it is prone to oscillate; if two transformers of similar design are employed in the same receiver this tendency is aggravated, of course. In order to guard against this trouble the transformers should be placed at a distance of at least a few inches from one another; they should also be set so that the windings of one transformer are at right angles to the windings of the other. The tendency to self-oscillation at audible frequencies can be further reduced by "screening" the instruments from each other by means of a small sheet of tin, the latter being connected to the earth terminal of the receiver. Most manufacturers nowadays produce "screened" transformers, in which the windings and core are completely enclosed in a metal case. These instruments are usually described as "shrouded," "shielded," "iron-clad," etc. The efficiency of a low-frequency amplifier can sometimes be increased by reversing the leads that go to the primary or secondary windings of the transformers. Different ways of connecting these leads should be tried until the connections that give best results are found. It should always be remembered that the low-frequency transformer is one of the most important instruments in any receiver. Cheap instruments of unreliable make rarely, if ever, give satisfaction.

DO YOU KNOW THE MORSE CODE?

FEW amateurs are able to resist the temptation to learn the Morse code, after having once experienced the delights of wireless. It is very pleasant and interesting, of course, to listen to speech and music by wireless, and to be able to switch from one broadcasting station to another in the course of an evening's entertainment. But however enjoyable this may be, the reception of Morse code signals from distant parts of the earth exercises a still more subtle fascination over the mind of the enthusiastic amateur. Sooner or later everyone who does a little experimenting with his receiver picks up Morse code signals from some station or other, either on sea or land.

It must not be imagined, of course, that signals cannot be heard from distant transmitting stations on a set that can only pick up weak signals from a broadcasting station at thirty miles range. The range of every receiver is relative to the power of the station from which signals are expected. Compared to some of the big commercial stations the broadcasting stations send on very low power. That is why they produce comparatively weak signals in a crystal receiver at about thirty miles range: they are only intended for reception over a limited area. Dozens of the big commercial stations, on the other hand, both at home and abroad, are specially designed to carry out direct transmission to other stations over distances of thousands of miles. Government stations are also designed for similar purposes, whilst practically all the merchant ships of the world are equipped with transmitting installations which can be heard over several hundreds, and even thousands, of miles.

Many of these stations can be heard at different periods of the day by any amateur who can tune in to them on his receiver. Ship stations transmit on a wavelength of 600 metres, and above this range, extending up to wavelengths of several thousands of metres, numerous naval and commercial stations can be heard. For instance, the well-known "time signals" sent out from Eiffel Tower, Paris, at different hours each day, are transmitted on a wavelength of 2,600 metres. A suitable "loading coil" for receiving these long wave signals can be obtained from any wireless dealer.

The instruments necessary for learning the Morse code are a tapping key, a buzzer, and a battery consisting of one or two dry cells. These should be connected up as shown in Fig. 1. When the key is depressed, a high-pitched note is emitted

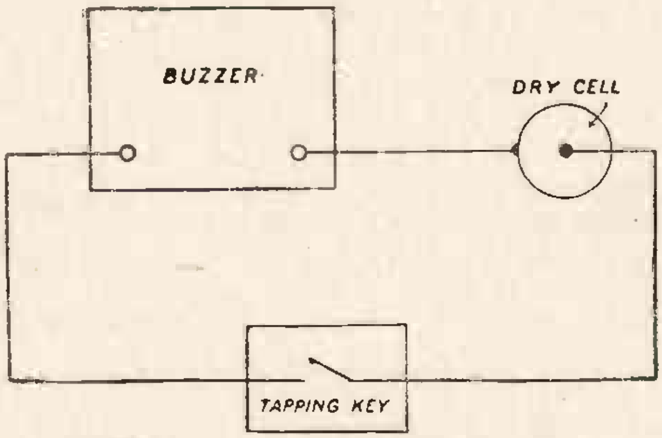


FIG. 1.—Showing connections of buzzer circuit.

from the buzzer, and, as the former is held down for short or long intervals, the buzzer emits "dots" and "dashes" in the Morse code. The Morse alphabet and conventional Morse signs are shown on next page. The beginner should commence by learning to send this alphabet *very slowly* on the tapping key, spelling out the Morse equivalent of each letter in his mind as he goes along thus: "dot-dash, dash-dot-dot-dot, dash-dot-dash-dot," etc. The pitch of the note emitted by the buzzer can be varied by turning a small regulating screw, being thus made to represent the notes received from stations which send out notes of different pitch. Two learners, working consistently together, and taking alternate turns at the transmitting key, can make rapid progress towards the attainment of sufficient speed to enable them to read Morse code messages from ships and commercial stations quite easily. When practising together, the aim of the receiver should be to concentrate on the buzzer sounds, totally excluding the " tap tap " of the sending key. The " dip " of the latter, which can also be adjusted by means of a small screw fitted to one end of the horizontal arm, should be made very small, so as to reduce the tapping noise to a minimum. The aim of the sender should be to transmit each letter clearly and evenly, at a uniform rate, concentrating the while on the buzzer sounds with a view to increasing his own familiarity with the Morse equivalents of the alphabet.

THE MORSE CODE.

ALPHABET.

a ·—	j ·———	s ···
b —···	k —·—	t —
c —·—·	l ·—··	u ··—
ch ————	m ——	v ···—
d —··	n —·	w ·——
e ·	o ———	x —··—
f ··—·	p ·——·	y —·——
g ——·	q ——·—	z ——··
h ····	r ·—·	é ··—··
i ··		

FIGURES.

1 ·————	5 ·····	8 ———··
2 ··———	6 —····	9 ————·
3 ···——	7 ——···	0 —————
4 ····—		

PUNCTUATION AND OTHER SIGNS.

Full stop (.) ······	Preliminary Call —·—·—
Note of Interrogation, or "please repeat" (?) ··——··	Erase ···········
Note of Exclamation (!) Also used to indicate laughter ——··——	End of Message ·—·—·
Hyphen or dash (-) —····—	Commence Transmission —·—
Bar indicating fraction (/) —··—·	Wait ·—···
Double dash (separating address from text, etc. —···—	Message received ·—·
	Communication finished ···—·—
	General Call to all Stations —·—· ——·—
	"TR" (prefix for preliminary correspondence) — ·—·

The time interval between each dot or dash of the same letter should be equal to the duration of a dot, and the time interval between each completed letter should be equal to the duration of a dash. The duration of a dash is twice that of a dot. That is to say, between the dots and dashes of each letter, a short pause is made (equivalent to the time taken to send the letter e), and between each completed letter a longer pause is made (equivalent to the time taken to send the letter t). The sender should learn to grasp the knob of the tapping key lightly and easily, and *work from the wrist.* Although each individual tends unconsciously to develop a "style" of his own in sending, a light touch is the main characteristic of every good telegraphist. If the key is held too rigidly, the fingers will become stiff, and jerky, uneven transmission will be the result. Moreover, if the tapping action is not performed freely from the wrist, the muscles of the forearm will become taut and painful, involving a suspension of work until they have regained their normal flexibility. These troubles can only be avoided by the sender restraining a premature, though natural, impulse to develop speed. The only justifiable way to develop speed is to

AMPLION PORTABLE LOUD SPEAKER.

The value of a portable loud speaker is well illustrated in this pleasant picture. The instrument shown is an "Amplion" (portable model). The strong telescopic tripod on which it stands can be collapsed and carried inside the box during transit. The box itself measures 13 in. × $7\frac{1}{2}$ in. × 7 in., and the total weight of tripod and box is only 7 lbs.

develop it unconsciously. Speed comes with practice, inevitably. Perfect spacing and perfect formation of each letter are the things to aim for in transmission. All incipient telegraphists find that speed comes much more rapidly in transmitting than in receiving, but each learner should endeavour to regulate his transmitting speed to suit the receiving speed of the other.

To avoid any temptation, on the part of the receiver, to guess at the words he is taking down, it is a good plan to send sentences backwards. breaking up the letters into groups of five or six, each group thus forming a " secret code word." " *Thus, the words I am now writing should be sent as follows* — swoll ofsat neseb dluoh sgnit irwwo nmais drowe htsuht."

Amateurs who cannot secure the co-operation of friends will be interested to know that gramophone records can be obtained which contain excellent Morse code " selections." The speed of the gramophone, of course, regulates the speed of transmission.

TELEPHONE TIPS

IT is a mistake to think that because telephones are robust instruments they do not require any care or attention. A faulty pair of telephones is often the cause of diminishing signal strength, although few amateurs think of suspecting the phones when their receiving outfit shows signs of losing its efficiency. A pair of phones may continue to function satisfactorily after being dropped on the floor accidentally, but every such accident tends to reduce the magnetism of the small magnets in the ear-pieces, with a consequent reduction in the sensitivity of the phones. Dampness can also affect phones adversely by causing a deposit of rust to form on the tops of the pole pieces; this can be removed with the aid of a rag and a spot of oil. The practice of cleaning the pole pieces with emery paper, or scraping them with a knife, is to be condemned, because, by lowering the surface of the pole pieces the efficiency of the phones may be seriously impaired. It is probable that decreased sensitivity is more often due to demagnetisation of the pole pieces than to any other cause. Manufacturers usually mark one of the tags of the telephone leads with a red binding thread to indicate that this tag should be connected to the positive pole of the high-tension battery when the phones are connected in series with the plate of a valve. If this rule is not observed the effect of the high-tension current flowing in the wrong direction will be to demagnetise the phones and reduce their sensitivity. Lastly, telephones should never be hung up by their leads; this practice is certain to cause a break in the wire sooner or later.

PROBLEMS SOLVED

1. Should an aerial be any particular height or length?

The Postmaster-General's regulations stipulate that the combined height and length of an amateur aerial should not exceed 100 feet. Within this limit any convenient height or length can be used.

2. Is there any advantage in using insulated wire for aerials?

For ordinary outdoor aerials there is little or no advantage to be gained from using insulated wire. But if the aerial has to be erected in such a position that there is a danger of it making contact with earth-connected objects (*e.g.*, trees, walls, etc.) insulated wire should be used.

3. What is the best kind of wire to use for an outdoor aerial?

No. 22 S.W.G. stranded wire. (S.W.G. =Standard Wire Gauge.)

4. What is a " T " aerial?

A " T " aerial is an aerial whose down lead is taken from the centre of the horizontal wire.

5. What is an " inverted L " aerial?

An " inverted L " aerial, as its name suggests, is an aerial whose down lead is taken from one end of the horizontal wire.

6. Is a " T " aerial better than an " inverted L " aerial?

In practice there is not much to choose between them as a rule. Under suitable circumstances an " inverted L " aerial yields louder signals from one direction by reason of its " directional effect."

7. Why do some aerials have two horizontal wires?

If space is limited—to, say, 30 feet—two wires, spaced 6 feet apart, give better results than a single wire.

8. What is a " sausage " aerial?

A " sausage " aerial is one which contains several horizontal wires, spaced fairly close together on a hoop " spreader." It is not suitable for a receiving aerial.

9. Are indoor aerials efficient?

An indoor aerial is never as efficient as a good outdoor aerial. Quite good results, however, can be obtained with indoor aerials up to a distance of about ten miles from a broadcasting station.

10. Should the horizontal part of an indoor aerial be perfectly straight?

Not necessarily. A long stretch of wire down a corridor is usually preferable to a wire running round the walls of a small room; but it is frequently necessary to make several bends in an indoor aerial. Several positions should be tried experimentally before deciding on the final position.

11. What is the best wire to use for an indoor aerial?

Rubber-covered " flex " wire is the best for this purpose.

12. What is a frame aerial?

A frame aerial is one which is wound in parallel loops round a wooden frame. The frame may be of any shape, but square frames are most commonly employed. An aerial of this kind need not be connected to earth. Both ends of the wire are joined to the receiver—one to the " aerial " terminal, and the other to the " earth " terminal.

13. Is a large frame better than a small one?

Yes; it may be taken that the larger the area of the frame the better will be the results obtained.

14. What are suitable dimensions for a frame aerial for broadcast receptions ?

Seven turns of wire on a square frame with 4-feet sides, the turns being spaced ½ inch apart from one another. For tuning purposes, a condenser of 0·0005 microfarad capacity should be connected across the ends of the wire.

15. Should a frame aerial be wound with insulated wire ?

Owing to the close proximity of adjacent turns it is advisable to wind a frame aerial with insulated wire. On the other hand, if very great care be taken to space the turns accurately this precaution need not be observed. No. 20 S.W.G. double cotton-covered wire is recommended for this purpose.

BATTERIES

16. What is a " high tension " battery ?

This is the name given to the battery which supplies the necessary voltage to the " plate " of a receiving valve. It usually consists of a number of dry cells connected in series.

17. What is a " dry " cell ?

A " dry " cell (or primary cell, as it is sometimes called), consists essentially of two electrodes (one *carbon*, and the other *zinc*) and an electrolyte, the latter being made up in the form of a paste. The voltage of such a cell is 1·55 volts, and it is capable of supplying only very small currents. Once it becomes discharged it cannot be recharged. A high-tension battery may contain anything from 20 to 100 of these cells.

18. What is a " low-tension " battery ?

The battery that heats the filament of a valve is usually called the " low-tension " battery. Although it sometimes consists of a couple of dry cells, more frequently it consists of one, two or three accumulator cells.

19. What is an " accumulator " cell ?

An accumulator cell is one in which the electrodes are specially prepared lead plates, whilst the electrolyte is in a liquid state. This type of cell (also called a secondary cell) can be recharged after it has run down. Its voltage is approximately 2 volts. Thus, a 4-volt accumulator consists of two accumulator cells, a 6-volt accumulator consists of three cells, and so on.

20. What is the purpose of a high-tension battery ?

The purpose of a high-tension battery is to exert a steady electrical pressure (or voltage) on the plate of the receiving valve, or valves, with which it is used. The efficiency of a receiver depends to a large extent upon the correct amount of high tension being applied to each valve.

21. What is the best high-tension voltage to use ?

This depends upon the type of valve. All reputable valve manufacturers supply the necessary information with their valves. In general, the amount of high tension required by a valve depends upon the position of the valve in the receiver. The second valve usually requires a little more than the first, the third a little more than the second, and so on. To obtain best results, therefore, each valve should be fitted with a separate high-tension " wander plug," and the high-tension battery should be variable between about 20 and 120 volts. A still higher range is required for certain " power " valves.

22. Can the same high-tension battery be used for supplying all the valves of a receiver ?

Yes ; this is the usual practice. As indicated in the answer to the previous question, the use of " wander plugs " enables the same battery to supply different voltages to different valves.

23. How does one know when a high-tension battery is "run down"?

The running down of a high-tension battery is always accompanied by a loss in signal strength; but this, of course, may also be brought about by the low-tension (accumulator) battery running down. Crackling or rustling noises in the phones are also a common indication of a voltage drop in a dry battery. It is advisable to test the voltage of a dry battery intermittently with a voltmeter.

24. Can a battery of accumulator cells be used for high tension?

Yes; some manufacturers produce small accumulator cells suitable for this purpose. They are, however, more costly than dry cells, as well as being more difficult to maintain.

25. Can dry cells be used for the filaments of valves?

Dry cells can be used for this purpose with certain valves of the dull emitter type—*e.g.*, valves which consume 0·06 ampere.

26. How can one tell when an accumulator is running down?

By the diminishing light of the valve, by the diminishing strength of signals, by the amount of resistance used in the filament circuit—as indicated by the position of the rheostat handle, or, best of all, by testing with a voltmeter. The latter is the only safe method. *The reading of the voltmeter should be taken while the accumulator is in use,* and the voltage should never be allowed to drop below 1·8 *volts per cell.*

27. What is meant by the term "ampere-hour"?

This term provides a convenient way of indicating the amount of current a cell is capable of yielding before it needs recharging. Thus, when we say that a certain cell has a capacity of 10 ampere hours, we mean that that cell can supply a current of 10 amperes for one hour, or 5 amperes for two hours, or 3·3 amperes for three hours, etc. A 30 ampere-hour accumulator will supply a current of 1 ampere for thirty hours.

CONDENSERS

28. What should be the maximum capacity of the aerial tuning condenser?

A suitable value for this condenser is between 0·0005 and 0·001 microfarad. Its minimum value should, of course, be as near zero as possible.

29. What should be the maximum value of the secondary tuning condenser?

The maximum capacity of this condenser is usually 0·0005 microfarad.

30. When is an anode tuning condenser employed?

This condenser is used when the high-frequency valve of a receiver is operated on the "tuned anode" principle—*i.e.*, when the anode circuit of a H.F. valve is tuned by means of a coil and variable condenser.

31. What is a "reservoir" condenser?

This is a fixed condenser, with a capacity of about 2 microfarads, which is connected across the terminals of the high-tension battery for the purpose of smoothing out any voltage variations that may occur in the latter. It also helps to reduce stray reaction between the valve, thus ensuring clearer reception.

32. What is the purpose of the "grid" condenser?

This condenser enables the valve with which it is connected to act as a rectifier or detector. Its best average value is about 0·00025 microfarad, though slightly lower or higher values are sometimes found to give better results; the most suitable value for a particular receiver can only be found by trial. The grid condenser must, of course, be used with a resistance ("leak") of suitable value.

33. What is a "vernier" condenser?

This term is usually given to variable condensers which permit of very fine tuning. Such condensers are frequently fitted with a single vane which can be moved independently of the main block of vanes; this, of course, enables the operator to obtain minute variations of capacity.

34. What is a "square law" condenser?

In a "square law" condenser the vanes are shaped in a special way to prevent groups of stations (of approximately the same wavelength) from "bunching" together at one point on the graduated scale. This type of condenser simplifies the work of tuning.

35. What is a "billi" condenser?

A condenser of extremely small capacity, usually tubular in shape. Its name is derived from the "billifarad," which is equal to a micro-microfarad.

36. Do the figures on the graduated scale of a condenser indicate the capacity of the instrument?

No; the figures on the condenser scale are quite arbitrary. They merely provide a convenient method of noting the setting of the condenser when a particular station is being received.

37. Why are some condensers fitted with long handles?

To reduce hand capacity effects.

38. How do hand capacity effects occur?

The body of the operator may be regarded as a conductor connected to earth, and when the operator brings his hand close to the vanes of the condenser he introduces an extra capacity, as it were, to the circuit. On removing his hand, this extra capacity is also removed, and the circuit is consequently thrown out of tune.

39. Do long handles constitute the only method of reducing hand capacity effects?

No; another good plan is to screen the condenser by fixing a small sheet of tin to the underside of the panel and connecting it by a wire to the earth terminal of the receiver.

40. Should the fixed vanes or movable vanes of the aerial tuning condenser be connected to earth?

If the end plates of the condenser are made of ebonite it is best to connect the moving vanes to earth, and the fixed vanes to the aerial. But if the end plates are of metal the connections should be made in the reverse way—*i.e.*, fixed vanes to earth and moving vanes to aerial. In the latter case, the top end plate will serve the purpose of the screen referred to in the previous question.

TUNING COILS

41. What is the purpose of a tuning coil?

In order to receive the waves sent out by a transmitting station the circuits of the receiver must contain approximately the same amount of "capacity" and "inductance" as the transmitter. The *product* of the capacity and inductance in the receiver must be the same as the *product* of the capacity and inductance in the transmitter; when this condition exists the receiver is said to be "in tune" with the transmitter. An aerial has a certain fixed amount of inductance and capacity, but in order to facilitate the process of tuning, an extra *variable* inductance, or an extra *variable* capacity, is also employed. Sometimes—in most cases, in fact—both are employed. The extra inductance takes the form of a coil of wire (usually called a tuning coil), whilst the extra capacity is, of course, provided by a condenser.

42. Is the strength of signals proportional to the amount of wire in a tuning coil?

No. Signals are at their loudest when the tuning coil contains the correct amount of inductance necessary to bring the receiver into tune with the transmitter.

43. Are all tuning coils "variable"?

No; tuning coils of fixed value are sometimes used. These, however, are usually called "loading" coils.

44. How many kinds of variable tuning coil are there?

Four main types of variable tuning coil are used for wireless reception, namely: (1) the slider coil, (2) the tapped coil, (3) the variometer coil, and (4) the plug-in coil.

45. What is a slider coil?

A slider coil consists of numerous turns of enamelled wire on a cylindrical former. By means of an adjustable contact that slides along a brass bar above the coil, any desired amount of wire can be included in, or excluded from, the circuit. The enamel insulation is, of course, removed from the turns of wire at the points at which the slider makes contact.

46. What is a tapped coil?

A tapped coil consists of several turns of wire (either enamelled or double cotton-covered) on a cylindrical former. From various points along the length of the coil (from every tenth wire, for instance), tappings are taken to a semi-circular row of metal studs on the base board on which the coil is mounted. By means of a rotating switch, which makes contact with these studs, any number of the tapped sections can be switched into the circuit.

47. What is a variometer coil?

A variometer really consists of two coils connected permanently in series with one another. The total inductance of the coils can be varied by altering their distance apart, or by altering the angle which the plane of one coil makes with the plane of the other.

48. What are plug-in coils?

Plug-in coils are really fixed coils—that is, coils of fixed value—but they are variable in the sense that a coil of any particular value can be removed quickly from a circuit and be replaced by a coil of another value. Quite a wide range of values is covered by a series of about half a dozen plug-in coils of different sizes. Each coil is fitted with a plug and socket which can be adapted to a corresponding plug and socket on a "coil holder" on the receiver.

49. What is the best kind of coil to use with a crystal receiver?

On the whole, variometer coils give best results with crystal receivers. There are several good makes on the market to-day. Slider and tapped coils can also be used effectively with crystals, of course, but they are not so popular as variometers.

50. What is the best kind of coil to use with a valve receiver?

Plug-in coils, used in conjunction with a variable condenser, are undoubtedly the most suitable for this purpose.

CRYSTALS

51. Where are crystals obtained?

Some are obtained from natural mineral deposits, whilst others are produced artificially.

52. How many kinds of crystal are there?

Dozens—perhaps hundreds. They are not all equally efficient as radio detectors, however.

53. What is the best kind of crystal to use?

It is not easy to say, because two pieces of crystal that have been chipped off the same parent lump will often vary a good deal in the matter of sensitivity. Galena, on the whole, is perhaps the most popular crystal on the market to-day. Many proprietary brands of artificially-produced galena are sold under such well-known names as Dayzite, Permanite, etc. Other crystals in common use among amateurs are bornite, zincite, carborundum, copper pyrites, iron pyrites, silicon, graphite, tellurium and molybdenite.

54. Is a large crystal better than a small one?

No, there is no relation in practice between the size of a crystal and its efficiency.

55. Can a crystal be used with a frame aerial?

No; not by itself. If combined with high-frequency amplifying valves—yes.

56. Can a crystal, without the aid of valves, operate a loud speaker?

A crystal alone cannot operate a loud speaker; it can do so, however, if it is assisted by a suitable amplifier—not necessarily consisting of valves. For instance, the Brown microphone amplifier can be used in conjunction with a crystal to produce loud-speaker signals.

57. Can signals be increased by connecting two crystals to the same aerial?

There are certain "double-crystal" circuits which, with careful manipulation, can be made to yield better results than those obtained with a single crystal.

58. In what way does carborundum differ from other crystals?

Carborundum will not rectify properly unless it has a small steady pressure applied to it. This is usually supplied from a local battery consisting of a few dry cells.

59. Why is it necessary to use a potentiometer with carborundum?

The actual voltage that must be applied to a carborundum crystal is very "critical"; if it is a fraction of a volt too low or too high the crystal will not rectify. A potentiometer enables very minute variations to be effected in the applied voltage.

60. What is a Perikon detector?

A Perikon detector consists of two crystals in contact with one another. That is to say, in this type of detector a second crystal takes the place of the contact strip, or catswhisker, that is usually employed with the ordinary type of crystal detector. The crystals that are most frequently used in a Perikon detector are zincite and bornite. They are mounted in separate cups and set "nose to nose," as it were, with a fairly firm pressure.

61. What is the best way of fixing a crystal in its cup?

A special substance known as "Wood's metal" affords the best means of fixing a crystal in its cup. Alternatively, a crystal can be held in position in its cup by means of small screws. Ordinary solder should never be used for this purpose.

62. Do crystals wear out?

Crystals lose their sensitivity in time, but a new lease of life can usually be obtained for a crystal by breaking it in two and working with one of the newly-exposed surfaces.

63. Can more than one pair of telephones be used with a crystal set?

Yes, if signals are sufficiently strong.

TELEPHONES AND LOUD SPEAKERS

64. How do telephones work?

Each telephone earpiece contains a coil of wire, wound on an iron core. When a pulse of current from the receiver passes through the coil the core becomes magnetised and draws the diaphragm of the earpiece towards it. When the pulse of current ceases the iron becomes demagnetised and the diaphragm springs back to its former position. A stream of impulses, therefore, causes a series of rapid vibrations of the diaphragm. As these vibrations occur at a low frequency (the frequency being the same as that of the current impulses), the resulting waves that they produce in the air are "audible."

65. What is the difference between high-resistance and low-resistance telephones ?

The efficiency of a pair of telephones depends partly upon the number of turns of wire on the iron core. The greater the number of turns the better the result. In order, however, to get a large number of turns into the small space available in a telephone earpiece, it is necessary to use wire of very small diameter. This, of course, has the effect of increasing the resistance of the coil, since thin wire has a higher resistance than thick wire.

66. Can more than one pair of telephones be used with the same receiver ?

Certainly, if the received signals are loud enough to give satisfactory results.

67. When several pairs of telephones are used together, should they be joined in series or parallel ?

Best results are usually obtained by connecting low-resistance telephones in parallel and high-resistance telephones in series.

68. What is a telephone condenser ?

This is a small fixed condenser which is sometimes used for storing up the high-frequency impulses that succeed in getting past the crystal. The telephones cannot deal with high-frequency impulses, of course, but the condenser stores up these impulses and passes them on to the telephones as low-frequency impulses.

69. What is a telephone transformer ?

It was stated in answer to Question 65 that the efficiency of a pair of telephones depends partly upon the number of turns of wire on the iron core. It also depends partly upon the current-strength of the impulses that pass through the core. The stronger the current the better the results. When using low-resistance telephones, therefore—*i.e.*, telephones which contain a relatively small number of turns of wire —it is particularly desirable that the current impulses should be as strong as possible. A telephone transformer, which steps down the voltage and steps up the current, is therefore used for this purpose.

70. Do loud speakers operate in the same way as telephones ?

Many loud speakers may be described as "large telephone earpieces with horns attached," insomuch as they consist essentially of a fixed coil, a moving diaphragm and a sound chamber. In some loud speakers, however, the diaphragm is fixed to the coil that carries the signal current, and both coil and diaphragm vibrate together when signals are being received. The vibrations are brought about by the action of a separate powerful magnet which draws the coil (and, therefore, the diaphragm) towards itself as each current impulse passes through the coil.

71. How many valves are necessary to work a loud speaker ?

This depends chiefly upon the distance between the receiving aerial and the transmitting station. Generally speaking, a loud speaker requires two amplifying valves in addition to whatever number is necessary for the production of clear telephone signals. It may be possible to operate a loud speaker on one extra valve, but this practice is not recommended, because it usually means that the valve has to be "forced" in order to make it do the work, and this invariably leads to distortion. It is much better to work two valves normally than to "force" one valve.

72. Why do so many loud speakers distort signals ?

The shape of a horn, or sound chamber, and the quality of the material used are frequently responsible for distortion. A still commoner cause, however, is the use of cheap and inefficient components in a receiver, as well as faulty manipulation of the latter. (See answer to previous question.)

73. Can a frame aerial be used with a loud speaker ?

Yes ; but extra valves are necessary in order to get results similar to those obtainable with an ordinary aerial.

74. Can two loud speakers, situated in different parts of the house, be operated simultaneously from the same receiver ?

Yes, this is quite practicable. Trouble may arise, however, from the use of long connecting wires, in which case a small fixed condenser of about 0·002 microfarad, connected across the latter, will prove helpful.

TRANSFORMERS

75. What is a high-frequency transformer ?

A high-frequency transformer consists of two coils of wire, wound on an air-cored former ; it is used for the purpose of coupling two high-frequency valves, or a high-frequency valve and a detector valve. Sometimes the primary or the secondary, usually the former, is tuned by means of a small condenser.

76. What is a low-frequency transformer ?

A low-frequency transformer consists of two coils of wire, wound on an iron core ; it is used for the purpose of coupling two low-frequency valves together.

77. Why are low-frequency transformers wound on iron cores ?

In order to lower the resistance of the path traversed by the magnetic field, as iron has a much lower magnetic resistance than air. If iron were used in a high-frequency transformer, however, the impedance of the instrument would be very high. (" Impedance " is equivalent to " resistance to high-frequency currents.")

78. Why do some receivers contain no transformer ?

Because there are alternative methods of coupling valves to one another. For instance, transformers are not necessary when " resistance-capacity " coupling is employed. In the latter case the coupling is done by means of condensers and resistances.

79. Is resistance capacity coupling better than transformer coupling ?

Each method has its own individual advantages and disadvantages. Generally speaking, transformer coupling gives a much higher degree of amplification than is possible with capacity-resistance coupling. On the other hand, the latter method, if properly controlled, is liable to lead to much less distortion than the former.

80. Why are the cores of low-frequency transformers made of thin metal sheets ?

To prevent unwanted currents from flowing in the core. When a current flows through the transformer in the ordinary way it sets up a magnetic field. This magnetic field induces small currents in the iron core itself, and as these currents —known as " eddy " currents—serve no useful purpose, it is advisable to eliminate them as far as possible. Eddy currents tend to flow backwards and forwards *across* the iron core, so that by building up the latter with a number of thin plates, each plate being insulated from its neighbour, the resistance of the path thus offered to the eddy currents is so great as to nullify their effect.

81. What is meant by the "ratio" of a transformer?

The ratio of a transformer is the ratio of the voltage across the primary to the voltage across the secondary. When we say that the ratio of a certain transformer is 1 : 4, for instance, we mean that whatever voltage be applied across the primary winding, the voltage produced across the secondary winding will be four times that amount. When the voltage across the secondary is greater than the voltage across the primary the instrument is called a "step-up" transformer, and when the secondary voltage is smaller than the primary voltage the instrument is called a "step-down" transformer. Any increase in voltage, of course, is accompanied by a corresponding decrease in current (*i.e.*, amperage), and *vice versâ*.

82. Does the size of a low-frequency transformer give any indication of its efficiency?

Yes, within certain limits. In order to guard against "burn-outs" the coils of the instrument should be wound with fairly thick wire; moreover, there should be a large number of turns. These factors, of course, tend to increase the size of the instrument. Again, in order to prevent "saturation" of the core, the latter should be of stout dimensions. The inefficiency of many of the cheap transformers on the market is due to the skimping of wire and iron in the coils and core respectively.

83. What is a "shrouded" transformer?

In order to prevent interaction effects taking place between adjacent transformers some manufacturers enclose their instruments in metal cases. These transformers are usually described as "shrouded," "iron-clad," "shielded," etc.

84. What is the effect of "earthing" the iron core of a transformer?

When an amplifier shows a tendency to oscillate and "howl" this can usually be prevented, and a condition of stability restored, by connecting the iron core of the instrument to earth.

VALVES

85. What are the functions of a valve?

A valve can be used to fulfil one of three functions: (1) As a rectifier instead of a crystal. (2) As a high-frequency amplifier—*i.e.*, for the purpose of amplifying signals before rectification takes place. (3) As a low-frequency amplifier—*i.e.*, for the purpose of amplifying signals after rectification has taken place.

86. What is a "general purpose" valve?

This name is given to valves which can be used for any of the purposes detailed in the previous question. Other valves are designed specially to fulfil one function only.

87. Is a one-valve receiver better than a crystal?

As a general rule, louder signals can be obtained with a one-valve receiver than with a crystal, although many records for long-distance reception have been established with crystals. Apart from the question of relative efficiency, however, the expense of building, or purchasing, a one-valve receiver is (relatively) somewhat high. For a small extra expenditure a two-valve receiver can be obtained, and this is well worth the money.

88. What advantage is gained by using a high-frequency valve with a crystal?

A high-frequency valve amplifies signals to five or six times their original strength.

89. What is the advantage of using a low-frequency valve with a crystal ?

A low-frequency valve doubles or trebles the strength of signals picked up by the crystal.

90. Why do some valves burn more brightly than others ?

The object of passing an electric current through a valve is to heat the filament, so as to make the latter shoot off electrons. The light produced in the process is a by-product, and has really nothing to do with the functioning of the valve. Some valves require much less heating than others in order to make them give off the necessary quantity of electrons, and therefore some valves burn less brightly than others. "Dull-emitter" valves require only a small amount of current to heat them to the correct temperature, whereas "bright-emitter" valves require a comparatively large amount of current.

91. Is there any relation between the brightness of a valve and the strength of signals ?

As between two different types of valve—No. That is to say, a dull-emitter valve, giving a very "poor" light, may bring in much louder signals than a bright-emitter valve that burns with a clear white light. If the question is applied to any individual valve, of course, it may be said that there is a certain relationship between the two factors, in-so-much as every valve gets gradually brighter when the current is first switched on, until the electron stream has reached its proper strength. Once this point has been reached, however, any further increase in brightness tends to reduce signal strength and injure the valve. The light from a valve should always be as low as is consistent with satisfactory results.

92. What is a "grid" leak ?

This is a high resistance which, when used with a small fixed condenser, enables a valve to rectify signals. The "natural" function of a valve is to amplify signals, and some arrangement of this kind is necessary in order to make it function as a rectifier, or detector, of signals.

93. What is a filament rheostat ?

A filament rheostat is a variable resistance by means of which the amount of current that is passed into the filament of a valve can be controlled easily.

94. Can an electric main be used for the purpose of supplying high tension to a valve ?

Yes; many experimenters make use of direct-current lighting mains for this purpose. Considerable care has to be exercised, however, if the results are to be satisfactory. It is difficult to obtain a steady pressure owing to the "ripples" caused by the commutator at the power station, although this can be minimised with the aid of a suitable condenser.

95. Can filament current be supplied from dry cells ?

With certain types of valve—Yes. Some dull-emitter valves require only about 0·06 ampere of current, and a good dry cell is capable of supplying this amount without suffering damage. Only the best and largest cells should be used for this purpose, however. It is false economy to purchase small cheap cells.

96. Is a high-frequency valve better than a low-frequency valve ?

The answer to this depends upon the purpose for which the valve is needed. See answers to Questions 88 and 89.

97. If a valve fits loosely in its holder, making a bad intermittent connection, what can be done to repair the fault ?

Remove the valve from its holder. You will notice that each of the legs of the valve is split. Insert the blade of a knife in each leg and "spread it" slightly. On returning the valve to its holder you will find that the faulty contact no longer exists.

98. Can signals be weakened by applying too much high tension to a valve?

Yes. It is a common fault among amateurs to apply too much high tension to their valves. Valves should be operated with as little high tension (and filament current) as possible.

99. Should the same amount of high tension be applied to all the valves in a receiver?

Satisfactory results can be obtained by this method, which certainly has the advantage of being very simple. It is advisable, however, to fit each valve with a separate high-tension lead, so that its high tension can be controlled independently of the other valves in the receiver. Very considerable improvement in signal strength can sometimes be obtained with this method.

100. What is a "power" valve?

This name is given to valves that are specially designed to carry large currents. When two or more stages of low-frequency amplification are used the last valve is usually a power valve.

101. What is the difference between high-frequency and radio-frequency amplification?

None; the terms are used synonymously. Similarly, the terms low-frequency and note-frequency are used synonymously with audio-frequency.

102. Do valves wear out?

Yes; with care, however, a valve will last a very long time. The length of life of a valve depends largely on the amount of trouble that is taken to operate it properly.

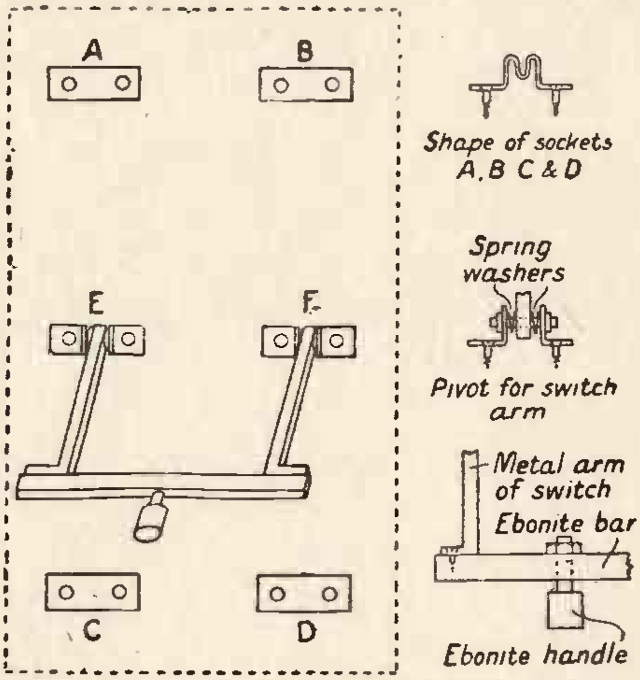
A SWITCH FOR WIRELESS

EVERY radio amateur learns sooner or later that it is both dangerous and inconvenient to have loose " leads " lying about his instrument table. Loose wires are dangerous, because they are liable to get crossed and form short circuits, and, although a short circuit may be quite harmless in certain circumstances, it may also result in a " dud " valve or a damaged accumulator. Disconnected wires are also inconvenient, because they tend to confuse matters when one is trying to do a little experimenting with a complicated circuit. Moreover, owing to the amount of extra care that they involve, considerable time may be wasted in keeping them out of harm's way.

The wise radio amateur will guard against trouble from this source by using simple switches whenever possible. The action of a small switch, for instance, provides a swift and easy method of disconnecting one instrument from a circuit and replacing it by another, automatically. Many amateurs, to take a case in point, possess a valve receiver which is capable of producing signals in a loud speaker. But although a loud speaker is very convenient for the purpose of entertaining a number of one's friends one frequently wants to listen-in on the ordinary headphones.

This is certainly a case in which a suitable switch should be employed as a means of saving time and trouble. The following instructions describe how to make a simple " change-over " switch for this purpose, and it should be remembered that the same type of switch can be used to serve a number of other equally useful purposes in a wireless circuit.

The lay-out of the switch, which can be mounted on an ebonite base board of any convenient size, is shown on the left of the accompanying diagram. A, B, C and D are two pairs of sockets, into which the arms of the switch are pressed. These sockets can be made by bending short copper strips into the shape depicted in the diagram ; small screws will suffice to keep them in position on the ebonite base. E and F are the pivots on which the arms of the switch move. These can also be made by bending short copper strips into right-angled pieces, as shown. A small pin, held in position by locking nuts, penetrates the right-angled pieces and the base of the switch arm. A firm contact between the switch arm and the right-angled pieces can be maintained by



Sketch-plan illustrating the making of a telephone loud-speaker switch for wireless.

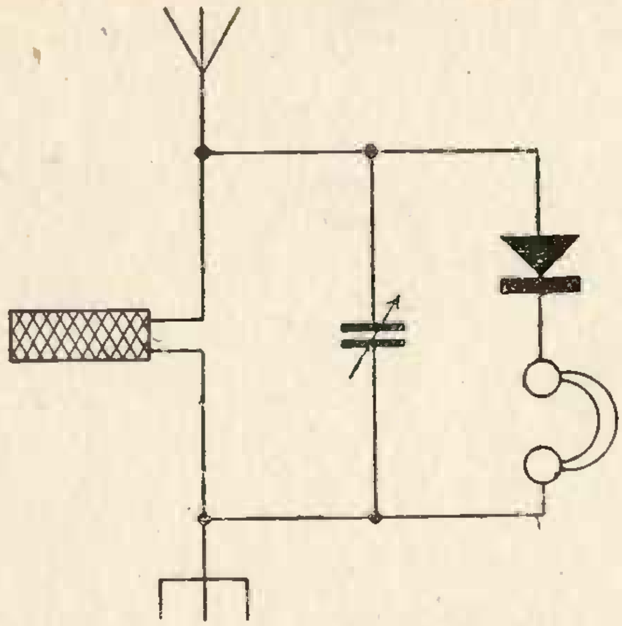
inserting spring washers on each side of the former.

Strong copper strip is suitable material for the arms of the switch. At their upper ends they can be fastened to the ebonite crossbar, as shown in the lower right-hand corner of the diagram. A small ebonite knob is also fitted to the cross-bar. Care should be taken to ensure that each pair of sockets is at the same distance from the pivoting pieces, and also that the switch arms are quite long enough to span this distance. The actual distance (from A to E, for example) need not be more than 1½ inches. A couple of inches is quite enough room to allow between A and B. (These dimensions are for a neat, handy switch; they can, of course, be doubled without affecting the efficiency of the switch.)

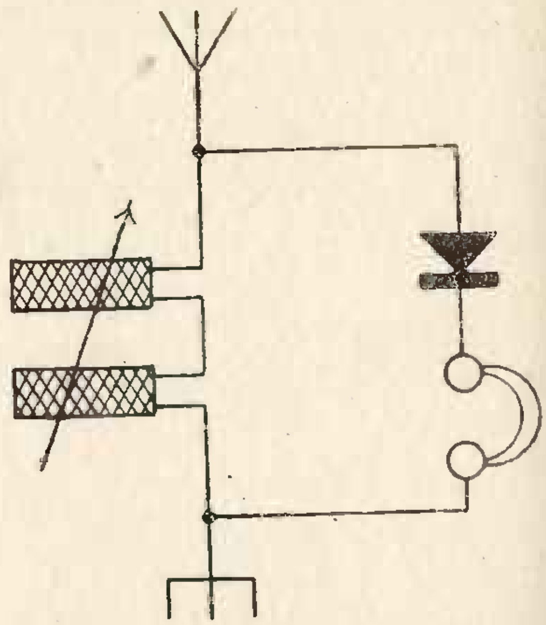
The wires that carry the signal current from the receiver should be connected to E and F. (The screws which hold the latter in position on the ebonite base can be used for this purpose.) The telephones should be connected to one pair of sockets in the same way, and the loud speaker to the other. The action of the switch is obvious.

RELIABLE CIRCUITS FOR THE AMATEUR

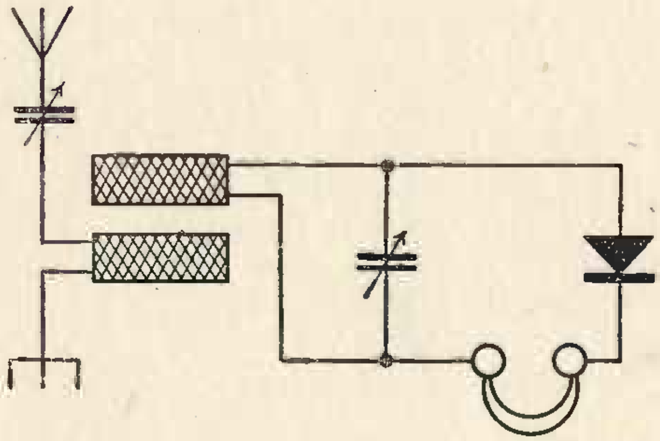
THE following pages contain a number of simple, straightforward circuits which the amateur can rely on to give results. Many of the circuits can be modified to suit individual tastes and requirements. For instance, in some circuits the aerial tuning condenser is connected in series, whilst in others it is connected in parallel. Again, the high-tension battery is sometimes shown variable and sometimes fixed. The final decision with regard to such details rests with the amateur, of course. Full information concerning the various alterations that can be made in different types of circuit will be found in the foregoing chapters.



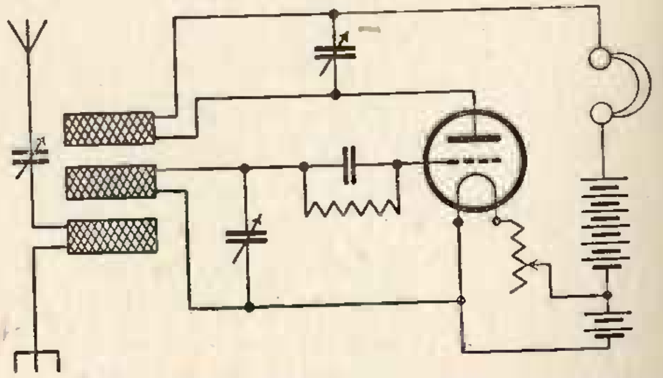
1. A direct-coupled crystal set, tuned by means of a plug-in coil and variable condenser.



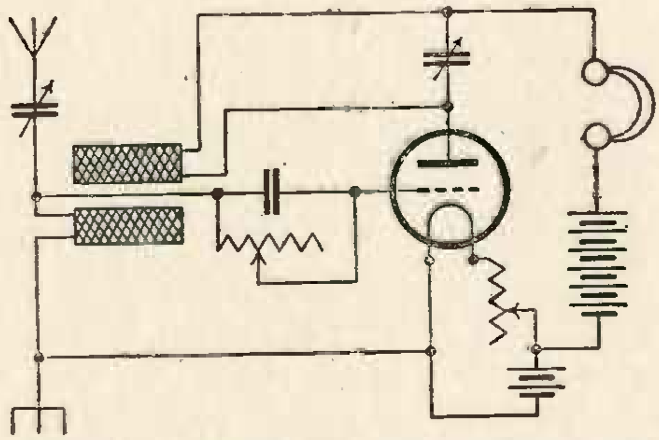
2. A variometer-tuned crystal set, the variometer consisting of two plug-in coils.



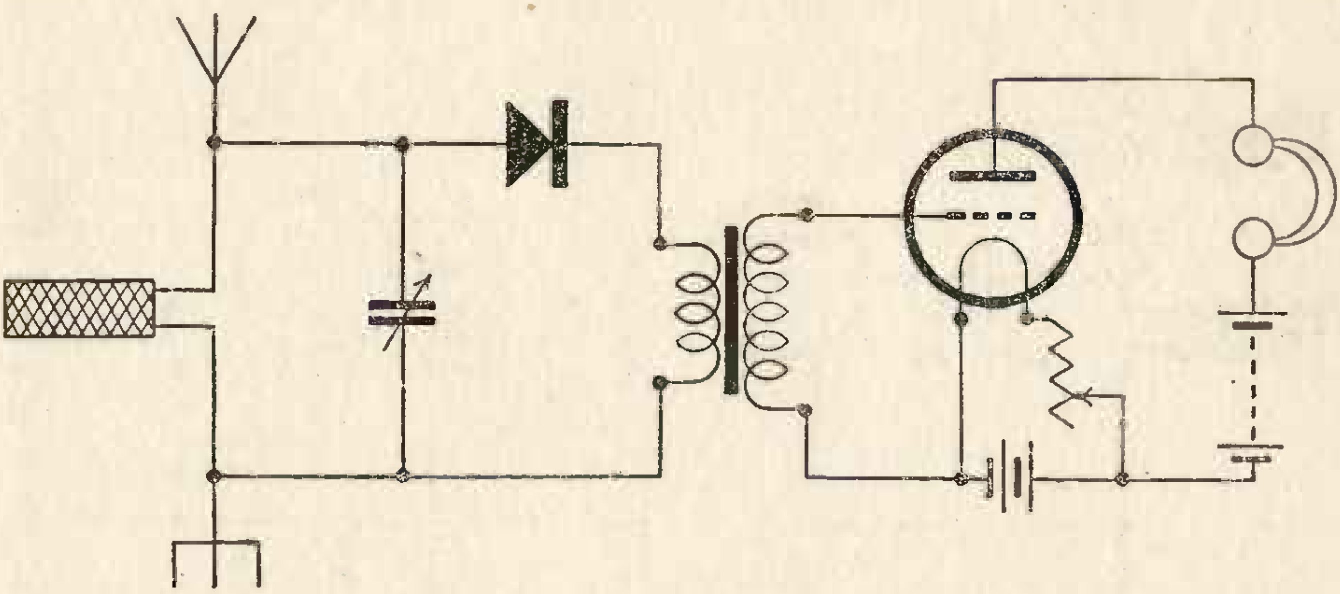
3.—An inductively-coupled crystal set: very "selective," and suitable for eliminating interference from unwanted stations.



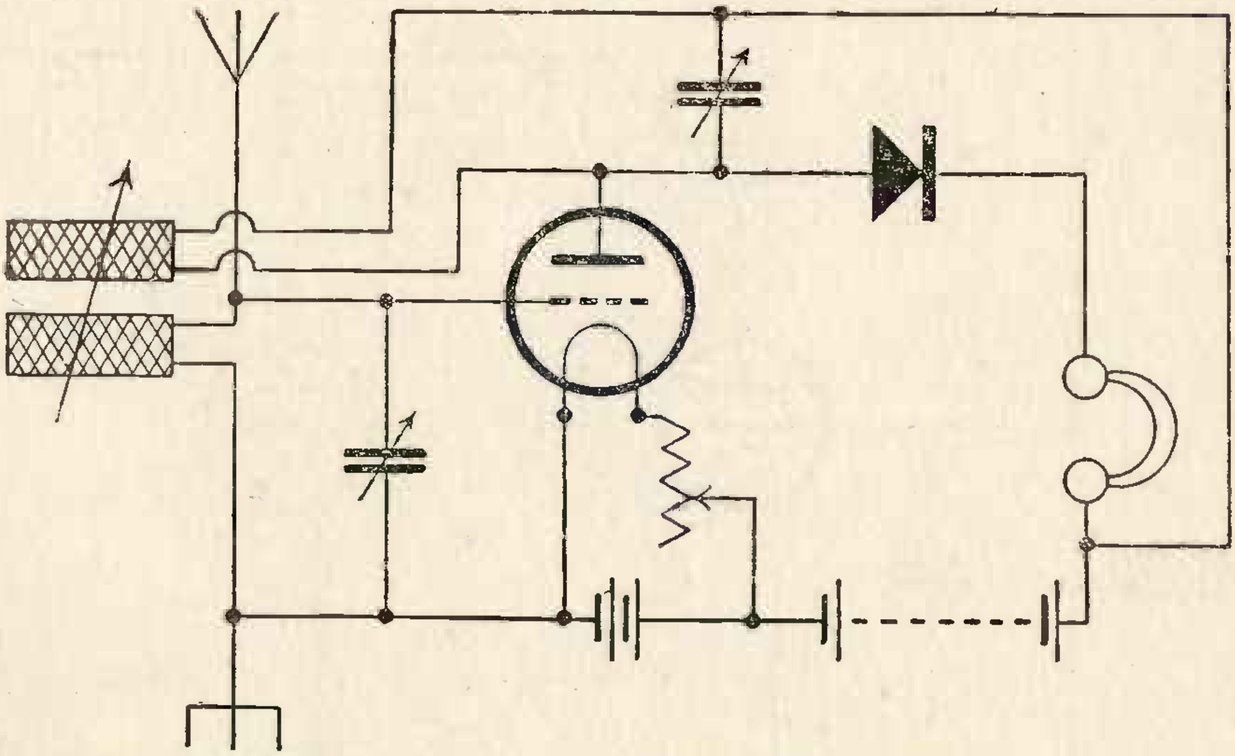
4.—A very sensitive and selective one-valve receiver with inductive coupling between aerial, grid and anode circuits.



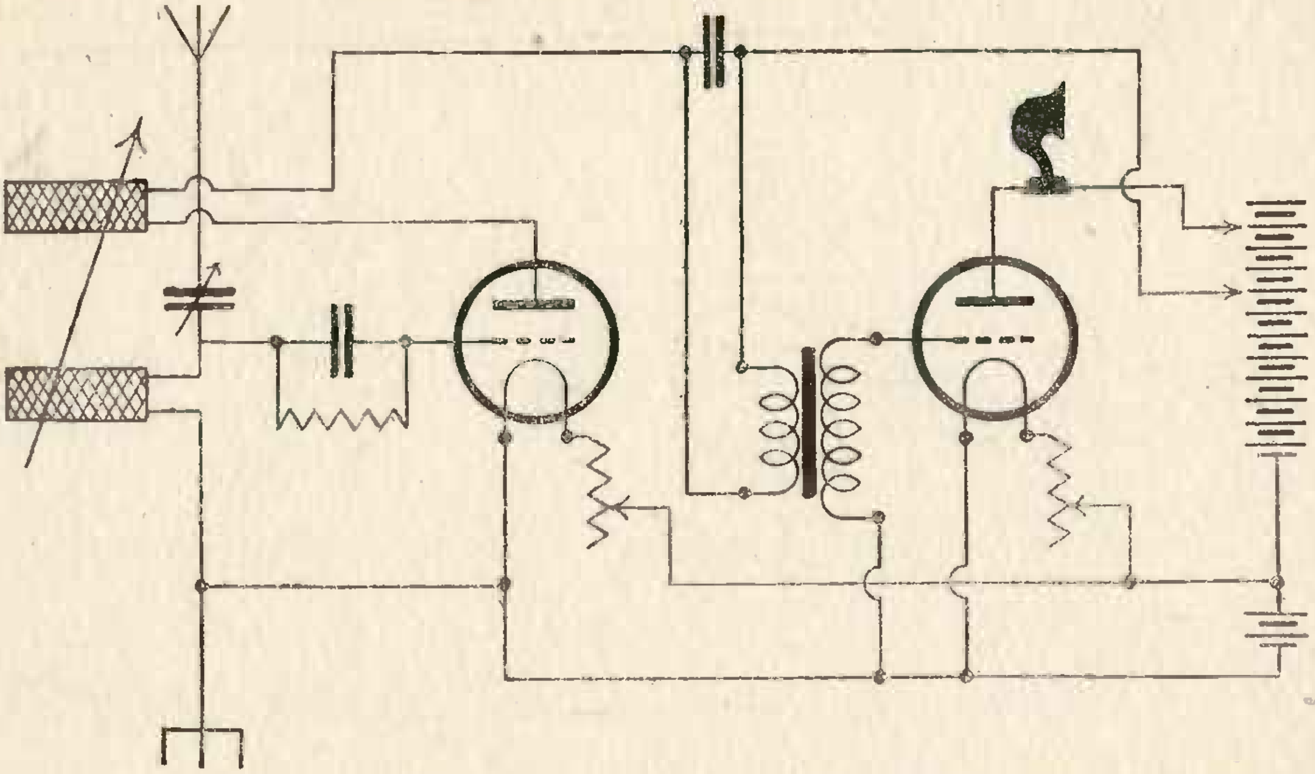
5.—A one-valve receiver, with "tuned-anode" reaction. A variable grid leak increases the sensitivity of this set, though a leak of fixed value may also be used.



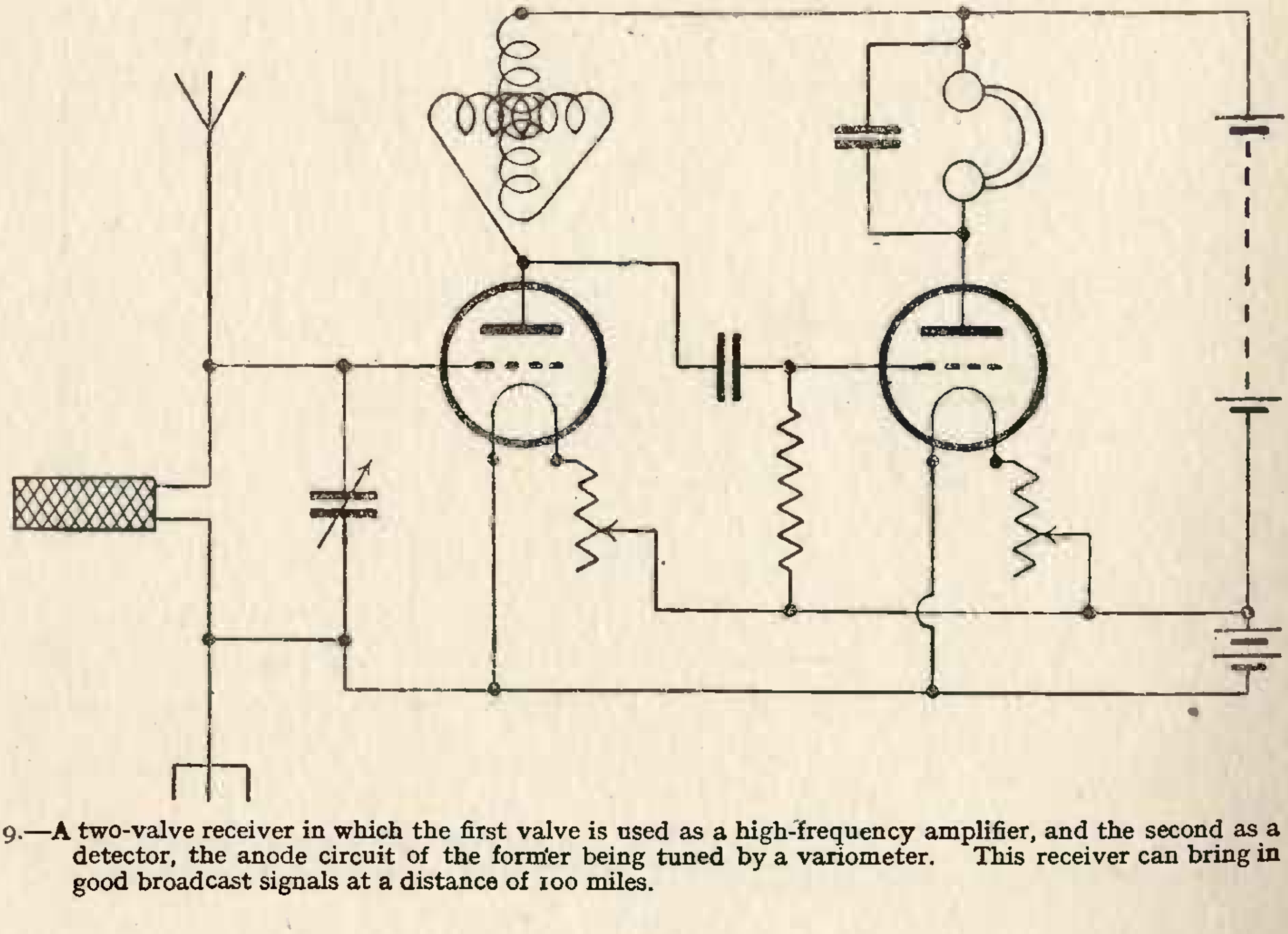
6.—A combined crystal-valve set. The valve functions as a low-frequency amplifier. Very loud signals can be obtained with this receiver at a distance of 25 to 30 miles from a broadcast station.



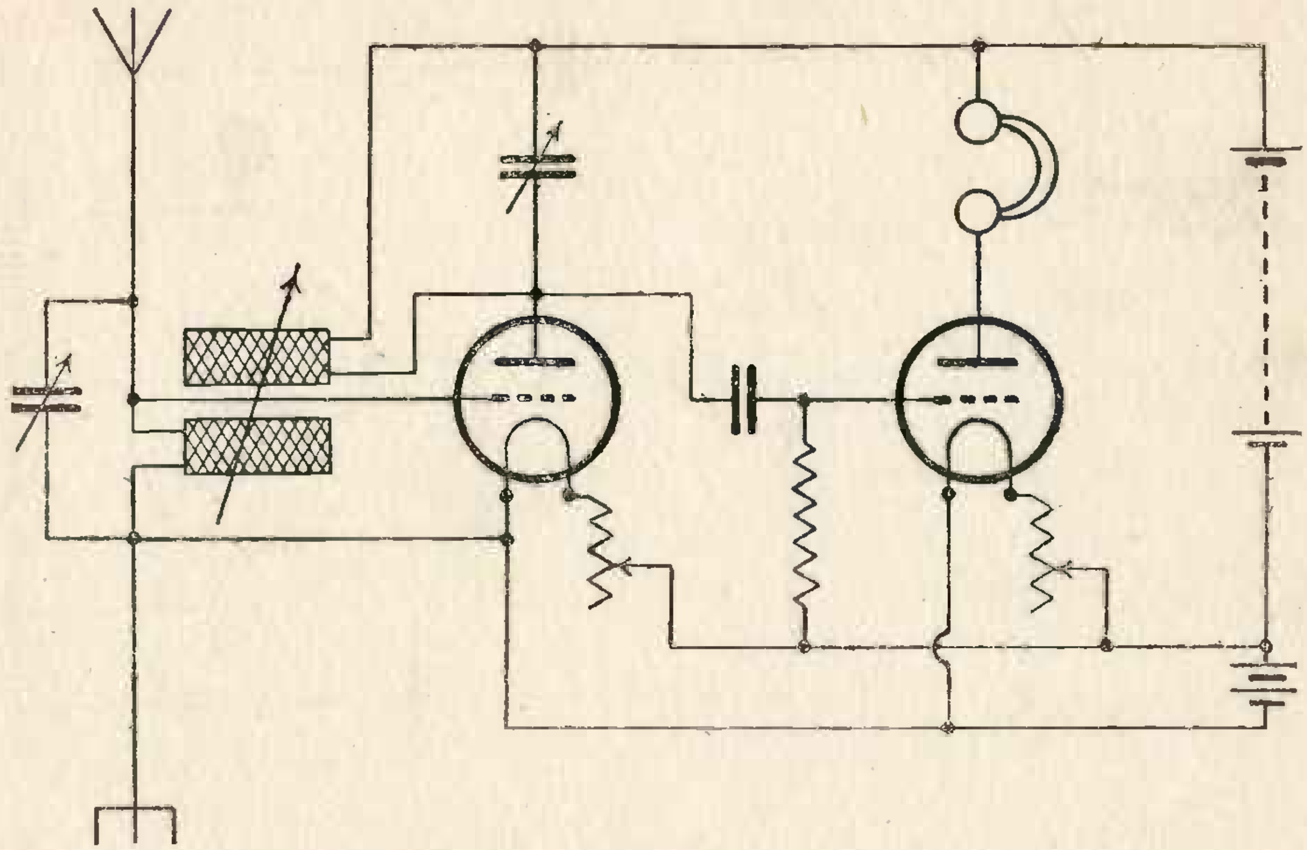
7.—A combined crystal-valve receiver, in which the valve functions as a high-frequency amplifier. The anode (*i.e.* plate) circuit of the valve is tuned by a plug-in coil and variable condenser, and maximum sensitivity is obtained by coupling the anode coil to the aerial coil. This instrument can receive broadcast signals up to 50 miles or more.



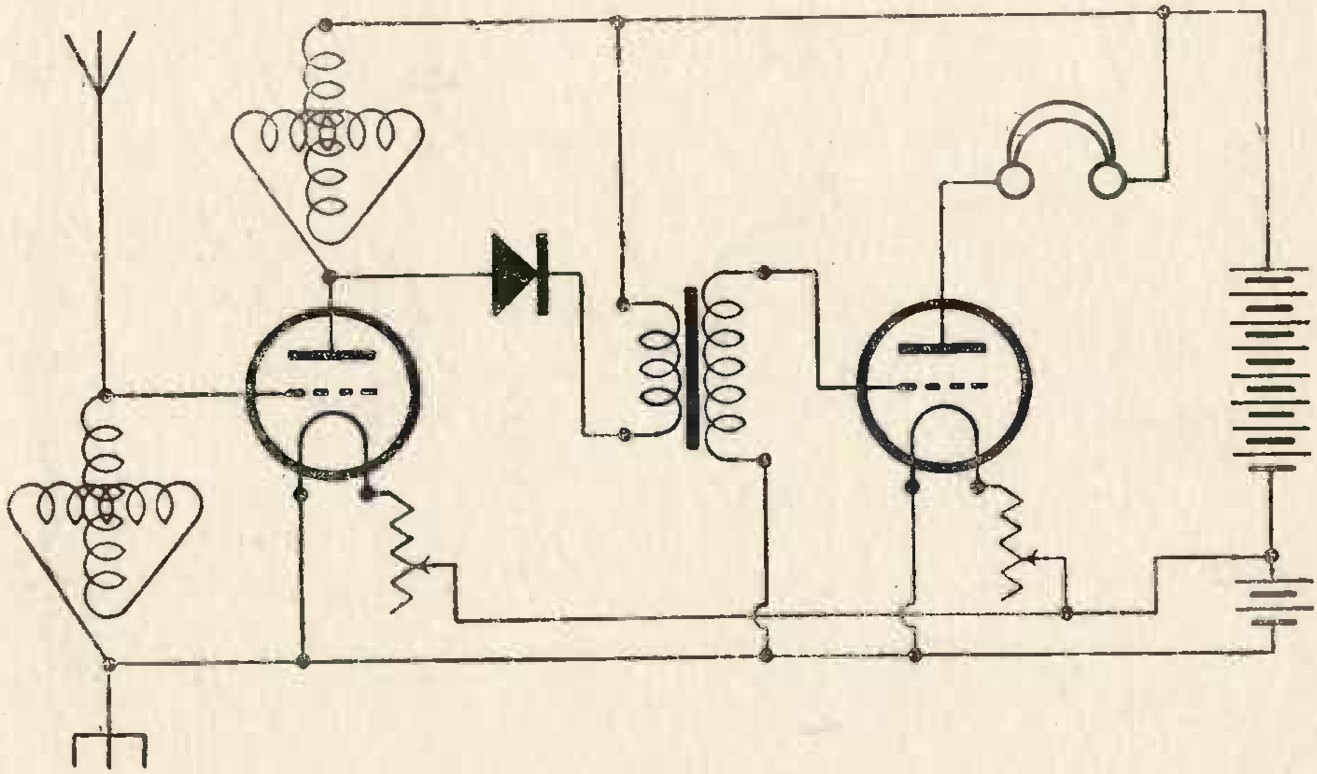
8.—A two-valve receiver in which the first valve acts as a detector, and the second as a low-frequency amplifier, reaction on the aerial being introduced from the plate of the first valve. This circuit can operate a small loud speaker within about ten miles of a broadcast station.



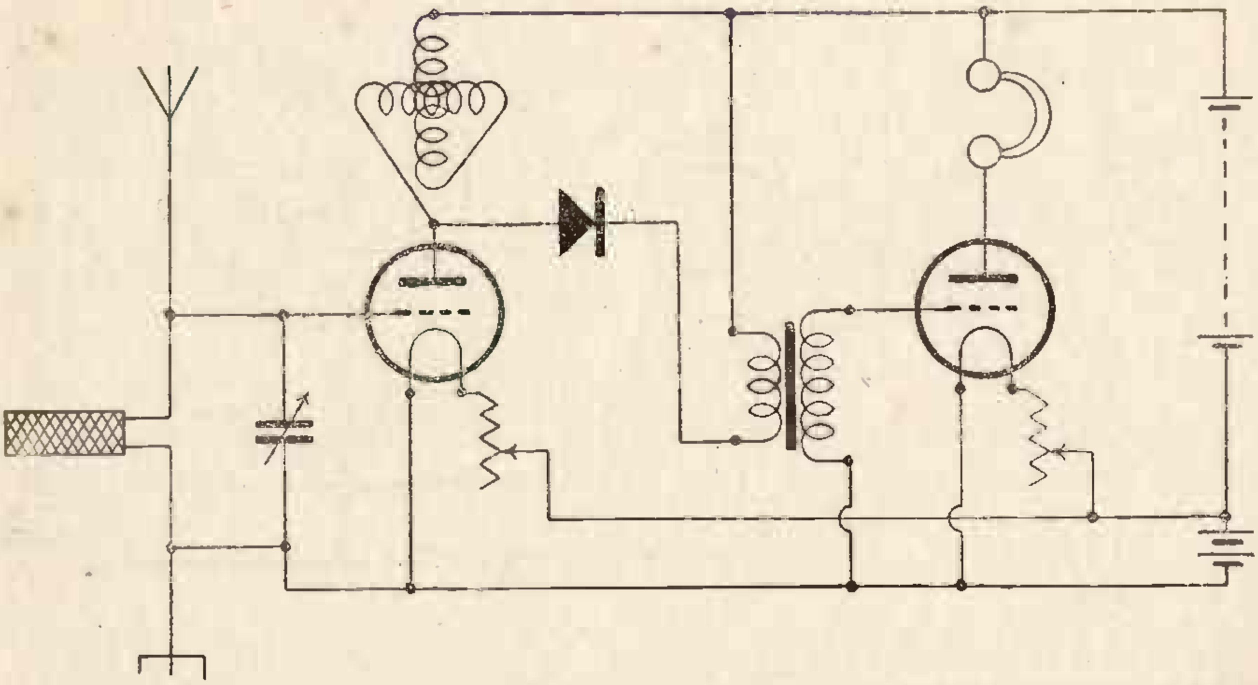
9.—A two-valve receiver in which the first valve is used as a high-frequency amplifier, and the second as a detector, the anode circuit of the former being tuned by a variometer. This receiver can bring in good broadcast signals at a distance of 100 miles.



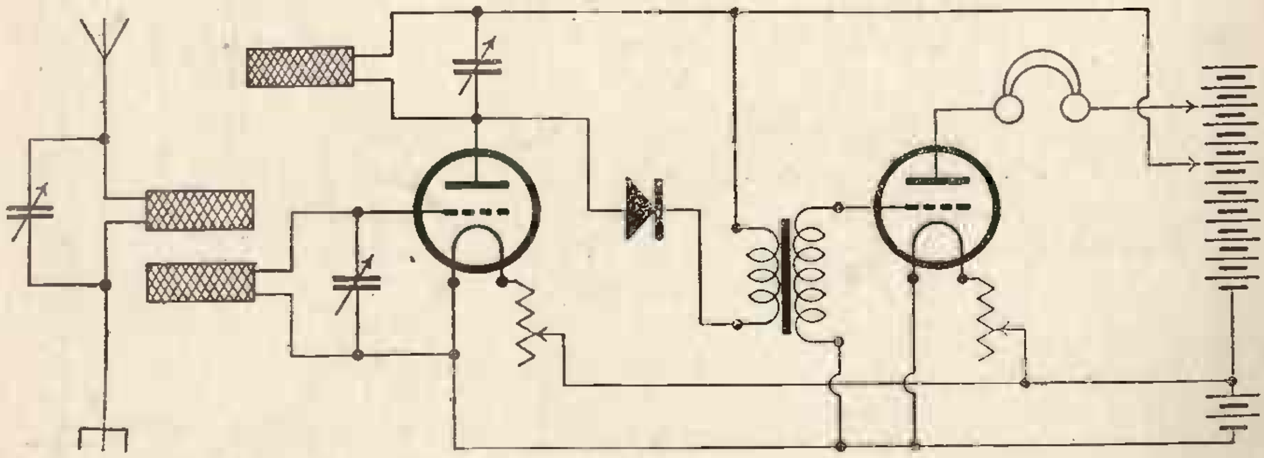
10.—This circuit is similar to the preceding one in every respect except that the anode of the high-frequency valve is here tuned by means of a plug-in coil and variable condenser. This permits of reactive coupling between the aerial and anode circuits and thus increases the sensitivity of the receiver.



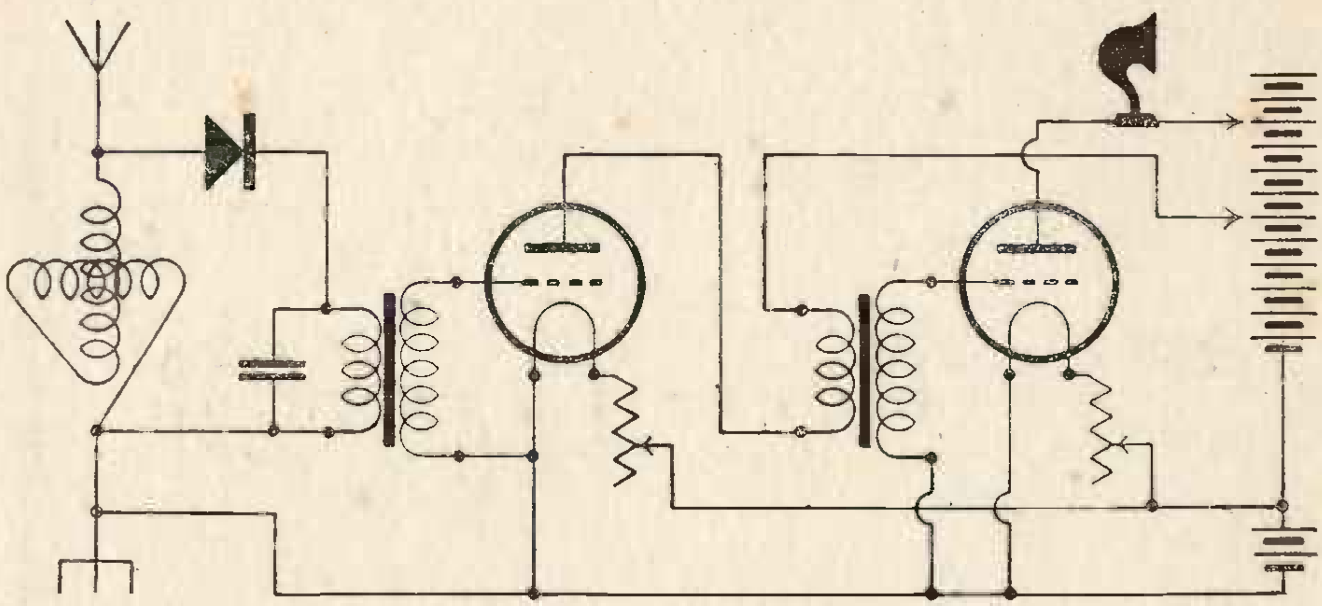
11.—A combined crystal and two-valve receiver, in which the first valve acts as a high-frequency, and the second as a low-frequency, amplifier. This is an extremely simple circuit to operate, both aerial and anode circuits being tuned by variometers.



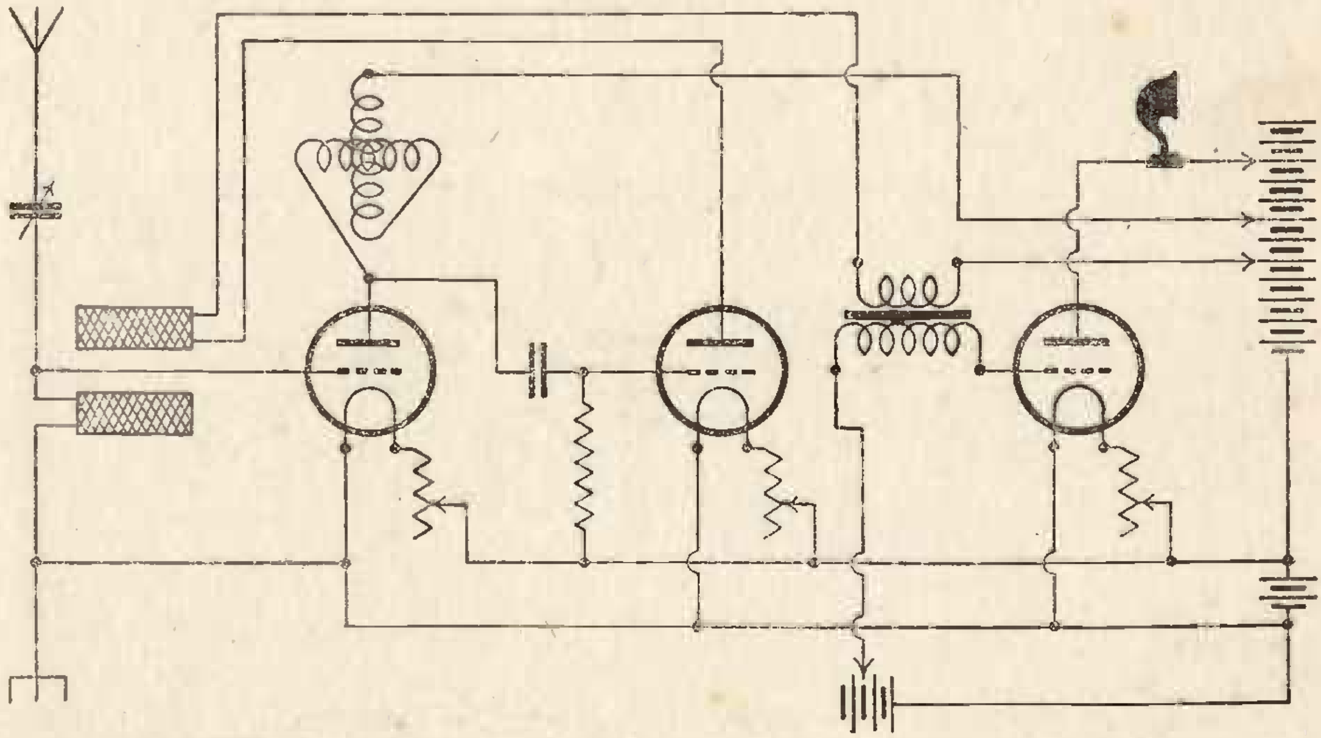
12. This circuit differs from the preceding one in that the aerial is here tuned by means of a plug-in coil and variable condenser. The same modification may, of course, be introduced in the anode circuit, as shown in next diagram.



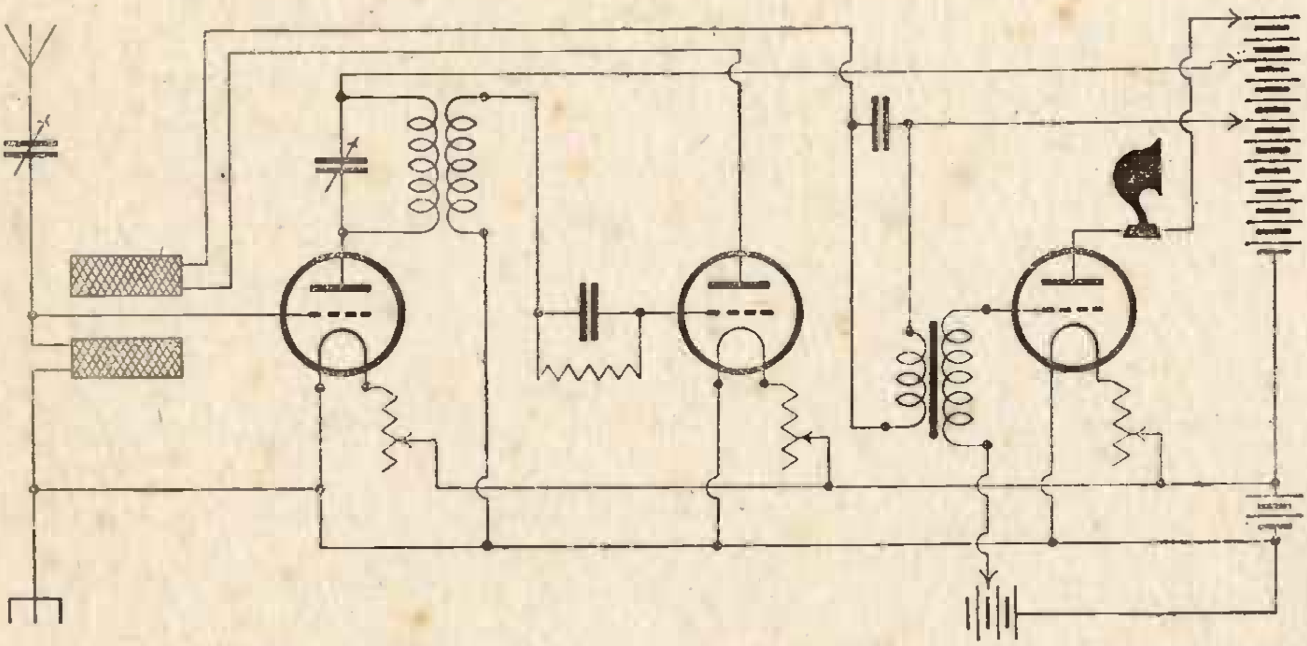
13. A crystal and two-valve receiver, in which a high degree of selectivity is obtained by coupling the aerial inductivity to the high-frequency valve. There are thus three tuned circuits, each being tuned by means of a plug-in coil and variable condenser. This receiver is particularly recommended for use in areas where bad " interference " is experienced.



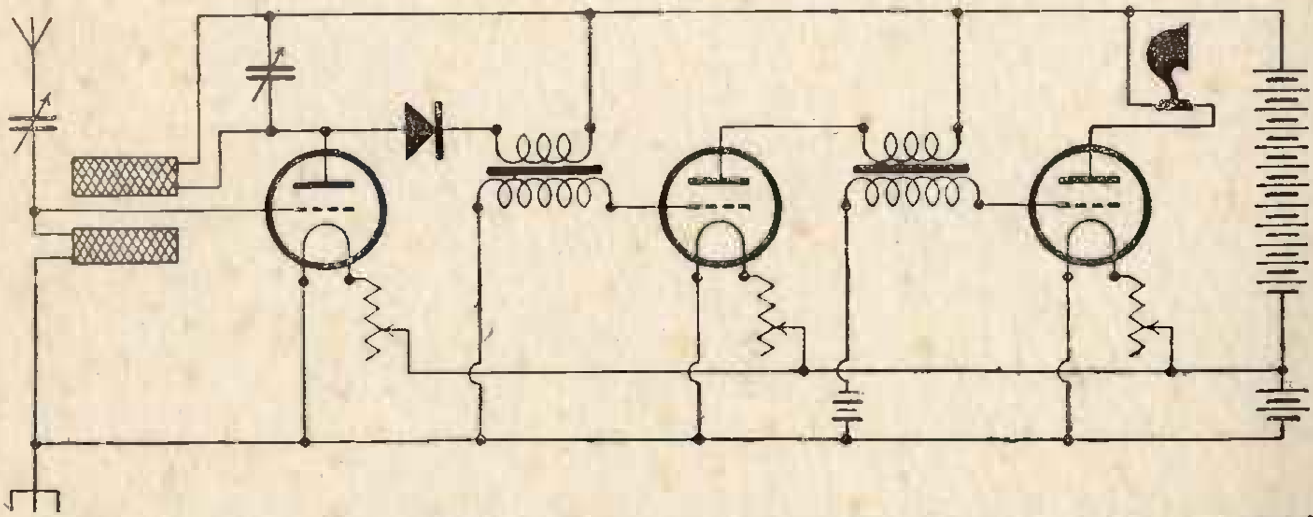
14. A very simple and reliable circuit, capable of operating a loud speaker at a distance of 25 miles from a broadcast station. The aerial is tuned by a variometer, and both valves function as low-frequency amplifiers.



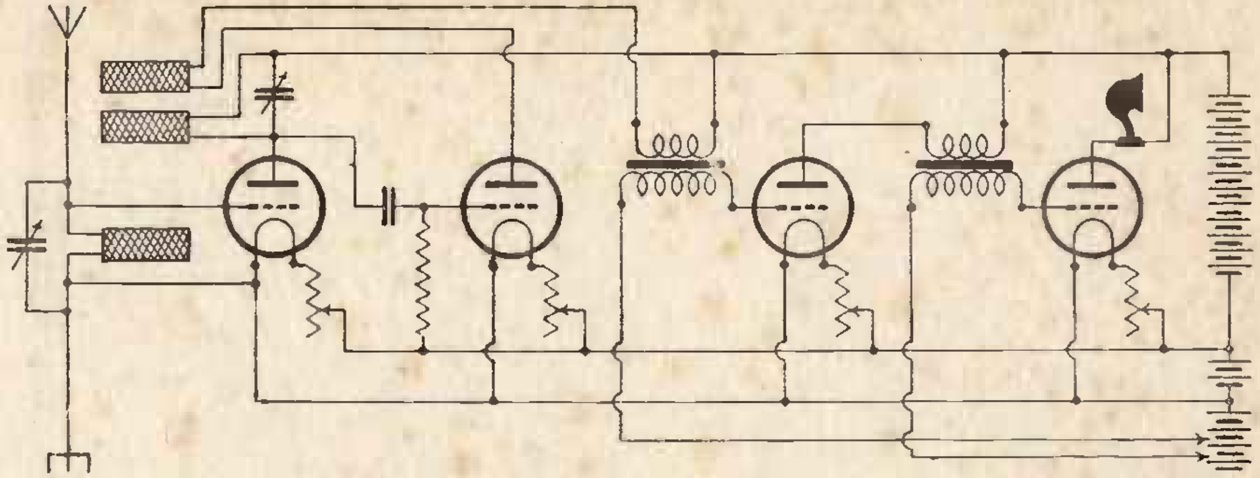
15. A three-valve receiver, employing one high-frequency, one detector and one low-frequency valve. The plate circuit of the first valve is tuned by a variometer and reaction is introduced from the plate of second valve. The use of a separate high-tension tapping for each valve, with a small grid bias on the last valve, renders this receiver very efficient.



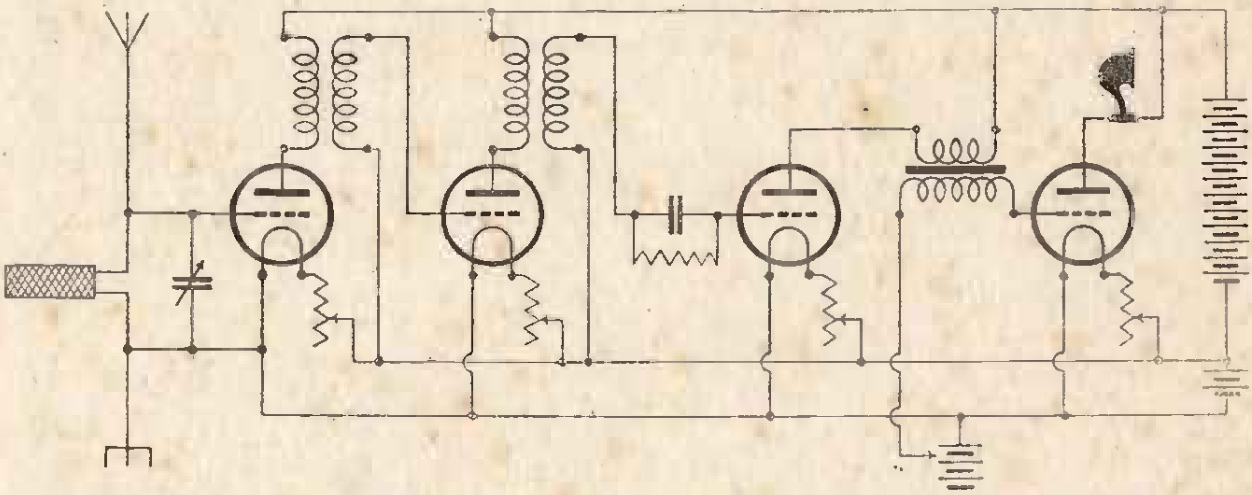
16. This circuit is similar to the previous one, except that the first and second valves are here coupled on the " tuned-transformer " principle. By using high-frequency transformers of the plug-in type, with a variable condenser across the primary, a very wide range of wavelengths can be received.



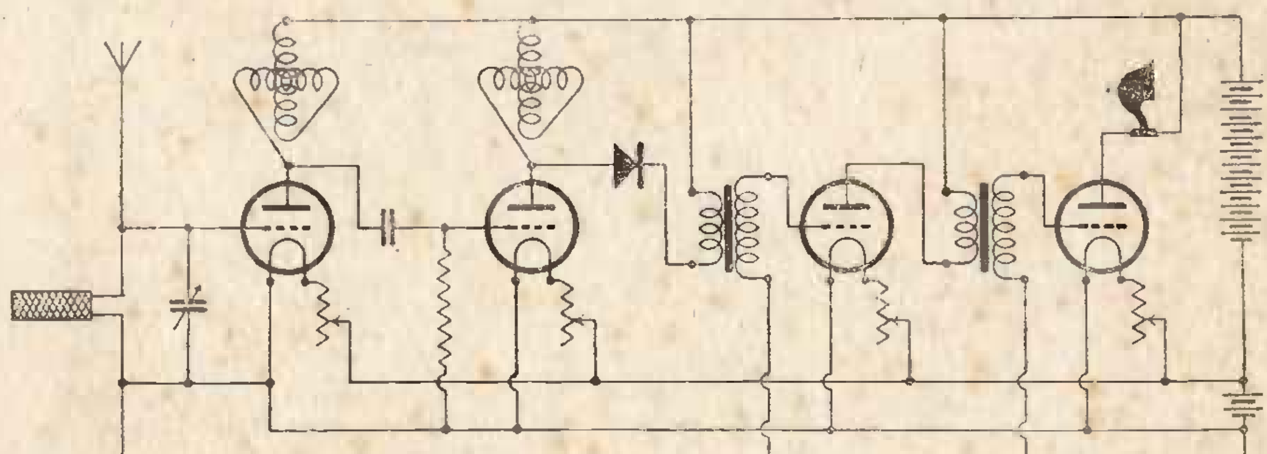
17. This is a very popular circuit for general use, employing one high-frequency valve, a crystal detector and two low-frequency valves. A separate high-tension tapping for each valve would increase the sensitivity of the receiver.



18. A four-valve, all-station receiver, in which the first valve is a high-frequency amplifier, the second a detector, and the third and fourth low-frequency amplifiers. Each low-frequency valve is provided with a separate grid bias.



19. In this four-valve receiver, which is suitable for long distance reception, the first two valves function as high-frequency amplifiers, coupling being effected by means of air-cored transformers. The third valve is a detector and the fourth a low-frequency amplifier.



20. This combined crystal and four-valve receiver is capable of operating a loud speaker at a distance of a couple of hundred miles or more from a broadcast station. It is comparatively simple to operate, the two high-frequency valves being tuned by variometers.