The LISTENER IN HANDBOOK 1932

THE BEGINNER'S BOOK OF RADIO

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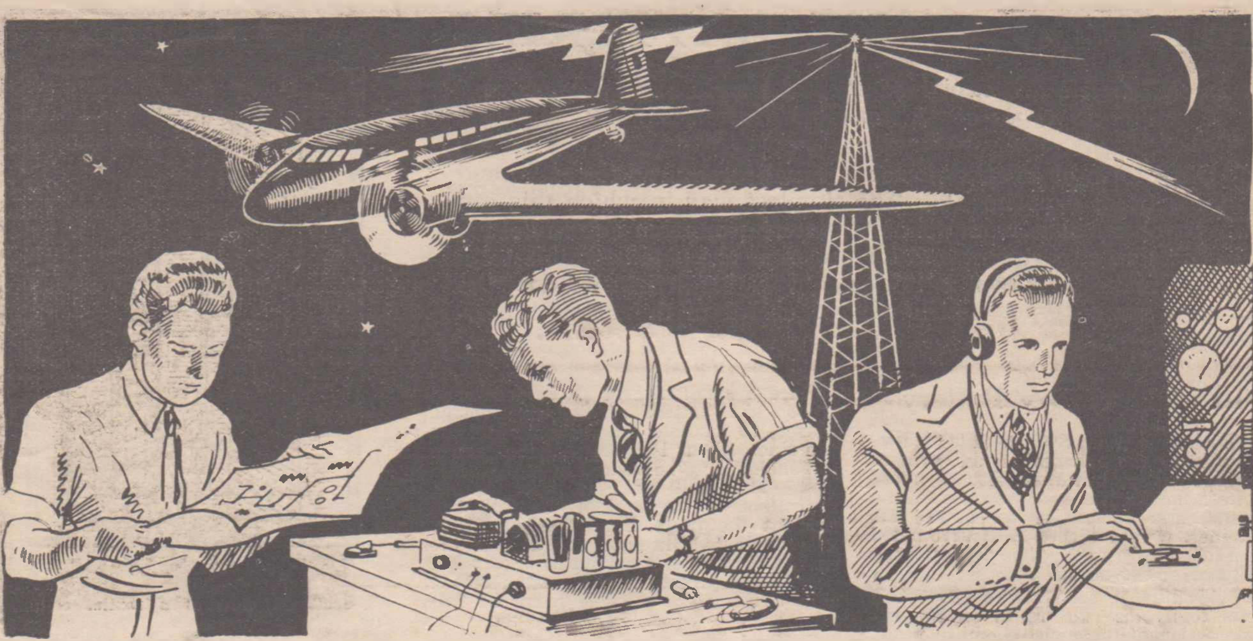


FRICTIONAL ELECTRICITY

Electricity—the magic slave of man — is interestingly dealt with in the following article and in addition are given some elementary and practical experiments which will provide hours of entertainment for the amateur radio enthusiast who is about to break into this field as a hobby.

ELECTRICITY received its name from the Greek word, Electron, meaning amber. The ancient Greeks discovered that when amber was rubbed with flannel it possessed the power of attracting light bodies. As an experiment to demonstrate this attraction. rub an amber pipe-stem on the sleeve of your coat and place the pipe-stem close to small pieces of paper. It will be seen that the paper is attracted by the amber pipe-stem.

If a vulcanite or ebonite comb is passed through the hair several times and then presented to some small pieces of paper the same attraction will be noticed.

A stick of sealing-wax rubbed with flannel will exhibit the same electrical properties.

Take a piece of brown paper about 1ft. square and warm it well on both sides in front of the fire. Place the paper on the table and brush it briskly with a clothes brush which itself has been warmed for a few minutes. If the paper be raised from the table it will probably give out crackling sounds and appear to cling to the table, thus making the action of lifting it more difficult than would otherwise be experienced. The fact is that the paper will have acquired electrical properties and a series of very interesting experiments may be conducted with it.

If placed against a wall or a blackboard it will be attracted and cling to the surface for some minutes. The reason is that neutral bodies attract charged bodies, the neutral board or table attracting the charged paper.

If the heated paper be placed above a person's head it will cause any loose hairs to stand "on end," and a tickling sensation will be felt by the person operated on. If held above small pieces of paper or other light substances the brown-paper sheet will attract them.

A sheet of paper placed on a hot board and rubbed with indiarubber will cling to the board, and when removed will attract light bodies.

Place an egg in a china egg-cup and balance a thin length of wood upon the egg. Then bring an electrified sheet of brown paper near one end of the piece of wood. It will be found that the wood will be attracted by the paper, and may be made to turn round on its centre.

Warm a glass rod and rub it briskly with a silk handkerchief or any piece of silk. It will become electrified and will attract light objects such as bran, feathers and small pieces of paper.

Cut from a piece of thin paper a "daddy-long-legs," making each leg about a quarter of an inch wide and three or four inches long. Place the paper on the table and brush it with a clothes-brush from the body to the feet. The legs will cling to the table. Lift the paper from the table by the body, and the legs will stick out in all directions, because charged bodies always repel one another.

More satisfactory results may be obtained, however, by using the following apparatus, which is really a simple form of electrophorus. Stand a drinking glass on the table and place on it an ordinary metal tray. Place the brown paper (electrified) on the tray. Touch the edge of the tray and then remove the brown paper, being careful not to touch the tray with the hands or any other part of the body, as this would conduct its electrical charge to the earth.

The tray will now be ready for our experiments. If the knuckle be presented near the edge of the tray, a spark of half-an-inch long — or even longer — will be produced, giving a sharp sting to the knuckle. This spark is entirely harmless.

It will be noticed that the tray, while charged with electricity, will attract light objects. If small pieces of paper are placed on a second tray, which is held a little distance under the electrically-charged tray, the paper will be attracted to the top tray. As soon as the pieces of paper come in contact with the electrified tray they will become charged with electricity and be repelled downwards. Thus the paper will continue to jump up and down. without any apparent reason, until the charge of electricity on the tray is exhausted.

It is important with these experiments with frictional electricity that the apparatus be perfectly dry. The reason for placing the tray on a glass is because glass is a non-conductor of electricity, but if the slightest amount of moisture be on its surface it will at once be changed into a conductor, and the whole effect will be spoiled. For this reason the glass should be thoroughly dried at the fire before being used. More, half-an-hour's use is liable to make it non-effective, and the glass should be dried very frequently if good results are desired.

HOW TO MAKE BATTERIES

In this article are explained several simple and inexpensive types of "A" and "B" batteries.

SOME form of electric power is usually required for radio and electrical experiments. The simplest way in which this can be obtained is from primary batteries or from accumulators. Both as an experiment and for practical use it is desirable to be able to make your own batteries, and in this article we describe several simple types which will be useful to the home experimenter.

To Make A Dry Battery

THE various makes of so-called "dry" cells on the market at the present time are many, but they all are, more or less, modifications of the Leclanche battery, and consist of an outer zinc container, with a carbon rod surrounded by a chemical paste, the paste taking the place of the porous pot.

It will thus be seen that a "dry" cell is not really dry, but relies on the exciting action of the moist chemical paste. Should this become dry, the cell is useless. Thus, an exhausted cell may often be made almost as good as new by boring a hole in the top, soaking it for a few hours in water or a solution of dilute sal-ammoniac.

A dry cell is not difficult to make. The outer containing vessel is composed of zinc, and may be of any shape or size, according to the fancy of the constructor. A handy size is a cylindrical form, having a diameter of about two inches. A zinc bottom is soldered to the cylinder, and a small length of copper wire is soldered to the outside of the zinc for purposes of connection. If desired, a terminal screw may be clamped to the zinc container and used instead of the piece of copper wire. All soldered joints should either be painted with asphaltum paint, or given a good coat of Brunswick black.

Place a small disc of paraffined wood (f) on the bottom of the zinc vessel. This is to insulate the carbon rod from the zinc. About 1½ inches of the carbon rod should now be soaked in hot paraffin wax. This will make it proof against the attack of the acid of the cell, and prevent the paste from "creeping." A hole is drilled through this end of the carbon, and a terminal screw inserted.

The next process is the pasting of the zinc. This paste is made from the following:—

Crushed or powdered sal-ammoniac	25 parts
Plaster of paris	50 parts
Water	25 parts
Glycerine	2 parts

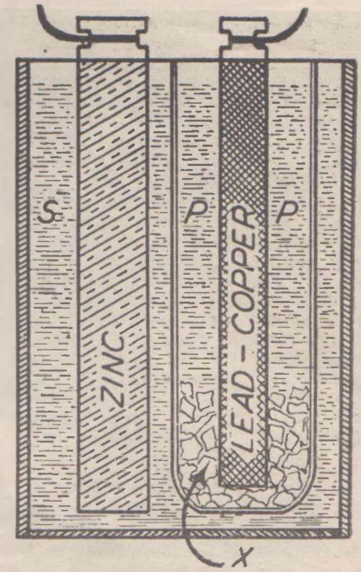
Mix these ingredients well together and paste the inside of the zinc cylinder to a thickness of three-eighths of an inch. (See diagram.)

Insert the carbon rod (b), which should stand on the paraffined disc of wood (f), and project about an inch above the edge of the zinc container.

Closely pack the intervening space (e) with a mixture made up as follows:—

Powdered carbon	50 parts
Crushed sal-ammoniac	25 parts
Binoxide of manganese	25 parts
Chloride of zinc	5 parts

This mixture should be well rammed down, the efficiency of the cell depending a lot on the ramming-down process.



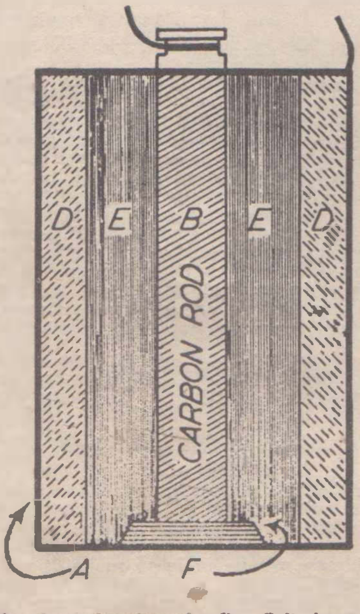
Sectional view of a Daniel cell.

The cell is usually sealed with a mixture of melted resin and beeswax, a straw or a glass tube being inserted to allow a passage for any escaping gases. The operation of sealing the cell prevents evaporation and spilling. A few sheets of greased paper should be wrapped around the outside of the zinc cylinder.

Dry cells have the advantage of being clean and portable. The absence of the porous pot, as used in the Leclanche cell, lessens the internal resistance, thus increasing the current.

Four cells should light a 4-6 candle-power lamp for a few minutes at a time, drive a small electric motor, ring an electric bell, or work a telegraph instrument.

Such a battery should not be used continuously, as it rapidly polarises, but, given a few minutes' rest between ex-ments, it will soon recuperate its powers.



The above drawing of a Dry Cell shows how the elements are arranged.

How To Make The Daniel Cell

Complete description of a primary battery which can be used as an efficient Trickle Charger for "A" Batteries.

BEFORE delving into the construction of a Daniel cell, it may be well to investigate some of the things which happen in a simple primary cell. This will greatly assist us in understanding what takes place in the Daniel cell when it is set up for work.

Imagine a vessel containing two electrodes, one of zinc, the other of copper, and both in the form of plates immersed in a solution of sulphuric acid and water So long as the two plates are not connected by a conductor exterior to the liquid, the electricity produced remains in a stationary condition. When, however, the plates are connected by a wire, the opposite chemical conditions on the respective plates neutralise each other, but they are instantly restored by the chemical action, and are again quickly destroyed; thus a constant transfer of current is obtained, and the electricity is now said to be in a dynamic state.

The positive electricity is considered to set out from the more oxidisable metal, called the positive or generating plate because it furnishes the supply of electricity and passes to the less oxidisable or negative plate, because it collects the electricity from the liquid.

Hydrogen is set free at the copper plate and in this its nascent state has the power of separating metals from their solutions. Thus when the zinc sulphate dissolved in the water has reached the copper plate it is decomposed by the hydrogen and the copper plate is coated with zinc, the final result of which is that zinc is opposed to zinc and there is no difference of potential. That portion of the hydrogen which is not reducing the metal assumes the gaeseous state and escapes as bubbles. Some, however, form on the copper plate.

Copper excited by hydrogen is at opposite potential to copper excited by sulphuric acid in the presence of zinc, therefore the power of the battery is lessened. It is now that the copper plate is said to have become polarised.

It is obvious that to make a battery constant and lasting in its action polarisation and deposit of positive metal on the negative plate must be prevented. The best method of bringing this about is to surround the negative plate by a strong solution of a salt of the metal itself, as this forces the hydrogen to confine itself to the reduction of metal from its solution and prevents it forming into gas and coating the metal plate with bubbles. As the metal reduced is the same as that of which the plate is composed, the battery will not lose, but gain as the negative plate will be constantly kept clean and bright by the new metal deposited on it.

Zinc the Negative Plate

The zinc terminal of a battery is called the negative because it is where the negative electricity is accumulated. When the zinc and copper plates are joined with a wire, the positive electricity passes from zinc to copper (via the liquid) and from copper via connecting wire to zinc. When the poles of a battery are joined by a conductor a current is established, and the water in the cells is decomposed into its component gases, oxygen at the zinc plate there to combine with the zinc forming zinc oxide, which the acid immediately dissolves, forming zinc sulphate.

The Daniel Cell

The Daniel type of primary cell in a great measure fulfils the foregoing conditions. It consists of a cell or jar containing a zinc rod which has been amalgamated, a cell of porous earthenware, in which is placed a plate of copper, and a solution of copper sulphate and water, while the outer jar contains the zinc rod and a solution of sulphuric acid and water.

As soon as the circuit is completed between the two plates, say by an external wire, the zinc is strongly attacked, but no hydrogen is given off at its surface as there is no local action (the zinc rod having been amalgamated). Water is decomposed and zinc oxide is formed which the acid dissolves forming zinc sulphate. The hydrogen passes to the copper, but instead of polarising it decomposes some of the copper sulphate. The acid of the copper sulphate passes to the zinc, assisting the sulphuric acid in the outer jar to form zinc sulphate.

The reason why acid is placed in the outer jar is to reduce the resistance of the fluid round the zinc, hence the internal resistance of the cell when large currents are required. The copper sulphate is often acidulated to half its bulk with sulphuric acid. When all the copper sulphate is decomposed the action of the cell ceases and any black powder on the copper plate is caused by zinc sulphate which has passed there from the outer cell.

When the acid in the zinc cell becomes saturated with zinc the battery will be much more constant in action. Zinc sulphate may thus be used in the outer jar. When the water in the outer jar becomes saturated crystals will form on the zinc plate. This is injurious, but may be vercome by the addition of extra water, having previously removed some of the liquid from the outer cell. If the porous cell be of bad quality, copper will be deposited in patches on it. When the pot becomes crusted with copper it should be removed. The porous pot should have its sides, back, top and bottom dipped in tallow, to prevent the solution passing through those parts that do not face the zinc. The crystals of copper sulphate should be about the size of an acorn.

If the water used contains lime it decomposes a part of the copper sulphate, forming a jelly-like substance. To prevent this, place a few drops of sulphuric acid in the water and allow to stand. This will deposit the lime.

The "copper" cell should be filled with the copper sulphate solution before the zinc sulphate is placed in the outer jar. This allows the pores to become filled with a good conductor.

When a battery is cleaned the plates should be well scraped and scrubbed, defective porous cells and zinc plates removed, and the battery again carefully charged. The liquid from the zinc cell may be used again.

Both the copper and zinc sulphates must be free from iron. Adding liquid ammonia will make the mixture appear cloudy, but the addition of more will deposit the iron, if any, as a brown powder. Ordinary zinc contains carbon, lead and iron. Only the best quality zinc should be used.

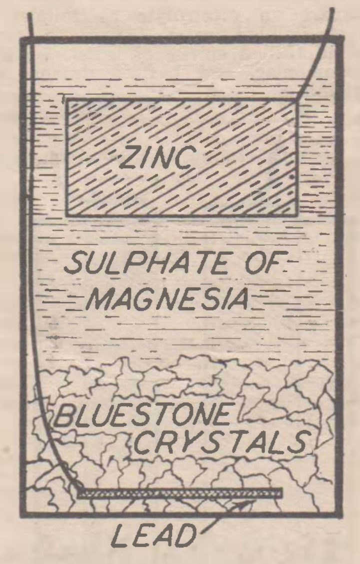


Diagram of a Gravity Cell.

To counteract the mixing of liquids through the porous pot, a battery has been devised in which the solutions have been kept separate by their weights alone. The copper being heavier than the zinc, it is placed at the bottom, the zinc plate being arranged near the top of the cell and zinc sulphate placed on top of the copper solution. This cell must be kept perfectly still for best results.

Parts Required for a Daniel Cell

1 Glass or earthenware outer jar.
1 Porous Pot. (P.).
1 Zinc rod, Leclanche type.
1 Copper or lead plate.
Quantity of distilled water, copper sulphate, and sulphuric acid or zinc sulphate. (S.).

Amalgamating the Zinc

Take the zinc rod and clean it by dipping it into a dilute solution of sulphuric acid; place one end in a small dish containing mercury and, using a rag tied on a stick, proceed to rub the mercury over the surface of the zinc until it has a bright silvery appearance.

Take the porous pot (such as is used in the Leclanche battery) and coat it with paraffin or tallow on all sides except that facing the zinc rod; in it then place a saturated solution of distilled water and bluestone, taking care to place the copper sheet in as well, and having one of its edges facing the zinc rod; about quarter fill the pot with bluestone, and allow it to stand for a few hours, thus permitting the bluestone to permeate the walls of the porous pot. While this is being done the outer jar may be filled with a solution of sulphuric acid and distilled water in the proportion of 20 parts of water to one of acid.

To assemble, place the copper pot inside the outer jar. With care this battery will last for weeks. When it runs down an addition of sulphuric acid to the outer jar, and a few more crystals put in the inner pot, will set it up again.

The E.M.F. of such a cell is approximately one volt, so that, to charge a four-volt accumulator, at least six such cells will be needed.

The copper cell is the positive pole and the zinc the negative. This means the copper pole of one side of the cell assembly is joined to the positive terminal of the accumulator, and the zinc to the negative.

Perhaps the best method of using these cells is to employ them as "trickle" chargers, leaving them permanently connected to the accumulator. They may be placed in another room and the wires brought to the accumulator.

Instead of sulphuric acid, ordinary Epsom Salts may be used to charge this type of battery. Make up a half-saturated solution by mixing as much Epsom Salts in water until no more will be dissolved, and then adding as much water again.

This battery should not be allowed on "open circuit." When not in use it should be short-circuited through a high resistance.

The Gravity Cell

THE gravity cell, a type of bluestone battery, is used where a constant current is required. Six of these cells may be used to charge a four-volt accumulator, whilst a battery of this description may be used on a burglar-alarm system where the relay has to be kept closed as long as the doors and windows are unopened.

An ordinary jam-jar may be used as the container. A round lead or copper plate is cut to fit the bottom of the jar, and to it is rivetted a length of covered copper wire long enough to pass upwards through the jar and allow a few inches free.

A cylinder or plate of zinc is hung from the top of the jar in such a position that a few inches is left between it and the lead or copper plate. To the zinc plate a piece of copper wire is soldered for convenience in connection to the next cell.

On the top of the lead plate a few bluestone crystals are dropped, care being taken to see that these crystals do not come near the bottom of the zinc plate.

The solution of the cell is made from ordinary Epsom salts, and should be what is termed a "half-saturated" solution. This is made by dissolving as much Epsom salts as the water will take up, and then adding the same amount of pure water as was previously used.

The cells should be connected up with the lead of the first to the zinc of the second, the lead of the second to the zinc of the third, and so on. When not in use, the battery should be short-circuited through a resistance, or it will soon be ruined. Some pieces of undissolved bluestone must always be resting on the lead or copper plate.

A gravity battery has a voltage of one, but its internal resistance is rather high.

A Simple Cell

THE simplest form of electric cell may be made by immersing a strip of copper and a strip of zinc in a tumbler containing vinegar. As soon as the two metals are joined together an electric current will flow. This will only be very slight, however, and such a battery will be of little use for experimental work.

Bichromate Battery

FOR heavy work the bichromate battery is the best, all things being considered. This type of battery is not very constant, however, and with a heavy output soon becomes exhausted.

The battery consists of a jar containing a sheet of amalgamated zinc and one or two carbon plates. The charging solution is made by mixing 8 parts of water with one and one-fifth lbs. of powdered potassium bichromate and three and three-fifths lbs. of concentrated sulphuric acid.

As the zinc is rapidly consumed, even when the battery is not in use, this plate should be removed from the solution when the battery is not in use.

A High Tension Battery

A CONSTANT high-tension battery for radio work may be obtained by altering the construction of the gravity battery slightly. Thirty-six test tubes are required for the jars or containers, 36 feet of No. 20 S.W.G. bare copper wire, 36 pieces of valve rubber, four inches long, 36 pieces of zinc, 4½ inches long by half an inch wide, a solution of Epsom salts for the exciting fluid, and a small quantity of bluestone crystals.

Take a piece of the copper wire one foot long and twist about half of it into a coil. Insulate the straight part of the wire with a piece of the valve rubber, and stand the copper in a test tube.

To the zinc a piece of wire is soldered, and the zinc is arranged to hang on the top of the tube. Fill the tube half full of a solution of Epsom salts, and then put in enough bluestone crystals to cover the coil of copper wire.

Each of the test tubes should be treated in a similar fashion. When complete, the cells should be arranged in a wooden stand, and should be connected together in series; that is, the zinc of one to the copper of the next, and so on.

Another Type of H.T. Battery.

A BATTERY suitable for "B" battery may be two inches high and three-quarters of an inch in diameter. The zinc container for this cell may be made from a piece of the zinc two inches wide and 2½ inches long. This is then cleaned and bent round an iron rod, the edges being soldered with soft solder. A disc of zinc, ¾-inch in diameter, is cut and soldered in one end of the container. A short piece of copper wire is soldered (22 tinned wire does very well for this job) to the top edge of the can.

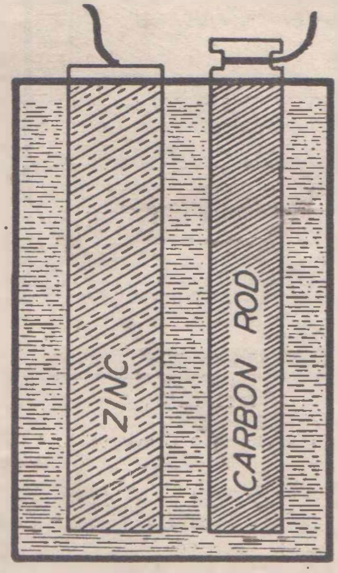
In the bottom of the can a disc of paraffined blotting paper is placed. Cut a piece of blotting paper 2 by 6¾ inches and place it inside the can against the inner walls. Place a layer of fine sand about ⅛-inch deep in the bottom of the can, and over it place another disc of paraffined blotting paper.

Carbon Rod

Take a carbon rod about the thickness of a lead pencil, perfectly straight and long enough to protrude above the top of the can and place a brass cap on its top, having first soaked the terminal end of the rod in hot paraffin wax. This prepared rod is now placed in the centre of the can.

Take equal parts by measure of needle manganese and carbon, reduce to a powder, and mix thoroughly: if the resulting mixture will pass through a sieve having holes, say, 1-16th of an inch in diameter in it, the mixture will be fine enough.

Prepare an electrolyte as follows:—1oz. of distilled water, 1 fluid oz. zinc chloride (killed spirits of salts), 7 dwt. sal ammoniac, and 1 fluid drachm of glycerine.



Bichromate Cell showing the elements standing in the solution.

The next thing to do is to make the manganese mixture slightly damp with this mixture, but not wet. Take a small wooden rod, such as a penholder, and pack the mixture tightly round the carbon rod. The thoroughness with which this is done determines to a large degree the efficiency of the completed cell. Continue to add the mixture until it reaches to within, say ⅛in. below the top of the blotting paper. Now add more electrolyte to the black mixture, a few drops at a time, until half a fluid drachm is consumed.

When the surface of the mixture appears to be dry, place a ring of blotting paper on top of the mixture and round the carbon rod. Then turn the edge of the blotting paper lining inwards over this, as shown in Fig. 2. Do not allow the lining to touch the rod. A second ring of paraffined blotting paper is placed over this, and then the cell is sealed, using paraffin wax and a blow torch to effect this. Cells constructed thus have given 1¼ volts, and about one-third of an ampere each. In these cells the carbon rod is the positive and the zinc container the negative pole.

Assembling the B. Battery

A number of these cells will make a very good B battery, 50 being required to give 60 volts. When all cells are ready for assembly, prepare strips of cardboard by paraffining them well, and place between the cells. In joining up cells, join carbon to zinc throughout, using 26 tinned copper wire.

One cannot expect to produce such a good article as the manufactured one, as individual manufacturers employ secret solutions in making electrolyte, etc. However, it will be found that the cells described give very good results, and are worth the effort necessary to construct them.

High Amperage B Battery

AN accumulator "B" battery which will hold its charge for any length of time, that is, if it is a home-made one, is a novelty, and for that reason I am going to describe the construction of a battery of relatively high amperage.

The only materials required are two shingling hatchets, or a heavy hammer.

On the head of most shingling hatchets will be found a design very useful to battery making. It resembles a plate with small crosswise grooves cut, which, when they make an impression, the grooves, on the contrary, stand out as small ridges, leaving small pits about ⅛ in. square.

If no shingling hatchet is procurable, cut cross-wise grooves with a file, about 1/16 in. deep and about ⅛ in. apart, on the head of a hammer (or on a block of metal suitable to hold in the hand), and with it strike the lead plate a heavy blow. Then cut another set of grooves exactly at right angles to the first set of grooves, forming a criss-cross pattern.

The plates should be sheet lead, about 1/16 in. thick, and of a size convenient to the jars or test tubes used for containers.

Now, put one hatchet or the pitted plate in a groove on your work-bench or in a vise, with the rough side up; then place the strip of lead on the plate, and hit it heavily with the other hatchet or hammer.

The short ribs in the resultant print, which run cross-wise, give mechanical strength, while the increase surface gives much more electrical capacity.

Continue the stamping until the whole surface to be immersed is printed.

After the battery is put together, and the electrolyte is poured in, it should be charged. For a 22½ volt battery this should take about 30 minutes the first time; then it should be discharged as quickly as possible. When almost completely discharged, the circuit for charging should be again connected, but in a different direction from the first charge.

When this alternation of the direction of the current has gone on for about five times, the plates will be found to be of a spongy consistency between the short ribs, owing to the decomposition of

(*Continued on Page 57*)

A SIMPLE ELECTROSCOPE

An instrument used to detect the presence of Frictional Electricity.

AN electroscope is an instrument used in frictional electrical experiments to enable the presence of electricity to be noted, and to give some idea of its quantity. The latter is determined by the extent to which the gold leaves are made to diverge.

A gold-leaf electroscope is a copper or brass wire, having a flat metal disc or cap fastened at the upper end, and two gold leaves hanging from the hook of the lower end, the wire being hung in a glass jar or bottle to shelter it from currents of air.

If a glass tube is connected with the cap or disc of the electroscope by a metal wire (copper wire, for preference) and the glass rubbed with a piece of silk, the leaves will diverge with the electricity that passes along the wire.

Many other such experiments can be performed with the apparatus by boys who are fortunate enough to possess such an instrument.

As, however, a gold-leaf electroscope is undoubtedly beyond the reach of the average boy, this article describes a simple little modification which can be built by even the youngest reader.

Cut a small arrow, about 2½ inches or 3 inches long, from light, stiff paper (Fig. 1). Into a piece of pine-board, stick a needle with the point uppermost (Fig. 2).

Mount the arrow on the needle by making a small hole with the point of a pin (Fig 3).

If a piece of writing or other soft paper is rubbed briskly with the palm of the hand and brought close to the arrow it will cause the arrow to turn and follow the paper.

A glass tube, a stick of sealing-wax, or an ebonite rod rubbed with a piece of cotton, silk or flannel cloth will affect the arrow, either attracting or repelling it according to the kind of electricity generated.

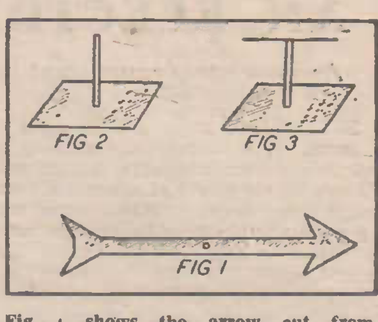


Fig. 1 shows the arrow cut from stiff paper; Fig. 2 is the needle mounted on the baseboard, and ready to receive the arrow; Fig. 3 is a rough illustration of the completed instrument.

An interesting experiment is to comb your hair with an ebonite or vulcanite comb, and then present the comb to the arrow. It will become very animated through the influence of the charged comb.

Many other such experiments will suggest themselves to the maker, and much profitable enjoyment may be had from this simple little scientific toy.

How To Make A Galvanoscope

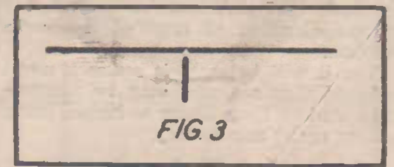
An easily-constructed instrument for detecting electric currents.

MOST boys who are interested in electricity have a desire to possess some kind of instrument by which they can measure and compare the strength of the current obtained from the various kinds of batteries.

Such an instrument is called a galvanometer. It usually consists of a double coil of fine silk-covered wire which encircles a magnetic needle. When the current is passed through the wire the needle endeavors to put itself at right angles to the passing current, and in so doing moves a small pointer which works over a graduated scale.

A galvanometer is rather costly to buy, but the little modification to be described—dignified by the name galvanoscope—while, perhaps, not being as sensitive as the more costly instrument, will serve most purposes of the boy experimenter, and has the recommendation of being both cheap and easy to build.

From cigar-box wood make a framework about 5 inches or 6 inches long, 1½ inches wide. and 1½ inches deep. (Fig. 1.)



How the magnetic needle is balanced on the needle-point.

This framework is now wound round and round with ten or twelve turns of silk or cotton-covered wire of about No. 20 to 26 gauge.

Fasten the framework to a rectangular wooden baseboard and attach the free ends of the wire to two terminal screws, as shown in Fig. 2. For the sake of clearness, only three turns of wire are shown passing round the framework.

With a compass draw a graduated chart on a piece of cardboard and glue it to the baseboard under the wires as shown, putting the zero of the scale under the centre of the wires.

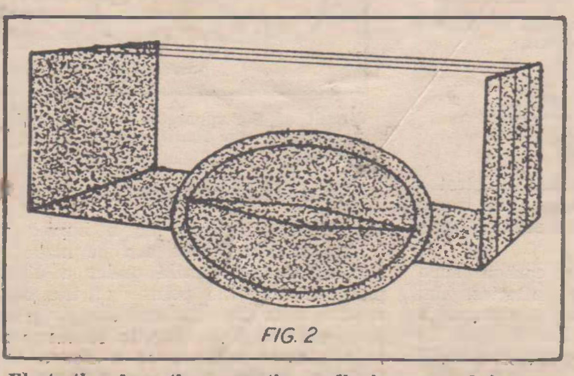
The magnetic needle is made from a piece of watch or clock spring, bent as shown in Figure 3. It is magnetised by stroking it several times from left to right, one way only, on a bar or horse-shoe magnet.

The magnetised needle is then balanced on the point of an ordinary sewing needle, pushed through the wood in such a way that the magnetised needle is able to swing clearly, and as close to the wires as possible.

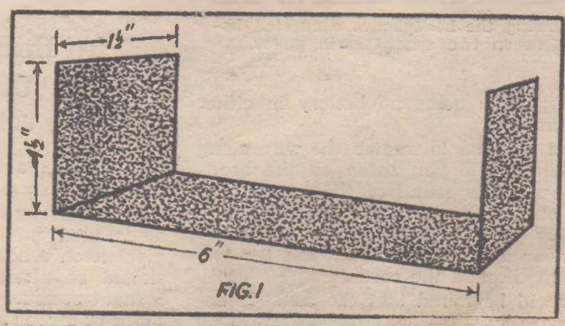
A compass needle makes an ideal needle, and has the advantage of being already magnetised.

The deflection of the needle shows the presence of a current when it passes through the coils; the direction of deflection shows the direction in which the current is flowing; and the amount of the deflection indicates the comparative strength of the current.

Owing to the small number of turns of wire used, the needle will not respond to very weak currents.



Illustrating how the magnetic needle is arranged in conjunction with the winding.



The sides and base of the Galvanoscope.

AN ELECTRIC SOLENOID

An interesting experiment for the radio amateur to carry out.

A SOLENOID is really a hollow coil of wire. If a current of electricity is sent through the coil of wire, the coil will exhibit the power of attraction, even though there is no soft-iron core; and if a piece of thin iron be brought near the hollow coil it will be drawn into the coil.

Wrap a layer of thick paper, about two inches square, around a lead pencil to form a cylinder, and paste the edges. When dry, withdraw the pencil and fit cardboard end pieces to the tube, forming a little cardboard spool.

Next wind this spool with four or five layers of No. 22 cotton-covered wire, leaving three inches of wire free at each end to fasten to the terminal screws.

Mount the coil upright on a suitable baseboard, fastening it with glue or sealing wax, and join the free ends of wire to two terminal screws, as shown in Figure 1.

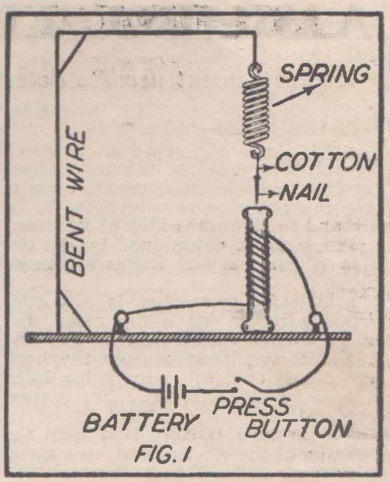
Bend a piece of stiff wire in the form of an inverted L (see Figures 1 and 2) and screw it to the baseboard. To the end (Z) fasten a thin retractile spring and to the other end of the spring tie a nail so that it will hang directly over the hollow coil.

Arrange a circuit as shown, with a press-button, battery and solenoid. Every time the press-button is operated the nail will be sucked into the spool, and as soon as the connection is broken the nail will be drawn out by the spring.

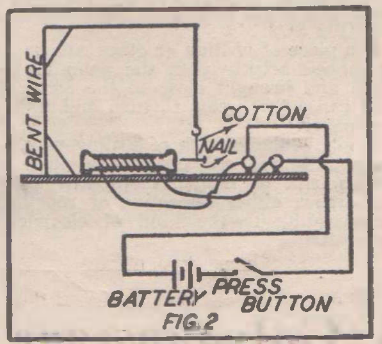
The retractile spring should be very weak. Sometimes the arrangement will work well if thin elastic is used instead of the spring.

A variation of the foregoing is made by mounting the solenoid as in Figure 2. The nail is arranged to swing from the point (Z) just in front of the hollow coil of wire. No spring is needed. Every time the circuit is closed the nail is drawn in and, as soon as the circuit is broken, it swings out.

Other instruments, such as an electric swing, an electric engine, and a battering ram will suggest themselves to the young enthusiast, the solenoid particularly lending itself to electric toy construction.



A simple vertical electric solenoid.



Another method of mounting an electric solenoid.

To Detect Earth Currents

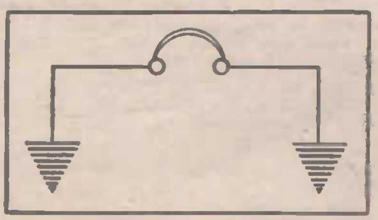
AN interesting little experiment to detect natural earth currents may be performed with a pair of head-phones and an ordinary coarse file. Place two wires about 20 feet or more in length end to end, earthing the ends of each wire, as in Figures 1 and 2. In Figure 1 place a file as shown, arranging the loose end of the wire so that it can be rubbed on the rough surface of the file.

Connect up the head-phones as shown in Figure 2, using no battery in either circuit.

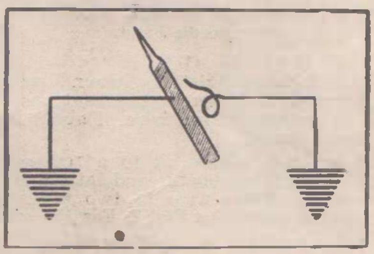
Get a friend to scratch the wire along the file while you listen on the head-phones. The sound of the wire scrapping on the file can be heard quite distinctly in the head-phones, although there is no connection between the two except through the earth.

It will be found that the distance between the wires may be increased to approximately twice their length, or perhaps a little more. The experiment will work best if carried out in a north-east to south-west direction, as this is the general direction of most of the earth currents.

This, it will be seen, is really a novel little wireless set, and may be successfully worked from house to house, using neither aerial nor battery.



Showing the headphones connected between two spaced earth plates.



The file and contact arranged to make and break the circuit.

To Hear The Tramp Of A Fly

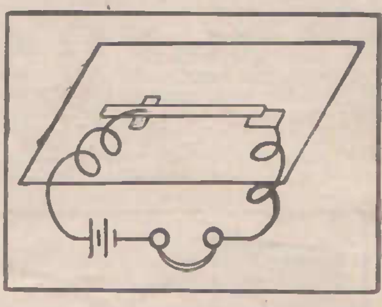
WITH the little instrument illustrated here, it is possible to hear the tramp of a fly over a distance of several hundred feet.

Get a round stick of carbon such as is used in small dry batteries, and pivot it on a brass support as shown. It should be arranged so that it rests by a slight pressure of its weight on a small block of carbon.

A length of wire is connected to the brass uprights and another to the block These wires are led to a battery and head-phones are shown.

The ticking of a watch will be very loud when heard through this simple little microphone. It will also transmit articulate speech if the speaker stands a foot away.

The playing of any musical instrument in the near vicinity of the instrument will be faithfully reproduced in the head-phones.



Circuit of the apparatus used to make audible the footsteps of a fly.

An Emergency Buzzer

A FAIR substitute for a buzzer for practice purposes can be made by slipping a table knife under a dinner plate so that the point of the blade reaches near the centre of the plate, and then operating the handle of the knife in the same manner as a Morse key. This, of course, is merely a "stop-gap."

ACCUMULATORS AND THEIR CARE

An explanatory article dealing with the upkeep, charging and testing of accumulators.

THERE is no doubt that the best "A" battery, though not the lowest in initial cost, is the ordinary lead accumulator. It is dependable and will stand a reasonably high rate of discharge without the falling off in output which, in the case of the usual primary battery, is noticed owing to polarisation.

Another point in favor of the lead accumulator is its constant current and the convenient fact that the normal voltage of the cell is practically two volts. When fully charged the E.M.F. is somewhat higher, and when practically "flat," it drops as low as 1.7 volts.

But, like every other good thing, the accumulator has its drawbacks. Its electrolyte is a corrosive acid solution, which, if split and not immediately attended to, will inevitably damage clothes and carpets. Fortunately, a remedy is at hand in the household ammonia bottle. Ammonia, if applied promptly, will neutralise acid before damage has ensued.

Diluted sulphuric acid is, of course a conductor of electricity. Otherwise it would not be electrolyte. This explains why a battery sometimes will not hold its charge. A film of dust moist with acid on the top of the battery will often bridge the terminals sufficiently well to let a very appreciable current pass. There is a second reason for keeping the top clean — to prevent corrosion of the terminals. Corroded terminals not only look untidy; they may present a high resistance to the passage of the current. The cure is to polish them till bright with emery cloth, finally applying a smear of vaseline.

Faults and Their Remedies

With proper care, radio accumulators will last many years, hence their economy. Most faults are due to carelessness or neglect. Never short-circuit a battery to see if it is charged; "shorts" cause buckled plates. When the solution evaporates or becomes electrolysed, it is only water which disappears. Therefore, the loss must be made up by the addition of sufficient clean distilled water to cover the tops of the plates. Despite statements sometimes made to the contrary, the addition of acid is only necessary to make up loss by spilling.

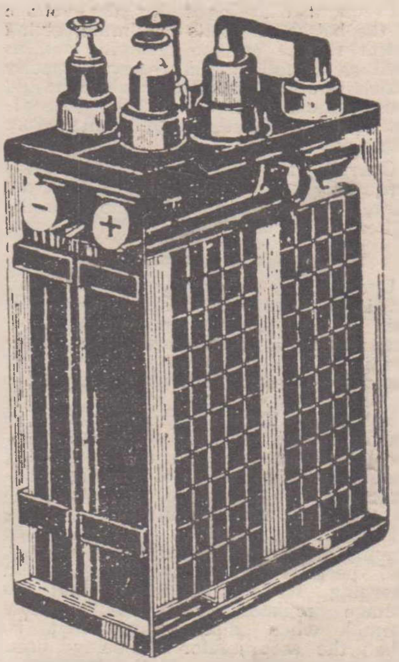
A curious effect results from a leak of electrolyte between two adjacent cells in series. Instead of the total E.M.F. being 4 volts, it becomes reduced to 2. Only the minutest of holes is necessary, as the result is due to the insulation failure — not to the mere mingling of the solutions. Internal "shorts" between adjacent plates are often the result of buckling, due to rapid charging or discharging, or to pellets of oxide falling out of the grids from rough handling. Sulphate deposits are another cause, while the gradual collection of sludge at the bottom of the cells is a fourth.

Storing a battery for considerable periods is a matter not quite so simple as it sounds, if deterioration is to be avoided. Two methods are available, "wet" and "dry."

To prepare for wet storage, have the battery fully charged, be sure the top is clean and dry, and coat the terminals with vaseline. Keep it in a cool place and see that it receives a freshening charge every two months.

Preparation for dry storage is more troublesome, but the necessity for periodical recharging is avoided. Give the battery a thorough charge; then empty out the acid and refill with distilled water.

Discharge the battery for a few hours until the voltage has fallen by 10 per cent., and immediately empty out all water. Drain the battery thoroughly, dry the top and outside, and store in a place free from dust, as described for the wet system.



This diagram shows the appearance of a typical 4 volt accumulator.

An accumulator consists of one or more cells. The cell fundamentally consists of two kinds of plates, the positives (lead peroxide) and negatives (sponge lead) in a solution, called the electrolyte. The electrolyte consists of a mixture of sulphuric acid and water in such proportions as to best meet the requirements of the service in which the battery is to be used.

When you consider that all the energy for the operation of a battery-operated receiving set comes from the accumulators, the care of them is insignificant. They are always ready, however, to do their work provided they are kept charged.

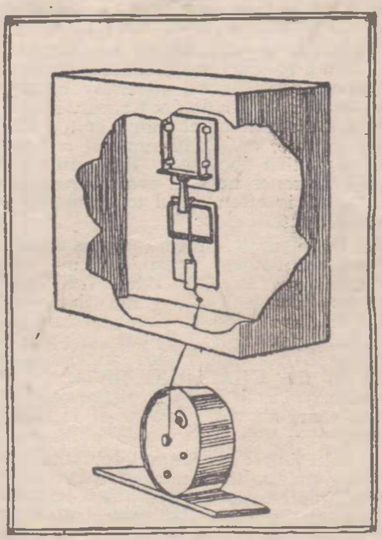
A point to remember is that distilled water should be added to the battery at frequent intervals. During operation the water evaporates and should be replaced. Never allow the electrolyte to get below the top of the plate: keep it at its proper level.

In order to understand the importance of a fully charged battery it is necessary to review the functions of the valve. This cannot detect and amplify properly unless it is supplied with an even flow of electrical current to keep the filament at the proper temperatures without fluctuation, to maintain on the plate a constant high voltage, and to place on the grid a potential which will keep it negative at all times, thereby preventing the grid from becoming positive and distorting the signals as they are received and amplified. A weak or partially discharged battery cannot give the filament, plate or grid an even flow of current.

A Time Switch

A TIME switch can be constructed that will turn out the electric lights at any desired time. A knife-switch, an alarm clock, and a rat-trap of the "spring-tensioned" type are the necessary parts of the apparatus.

The knife-switch is connected in the circuit through which the current for the lamp flows. Beneath the switch handle, the rat-trap should be fastened by screws or nails to the wall. When the trap-trigger is pulled, the spring will fly up, disengaging the blades of the switch.



A drawing showing the assembly of the various parts of the time switch.

A length of wire should be connected to the trap-trigger and tied to the alarm winding key of the clock. When the prescribed time arrives the key will tighten the cord, pull the trigger, and release the spring, and the switch handle will be thrown up.

Frequent charging keeps the voltage of the battery near its maximum, giving better results on the receiving set, as well as establishing a reserve capacity which is always available, which would not be the case if the battery were allowed to reach discharge point before charging.

Charging the battery may be done as frequently as is convenient provided the charging is proportional to the time the battery is in use.

Troubles

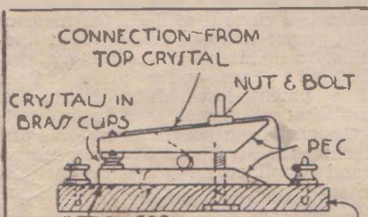
Undoubtedly the commonest trouble of all is that known as sulphation. If this is a long-standing complaint — the result of undercharging or standing in a discharged state over lengthy periods — the negative plates may have so hardened as to become almost worthless. This accumulation of sulphate, in the form of white, powdery patches, or a complete coating greatly reduces the capacity of the accumulator. That is, it will not stand up to the task as it should if maintained in perfect condition. The specific gravity registers lower than normal, and peculiar symptoms appear. On charging, it will be found that the voltage registers high, but below normal when discharging, that is, when the accumulator is being used with your receiver. If the trouble is only slight, several good, full charges not exceeding normal rate, may correct it, due to the fact that the sulphate is easily soluble in the early stages. When, however, the trouble remains obstinate, a charge at a somewhat higher rate may break up this coating and crack it off. This is not recommended as the best way to treat the trouble, as the action resulting from this heavy charge sometimes tends to dislodge some of the active material from the plates also.

The better way is to drain off the electrolyte and replace with a solution consisting of 4 oz. of sodium sulphate (Glauber's salts) to each pint of distilled water. Charge the accumulator for the specified time in the usual way, drain off the solution, rinse the interior thoroughly, and then fill with fresh electrolyte and charge fully. Keep the cells well charged during the next week or so by applying frequent "freshening" charges, whether the accumulator is in use or not.

Where plates are so thickly covered with a particularly hard surface of sulphate, the only other chance is to remove plates from the container and scrape them clean; then complete by using the solution as described.

Clothes Peg Detector

The accompanying sketch, which is self-explanatory, shows how a crystal detector can be made from a common clothes peg.

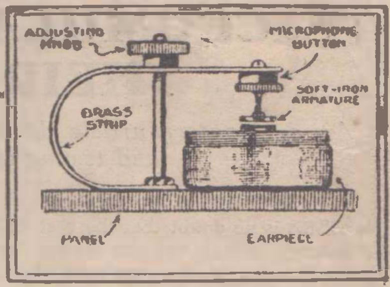


Microphone Amplifier

A signal booster.

MANY amateurs who are unable to go to the expense of valve amplifiers for their crystal receivers will obtain excellent results from this microphone amplifier. It is necessary to purchase a microphone button. An ordinary one pole piece 2000 ohms headphone is screwed to the panel. A piece of 5/32in. threaded rod is then bolted to the panel next to the phone in the manner shown in the diagram. The brass strip is then bent and drilled at both ends. The button is attached to one end and fitted to the panel by means of the threaded rod at the other. A soft iron armature of diameter the same as the pole piece is then fitted to a reed, which in turn is fitted to a diaphragm of the microphone button. The knob, if threaded right through, has a great effect on the results produced. The connections are made as follows:—

The headphone is connected to the receiver in the usual manner. From one terminal of the microphone button to the positive of a four volt dry cell; from the negative of the cell to loud speaker terminal or phone tip. The finishing connection is from the remaining terminal on the button, and the other phone tip or speaker terminal.



A diagrammatic sketch of the finished amplifier.

Loss of density of the electrolyte may also be caused by impure electrolyte; short-circuits (caused by active material from one set of plates making contact with the other set of plates) or through sediment filling the space at the bottom of the container and touching the plates, thus causing a loss of capacity.

When impure electrolyte causes the trouble, have it replaced with fresh acid of the correct specific gravity without delay. If sediment is causing the trouble, remove the top cover of the accumulator, lift the complete set of plates out and thoroughly clean out the interior of the container, and the plates themselves before replacing. In all cases, place the cells on charge immediately fresh electrolyte has been poured in.

In addition to sediment causing trouble, it sometimes happens that an internal "short" occurs which may be hard to locate without removing the plates.

Buckling, or warping of the plates is not such a common occurrence nowadays, as stronger plates are generally utilised. The trouble, when it does occur, is generally the result of charging at too high (fast) a rate, or discharging at a faster rate than that specified. The latter is a rare occurrence now as even a small accumulator is often rated to discharge at a 3 amp rate.

In these days of low consumption valves, the damage done by heavy discharge is usually the result of short-circuits in the leads, when the wires start to burn, and smoke appears. If you have not subjected your cells to this treatment, yet the plates are buckled, look to the CHARGING RATE. An ammeter placed in the negative lead when charging will show what is taking place.

In selecting an accumulator, the important points to remember are: good, strong plates, good separators between plates, ample space between bottom of plates and "floor" of container (to allow sediment to fall clear), roomy vent holes, allowing easy changing of electrolyte, and a transparent container enabling the condition of the plates to be ascertained at a glance. Anyone, by noting the following action described, is enabled to do so with very little practice, when a knowledge of the chemical action which takes place in an accumulator is gained.

Another thing which puzzles a great many users of accumulators is the direction of the current flow. With accumulators, the current flow in the external circuit is from positive to negative, but, following this process through, it is discovered that the current flow inside the cells is from negative to positive. This is not as confusing as it seems at first glance. Imagine the accumulator to be a house with just two doors—one front, one back. The "front" is regarded as the positive, the back as the negative. You start from the front door (positive) and move outside and towards the back door (negative). You arrive there, but to complete the circuit you now have to travel through the house (accumulator) from "negative" to "positive." Likewise, when current flows it completes a circuit, first using the external connecting circuit and then returning through the interior of the cells which comprise the accumulator.

The Use of an Hydrometer.

A hydrometer permits the operator to know the conditions of charge that exists within the battery. A hydrometer is a small glass tube-like barrel container with a small glass float within. A rubber bulb is connected at one end and the electrolyte is sucked up into the barrel chamber. The glass float will float differently at different specific gravity readings. The float is graduated and readings are at the point where the float submerges under the electrolyte.

A full charge will float the graduated tube high and when the battery is discharged it will sink.

When a battery is fully charged, the density should read about 1280 on the scale, and this may fall to 1175 quite safely. If, however, it reads as low as 1150 or 1125, recharging is necessary.

These figures, of course, apply only to electrolyte of standard strength.

When carrying out these tests, test solution from each cell separately, and replace it in the cell from which it was drawn. Use only glass or earthenware vessels, funnels, etc., for the battery resents impurities, especially of a metallic nature.

It is when the battery is in a discharged or partially discharged condition that the acid attacks the plates and causes the noises that are often mistaken for static. Always keep the electrolyte solution about one-eighth or one-fourth inch above the top of the plates.

LEARN THE MORSE CODE

An elementary description and symbol chart for the learning of the Morse code.

ANYONE can learn to read and to send the Morse code if he sets his mind to it. There is no short-cut to success in learning Morse, although one hears every now and then of some such system. The mere fact that these systems do not stand the test of time is proof enough that these "short-cuts" are not worth bothering with.

The man who wishes to become proficient at Morse must be prepared to stick to it and practise every day, for, like learning anything else, it is practice that makes perfect.

Learning to read the Morse code is like learning another language, only more simple.

The Morse code comprises two sounds, a short sound and a long sound, of the same pitch and intensity. These sounds are known as dots and dashes. They have a certain relationship to each other and they have certain spacings of silence between them.

An examination of the chart shows that the Morse character corresponding to the letter E is a single dot, I comprises two dots, T is one dash, and A is a dot followed by a dash, and so on. Now a dot comprises a very short sound, and the length of a dash is equal to the length of three dots sent without any spacing between them.

It was stated that Morse was like another language, for the art of translating the Morse characters into writing must be learned. Thus, when someone pronounces the letter A that letter is immediately written without any conscious effort, because the brain has been so trained for many years. In school a teacher will draw the letter A on the blackboard; then pronounce it so that the scholar is able to learn which letter corresponds to that sound. So in Morse it is necessary to learn the sound corresponding to each letter of the alphabet. For instance, the letter Z is pronounced as said, with the S slurred (zed), whereas the Americans pronounce it as See (again the S is slurred, Zee).

Therefore, the first thing to do is to learn all of the characters as sound. This is usually done by substituting the sound of Dit for a dot and Dah for a dash. Start off by taking the first five characters and saying them out aloud, as A, dit dah; B, dat dit dit dit; and so on. When you have memorised these, continue with the next five until all of the characters have been learnt.

Do not attempt to learn all of those consisting only of dots; then all of those with dashes only, as this so-called short-cut inevitably leads to confusion.

Once you have memorised the sounds you must practise by listening in to a Morse station that is sending slowly. At first you will not be able to make very much of it, but after a while you will find that you will be able to get some of it. Keep at it, and always listen to transmissions that are faster than the speed at which you can read. Logically, if an attempt is never made to copy 20 words a minute, the 20-word-a-minute speed will never be attained.

A	·—	T	—
B	—···	U	··—
C	—·—·	V	···—
D	—··	W	·——
E	·	X	—··—
F	··—·	Y	—·——
G	——·	Z	——··
H	····	NUMERALS	
I	··	1	·————
J	·———	2	··———
K	—·—	3	···——
L	·—··	4	····—
M	——	5	·····
N	—·	6	—····
O	———	7	——···
P	·——·	8	———··
Q	——·—	9	————·
R	·—·	0	—————
S	···		

The Morse Code Symbols.

If a commercial station sending slow automatic Morse is on the air, persevere with it, although perhaps only a few letters are receivable. Most likely, the transmission is in cipher, but this affords the best practice of all, as it eliminates any tendency towards guessing.

Learning To Send

Remember that it is the spacing between letters and words that alters the speed of a message. At 10 words per minute the word "ace" should be overspaced like this:— "a —— c —— e"; at 20 words per minute it would be "a" — c — e," and at 30 w.p.m. it would be "a c e."

Thus the first necessity after memorising the Morse code is to learn timing. The joining of the dits and dahs in a letter must be uniformly done, or something quite different will be signalled. Thus the letter V should be sent (...—). If the three dots are spaced from the final dash it becomes ST.

Timing, therefore, is of paramount importance, and the man who intends to become a first-class operator must learn timing. This is mainly a matter of perfecting his timing at a low speed and then raising his speed. Many operators attempt to send as quickly as possible, and never have any sense of timing.

A key and buzzer should be used for practice, and practice must be kept up until the sense of timing has become sub-conscious. Only then should the speed be increased—and increased very gradually.

A quarter of an hour's practice every day for several months will soon break the back of learning to operate and read the signals that make up the Morse code. Practice—with receiver and with key and buzzer—is all that is necessary, and when you can read Morse at a fair rate (say, at 20 words a minute), a new world of radio will be opened. Amateurs in foreign lands, ships at sea, news services, all are there for the listening.

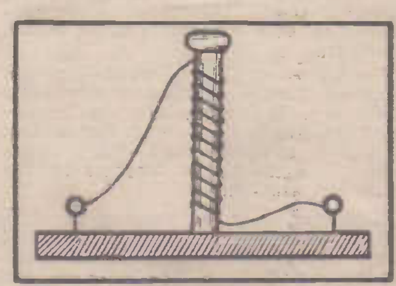
A Simple Electro-Magnet

A SIMPLE, yet effective little electro-magnet may be easily constructed as follows:—

Get a 2½-inch wire nail and anneal it by making it red hot in the kitchen fire and allowing it to remain in the hot ashes overnight, so that it will cool slowly as the fire gradually dies down.

Hammer the point of the nail into a suitable square of wood to serve as a baseboard, and wind the nail, end to end, with three or four layers of No. 26 gauge silk or cotton-covered copper wire, winding round and round clockwise, that is, in the direction of the movements of the hands of a clock.

Fasten the final layer by tying it securely with a piece of strong cotton or thread, leaving an inch or two of the wire with which to connect it to the terminal screws.



A diagram of a simple electro-magnet.

Fasten a couple of terminal screws into the baseboard, and connect an end of the wire to each.

If the terminals of a good dry cell are connected to the terminal screws of the electro-magnet, strong magnetism will be induced in the nail, but as soon as the circuit is broken at any point the magnetism will immediately disappear.

If a small tapping-key is inserted in the circuit to open and close it at will, and a thin nail suspended a short distance away, the nail will be attracted every time the key is closed.

A code of signals may be arranged, and messages signalled from one room to another.

A WOODEN TELEGRAPH

A simple and inexpensive telegraph key and sounder which is capable of doing really useful work.

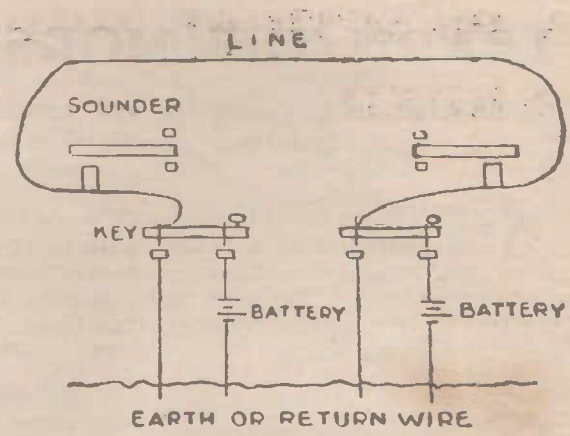
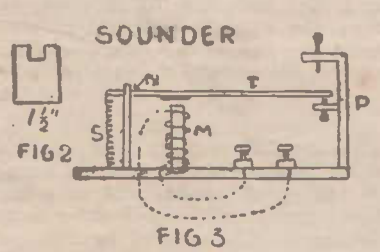


Diagram of an Open-Circuit Telegraph Line.

A TELEGRAPH instrument which will work—and work well—is of interest to almost every radio experimenter. But even the cheapest telegraph combinations are expensive, and beyond the reach of many would-be amateur telegraphists.

In order to make the construction of this telegraph key and sounder very simple, it was decided to build it of wood. Actual experiments have shown that this is possible, and the result is a telegraph combination which is capable of doing really useful work.

A telegraph set consists of a key, sounder, battery, and the necessary connecting wires. The first instrument,



Figs. 2 and 3: Diagrammatic sketch of an easily-built telegraph sounder.

therefore, to engage our attention is the sending key, usually a lever of brass playing between two platinum points.

The baseboard (a) (Fig. 1) is made of half-inch pipe. It should be about seven inches long and three inches wide. Sandpaper it thoroughly, and give it a coat of shellac or ordinary varnish.

The next is the block, or upright in which the lever works. The general shape of this can be seen in Fig. 2, a side view being denoted by (b) in Fig. 1. This should be two inches high, and one and a half inches wide, with a gap of half an inch to take the lever. This, too, should be smoothed and varnished. When dry it should be screwed firmly to the baseboard, as in Fig. 1.

Then comes the lever. This is sawn from a piece of half-inch pine wood, and should be ½ x ½ x 5 inches. A knob (c) (Fig. 1) is shaped and glued as shown. This knob may be fashioned from either cork or wood. Half an inch from each end a brass screw is let in, the screws being connected by a piece of thin, bare copper wire which should be twisted round the head of one screw, brought along the top of the lever, and twisted around the head of the other. The back screw (d) is connected with a terminal screw on the baseboard by a short piece of flexible wire.

The lever is arranged so that it works freely on a pin in the upright; but, before this is finally fixed, two small pieces of brass (x and y) should be screwed to the baseboard so that the screws (d and e) make good contact with them as the lever is worked. A short length of spiral spring (z) is arranged near the back stop so that the lever is drawn sharply down when not in use. This completes the key.

The next is the sounder, the instrument which makes the signals audible.

The electromagnet (m) (Fig. 3) is the next to engage our attention. Get a bolt about two inches long, and soften it by heating to a red heat and then letting it cool slowly. It should then be cleaned and wound evenly with five layers of No. 24 cotton or silk covered wire, the ends of which should be connected to two terminal screws in the baseboard.

The lever is a piece of wood ½ x ½ x 4 inches, similar to that of the lever of the key. It is made in a wooden upright (n), Fig 3, which is similar to that of Fig. 2, except that it is 2½ inches high. This upright is screwed to the baseboard as shown.

Place the lever, or tongue, as it is called, temporarily in position, and mark the place which hangs directly over the iron core (bolt) of the electro-magnet. At this point, a small piece of soft iron —the armature — must be tacked or screwed. Brass is useless, and must not be used.

Then put the tongue (t) in position, allowing half an inch of it to pass beyond the upright (n). A spiral spring

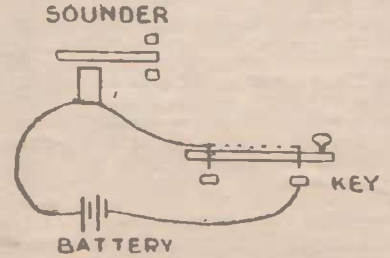


Diagram of a closed-circuit Morse line.

(s) is fastened from the overhanging point to the baseboard, so adjusted that it will draw the lever upwards.

The end piece (p) is made of wood, and is cut so that the tongue plays freely between the two screws, as shown. The bottom screw should be adjusted so that the armature almost touches the core. There should be just room enough to pass a piece of writing paper between the armature and the core. If two tiny metal plates are tacked to the end of the tongue where it beats between the screws, the metallic sound will be almost that of a professional instrument.

Two dry or leclanche cells will work it well, and the set should be connected as shown. If two boys wish to

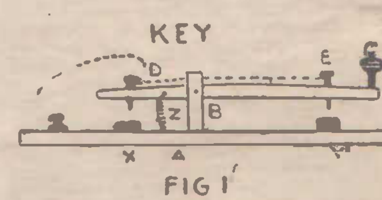


Fig. 1: A telegraph key in detail.

work together, they should use the second method of connection known as the "open circuit Morse." In this, the batteries are in use only when signals are actually being exchanged, the keys being kept open (i.e., drawn back by the spring so that the back screw makes contact with the back stop.)

In the first instance, one wire from the sounder is connected to either screw of the key-lever, the other wire being joined to the battery, which in turn is connected to the front stop of the key. In this diagram, the back stop of the key is not used.

When two stations are connected in open circuit, the line wire is joined to one of the sounder wires, the other sounder wire being connected to one of the screws of the key-lever. The front stop of each key is connected with the battery, and the other battery terminal with the earth or the return wire, the back stop of each key being connected with the earth or return wire.

Elsewhere will be found a copy of the Morse code. This should be memorised and soon it will be found you are able to exchange readable Morse signals between any two points.

A PRACTICAL MORSE SENDER

This novel method of sending Morse code signals will interest the junior experimenter.

MANY a boy studying Morse receiving has longed for someone to "send" to him for an hour or two each day to give him the necessary practice and get his ear accustomed to the sounds which represent the various letters comprising the Morse Code.

With the little instruments described in this article it is possible for anyone to "send" Morse signals, even if, as a boy once put it, the operator doesn't know a dot from a broomstick. No knowledge of the Morse code is necessary, yet good Morse signals can be accurately transmitted.

First, get a piece of deal board to form the base of the instrument, and smooth it with sandpaper. The dimensions, which, however, are not very important, should be about 12 inches by 9 inches.

Next get a piece of tin, or better still, thin brass of the same size as the board, and tack it evenly on the board. This tin or brass must then be thoroughly cleaned, for it is through this metallic plate that the electrical contacts have to be made.

The next operation is to paste or glue a sheet of stout brown paper over the metal, cutting away the left hand bottom corner. (See diagram.)

Give this paper a good coat of varnish; then, when dry, cut out, with a sharp knife, the dots and dashes which stand for the alphabet in the Morse code, leaving the shiny surface of the metal beneath.

Beginning with "A," go right through the alphabet, line after line, and, if there is any room left when the letter "Z" is reached, cut out the numerals as well, from one to nought. The dashes should be cut three times the length of the dots, and a little space left between each of the letters.

This is not as big a job as it may appear. The writer recently made a very workable instrument in less than half an hour.

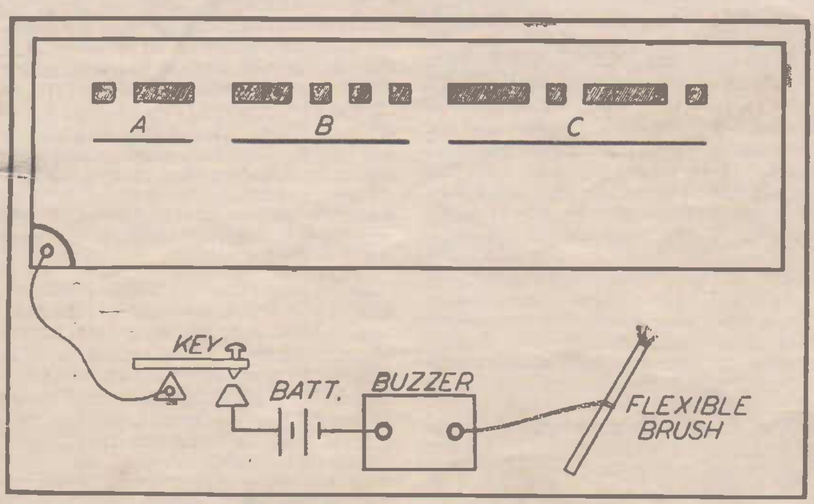
With the exception of a metallic brush, the instrument is complete. This brush is made from a length of single flexible wire. Get about three-quarters of a yard and bare about an inch of the fine wires at one end. Spread these out in the form of a brush, and bind the wire to the end of an old pen-handle. The other end of the flexible wire is connected with one of the buzzer terminals, as shown.

The diagram explains the actual connections, but perhaps a word or two concerning these may help.

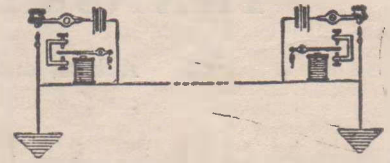
A wire is connected with the metallic plate (tin or brass) at the left-hand corner, where the paper was cut away. A brass screw through the metal into the wooden base will hold the wire securely The other end of this piece of wire is connected with the lever of the key, and, what is known as the front-stop of the key, is connected with the battery, which, in turn, is joined to the free terminal of the buzzer, the other buzzer terminal being joined to the flexible wire connected with the metallic brush, as explained previously.

Now, to work the instrument! The brush is taken in the right hand, between finger and thumb, and is moved firmly and evenly from left to right, over the letter to be transmitted. If the metal is perfectly clean, and, if moderate care has been taken in cutting out the signals, the tongue of the buzzer will respond at once with perfect signals.

When operating the instrument, the circuit-closer of the key should be kept open, as the "sender" is joined up in parallel with it.



A diagram of the Morse code sender. When sending messages by means of the flexible brush it is necessary to have the key closed.



Circuit diagram of an open-circuit telegraph line.

An Open-Circuit Telegraph System

AN open-circuit telegraph system, operating between two rooms, is the desire of every boy. By following the diagram given, and the few simple details provided, any boys can arrange this little installation.

Elsewhere in this book the construction of a wooden key and sounder is detailed. These instruments may be used, the circuit being so arranged that the batteries are only brought into action when a key is depressed.

The line is of the ground-return variety or two wires may be used if desired, the second wire taking the place of the ground. One terminal of the battery is connected to the line, and the other is connected to the key, which leads to the ground. The sounder is connected with the ground and the line.

In using a combination set, the wiring of the set will have to be altered, as in the diagram. The circuit switch should be removed from the key, it being unnecessary, and, if accidentally left closed, would soon exhaust the power of the battery.

An extra terminal screw is added to the keys. Wires are run from the sounder to the line and the ground, and from the key to the ground, while battery wires are connected to the line and the key.

The advantages of this system are apparent. The use of dry cells in place of wet batteries is much cheaper, cleaner and simpler. Either party may call at any time. There is no switch to handle when changing from receiving to transmitting, and vice versa. No battery is used at the receiving end, the current coming altogether from the sending station.

A Simple Primary Battery

A SIMPLE battery, for short experiments, may be quickly made as follows:—

Get a quart jar, a zinc rod and four rods of carbon, such as those used in dry cells. Tie the four sticks of carbon together and twist a piece of copper wire around them at the top to make a good connection with each carbon rod. This forms one plate of the battery, the zinc rod being the other.

Stand the carbon and zinc elements in the jar and charge it with an extra strong solution of sal-ammoniac. Sometimes common salt is used instead of the sal-ammoniac, but the battery is then not so satisfactory.

Owing to polarisation, this battery is used only for short experiments.

TRANSMISSION AND RECEPTION

A brief outline of the effect which the Heaviside Layer has on the waves propagated from radio broadcasting stations.

Present-day radio broadcasting presents a fascinating subject for study. In its existing form the art has for its aim the picking up of programmes of either speech or music, the translation of them into electrical impulses, and the transmission of these impulses, through the ether, to millions of listeners who are equipped with suitable receiving apparatus.

Broadly speaking, the sequence of events which takes place during the broadcast of an item begins with the picking up of, shall we say, the singer's voice, by means of a microphone. This delicate electrical ear possesses the ability to translate into tiny electrical impulses the sound pressure impulses brought about by the action of the singer's voice upon the surrounding air.

The electrical impulses from the microphone are amplified some one million-fold and are superimposed upon the "carrier wave" generated by the transmitting apparatus at the broadcasting station.

This generative apparatus produces an alternating electric current of very high frequency but of constant amplitude or strength. This frequency cannot be heard by the human ear, which will respond to tones or frequencies lying between the alternation range of 20 and 15,000 cycles per second.

The amplified electric currents, which are the electrical replica of the intonations of the speaker's voice, can, however, be detected by the human ear if they are passed through a system which is the reverse of that which created them.

In this circumstance they will be recreated as intelligible speech or music. Now, these amplified voice currents are superimposed upon the constant amplitude of the carrier-wave, which is then said to be modulated. The result is that the carrier-wave, which may be alternating or changing its direction of flow at a frequency of 1,000,000 times per second, is now caused to alternate at frequencies from 985,000 to 1,015,000 times per second in accordance with the frequency range of the superimposed voice currents which are thus summative. This varying electrical pulsation or series of pulsations is caused by radiation from an aerial system, to disturb the conducting material which is known to physicists as the ether.

Through this means the modulated radio wave travels radially for distances dependent upon the power of the transmitting stations, the type of terrain over which it passes, and the time of the day and season of the year.

The elastic fluid which we call the ether is in a constant state of flux; so, too, do the transmission conditions and, consequently, the range of a given broadcasting station vary. The greatest variations, naturally, are to be noticed at great distances from the broadcasting station.

At the receiving station we find that the process of transmission is completely reversed.

First we have the aerial system, which is merely a collector of the etheric pulsations which have been caused by the distant transmitting station.

Next we have a tuning system which can be broadly spoken of as a means of resonating the receiving set with the transmitting set in the same way as, perhaps, a violin or similar musical instrument in an orchestra may be attuned to a piano.

This tuning system is rather important, so we shall deal more fully with it later on.

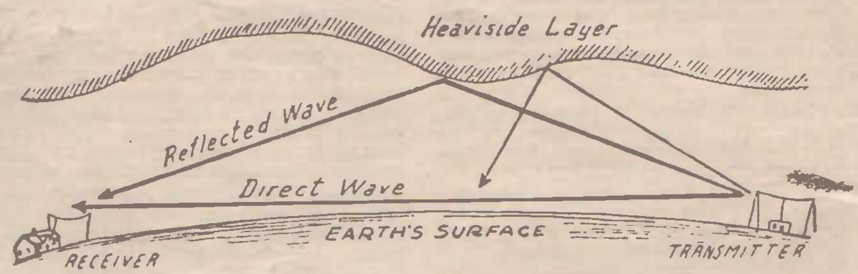
Following the tuning system we have a detector or de-modulator, the purpose of which is to eliminate the high frequency and inaudible "carrier-wave" and to leave the still inaudible electrical impulses of the original speech or music. These now undergo further electrical treatment in that they are boosted or magnified by an amplifier and then are fed to a loud speaker, where they set up a varying magnetic field and cause the movement of what we might call an electric piston to which is attached the diaphragm of the loud speaker.

The action of the amplified electrical impulses is to cause the piston of the loud speaker to move the diaphragm back and forth in such a way that the air displaced by the cone causes the same effect upon the auditory nerves of the listener as would the singer's original voice.

To recapitulate. It should be remembered that the singer's voice is first transformed into low frequency electrical impulses of varying magnitude by means of the microphone. These low frequency impulses are super-imposed upon the broadcasting station's high frequency carrier-wave which is transmitted at a fixed magnitude. The receiving set is fitted with a detector valve which eliminates the now useless high frequency impulse and passes the varying low frequency impulses on to the loud speaker by means of a device, called an amplifier, which magnifies them.

Acting upon the loud speaker by means of electro-magnetism, the amplified impulses, still at low frequency, cause the diaphragm of the loud speaker to disturb the surrounding air and thus to simulate the cadences of the voice of the broadcasting artist.

We touched earlier upon the necessity for tuning the receiving set. This is necessary because the transmitter itself must be tuned in order to ensure that it generates impulses of only one fixed frequency. If the receiver were not tuned to the same frequency, in other words, was not resonant with the transmitter, a large proportion of the already minute energy released from the transmitting aerial would be lost and, at the same time, other stations operating near the frequency of the first station would be heard simultaneously. This latter phenomenon is called "jamming" or more commonly, "interference."



This diagram shows the two transmission waves sent from a broadcasting station, and the effect the Heaviside layer has on the reflected wave.

Even when a receiver is provided with a tuning system this may not be highly efficient and interference between powerful stations operating at closely allied frequencies will swamp the desired station's transmission. In these circumstances the receiver is said to be "broad" or in-selective. Some types of receiver are more selective than others and, generally speaking, the more tuned circuits—combinations of capacity and inductance which set the electrical resonant period of the receiver—the more selective will be the receiver.

There is another phenomenon attached to the transmission of radio signals which has an important bearing upon subsequent reception. This is the fact that two wave-trains or sets of modulated high frequency impulses are released from the aerial simultaneously. One of these is known as the "ground-wave" and is believed to travel radially from the transmitting aerial just above the surface of the earth.

The other wave-train is known as the

"sky-wave" and is projected towards the upper atmosphere until it strikes a non-conducting layer known as the "Heaviside Layer," which may be likened to an opaque wall which stops the passage of a beam of light.

Having impinged upon the Heaviside layer at an angle the radio sky-wave is refracted and reflected back towards the earth, which it strikes at a considerable distance from the transmitter. Both wave-trains lose intensity (and so are said to be attenuated) the further they travel but the ground wave, being absorbed by the earth over which it passes, is the first to die out. Thus a station may provide progressively weakening reception over distances up to a hundred miles and then die out only to reappear at apparently undiminished strength at distances farther than 200 miles from the station.

The intervening distance, between the point where the signal died out and the point at which it is again audible is said to be the "skip distance area" and varies with different stations and different transmitting frequencies.

The Heaviside Layer, although it is a good friend to the radio listener, has its own peculiarities. Like the intangible ether, through which the radio signals are transmitted, the Heaviside Layer is in a constant state of flux and can be compared with the movement of the ocean. Thus, if the radio signal is being consistently directed towards one point in the Layer, it can be understood that, as this point is constantly changing its distances from the earth, so the angle of refraction and reflection will alter and the signal will come down to earth again at widely differing angles.

This movement of the Heaviside Layer produces one form of "fading" which is the waxing and waning of the strength of distant stations.

There is another form of "fading" which is caused by the simultaneous arrival at the receiving aerial of both the ground wave and the sky wave. This form can be particularly troublesome because if the two waves are in phase or in step, the signal strength will increase, their gradual getting out of step, due to movements of the upper layer, will cause not only fading but distortion of the broadcast speech and music.

One of the forward steps in radio receiver design which has done much to overcome the trouble of fading signals has been the introduction of "automatic volume control." Briefly, the function of automatic volume control is to govern the sensitivity—response to weak signals—of the radio receiver in the same way as the mechanical governor controls the speed of a steam engine. When the strength of the received signal falls off, as it will during a period of fading, so the automatic volume control system acts upon the receiver to increase its sensitivity and thus restore the audible signal to a pre-conceived level.

When the fading period has passed the automatic volume control reduces the set's sensitivity thus ensuring that the receiver will, within limits, keep the output signal in the loud speaker always at the same volume.

Automatic volume control is an electrical device built into practically every modern receiver and is one which requires no adjustment by the set-user.

One other drawback to successful radio reception, particularly reception in which the transmitting and the receiving stations are separated by great distances is "static."

This is a form of electrical interference which possesses all the characteristics of a radio transmitter in that it will actuate the detector valve of a radio receiver. It is caused by electrical storms which may be either local or come from outer space, and, unlike the radio transmission, is absolutely untuned. Thus it is capable of energising the receiver, which it proceeds to do in the form of a succession of splutters, crashes and bangs, irrespective of the frequency to which the former is tuned.

Although it can be very troublesome, even in the temperate zones, static is most virulent in the tropics, where it has for days caused the complete cessation of all forms of radio communication.

A similar electrical disturbance which plays funny tricks with radio reception is caused by electrical phenomena such as the Aurora Australis.

Nowadays, in Australian coastal areas at least, static is not such a serious matter, because the large number of comparatively high-powered transmitting stations which are in use ensures that the majority of listeners will be in radio reach of a broadcast signal of such strength that static will not cause any inconvenience.

It is in the inland areas of New South Wales, Queensland, South and Western Australia that King Static holds his sway.

In the urban areas, however, natural static is replaced with artificial static generated by the multitudinous electrical apparatus to be found in the modern city. Electric trams, trains, industrial electrical motors, and kindred electrical machinery, and even such domestic aids as vacuum cleaners and refrigerators, do their share to make the life of the radio listener miserable.

Fortunately, however, science has stepped in and shown the city dweller how to overcome the greater part of this "man-made" static's effect upon his reception.

Specially designed aerial systems, filter circuits which prevent the electrical interference from entering the receiver via the domestic electric supply system, and special screening of the receiver itself all help to prevent the reception from being marred by the crackles and bubbles of near-by electrical machinery.

Radio has developed markedly since the day when Marconi laboriously tapped out the three dots of the letter S to his colleagues listening in far Newfoundland. Today, with the agency of the wonderful "short-waves," those radio frequencies which lie between 3 million and 20 million cycles per second, it is possible for the listener in Melbourne, Sydney, Adelaide, or Perth, to hear the broadcast description of the English Derby, the latest American baseball match, the progress of one of Russia's five-year plans, or a German song festival, without leaving his own fireside.

Every hour of the day, from early morning until late at night, the short-wave listener can find something of interest. With the aid of a simple, although sensitive receiver, he literally has his ear at the key-hole of the world's door, and has a choice of programmes which could not but please the most critical of musicians.

All this is possible, because with the short wavelengths the signals of very high frequencies, strike the ionised "Heaviside Layer" at acute angles, and thus are reflected at similarly sharp angles to come down to earth at points thousands of miles away from the broadcast stations from which they originated.

Fading, although present, is not usually severe on short wavelengths, while static, that arch enemy of the listener who likes to tune in distant stations, is almost non-existent. Unfortunately, the ground wave of a short-wave station is not audible at more than a few miles from the transmitter, so that we find that the "skip distance area" may extend for two or even three thousand miles.

There are other frequencies, known as the Ultra Short Wavelengths, which lie in the frequency range above 30 million cycles and extend from 10 metres down to below 1 metre. These are now in process of being explored.

At present these frequencies exhibit characteristics which make them useful for communication only over "visual" distances, i.e., distances over which the transmitting station is in the optical range of the receiver. Further experiment, however, seems likely to show that these frequencies can be used for transmission over greatly extended distances so that their present usefulness cannot be truly gauged.

STANDARD RESISTOR COLOR CODE

In the RMA (American) standard coding, ten colors are assigned to the figures as shown in the following table. The body of the resistor is colored to represent the first figure of the resistance value. One end of the resistor is colored to represent the second figure. A band or dot of color, representing the number of ciphers following the first two figures is located within the body color.

Body		End		Dot	
Brown	= 1	Black	= 0	Black	= No ciphers
Red	= 2	Brown	= 1	Brown	= 1 "
Orange	= 3	Red	= 2	Red	= 2 "
Yellow	= 4	Orange	= 3	Orange	= 3 "
Green	= 5	Yellow	= 4	Yellow	= 4 "
Blue	= 6	Green	= 5	Green	= 5 "
Violet	= 7	Blue	= 6	Blue	= 6 "
Grey	= 8	Violet	= 7	Violet	= 7 "
White	= 9	Grey	= 8	Grey	= 8 "
		White	= 9	White	= 9 "

AERIALS AND HOW TO INSTALL THEM

An explanatory article dealing with many types of efficient aerials used for the reception of radio signals.

THE aerial is the first link in the chain which joins the announcer to his listener. The aerial serves as the collector of the minute impulses sent out from the radio transmitter, and as such must be given a certain amount of consideration.

One cardinal rule to remember about aerials is that the more efficient they are the better will be the results obtained from the receiving set. In earlier years, considerable attention was paid to the aerial system, which was designed and erected with one idea—efficiency. To-day the increased sensitivity of the average receiving set has more or less overcome the necessity for an efficient aerial system.

However, even with the most efficient radio receiver, the best results will only be obtained if the aerial system is electrically efficient and if it is erected in such a way that the aerial wire is well above earthed objects and as little subject as possible to screening effects of nearby buildings and trees.

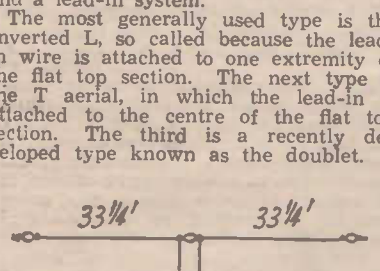
There are three main types of aerials in use today. These are the outdoor aerial, the indoor aerial, and the mains aerial. Let us take them one by one.

The Outdoor Aerial

This is the most efficient type of receiving aerial for all-round use. When properly erected it provides an excellent signal pick-up and almost complete freedom from the electrical interference experienced around the average large city.

The outdoor aerial may be supported from one or two masts. It should be erected as high as convenient and as far away from buildings and other earthed objects as possible. There are several types of outdoor aerial. Each consists of a flat top section, i.e., a section suspended between two supporting masts, and a lead-in system.

The most generally used type is the Inverted L, so called because the lead-in wire is attached to one extremity of the flat top section. The next type is the T aerial, in which the lead-in is attached to the centre of the flat top section. The third is a recently developed type known as the doublet.



A doublet type aerial system employing a transposed lead-in.

In the doublet type aerial the flat top section is divided into two carefully proportioned sections of equal length. The junction of these two points is made by two or more insulators, so that each half of the flat top is electrically separated from the other.

To each inner section of the flat top is soldered a lead-in wire which may be twisted together or crossed over by means of what are known as transposition blocks until it reaches the receiver.

It must be borne in mind that the operation of a doublet aerial is dependent upon the careful proportioning of the length of each of the flat top sections and of the length of the two wire lead-in.

The chief advantages of the doublet type aerial are in short-wave reception or for use in areas in which electrical interference noise mars reception. We shall have more to say about the erection of aerials later on.

The Indoor Aerial

This type of aerial is used mainly by city dwellers who are close enough to broadcasting stations or who possess receivers sufficiently sensitive to enable the outdoor aerial to be eliminated. The average indoor aerial consists either of a wire suspended between the roof gables of the house or merely slung around the room on the picture railing. With very sensitive receivers even a few feet of wire coiled upon the floor will provide sufficient pick-up to act as a reasonably good aerial.

The indoor type of aerial does not claim to be efficient, but, as pointed out earlier, it has its advantages from the convenience viewpoint.

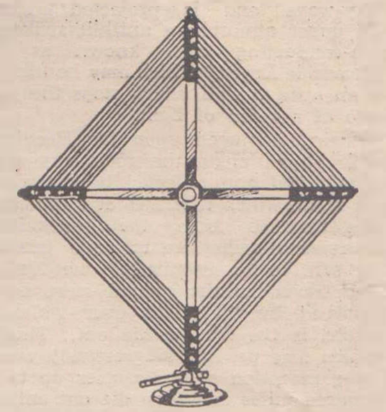
The Mains Aerial

This type of aerial has never been very popular in Australia, although it is used to a considerable extent on the Continent. The mains aerial makes use of the power supply mains wires which usually travel long distances suspended on high poles. It is necessary, however, to ensure that no electric supply from the power mains reaches the radio receiver except through the latter's power system. Failure to watch this point would result in dangerous electric shocks or, at best, the blowing out of the lighting and power system.

To overcome this possibility, and to make the receiver safe, a small capacity fixed condenser is connected between the aerial coil of the receiver and the electric supply mains.

The mains type aerial represents a definite improvement on the indoor aerial from the viewpoint of signal pick-up, but it suffers from the disadvantages that electrical interference caused by faulty contacts, arcing generators and power equipment, which is carried along the mains, reaching the receiver and creating a good deal of crackling and frying which mars reception.

One type of indoor aerial which has not been listed is the frame or loop aerial. As its name implies, this aerial consists of a number of turns of wire wound round a square frame. This type of aerial also has had its day and is not used much now except for specialised work such as radio direction finding. Like the indoor aerial it is very inefficient, but it possesses great directional characteristics which often are useful to overcome station interference.



A frame or loop aerial.

Another uncommon type of aerial is the buried one in which a long wire is carefully insulated and buried underground.

Then we have one of the commonest makeshift aerials in which the earth wire itself is attached to the aerial terminal of the receiver. This type of aerial often gives better results, as far as reception of nearby stations is concerned, than does a regular outdoor aerial.

How to Erect an Aerial

THE first thing to decide in erecting an aerial system is which type is to be used. We again stress the value of the outdoor aerial if best results are to be obtained. Let us consider an outdoor aerial first. The gauge of the aerial wire has some small bearing on the electrical efficiency of the system, but is not of sufficient importance to warrant attention from any but the most finicky.

The main thing to watch is that the wire has sufficient strength to prevent breakages under normal conditions. Remember that the longer the aerial the stouter must be the wire.

For ordinary purposes a single 16 gauge hard-drawn copper wire should suffice. Note that the wire should be of the hard-drawn variety, otherwise it will stretch and finally break under service.

Another type of aerial wire which also is very satisfactory is the stranded type. This may have either three or seven strands and is termed 3/20 or 7/22 gauge wire. The stranded wire is slightly more efficient electrically and possesses the advantage of being mechanically stronger than the single-strand wire.

We are great believers in the use of insulated aerial wire in city and suburban areas or for use by the seaside. The reason for this is that soot and kindred impurities in the air form a deposit on the aerial wire, oxidise it, and cause it to be only partially conducting.

The salt air from the seaside performs a similar function and, in addition, corrodes the copper wire. The effect on the ordinary rubber, or enamel insulation is not so serious as either of the oxidising actions so that the insulated aerial wire will definitely prove more efficient in the long run. The cheapest and probably best type of insulated aerial wire is that which is covered with enamel.

We come next to the question of the aerial's length. Remember that the longer the aerial is the more the signal pick-up will be, but the more will be the damping which the aerial imposes on the receiver tuning circuits.

A long aerial will improve the set's range, but it will also impair its selectivity. Where highly selective reception is desired the aerial should not be more than 40 feet in length. To this, of course, must be added the length of the lead-in.

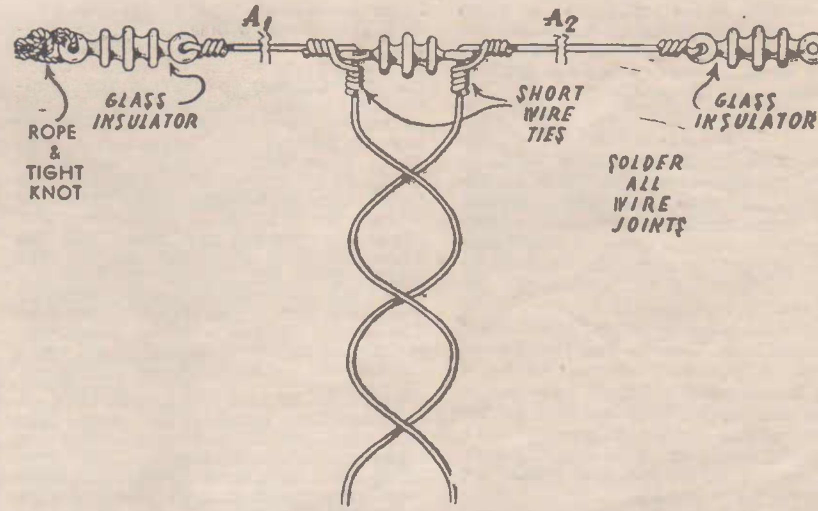
Having decided upon the length of the aerial, the next thing to do is to seek convenient points at which the supporting masts can be erected. Remember that at this juncture we are considering the ideal outdoor aerial. Later we will explain how aerials can be attached to existing high points, such as chimneys and roof gables.

The masts should be as high as possible and should be so placed that the aerial is kept clear of earthed objects. If you can avoid it, do not run the aerial nearer than 15 feet from a building wall or roof. Keep it even further away from growing trees and provide a separation of at least 20 feet from iron roofs and similar structures which can absorb aerial power.

The best height for aerial masts for distant reception is between 40 and 50 feet. Masts of this height, however, are difficult to erect and require a considerable amount of guying to protect them against wind stresses. The best all-round mast height is 30 feet. Masts this height, and made from selected oregon tapering from three inches square at the base to two inches square at the top, can be erected single-handed without difficulty. Higher masts require a number of helpers and some form of hoisting gear.

The 30-feet masts require no guys if firmly embedded in the ground, but, if additional safety is wanted, a single back guy, which takes the strain in the opposite direction to the aerial pull may be used.

Having erected the aerial masts the next job is to make the aerial. For this at least four strain type insulators will be required. Two of these should be connected in series between the aerial and the halyard wire, which should have been run through the pulley attached to the masts before the latter were erected. Remember, the more insulators connected in series the greater



This condensed type of doublet aerial shows the method employed to attach the transmission line to the aerial. The line consists of a tightly twisted pair of wires.

the resistance to leakage and the more efficient the aerial.

Figure two shows the method of attaching insulators to aerials and the method used in erecting an inverted L type aerial so that no join is made in the wire. This is done by attaching the insulator at the far end of the aerial, extending the latter to its correct length, and threading it through the near end insulator and making a tie between the the wire where it went through the near end insulator. The remaining wire is lead down to the receiver and clipped off at the desired length.

Wherever it is necessary to join an aerial wire, such as when a lead-in is attached to a T type aerial, be sure to solder the join and to paint it with varnish to prevent corrosion.

The lead-in should be kept from contact with the building wall. For this purpose, stand-off insulators are used, these being attached to the wall and the lead-in twisted around them.

Where the lead-in passes through the wall of the building to the receiver it should be very heavily insulated. For this purpose a suitable length of rubber-covered wire can be soldered to the main lead-in wire or the latter and be brought in through a lead-in insulator which is pushed through a suitable-sized hole drilled in the wall or window sill. In drilling the hole for this lead-in insulator be sure to point it down towards the outside so that no rain can enter the inside of the house via the lead-in tube.

So much for our ultra-efficient aerial system. In most city homes there is either not sufficient room for the erection of two aerial masts, or the lady of the house considers that they will spoil the appearance of the place. In these circumstances, the radio experimenter must resort to more subtle methods. He should cast his eye over the building roof, noting the location of tall chimney pots, roof gables and similar projections. To any of these, suitably placed and separated, it should be possibly to attach a reasonably-efficient aerial system. Where the lead-in must cross the gutter, it is a good idea to arrange a piece of wood so mounted that insulators can be screwed to it in such a way that the aerial will not come into contact with the spouting or the building roof. Another way out of the difficult is to erect one mast at the rear of the house and run the other end of the aerial to a convenient chimney-pot or to a small sub-mast fastened to this chimney pot by wire or iron bands.

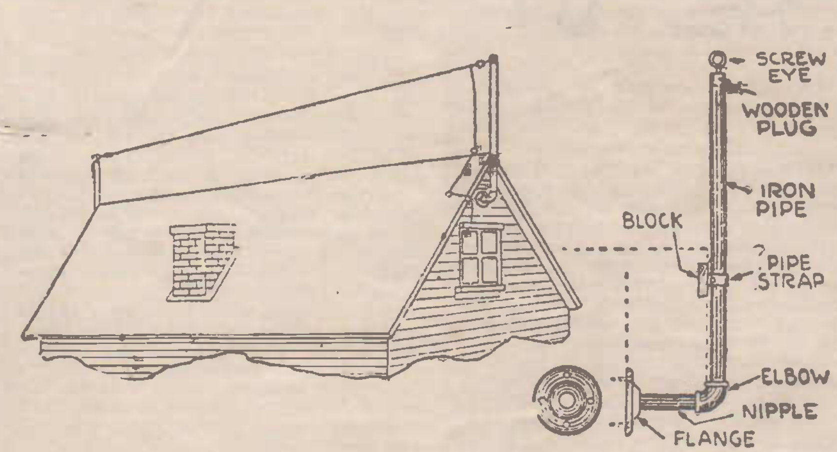
A point which should be borne in mind is the directivity of outdoor aerials, i.e., the direction from which they will pick up the strongest signals. The inverted L type aerial, provided that its flat top section is perfectly horizontal, will provide peak reception from the end to which the lead-in is attached. If the aerial slopes downwards away from the lead-in end the directive pick-up at the lead-in end will be further increased.

The T type aerial picks up equally well from either end but is not very responsive to signals coming at right angles to its length.

The frame aerial, as we said before, is very directional and picks up best when its edge is pointing directly towards the station it is desired to receive. When the loop is swung round at right angles to this desired direction its pick-up is practically nil.

The doublet type aerial will receive best from stations situated at right angles to its length.

The indoor aerial is subject to the same general conditions of directivity as are the T and L aerials with the dif-



A simple method of erecting an aerial system on the gable of house roof.

ference that, if the aerial wire is taken around the four sides of the room, the directional effect is nullified and practically equal strength reception will be obtained from all points.

Indoor Aerials

The erection of an indoor aerial is usually governed by (a) ease of installation, and (b) inconspicuous appearance. Most modern homes have a conveniently recessed picture railing about six or seven feet above the floor level. The recess between this railing and the wall can be used to hide the aerial wire. Insulated wire of the type known as beluen wire can be used for indoor aerials. It possesses the advantage of being flexible and is highly insulated so that it can be attached directly to the picture railing by being pressed down under the heads of small drawing pins. Be sure not to let the pins pierce the insulation on the wire.

The average indoor aerial might conveniently be made 25 feet in length. Shorter or longer lengths can be used if desired, but the length will depend upon the degree of signal pick-up and the degree of selectivity desired. Shorter aerials will improve the selectivity and reduce the pick-up whilst longer ones will operate in the opposite way.

It is desirable, when installing indoor aerials, to keep them as far away as possible from electric light and telephone wires. Interference between the radio aerial and either of these public utility wires can be very annoying. In certain circumstances it is possible to operate a receiver from an aerial consisting of only two or three feet of wire attached to the set's aerial terminal. Reception will in these circumstances be almost entirely confined to the local stations and electrical interference difficulties are likely to be great.

Another simple indoor aerial system consists of the attachment of a 25ft. length of wire to the receiver's aerial terminals and the coiling up of the wire in the set cabinet.

The more elaborate types of indoor aerial are attached to the rafters in the roof gable, but these follow the general installation principles of outdoor aerials, so need not be touched upon here.

The Mains Aerial

For this type of aerial system we require a knowledge of soldering and some knowledge of the circuit of the receiving set. Two fixed condensers, one of .006 mfd. capacity and the other of .0001 mfd. or .00025 mfd. capacity, are connected in series. The vacant lug of the .006 mfd. condenser is connected to one of the A.C. supply mains, whilst the vacant lug on the smaller condenser joins to the aerial terminal on the receiver. These connections are best made under the receiver chassis. The condensers used for the job should be of the highest grade mica dielectric type, for faulty condensers will result in a leakage or a short-circuit which may have very serious consequences for the set user.

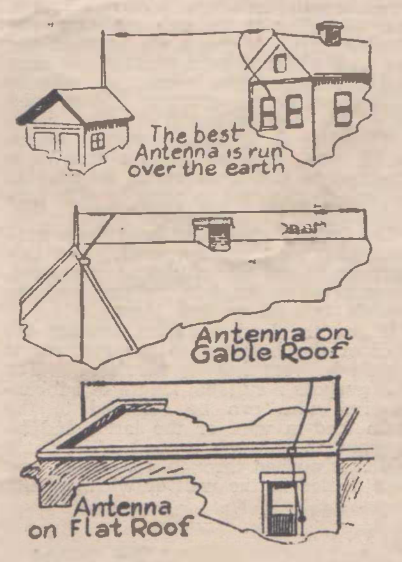
Special Types of Aerials

We come now to the special types of aerials used for short-wave reception and for the elimination of electrical interference which spoils radio reception in so many city and suburban homes. As mentioned previously, the most popular short-wave aerial is the recently-developed doublet.

There is another type of short-wave aerial, however, which is not so difficult as the doublet to erect and yet possesses at least one advantage which the doublet hasn't. This is the semi-vertical aerial. This may be of any convenient length, but should be as high as possible. If convenient, a mast 45 or even 50ft. in height should be used. Only one mast is wanted. The aerial wire is brought down from the top of the mast to a point, say, 12ft. above the ground and about 6ft. out from the base of a 50ft. mast. (For shorter masts this distance out from the base will be proportionately reduced.) From the 12ft. high anchor point take the lead-in to the receiver, supporting it from contact with buildings and other earthed objects by means of insulators.

This type of aerial is practically non-directional, is excellent for short-wave reception and is not susceptible to motor car ignition interference to anything like the degree that horizontal aerials are. Naturally, it should be insulated and generally constructed in accordance with the principles laid down for our ideal broadcast outdoor aerial.

The next type of aerial is the doublet. Now it is useless to attempt to build a doublet aerial unless you are prepared to follow directions closely. There are various types of commercially-made doublet aerials, all of which work very



Three simple methods of erecting aerials in confined spaces.

well under suitable conditions. They all suffer from one failing in that they cannot be tuned and are only fully responsive to a very narrow band of wavelengths. Untuned aerials do not matter much for broadcast reception, but on short waves, where every effort must be made to get the maximum from the receiver, if really distant reception is desired, it is almost essential to use a tuned aerial.

The doublet type aerial with which we shall deal is quite simple in design, yet has proved remarkably efficient. It consists of two flat top sections, L1 and L2, separated by a distance of 15 inches by means of two or more insulators. To each of these flat top sections—in the middle of the complete aerial system—are attached feeder lines F1 and F2.

The flat top sections must each be the same length and should measure exactly 33ft. 3in. in length. This distance is measured from insulator to insulator on each of the sections. After being taken through the insulator at each end, the end of the wire should be cleaned, wrapped around the aerial and soldered. The feeder lines should be soldered to this same point on each of the flat top sections. The total length of each feeder line should be 66ft. 6in. These dimensions are very important and should be checked carefully.

The flat top section should be made from gauge 14 enamel-covered wire.

The feeder lines may consist of ordinary twin lighting flexible wire or, better still, of 3/20 electric light wire insulated with rubber and waxed cotton. The latter type of wire will not suffer so much from exposure to the weather.

To tune this doublet aerial to the wave length on which it is desired to listen, it is necessary to construct a small coil. L3 and L4 consist of 15 turns of 26 gauge d.c.c. wire wound in the same direction on a 1in. diameter former and separated from one another by 3-16th of an inch. In the gap so formed wind L5, which consists of 12 turns of the same gauge wire and is wound in the same direction as the other two windings. L5 is the coupling coil which will couple the aerial system to the receiver. Join one of the feeder lines, F1 to the start of L3 and join the other feeder line F2 to the end of L4. The end of L3 and the start of L4, the two inner connections, join respectively to the fixed and moving plate terminals of an ordinary .0005 mfd. variable condenser.

One lead of the coupling coil L5 is joined to the aerial terminal of the receiver whilst the other joins to earth. The condenser, C, tunes the doublet aerial system to the desired wave length. Note that this tuning is not critical but a definite point at which signal strength increase can be found at any point in the wave length range between 16 and 50 metres.

The advantages of the doublet aerial are (1) it is less susceptible to electrical interference than is the ordinary type of flat top aerial, (2) it is resonated broadly to the wave lengths over which the set is to be tuned and thus increases signal strength, and (3) it can be tuned definitely to the desired wavelength with the result that both selectivity and sensitivity are improved.

Other more elaborate doublet aerial have been developed but to the writer's way of thinking this particular type will fulfil every demand placed on it by the critical short-wave listener.

The last type of aerial system with which we propose to deal is what is known as the noise-reducing aerial. The advantage of this type of aerial is that whilst it provides a reasonably efficient pick-up of radio signals, it will not respond to the "signals" of electrical interference.

To understand why this is it is necessary to realise that electrical interference — not to be confused with static — is caused by the sparking of electric motors, the ignition system of motor car engines, domestic and medical electrical machinery, and faulty electric power and telephone systems.

This interference forms what may be

(*Continued on Page 57*)

CRYSTAL RECEIVERS

A theoretical and constructional description of a collection of simple crystal sets.

AS we explained when dealing with the fundamentals of radio transmission and reception, it is necessary at the receiving end to separate the sheep from the goats. In other words, we must eliminate the high frequency carrier wave and leave only the alternating currents which can be changed in audible tones of speech or music by means of the headphones.

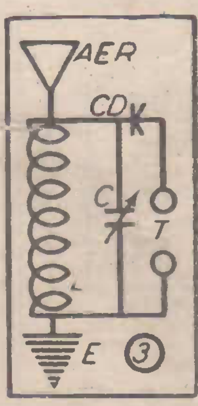
This involves the use of what is known as a detector or rectifier. This particular component possesses the property of allowing current only to flow in one direction. The alternating currents of our speech and music, when electrically transformed at the broadcasting station, flow in both directions. When we deal with headphones and loud speakers it will be understood why it is that these components cannot respond to any but uni-directional currents.

One of the very earliest forms of detectors or rectifiers was the crystal. It was discovered that certain minerals, or combinations of minerals, possessed the property of permitting current to flow only from negative to positive and not from positive to negative. Thus, if one of these crystals was interposed between the aerial and the headphones, only pulsations of direct currents and not the alternations of alternating current would be passed on to the headphones.

There have been many crystal combinations developed for detection of radio signals. Each had its merits, but most of the complicated ones have passed into oblivion, leaving us with only two or three standard crystals. These include silicon, galena, iron pyrites, carborundum and perikon.

Galena is highly sensitive but, being very smooth and requiring a light catwhisker adjustment, is quite unstable in operation. Silicon requires a heavier contact, but is much less sensitive than galena. Perikon and carborundum are very stable in operation, but are not so sensitive as either the perikon or the silicon detectors.

With crystals such as galena and silicon a cat-whisker contact is made with the crystal by means of a light wire.



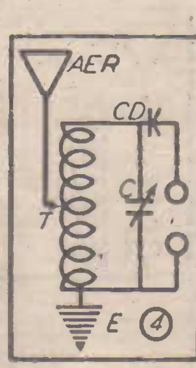
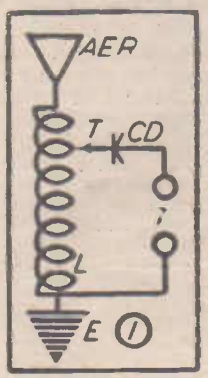


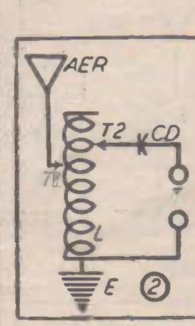
Fig. 3 illustrates the simplest crystal receiver employing a tuning condenser.

Fig. 4 is another version of the same circuit with the aerial tapped into the coil.

The carborundum and perikon detectors rely upon heavy spring-loaded contacts.

The next important thing to the detector in the crystal receiver is the type of headphones. Crystals are incapable of amplification, so that no wastage of





Two circuit versions of the slider type crystal set. Figure 1 shows the single-slider, whilst circuit 2 illustrates the double-slider arrangement.

the minute impulses which they rectify is possible. For this reason the headphones must be highly sensitive.

It is a fallacy to believe that the resistance of the headphones is a guide to their sensitivity. Headphones of 4000 ohms resistance are not necessarily more sensitive than 2000 ohm phones. Sensitivity of headphones is governed by the efficiency of their permanent magnets, the lightness of the diaphragms and the closeness of the gap between diaphragms and pole-pieces.

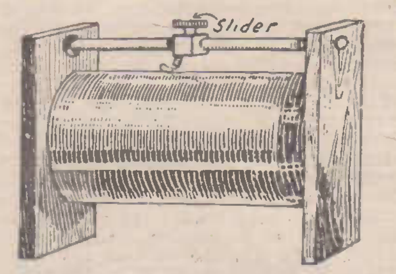
Having decided upon the crystal detector and the type of headphones which are to be used, we next must concentrate upon the selection of a circuit which will give the results for which we are seeking.

Crystal circuits are like sands on the seashore. Some are simple to the point of absurdity, whilst others bristle with refinements and complications. Glance now at Figure 1, which depicts the very simplest form of crystal receiver. Here we find that the coil L is connected directly between the aerial and earth. Tuning is effected by means of a slider, shown diagrammatically as T, which is so mounted as to traverse the coil horizontally. This movement of T along the coil removes insulation from adjacent turns of the windings allowing turn by turn to be tapped until the coil is tuned to the wavelength of the station it is desired to receive.

The crystal detector is connected in series with the crystal detector, CD, and the headphones, T. The other side of the headphones returns to earth.

It should be mentioned at this juncture that slider crystal sets have long since passed out and no slider units are available from the radio supply houses.

For the benefit of those who wish to experiment with slider sets, the following brief description of the slider and its method of mounting will be given.



A drawing of a simple single-slider type crystal set.

The slider may conveniently consist of a block of wood or bakelite measuring one inch cube. Through the centre of the block a hole, one-quarter of an inch in diameter, should be drilled out. This hole then should be cut out with a pocket knife to take a quarter-inch square brass rod. When the coil is wound (it should consist of approximately 250 turns of 26 gauge d.s.c. wire on a 4-inch diameter former) it should be mounted on wooden end blocks so proportioned that, when the slider rod is attached to these end blocks the slider will bear down on the wire.

Next attach to the bottom of the slider block by two wood screws a strip of phosphor bronze or spring brass. To this should be soldered a lead which can conveniently be brought to a terminal mounted on one of the end blocks.

Another two terminals, one mounted on each end block, will be required for the aerial and earth connections to the tuning coil.

It should be explained again that this type of crystal receiver is very unselective and should be built only from an idea of experimental interest.

We come now to Fig. 2 which shows a crystal circuit which retains the slider principle but which is more selective than the first version. In this receiver two sliders are used. They are mounted on opposite sides of the coil former in the manner previously explained for the single slider.

To slider No. 1 is connected the aerial whilst slider No. 2 carries a lead from the crystal detector, CD. The detector is connected in series with the headphones, T, which join to earth.

This type of slider-operated crystal receiver is more efficient than that shown in Circuit No. 1, because it is possible to tune the aerial by moving slider No. 1 up or down the coil. The effect of this is to resonate or tune the aerial to the wavelength of the station to which it is desired to listen.

This circuit is more selective than the first. but still does not give that control of tuning which is the looked-for feature of modern radio receivers. Incidentally, the number of turns for L may be the same as for the single slider receiver.

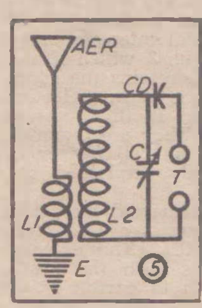
In Figure 3 we find that the idea of the slider tuned set has been scrapped. In this circuit we have replaced the slider with a variable condenser which, in conjunction with the coil L resonates the receiver to whatever wavelength it is desired to listen. The condenser, C, should have a capacity of .0005 mfd., whilst the tuning coil, L, should consist of 50 turns of 26 gauge d.c.c. wire wound on a 2¾inch diameter cardboard or bakelite former. Here, again, we find the crystal detector connected in series with the coil and the headphones, the latter returning to earth. Note that this circuit is identical with that of Fig. 1 except that in the former tuning was effected with a slider which reduced or increased the amount of inductance (coil) in circuit.

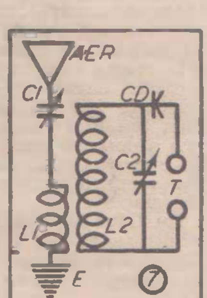
Like Fig. 1, it suffers from lack of selectivity, but otherwise is very efficient when properly built.

In Figure 4 we see what at first glance seems to be a reversion to the old slider. This is not so, however, for T in this diagram merely represents a tap on the tuning coil, L, to which the aerial is connected. The purpose of this tap is to reduce the loading effect which the aerial has on the coil and thus to improve the selectivity of the receiver.

In other respects, the circuit of Fig. 4 is similar to that of Fig. 3. The tuning-coil, L, has the same dimensions. The tap may be made at the 15th turn from the earth end whilst winding the coil. To do this merely make a loop in the wire (one about six inches in length will do), twist the wire together, and proceed with the winding. The insulation should be bared from the loop and the wire fastened to the set's aerial terminal.

Although we have suggested that the loop be made at the 15th turn from the earth end, it would be a good idea to make three loops. The first should be made at the 15th turn from the earth end of the winding, the second at the 10th turn, and the third at the fifth turn. This will permit the experimenter to determine which aerial tap gives him the best compromise between sensitivity and selectivity. The tap which gives best results should be permanently connected to the aerial terminal. Roll the other two loops up out of the way and see that their bared leads do not come in contact with each other.



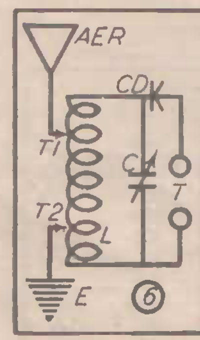


Figures 5 and 7 are two standard aperiodic coupled aerial crystal circuits, the latter having a variable condenser in the aerial lead.

In circuit No. 5 we meet, for the first time, what is known as a loosely-coupled circuit. Here we have the aerial connected to a coil of few turns which is so placed in relation to the main tuning coil, L2, that inductive effects will cause currents in the aerial coil, L1, to be transferred to the main coil, L2. This arrangement effectively removes the damping which the aerial exerts on L2 and thus improves the selectivity of the receiver to a marked extent. The farther that L1 is separated from L2 the greater will be the selectivity and the less will be the volume.

L1 may consist of 15 turns of 26 gauge d.c.c. wire wound on a 2¾in. diameter former. L2 consists of 50 turns of the same gauge wire wound on the same former as L1 but separated from this coil by ⅛ of an inch. Both windings should be laid on in the same direction. CD is connected in series with the coil and the headphones, T, the other side of which join to the earth end of L2 which is, in turn, connected to the earth end of L1. The earth ends of L1 and L2 are those ends of the coil nearest to each other.

This circuit is by far the most selective we have yet examined and it can be relied upon to give complete separation of local stations when used on a small aerial. However, due to the use of moderately loose coupling and to the employment of a small aerial, volume will not be all that could be desired.



In order to obtain greater selectivity, it will be seen that both the aerial and earth leads are tapped into the tuning coil.

In Figure 6 we come back to tapped tuning coils used in a circuit which has proved to be the most efficient of the simple crystal sets yet developed. In this circuit both the aerial and the earth leads have been tapped into the grid coil in a manner which practically reduces all load on this coil. It will be noticed that the crystal detector has been connected in series with the headphones and the tuning condenser, C, which is connected across the coil. The coil, L, consists of 50 turns of 26 guage d.c.c. wire wound on a 2¾-inch diameter former and tapped at the 17th and 34th turns from the start of the winding.

The crystal detector is connected to the start of the winding and the aerial to the 17th turn tap. The earth joins to the 34th turn tap, whilst one side of the headphones is returned to the end of the coil. This circuit is particularly selective, yet is so constituted that it also is sensitive enough for suburban receiving conditions. Considering its general performance and its simplicity of design, it represents a design which should appeal to all crystal-set builders.

In Fig. 7 we have a refined version of the crystal receiver dealt with in Fig. 5. The two circuits are identical but for the fact that a condenser, C1, is connected in series with the aerial coil and used to tune the aerial. In these circumstances, the aerial coil can be increased to 25 turns and the condenser, which should be variable, may have a capacity of .0005 mfd.

Besides improving the signal strength on all stations, due to the fact that the aerial can be resonated to the desired wavelength, this arrangement adds to the receiver's selectivity. At the same time Fig. 7 cannot be compared with Fig. 6 as far as all-round results are concerned.

In Fig. 8 we have the de-luxe type of crystal receiver in which selectivity is obtained by what is known as pre-selection. This involves the use of two tuning circuits between the crystal detector and the aerial coil. The coil, L1, is the aerial and may consist of 15 turns separated from the main winding, L2, by ⅛ of an inch.

L2 consists of 55 turns. Both L1 and L2 are wound in the same direction on a 2¾-inch diameter former with 26 gauge d.c.c. wire. The second tuned winding,

The simplest form of crystal detector.

L3 consists likewise of 55 turns of 26 gauge d.c.c. wire on another 2¾-inch diameter former. The two coils, L2 and L3, should be mounted inside separate 3-inch diameter screening cans and the connecting leads from each kept apart.

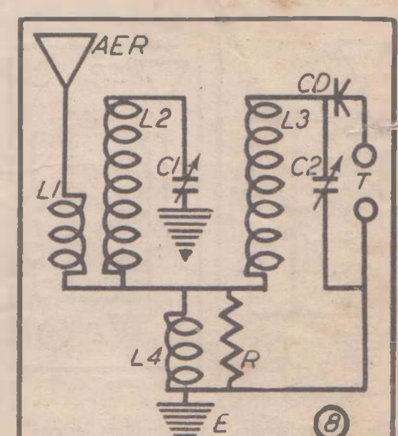
The coupling coil, L4, consists of 25 turns of 30 gauge d.c.c. wire wound on a half-inch diameter rod. R is a 25,000 ohm resistor, the purpose of which is to provide the leakage necessary for satisfactory coupling between the two tuned circuits.

The crystal detector, CD, is connected in series with the telephones, T, which return to earth. C1 and C2 are standard .000375 mfd. condensers connected together to form a gang unit. It should be noted that one form of this receiver has been developed using the latest type iron-dust tuning coils. The high efficiency of the iron-dust coils, and the careful matching of their windings, has resulted in the pre-selected crystal receiver being an excellent performer. It is capable of extreme selectivity and good volume and is especially recommended to listeners residing in districts near powerful broadcasting stations.

It should be stressed, however, that success with the receiver will hinge upon the matching of the coils. They should be wound alike mechanically and the gang condenser should be carefully trimmed in order that its two sections shall keep in step throughout the tuning range. The receiver is essentially one for the crystal set experimenter who has had considerable experience. It has been included to make this review of crystal receivers complete.

One point which should be borne in mind by the crystal set builder is that there is no room in crystal set design for slipshod workmanship and poor connections. Solder every lead, insulate all parts of the receiver and wind the coils carefully and to the specifications set down.

Even the humble crystal can be made to perform well if it is properly handled, but care must be taken to conserve every scrap of the minute energy picked up by the aerial system.



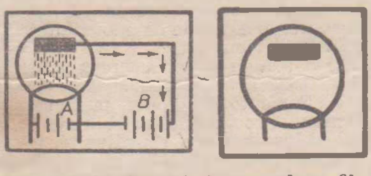
This crystal circuit arrangement depicts how a pre-selector can be added.

— VALVES —

Their Theory and Their Operation

THE valve is the most versatile component in the radio receiver. It can be used as a detector, as an amplifier and as a rectifier of alternating current power. Other specialised tasks also can be carried out.

To understand fully the functioning of the valve we must go back to Edison's early experiments. Whilst investigating the properties of incandescent electric lamps, Thomas Edison discovered the effect which later was given his name. The Edison effect is the phenomenon which takes place when in an evacuated bulb is placed a filament and another element which is called a plate. When the filament is made incandescent it emits a number of electrons. If a positive potential is applied to the plate, and the filament is lighted, it will be found that electrons emitted from the



Showing the flow of electrons from filament to plate and the current flow from plate to filament. (Right): The symbol for a diode or two electrode valve.

filament are attracted to the positively-charged plate and current is caused to flow from the plate to the filament. Remember this, for it is the basis upon which all valves function. **Electrons flow from Filament to Plate. Current flows from Plate to Filament.** Now, as current flows only in one direction, it can be seen that this valve is a rectifier just as is the crystal used in a crystal receiver.

Edison's discovery was applied by Dr. Fleming, an eminent British scientist, to develop the first receiving valve. Fleming's valve, however, represented little if any, improvement on the crystal detector. It was not sensitive and it could not amplify signals.

Then came DeForest, who introduced a third element, the grid, into the Fleming valve. The improvement changed the whole face of radio transmission and reception and made possible the present broadcasting system.

The Grid may be called the Radio Traffic Cop, for it controls the number of electrons which are allowed to reach the plate from the filament. We know that the more electrons which reach the plate the greater will be the current flow, so it can be seen that the grid will control not only the electron flow but the current flow from plate to filament

Glance at the diagrams of the two types of valve. In the diode or two-element tube we see that the electron flow will be fixed by the capability of the filament to emit electrons and by the potential which is applied to the plate. The higher the potential the greater will be the attraction of electrons.

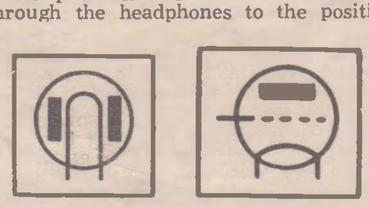
Now, we must understand that the filament is always operated at a more negative potential than is the plate. In the second diagram we find that the grid, which is a fine-wire mesh interposed between the filament and the plate in the valve structure, is operated also at a negative potential. In this case it is at the same negative potential as the filament. There is a fundamental electric law that Unlikes attract and Likes Repel. Thus, the more negative we make the grid of the valve with respect to the filament the more repulsion will be offered the negative electrons emitted from the filament. If we make the grid positive it will attract electrons from the filament and allow these to pass through its open mesh to the plate.

Let us now examine the operation of a valve as a detector.

In the circuit diagram of the one valve receiver we find that the aerial is connected to the tuning coil, L, which is tuned by means of the variable condenser, C. So far, we have the conventional tuning circuit we have been examining in the crystal sets. The valve, V, is a triode, i.e., a valve possessing a filament, a plate and a grid. Between the tuning circuit and the grid of the valve is a small condenser, C1, which has a capacity of between .0001 mfd. and .00025 mfd. This is known as the grid condenser

Connected between the grid of the valve and the positive side of the filament is a resistance, R, which may have a value of from one to two megohms. This is the grid leak.

The plate of the valve is connected through the headphones to the positive



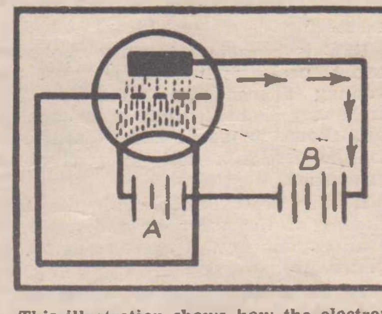
These two symbols illustrate a duo-diode and a three electrode valve respectively.

side of a "B" battery having a potential of from 20 to 60 volts. The negative side of the "B" battery is joined to the negative side of the "A" battery.

In operation, we find that the alternating current impulses picked up by the aerial reach the grid condenser, C. This condenser has the property of allowing alternating currents to flow through it but of blocking direct currents. Now, at a given instant, we shall presume that at a negative half-cycle of the alternating current signal reaches the grid of the valve, making it more negative than ever with respect to the filament. In these circumstances, none of the filament electrons will be permitted to pass through the grid mesh and no plate current will flow.

On the next half-cycle of the alternating current the polarity reverses and the grid receives a positive potential from the signal. This results in the grid being made positive with respect to the filament. Electrons flow from the grid to the plate and current flows from plate through the headphones to filament.

This see-saw action goes on at a speed corresponding to the speed or frequency of the alternating current impulses from the broadcasting station.



This illustration shows how the electron flow is controlled by the grid, whilst the direction of current flow is shown by the arrows.

The negative potential left on the grid during the negative half-cycle must be removed or it would cause the valve to "block" and cease to function. To do this, the grid leak, R, is connected between grid and filament.

From this brief survey of the action of a detector valve it can be appreciated that small potential changes on the grid cause larger current variations in the plate circuit. This feature of the valve is very useful, for it permits us to make the valve amplify if desired.

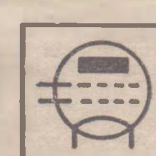
The simple detector circuit shown is only a little more sensitive than the crystal detector and is rarely if ever used in modern receivers. To improve the sensitivity of a detector we employ what is known variously as regeneration, reaction, or feedback. Glance at the second detector circuit whilst we explain how regeneration is obtained.

This circuit is slightly different to that of the original detector circuit. It has a loosely-coupled aerial system in which the aerial coil, L1, is coupled to the main tuning coil, L2. This does not have any bearing on the functioning of the regenerative detector, though.

Regeneration is obtained through the medium of the coil, L3, its degree being controlled by the variable condenser, C2. L3 is coupled fairly closely to the grid coil. When a positive potential was impressed on the grid through the condenser, C3, we found that current was made to flow from plate to filament. This momentary current flow sets up an alternation in the coil, L3, and, because this coil is coupled to the grid coil, L2, the alteration is transferred to the latter coil by induction.

Thus we have fed the same signal impulse through the detector valve twice.

By the inclusion of a second grid a valve is known as a screen grid tube, and is illustrated as shown in the accompanying diagram.



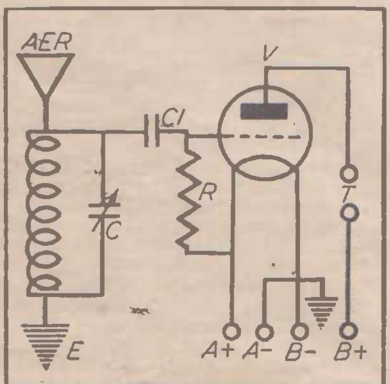
The number of times which the impulse can be fed back is limited, for if it goes over a certain point the detector valve will go into oscillation and all the advantages of regeneration will be lost.

Regeneration is really a form of amplification and increases the sensitivity of the detector to an extent that it will respond to very weak signals. Control of regeneration can be obtained either by varying the separation between the grid winding and the feedback winding or by means of what is called a Throttle condenser which allows more or less of the feedback energy to leak away to earth.

RFC is a radio frequency choke coil which possesses the property of preventing alternating currents of high frequency from travelling through the headphones to earth instead of passing to the feedback coil to produce regeneration.

Having dealt briefly with the functioning of the valve as a detector, we shall explain how it operates as an amplifier.

To understand how the valve amplifies let us consider the analogy of a



A simple detector circuit.

lever. If we have a long rod and pivot it close to one end we find that a small movement at the short end of the pivot will cause the extremity of the rod to move over a wide arc.

This is exactly what happens when the valve is used as an amplifier.

A small signal impressed on the grid causes wide changes in plate current, so that it becomes possible to control large amounts of power with very small variations in input voltage to the grid. Some valves have amplification factors of up to 1500, that is to say, a change of one volt on their grids would result in a voltage change of 1500 in their plate circuits.

The positioning of our pivot point on the valve — again using the analogy of the lever — is arranged by varying what is known as the grid bias or "C" bias potential. This is usually derived from an auxiliary or "C" battery so arranged in the circuit that it impresses a steady negative potential on the grid of the valve. The more "C" voltage applied to the grid of the valve the less the response of the valve to small variations of incoming grid voltages (corresponding to shifting the pivot of our lever to a central point). On the other hand, too little "C" voltage will result in improper operation of the valve and distortion will result.

So far we have dealt only with two types of valve — the diode and the triode. There are other types of valve in which additional elements have been included for special purposes. Chief amongst these are the screen grid valve and the pentode. In still other types two complete sets of elements have been included in the one bulb so that the single valve is able to perform two or more functions simultaneously. We shall touch upon the latter type but briefly.

The Screen Grid Valve

This type of valve has been developed specially for amplification at radio frequencies. We have seen how, with the triode valve, it is possible to obtain regeneration or feedback by means of a coil coupled to the grid circuit. It also is possible to obtain the same effect by means of a condenser connected between the plate and the grid.

A condenser consists of two metal plates separated by a dielectric. A vacuum is a dielectric and the two plates of the condenser in a valve are the Grid and Plate. If the capacity between these two is high enough energy will pass back from the plate to the grid and oscillation will take place.

We have found that regeneration is useful to increase amplification, but that oscillation impairs the sensitivity.

When triode valves are used as radio frequency amplifiers their internal capacity, as this condenser effect is called, prevents full use being made of their amplifying characteristics.

To overcome this defect a fourth element, called the Screen Grid, has been introduced into the latest type of radio frequency amplifying valves. This has the effect of reducing the internal capacity and at the same time of screening the grid from the plate. Another advantage of the screen grid is that it permits very high amplification factors to be obtained from the valves. The screening grid is usually operated at a lower voltage than the plate. For example, if the plate voltage is 135 the screening grid voltage is 67½.

Another type of radio frequency amplifying valve is known as the radio frequency pentode. This has three grids, a plate and a filament. The pentode possesses even better amplification characteristics than the screen grid valve, and the screening grid in it is operated at a much higher potential than in the first type. The third grid is a suppressor grid placed between the filament and the true or control grid.

There are also audio frequency pentode tubes which have been designed for maximum efficiency. Only small input signal voltages are required to get large power outputs from these valves.

We come to the special purpose valves, such as the frequency changer tubes used in super-heterodynes, diode-triode and diode pentode types for detection and audio or radio frequency amplifiers, twin valves for class "B" audio amplification and the like. Each of these has been designed for use in fairly complicated receiver circuits, so we shall not deal with them here.

The final type is the power rectifier type. This is a diode valve provided with one or two rectifying plates. The single plate type is known as a half-wave rectifier, whilst the two plate types are full-wave rectifiers. Both types are used to change high voltage alternating currents into direct currents suitable for use as plate and grid voltages for the receiver valves.

The operation of these valves will be dealt with when we come to power packs.

Operation of Valves

The application of the various valve types is governed mainly by circuit requirements.

In battery receivers, where economy of operation must be considered, the question of filament consumption must be watched. There are battery valves which require a filament current as low as 50 milliamperes, whilst others go as high as 300 milliamperes. In general, it may be said that the two-volt low consumption type valves will give best all-round performance in battery receivers.

Valves for all electric receivers may be selected from either the 2.5, 4 or 6.3 volt filament type. Each is efficient and each is equally economical in regard to filament power. In any case, slight difference in power requirements are not worth considering with an all-electric receiver which derives its power from the supply mains.

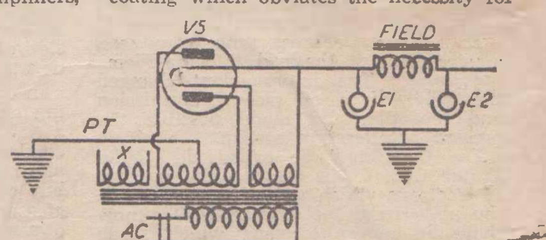
In general, we may say that for radio frequency amplification screen grid or radio frequency pentode valves are desirable. Triodes are no easier to wire into circuit and cannot give the amplification of the newer type valves. Furthermore, the triode is more subject to oscillation troubles.

For detection either a screen grid valve or a triode may be used. The triode is very simple to get going, particularly if reaction is to be applied, but the screen grid valve is more sensitive.

For audio amplification either the pentode or the triode can be used. Modern pentodes possess excellent tonal qualities and are much more sensitive than triodes. It should be remembered that, with a pentode power valve, it is undesirable to include an additional audio stage between the detector and the output valve.

When selecting a power valve for battery receivers always keep an eye on its consumption. Pentodes give the most audio power for the least "B" battery consumption. Rectifier valves for all electric receivers should be selected with regard to the total plate current consumption of the receiver and the voltage at which the rectifier must work.

There is not a great deal to choose from between the performance characteristics of any of the modern valves. Some valves are sprayed with a metal coating which obviates the necessity for



A conventional power-pack circuit using a full-wave type rectifier.

shielding in high gain circuits. Others require external metal shields. In the range of A.C. valves for all electric receivers we find the newly-developed metal tubes. These give equally as good a performance as glass envelope types and are more compact in design.

Care should be taken when using any valves to be sure that the socket connections are made correctly. Half the trouble and nearly all the premature burn-outs of valve filaments can be traced to incorrect wiring to the valve sockets.

Don't try to operate valves of great or less filament voltages than those

(Continued on Page 44)

AUDIO FREQUENCY AMPLIFICATION

This discussion of audio frequency amplification covers all conventional methods of coupling and deals interestingly with constructional and control points.

WE already have explained how the valve amplifies weak impulses fed into its grid. In this section we shall now deal with the practical design of audio frequency amplifiers.

The audio amplifying stages can be divided into two classes; those stages which amplify voltage and those which amplify current or power.

In all types of radio receiver it is only the final amplifying stage which is a power amplifier. The preceding stages simply build up the voltage until it is of sufficient magnitude to swing the grid of the power valve; in other words, to energise the valve sufficiently to enable the rated power output to be obtained.

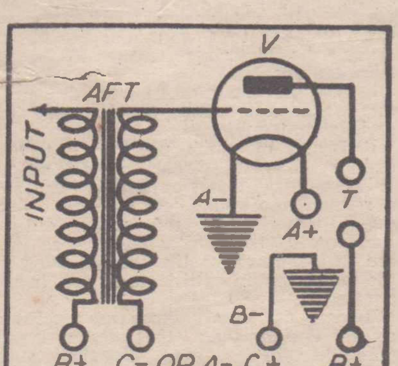
There are a few points which must be cleared up before we deal with amplifier design.

The yard-stick of volume is Power Output in watts or milliwatts. An output power of 500 milliwatts is sufficient for good loud speaker volume in a room of average dimensions. For greater volume, we may go to powers of the order of 3000 milliwatts or three watts. Amplifiers for public address work range in output from 5 to 50 watts. Greater output power implies better reproduction of the low notes, all other things being equal.

The grid swing of a power valve is the amount of signal voltage necessary to obtain the rated power output. Pentodes are more economical in this respect than are triodes. The less the grid swing the fewer the number of voltage amplifying stages required between the input signal and the power valve. A "stage" consists of a valve and its associate coupling circuits. The amplification per stage is the product of the amplification factor of the valve and the step-up or step-down ratio of the coupling unit.

A resistance coupling unit has a loss and usually is considered to have a stage gain of 9/10ths, or .9. A transformer coupling unit may have a gain of from .5 to 7.

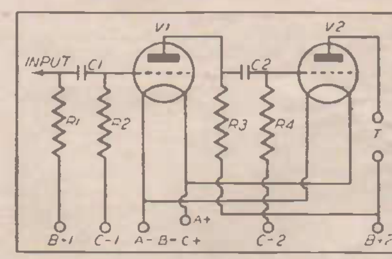
To calculate the amount of amplification required it is necessary to know the input signal voltage at the start of the audio amplifier and the voltage which must be delivered to the grid of the power tube. This is the grid bias voltage divided by .707.



A single-stage transformer-coupled audio amplifier.

For example, take the case of a pentode, such as the AL3, which requires a grid bias of 6 volts when operated at its rated plate voltage. Suppose, then, that the audio frequency voltage delivered from the detector plate circuit is .2 volts. Then we require a total amplification of:—6 volts x .707 divided by .2 or 21.21 between the detector output and the power valve grid.

We look up our valve charts and find that we can use a triode valve having an amplification factor of 10. Perhaps we have a 3/1 transformer on hand. The total stage gain we can expect from this stage then is 30.



A resistance-coupled two stage amplifier.

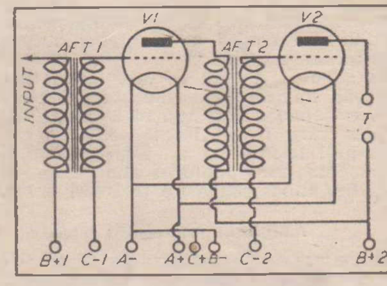
But we still have to couple it to the detector stage. We shall use resistance-coupling which we have decided has an amplification factor of .9. Thus the overall amplification of our stage is .9 times 30 or 27, which leaves an ample margin for weaker signals than the .2 volts on which we based our calculations.

On stronger signals the output valve will be overloaded, so we have to place a volume control in circuit. Volume controls may consist of high-resistance potentiometers. They can be connected either in the grid circuit of a resistance coupled stage, where they replace the grid resistor, or across the primary of an audio frequency transformer.

In the first circumstance they should have a resistance of 500,000 ohms, whilst in the second 100,000 to 250,000 ohms will be sufficient. Methods of connecting the controls into circuit are shown in the diagrams.

Volume controls should always be connected as early as possible in the amplifier. If they are connected in the final stage there is always the possibility of overloading taking place in the preceding valves.

Now, in regard to the valve used as a pre-amplifier. This should always be chosen with an eye to its grid swing. Generally speaking, high amplification factor valves require less grid swing than do low amplification types. It is not of much use placing a valve with, say, a grid swing of 1 volt in a part of the amplifier circuit in which 2 volts will be delivered in order that the power valve shall be fully loaded. It would overload the first amplifier valve and cause distortion.



A two stage transformer-coupled audio amplifier.

To make this matter clear let us take another amplifier set up. Suppose it is decided to use a 45 type valve in the final stage. This valve requires a grid bias of 50 volts and thus has a grid swing of 50 divided by .707 or approximately 35 volts. The output from the detector circuit is .2 volts as in the previous example so that the total amplification necessary will be 175.

Now suppose we have a 3/1 ratio transformer and a valve having an amplification factor of 10. The total stage amplification is 30, so we must employ another stage. If we make this a resistance-coupled stage we will have two resistance coupling units between the detector output and the grid of the second last amplifying valve. The total loss will be .9 x .9 or .81 for the two stages. We now want a valve having an amplification factor equal to 30 divided by 175 x 1.1, or approximately 8.

Let us check this back. The gain of each resistance coupling stage is .9 The amplification factor of the first stage tube is 8. The amplification factor of the second stage tube is 10 and of the audio transformer 3. We require 35 volts on the grid of the final tube and have .2 volts input to the amplifier. Therefore .9 x .9 x 8 x 10 x 3 x .2 equals 35.

Actually, this equals nearly 39 volts, so that we have a little more amplification than we require.

The point is, however, that we shall have 1.1 volts at the grid of the second amplifier tube when we get full output from the power tube. If the second amplifier tube is biassed only to 1 vote it will be overloaded and distortion will result. Be sure, therefore, in planning an amplifier that the valves before the power tube are not overloaded before the latter delivers full output.

If a one-volt signal will reach the grid of an amplifier tube, bias it to two volts to provide a safety margin. Remember that the bias also is dependent upon the plate voltage applied to the tube.

A point which must be borne in mind is the matching of the loud speaker to the output tube. With battery tubes the average magnetic-type speaker will provide a reasonably good match. With dynamic loud speakers, however, it is essential that the impedance match shall be as close as possible.

The actual plate impedance of the valve is not the impedance on which to work for this match. Most valve manufacturers provide information on the rated load impedance under working conditions and this is the figure which should be followed in arranging output transformer matching.

As a guide it may be mentioned that the load impedance of the average pentode is between 7000 and 8000 ohms. The triodes vary from 1500 to 3500 ohms, push-pull triodes go as high as 6000 ohms. Push-pull pentodes and class B amplifier tubes range up to 20,000 ohms.

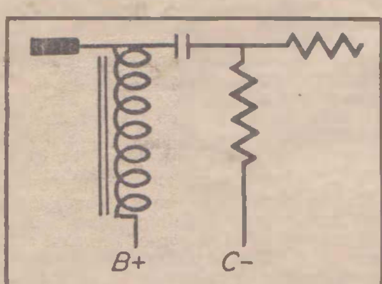
Amplifier Couplings

There are three main types of amplifier couplings. These are transformers, resistance-capacity units and impedance-capacity units and direct coupling.

Transformers are still widely used, and in certain amplifier circuits are indispensable. The modern audio transformer has a low step-up ratio which never exceeds 3½ to 1. The higher the step-up ratio between the primary and secondary windings the higher the amplification of the transformer but the poorer its frequency response, i.e., its even amplification of all audible tones from 30 to 10,000 cycles per second.

Good transformers have large cores, a large number of turns on the windings, and very little capacity between portions of the windings.

They are capable of flat, i.e., even, amplification throughout the audible range. When it is desired to use valves in push-pull connection the audio transformer must be of the centre-tapped variety. In this circumstance one grid is connected



A standard choke-coupled system.

to each outside terminal of the transformer and the centre terminal becomes "C" bias terminal.

Some English and Continental transformers are differently labelled to the American and Australian types. The markings on the terminals of the latter are:—P, plate; B, "B" battery positive; G, grid; and C, "C" battery negative. On the Continental transformers we find the markings are as follow:—IP, plate; OP, "B" battery positive; IS, "C" minus; and OS, grid.

Transformer coupling gives a definite step-up depending upon the ratio of primary to secondary turns. The more turns there are on the secondary, in relationship to the primary, the greater the ratio and the greater the step-up.

Resistance and impedance coupling arrangements have no natural amplification; in fact, they reduce amplification by 1-10th.

The various circuits show the methods of employing these forms of coupling.

Usually, the grid resistors in a resistance or impedance-coupled units have a maximum resistance of 500.000 ohms. The chief advantage of the impedance coupling is that it allows much greater voltages to be applied to the plates of the amplifier valves than does the resistance coupling system, which might employ 100,000 or 250,000 ohm resistors. Both the resistance and the impedance coupling methods are noted for the tone quality which they are capable of providing when properly designed.

It is worthy of note that, in order to ensure good low note response, the coupling condenser between the grid and plate of each amplifier tube should not have a capacity of less than .02 mfd. This can be increased to .05 or .1 mfd. with advantage. These condensers, however, should be of the very highest quality, for any leakage of the "B" battery voltage across to the grid of the amplifier tube will destroy the bias on the latter and cause distortion. For this reason. mica condensers should be used whenever possible. From the design viewpoint it is desirable to avoid the use of more than one transformer-coupled stage. No pre-amplifier stage should be used when a single pentode output tube is employed, if this can be avoided. Two or even three resistance-coupled stages can be used together. In fact, two resistance-coupled stages are usually necessary to obtain the amplification normally possible from a single transformer stage.

We come now to a discussion on the practical side of amplifier building. The type of amplifier to be used will depend upon the power output required. For powers up to 2.5 watts a single triode or pentode may be used. Modern pentodes will deliver audio outputs of up to 7 watts at reasonably low plate voltages. When more power than this is required. it is necessary to go to a push-pull amplifier stage.

A suitable single valve battery amplifier might consist of a single pentode such as the C243N, the PM22A or the 1D4. This type of tube will deliver an audio output around 500 milliwatts at a plate voltage of 135 and is most economical to operate. No pre-amplifier stage will be necessary with any of these valves when transformer-coupled to the plate of the detector tube of the ordinary battery receiver. Be sure, however, when using any amplifier tube, to see that it is biassed in accordance with the manufacturer's instructions.

Bias can always be juggled to suit the particular operating requirements. For example, if a valve requires a bias of 9 volts at 180 volts plate potential, it is fairly safe to give it a 3 volts negative bias at 60 volts plate potential. Reduce the bias in proportion to the reduction in plate voltage and you'll not go far wrong.

On the other hand, a valve which requires only, say, 4½ volts bias at 150 volts, may work quite satisfactorily without bias at some lower plate voltage—60 for example.

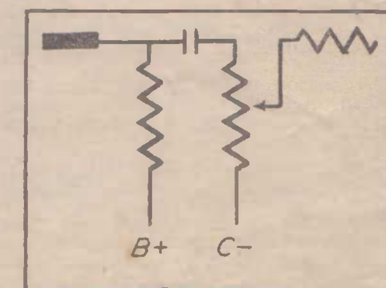
In battery receivers the pentode offers the most economical form of power amplification. In all electric receivers it may be desirable to use triode valves in push-pull. The principle of a push-pull amplifier is that the alternating currents of the input signal are fed to the primary of the coupling transformer and are reproduced, stepped up in voltage according to the turns ratio of the transformer, in the secondary winding. At one instant one end of the secondary winding is negative and the other is positive. The negative end feeds a negative voltage to the grid of the valve to which it is connected.

This, in conjunction with the fixed bias on the grid of the valve, is sufficient to prevent all electron flow and valve is inoperative.

At the same instant, however, a positive voltage is being fed to the other end of the transformer and thence to the grid of the other push-pull valve. The result is that electrons and thus plate current is caused to flow and the valve delivers an amplified signal to the loud speaker.

The next instant the cycle of events reverse and Valve No. 1 operates whilst No. 2 remains quiescent. Thus each valve of the pair works alternately.

The advantage of push-pull amplification is that it permits three times the power available from a single valve to



This diagram shows how a volume control is wired in a resistance-coupled amplifier.

be obtained from the pair, and that the distortion is reduced considerably because the inequalities in each of the valves cancel out.

It is a recognised fact that the better the amplifier the more it is prone to motor-boating and kindred effects. These effects are only symptoms of oscillation at audio frequencies, but of a similar type to that experienced in detectors and radio frequency amplifiers. These oscillations are caused by the feed-back of energy from one stage to another via the "B" battery supply. The cure for motor-boating is to de-couple the grid and plate circuits of each stage of the amplifier by means of condensers and resistors. For example, a resistance may be connected between the "B" plus terminal of the audio transformer and the "B" supply line. A condenser also is connected between the transformer "B" plus terminal and earth. The usual decoupling resistor has a resistance of 10,000 to 15,000 ohms whilst the condenser may have a capacity of from .5 to 2 or even 4 mfd.

In the grid circuit the de-coupling resistances are connected between the "C" minus terminal of the audio transformer and the "C" supply line. The condenser is connected between the "C" minus terminal on the transformer and earth. The condensers should have a capacity of 1 to 4 mfd. and the resistances should range from 100,000 to 250,000 ohms.

It may not be necessary to de-couple more than one stage to overcome the oscillation trouble.

It is not of much use trying to decouple the plate circuit of the output valve because this would only result in a reduction of plate voltage and consequent lowering of the power output. Incidentally, these filter circuits, as they are called, improve the tonal fidelity of the amplifier in which they are incorporated.

Remember, in all types of amplifiers so to design them that there is no possibility of any but the final stage overloading. Use the best components available. Poor transformers will result in poor quality and poor resistors will

(Continued on page 28)

RADIO FREQUENCY AMPLIFICATION

The different systems and operation of the various methods of radio frequency coupling are fully dealt with in this article.

ALTHOUGH the volume which can be delivered from any receiver can be increased tremendously by a properly designed audio frequency amplifier, the actual sensitivity of the set cannot be improved by this means.

If a given signal is too weak to actuate the detector valve, all the audio amplification in the world will not make the signal audible.

For this reason we employ amplifiers operating at radio frequencies. These increase the strength of signals before they are detected or rectified, add to the selectivity of the receiver by reason of the tuned circuits they employ, and reduce the noise level by providing a more powerful signal for the detector to handle.

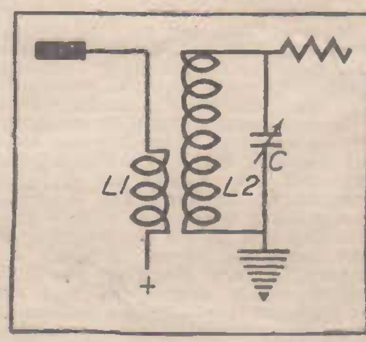
It is not proposed to deal with the obsolete type of triode valve r.f. amplifier. There are too many snags in the successful operation of this type of amplifier for the beginner. On the other hand, the screen grid valve is particularly suited to r.f. amplification, is easy to install, and is capable of providing high amplification without regeneration and kindred troubles.

On broadcast wavelengths it is possible, by careful design, to obtain amplifications of 120 per stage without the slightest trace of instability. These high figures, however, pre-suppose the use of highly-efficient coils and the careful layout of components. One point which must be kept very much in mind, when building radio frequency amplifiers, is that the grid and plate leads to any valve must be kept entirely separate. Even at audio frequencies, coupling between the grid and plate leads can cause trouble, but at radio frequencies it is suicide to bring the leads into proximity to each other.

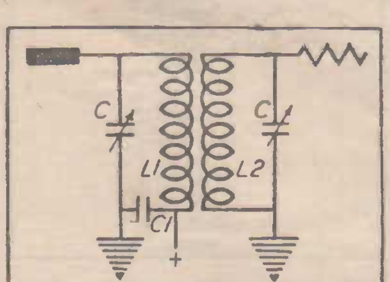
Incidentally, it is of interest to note at this juncture a fault which often occurs with a receiver incorporating an r.f. amplifier and a regenerative second detector. Regeneration does not take place at certain parts of the waveband when the r.f. amplifier is connected into circuit. With the r.f. valve removed, and the primary of the r.f. transformer used as an aerial coil, it is possible to obtain smooth control of regeneration but, as soon as the r.f. valve is plugged in, the set refuses to function satisfactorily.

This is always caused by oscillation in the radio frequency amplifier. When this valve oscillates it throws the detector out of oscillation and prevents the receiver from functioning properly. Correct placing of the radio frequency valve and its components and careful screening of the r.f. circuits from the detector circuits always cures this trouble.

We come now to a question of the coupling circuits to be used between the radio frequency valve and the detector valve. There are four general methods of coupling an r.f. valve to the following tube. These are:—(1) The Tuned Anode coupling, (2) the transformer coupling, (3) the impedance coupling and (4) the band-pass coupling.



A radio frequency transformer is used here for coupling the two valves.



This method of coupling is known as "Band-Pass" coupling.

Let us examine them one by one, enumerate their advantages and faults, and generally put them under the microscope.

Tuned Anode Coupling

It is worthy of note before starting this discussion that, in order that maximum energy shall be transferred from one circuit to another, it is necessary that the impedance of the load, i.e., the circuit into which the energy is to be fed, shall equal the impedance of the source from which the energy comes. Practically speaking, this means that the impedance of the radio frequency valve must be matched by the impedance of the coupling circuit.

In practice this is rarely possible, so we have to accept a compromise. This means that we cannot hope to obtain the full amplification of which the screen grid valve is capable.

Despite the fact that under almost ideal conditions it is possible to obtain stage gains of 120 the average set-builder must feel quite happy if he gets a stage gain of 50, because the average stage gain never exceeds 30.

Realising, however, that an impedance match is necessary for best results, it behoves us to pay considerable attention to the coils. The more efficient these are the higher will be their impedance and the better will be the transfer of energy from the plate circuit of the r.f. valve to the grid circuit of the following valve.

It was for this reason that the tuned anode or tuned plate method of coupling was adopted for use with screen grid tubes. The impedance of these valves is so high that it seemed practicable at least to approach this impedance with a tuned plate circuit.

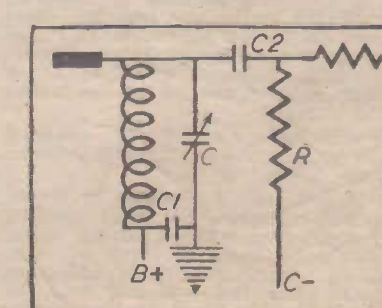
In the circuit diagram it will be seen that the "B" supply voltage is fed to the plate of the valve through the tuning coil, L, which is tuned by the variable condenser, C. In order that the moving plates of this condenser may be earthed, and that it will still do its job of tuning L, the bottom end of L is earthed through a fixed condenser, C1.

The following valve receives the radio frequency energy from the r.f. tube through the small condenser, C2, which permits r.f. to pass but blocks the direct current of the plate supply. In order that the valve following the r.f. tube shall be supplied with bias a high resistance, R, is connected between the grid of the valve and the source of bias voltage.

L is a tuning coil wound to the dimensions of the other tuning coils in the receiver and to suit the capacity of the condenser, C, with which it is tuned. The by-pass condenser, C1, may have a capacity of from .1 mfd. upwards and should be tested to withstand the potential of the "B" supply. The coupling condenser, C2, may have a capacity of from .00025 mfd. to .001 mfd. and should be of the mica dielectric type which is not susceptible to leakage.

The resistance, R, may have a resistance of from one to two megohms.

Undoubtedly this type of coupling gives a high gain. In fact, on occasions, the gain may be too high and the r.f. valve will go into oscillation. Its chief drawback is its lack of selectivity caused by the damping imposed on the tuned circuit by the r.f. valve.



A tuned anode coupling.

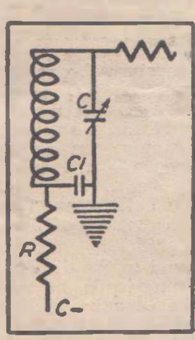
Transformer Coupling

This is probably the most popular method of coupling an r.f. valve to the next stage in the receiver. Radio frequency transformers can be made to have stage gains of up to 50, but these high figures require careful design of the coupling coil and its associate circuits.

A point to bear in mind in designing radio frequency transformers is to keep the coupling between primary and secondary as tight as possible inductively and at the same time as free from capacity effects as possible.

This is attained by winding the primary, L1, with fine wire in the grooves left between turns of the heavier wire used for the secondary winding.

For example, an excellent r.f. transformer may be made by winding 50 turns of 26 gauge d.c.c. wire on a 2¾in. diameter former and, starting at the earth end, winding in the grooves of the secondary winding a 30 gauge d.s.c. primary of 25 turns. This should be laid on in the same direction as the secondary. If it is desired to add reaction to the detector stage a reaction winding of 25 turns of 30 gauge wire may be laid on the former one quarter of an inch below the earth end of the secondary. This is wound in the same direction as the other windings.



This diagram illustrates how a negative bias battery can be connected into the circuit.

The chief advantages of the transformer method of coupling r.f. valves is that it provides adequate selectivity and reasonable gain.

Impedance Coupling

This is a highly satisfactory method of coupling radio frequency valves but, unfortunately, it can only be duplicated by the home-builder after considerable experiment. The tuning coil, L, is not difficult to construct; in fact, it quite easily could duplicate the design of the secondary coil used for transformer coupling.

The primary consists of a radio frequency choke the windings of which are so proportioned that the choke is resonant at a wave length slightly above the broadcast band, say 570 metres.

The coupling condenser, C1, is a midget, semi-fixed condenser having a maximum capacity of .0001 mfd. The advantage of this arrangement is that it has a maximum response at the high wave length end of the broadcast band around 450 to 550 metres, so that stations on this wave length, which normally would be weak, come in at a strength equal to that of the low wave-length stations.

This is the system of r.f. coupling which, when properly arranged, provides a stage gain of 120.

It is quite selective, stable in operation and represents the most satisfactory method of coupling an r.f. valve. It should be borne in mind, however, that, to ensure stability of operation, the r.f. valve and grid coil must be screened from the transformer unit comprising the r.f. choke, the coupling condenser and the secondary, L.

Band Pass Coupling

This form of r.f. coupling is highly efficient and for a long time enjoyed considerable popularity. This was because it not only provided high-stage gains, but it also was highly selective because two tuned circuits instead of one were interposed between the plate of the r.f. valve and the grid of the preceding valve.

The coils, L1 and L2, in the circuit diagram are of identical dimensions and may consist of 50 turns of 26 gauge d.c.c. wire on a 2¾in. diameter former. Each section is tuned by a condenser, C, of identical capacity. In order to allow the moving plates of the plate circuit condenser to be earthed, a by-pass condenser, C1, is connected between the "B" plus side of the coil, L1, and earth.

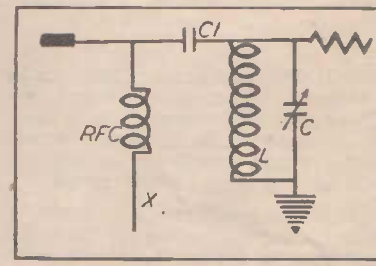
Coupling must be arranged between the two coils, L1 and L2. This may be effected by winding the two coils on the one former, but separated from each other by half an inch.

A better method is to wind them on separate formers and so mount them that coil L1 is parallel with coil L2, but its plate end reaches only one inch up from the earth end of L2. Both coils must be enclosed in a screening can to ensure stability of operation.

The only drawback to the band-pass method of coupling is that it requires two coils and two condensers, which should be ganged for ease of control. The gain is high and the selectivity is excellent with this coupling arrangement.

We come now to a consideration of the constructional features of radio frequency amplifiers. There are two types of r.f. amplifier tubes. The English and Continental type usually has the plate connection of the top. The American and Australian type tubes usually have the control grid on the top. Slightly different component lay-out methods are necessary in each case, but the main thing to watch is that the grid and plate leads are kept as short as possible and do not come close to one another.

In modern radio receivers considerable use is made of shielded or braided cable in order to eliminate stray couplings. This should not be used on the grid and plate wires of a radio frequency amplifier because the capacity effect of the braid results in the by-



An impedance-coupled radio frequency stage.

passing to earth of considerable amounts of radio frequency energy.

Be sure to screen the grid and plate coils of the radio frequency stage from each other, either by enclosing them in metal coil-cans or by placing a metal shield across the chassis between the two stages of the receiver. In any case the shield must be earthed.

Remember, that any care which is devoted to the radio frequency amplifier will be amply repaid by increased sensitivity of the receiver. Do not introduce losses into the r.f. stage unless it is unavoidable.

Some radio frequency valves require a negative bias for their successful operation. Battery-type valves are biassed from the "C" battery by means of the arrangement shown in Fig. 5, where the desired battery voltage is fed through the 100,000 ohm resistance R, which is connected in series with the tuning coil and by-passed to earth by a .1 mfd. condenser, C1.

In all-electric receivers which use indirectly-heated valves, the bias is derived through the cathode resister.

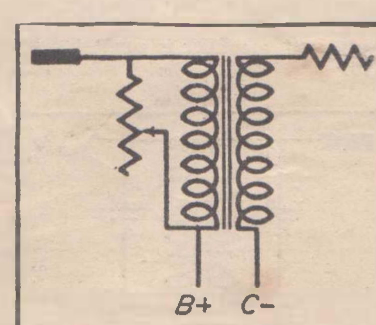
Audio Frequency Amplification— *(Continued from page 26)*

be noisy. Poor condensers will be likely to break down or at least to allow "B" battery voltage to leak through to the grid of the following valve.

In A.C. operated amplifiers remember that the hum can be caused by pick-up from the filament leads, by long grid leads and by incorrect placing of the audio transformers. Twist the filament leads together, keep the grid leads short and as far away from the filament and plate supply circuits as possible, and try twisting the audio transformer about on the chassis until a position is found in which hum is neutralised. Incidentally, de-coupling of the plate circuits will always help to remove hum. The de-coupling resistors should not exceed 15,000 ohms in value, but the by-pass condenser may be increased to 4 or even 8 mfd.

Remember that after all an amplifier can produce only what is put into it. The best amplifier in the world can be ruined by a poor receiver, detector, or gramophone pick-up. Even the best combination of amplifier and receiver or gramo. pick-up can be ruined by a faulty loud speaker.

Get a good speaker. Make sure it is in perfect adjustment, and provide it with a baffle-board of generous dimensions if you want to get the best reproduction which modern technique makes possible.



This circuit diagram shows a simple form of adding a volume control to a standard transformer couped audio-amplifier.

TROUBLE CHART

POSSIBLE SOURCE OF TROUBLE.	NO RECEPTION.	VOLUME WEAK.	IRREGULAR RECEPTION.	DISTORTION.	NOISY RECEPTION.	HUMS & WHISTLES.
"A" BATTERY	Battery exhausted. No water in accumulator battery. Battery terminals corroded.	Battery exhausted. Poor connection at corroded terminals. Charger not equal to demand on battery. Trickle charger not functioning.	Loose connection.	Battery exhausted.	Battery sulphated. Connected with charger operating.	Hum from charger operating. Whistles from depleted battery.
"B" BATTERY	Battery exhausted. Battery not properly connected.	Battery exhausted. Volume starts off well but quickly diminishes while set is played.	Defective cell. Loose connection.	Battery exhausted.	Erratic noises—battery exhausted. Fluttering, motor-boating high resistance of run-down battery.	Whistles from run-down battery.
POWER PACK	Not connected to power socket. Rectifier valve not operating. Filter coils burned out. Resistor burned out. Fuses in power supply burned out. Plate of rectifier valve red-hot — condenser broken down or short circuit in filter. Electric light line power off — or fuse blown.	Eliminator overloaded. Rectifier valve worn out. Transformer short-circuited. Buffer condensers punctured. Filter condensers punctured. Improper resistor values in voltage divider. Electric light line voltage too low.	Interrupted current supply from power lines. Poor voltage regulation of power line.	Plate voltage too low. C bias resistors not properly adjusted. Too high resistance in choke coils. Insufficient capacity of filter condensers.	Defective resistor in voltage divider. Sparking over punctured condenser. Motor-boating — insufficient capacity of last filter condenser. Improper value of resistors in voltage divider. Rectifier valve wearing out. Broken down electrolytic condensers.	Transformer not balanced on centre tap return. Eliminator overloaded. Insufficient inductance in chokes; cores too small; resistance too high. Insufficient capacity in condensers. Choke coil short circuited. No earthed shield between primary and secondary of power transformer. Eliminator not shielded. Coupling between A.F. amplifier stages and power pack.
AERIAL AND EARTH	Aerial earthed. Aerial disconnected. Earth connection open. Defective lightning arrestor.	Aerial disconnected. Aerial poorly insulated, earthed or wire corroded. Aerial too short. Aerial too long; insert midget condenser. Coupling between aerial coil and secondary too loose. Loose or corroded earth connection.	Swinging aerial becoming earthed, at times. Loose or corroded earth connection.	Parallel, or too close to aerial of near-by oscillating receiver.	Aerial too close, or parallel, to power lines. Aerial too long, picks up too much stray noise. Loose or corroded earth connection. Aerial runs too near interfering electrical devices.	A.C. hum or commutator ripple picked up from near-by power lines. Negative side of filter circuit not earthed. (B—).
VALVES	Valve burned out. Valve paralysed. Valve prongs not making contact.	Valves exhausted. Wrong type of valve used. Detector not warmed up. Too much grid bias. Corroded valve contacts.	Imperfect prong contacts. Detector valve paralysed. Improper value of grid leak.	Valves worn out. Valves getting insufficient current. Improper C bias on grids. Detector valve overloaded. Wrong type of valve in last stage.	Microphonic valves; require cushioned sockets. Rectifier valve ageing. Hissing, due to power detector valve starting. Characteristic of worn-out valve.	Valve deteriorating. Too high voltage on detector valve. Wrong type of A.C. valve in detector stage. No centre tap on detector valve filament circuit.
CIRCUIT	Switch open. Open circuit in set. Burned out A.F. transformer winding.	Insufficient regeneration (S.W. set). Aerial too long (S.W. set). Grid leak improper value. Imperfect contacts. Defective piece of apparatus. Insufficient plate voltage. Burned out A.F. transformer winding.	Loose connection somewhere in set, eliminator, power supply or speaker connection. Sharply moving wires or set while in operation will accentuate trouble.	Over-regeneration. Near-by oscillator. Poorly designed transformers. Coupling condenser's too small. Circuit too sharply tuned. Last stage inadequate. No biasing on valves.	Squeals, howls, set oscillating. Defective grid leak. Motor-boating — lower the value of resistors in resistance coupled amplifiers. Broken wire or imperfect contacts. Burned out audio transformer.	Oscillation from over-regeneration. Set not properly neutralised. Magnetic feed back between stages. Open grid circuit. Centre tap of transformer not balanced. Grid return to centre point of potentiometer across A.C. valves not properly adjusted.
SPEAKER	Speaker disconnected. Open circuit in speaker unit, plug or cord. Speaker short - circuited. Coil in speaker unit burned out.	Speaker out of adjustment. Loose contact. Leak across speaker cord. Choke coil in output circuit has too high resistance or insufficient impedance.	Defeotive cord or plug.	Speaker overloaded; eliminate direct coupling by using output transformer or choke condenser coupling. Not matched to valve in last stage. Poorly designed speaker.	Sound vibrations communicated from speaker to valves in set. Electrical feed back from speaker cord to amplifying circuits.	Buzz or rattle in dynamic speaker due to moving coil rubbing against pole pieces. Hum due to worn-out rectifier. Feedback from speaker circuit to amplifying stages due to sound vibrations communicated from speaker to valves in set.
GENERAL	Incorrectly wired set. Shielded location or dead spot. Set not turned on. Breakdown at broadcasting station — try another station.	Set inadequate. Spot poor for reception. Fading.	Breakdown at broadcasting station — try another station.	Improper tuning. Fading. Weather condition. Unsatisfactory transmission from station — try another station.	Static—try disconnecting aerial and earth. Eliminator too close to set. Near-by regenerative set. Sparking electrical machinery.	Two stations on nearly same wave-length cause heterodyne whistle. Interference from near-by oscillator. Near-by regenerative or oscillating receiver.

POWER UNITS AND A.C. VALVES

In this article are discussed the general principles and operation underlying the electrical side of the modern receiver.

WE have dealt elsewhere with battery-operated receivers, the general principles of which apply equally to the type of receiver we now shall discuss—that which derives its power from the alternating current electric supply mains, which provide most of the light and power in the city and suburban areas. In our talk on battery-operated receivers we took it for granted that the filaments of the valves would be lit from direct, or unvarying, current and that the plate and grid voltage supplies would be of the same type. Unless this were so it would be impossible for the receiver to operate properly, for the very fluctuation of the valve supply would prevent the valves being kept in the stable operating condition necessary for their correct working.

On the other hand, battery operation entails the problem of battery charging or replacement whilst the household lighting supply provides a never-failing source of electric power. The A.C., or alternating current, valve was first developed in 1926, but it was not until four years later that it came into general use. The principle upon which this valve operates is quite simple. Actually its operating characteristics, except for the fact of its filament supply, are identical with those of the battery-operated valve.

To understand how an A.C. valve functions it is necessary to go back to the explanation of the single valve receiver in which we explained that the operation of a valve depended upon the "Edison Effect." This was the discovery by Edison that a heated body, enclosed in a partial vacuum, would emit electrons which were attracted by a positively charged body near the heated element.

What the designers of the A.C. valve did was to use alternating current to heat the emitting element, which they called the cathode. This cathode was a hollow tube inside which were placed the filament wires which were to be heated by the passage of an electric current. Thus the alternating current was used to light the valve filament and at the same time was kept out of the actual operating part of the valve as the electron emission took place from an indirectly heated cathode.

It should be noted that not all the valves which are used in all-electric receivers are indirectly heated. Experience has proved that it is possible to operate the final stage audio amplifying valve's filament from an alternating current supply without disturbing the valve's functions. This possibility, however, does not apply to the other valves in the receiver, for, if the radio frequency or detector valves were similarly operated there would be a loud humming noise (called "hum") produced in the loud speaker.

The overcoming of the filament lighting difficulty did not mean that the all electric receiver had been produced. Before this could be claimed it was necessary that some means be arranged to supply the "B" and "C" voltages necessary for the set's operation.

This was made possible by the development of the rectifier valve, which is capable of passing current only in one direction.

Look now at Fig. 1 in the lower portion of the diagram. We find a straight line which is cut at intervals by a succession of wavy lines. This illustrates diagrammatically the operation of a "radio power pack" (as the unit which supplies the "B" and "C" potentials to an all-electric receiver is called). The schematic diagram of the power pack is shown in the top part of the diagram. In this we see that it consists of a power transformer, T, a rectifier valve, V, a filter choke, CH, two filter condensers, C1 and C2, and a voltage divider VD.

The power transformer, PT, has a primary winding, P, and three secondary windings, S1, S2, and S3. The winding, S1, has a step up ratio, while S2 and S3 have step down ratios with respect to the primary winding, P.

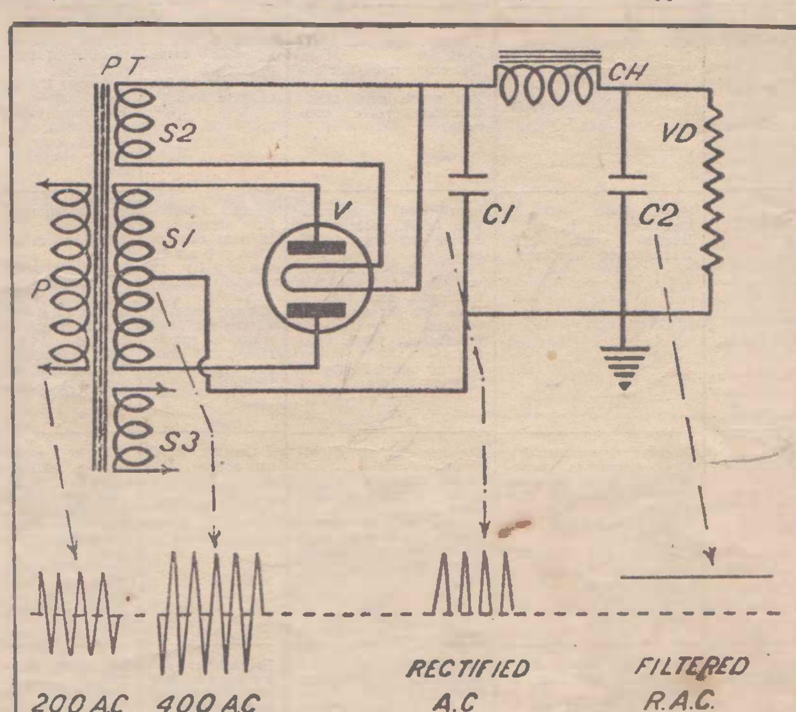
All three windings consist of a number of turns of wire, more for the primary and step-up windings than for the other two, wound on a bobbin and surrounded by an iron core made up of laminations or thin sheets of special transformer steel. Just as in the case of the audio transformer, alternating current flowing in the primary winding, P, is induced into the three secondary windings. If the step-up ratio between the primary, P, and the secondary, S1, is 1 to 4, and the voltage at the primary is 200, then 800 volts will be available across the outside terminals of the secondary winding. Similarly, if a step-down ratio of 40 to 1 exists between P and S2, and a step-down ratio of 80 to 1 exists between P and S3, voltages of 5 and 2½ respectively will be available across the outside terminals of these two windings. The potential available at S1, S2 and S3 all is alternating current. While S2 and S3 are used for lighting the rectifier valve filament and the filaments of the receiving valves respectively, S3 is to supply the plate and grid potential, and, therefore, its output must be rectified or changed into direct current before it is of any use.

This rectification is carried out with the aid of the valve, S, which is fitted with one filament and two plates and is known as a full-wave rectifier. To trace the operation of this valve we must first draw attention to the centre-tap on the secondary winding, S1. This centre-tap is connected to earth, and is the negative point in the high voltage system. Between each side of the high voltage winding and the centre-tap of our suppositiitious transformer there is an alternating potential of 400 volts.

Power Packs

The external terminals of the secondary winding, S1, are connected to the plates of the rectifier valve, V. At a given moment the potential on one plate of V is positive, while the potential on the other plate is negative. The electrons from the heated filament bombard the plates and from the positively charged one current flows to the filament, thence through the filter choke, CH, and the voltage divider, VD, to the centre-tap, which, like the end of the voltage divider, is connected to earth. At the next moment, reversal of the alternation, the other plate is positively

(Continued opposite.)



The schematic diagram of a power-pack which is used to supply plate and filament potentials for an all-electric receiver The bottom part of the diagram illustrates the changes undergone by the alternating current before it is changed into direct current.

THE OCTODE VALVE

This pictorial diagram of a modern radio valve should prove of great interest to the novice and the advanced experimenter.

ELSEWHERE in this handbook we have dealt extensively with the the theory and operation of all types of radio valves. These have ranged from the simple diode or rectifier through to the complex multi-element types used in modern receivers.

It will be remembered that we touched only briefly upon the Octode and similar type frequency charger tubes used in super-heterodyne receivers. A good idea of the element structure of a modern frequency charger tube is furnished in this diagram of the new Philips EK2 Octode, recently developed for use in super-heterodyne receivers.

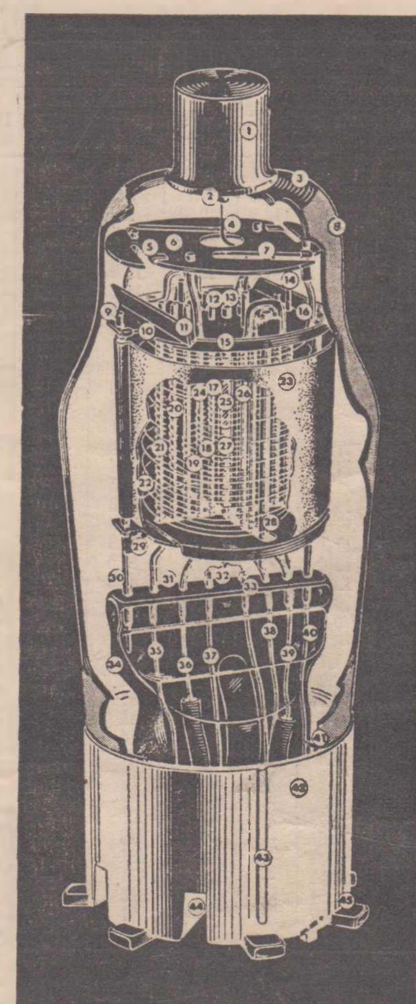
This wonder valve possesses no fewer than six grids. Only two of these are control grids. The valve actually consists of two sets of elements. One of these functions as a triode valve, and is used in the super-heterodyne circuit as an oscillator. The other is a screen grid valve, and is employed as the modulator or detector of the incoming signal impulses.

The two sets of elements are separated electronically by a screen of negative electrons, but the powerful positive electrons from the oscillating triode of the EK2 force their way through to the control grid of the pentode section of the valve, where they mix with the incoming signal impulses A common cathode or heater element is used for the two sections of the valve.

It is due to the development of highly efficient mixer tubes such as the EK2 that the modern super-heterodyne has been brought to such a pitch of efficiency as to provide regular reception of international stations.

The following is a key-numbered explanation of the various constructional features of the Philips EK2 octode:—

1—Top contact (control grid No. 4).
2—Lead-in insulator for the control grid connection (grid 4).
3—Glass bulb.
4—Internal connection to grid 4.
5—Lock for securing the mica centering disc.
6—Flexible mica centering disc.
7—Split in mica disc, giving enough flexibility to fit contour of inside of bulb.
8—Metal coatng.
9—Support for plate.
10—Mica disc for spacing the electrode supports.
11—Support for grid 3.
12—Support for grid 1.
13—Top of cathode.
14—Support for grid 6.



A sectional diagram of the Philips EK2 Valve.

15—Metal disc for reinforcing the mica disc mentioned under 10.
16—Support for mica centering disc.
17—Grid 1.
18—Grid 2.
19—Grid 3.
20—Grid 4.
21—Grid 5.
22—Grid 6.
23—Plate.
24—Support for grid 2.
25—Heater with insulator.
26—Support for grid 4.
27—Emitting layer on cathode.
28—Support for grid 6.
29—Lock for securing electrode structure.
30—Support for electrode structure.
31—Special layer of surface insulation.
32—Heater.
33—Lock for securing filament to connecting wire.
34—Glass insulator.
35—Connection to grid 6.
36—Connection to grid 2.
37—Connection to filament.
38—Connection to grid 1.
39—Connection to grids 3 and 5.
40—Connection to plate.
41—Connection to metal coating.
42—Phillips "P" type valve base.
43—Locator for determining position of valve in socket.
44—Air gap to prevent R.F. losses.
45—Silver-plated side contacts on valve base.

POWER UNITS AND A.C. VALVES — Continued from opposite page.

charged and current flows from it to the filament, thence through CH and VD back to the centre-tap. This is known as full-wave rectification. The push-pull action goes on indefinitely as long as the valve filament is lighted and the power transformer secondary, S1, draws current from the primary, P.

Glance now at the bottom half of the diagram. At the left will be found a wavy line which starts from the base line (zero point), rises to the crest (positive half of the alternating current cycle), falls to the zero point and travels downward to a crest (negative half of the cycle), and returns to the zero line. This is a complete cycle of operation.

Next we find a larger wavy line which serves to indicate the same cycle of operation only on a larger scale. This is what is happening at the extremes of the secondary terminals of the high voltage winding of the power transformer. Next we find that only the upper (positive half) of the cycle is represented.

Actually, two half-cycles are shown, indicating a complete cycle of operation of the rectifier valve, V.

Smoothed In Filter

We see by this that the current rises from zero to a maximum positive position and then falls to zero. This is what is taking place when each rectifier plate in turn has been fed with a positive potential and has passed current through the filament to the C1 side of the filter choke, CH.

This "ripply" current is useless for plate supply purposes and must be "smoothed" by means of a filter system before it can be used. Earlier in this series we explained that a condenser had the property of allowing alternating current to flow through it while a choke coil operated in the reverse way and prevented the passage of such currents. This is what happens when the "ripply" direct current fed from the rectifier valve attempts to pass through the filter system. The condensers, C1 and C2 store up the current, and as the humps are smoothed out of the ripple by the choke coil, CH, release the stored current to make up the deficiencies. This is rather a broad way of describing the function of the filter system, but it will suffice in the present instance.

It should be pointed out that this filter choke consists of a number of turns of fine wire wound upon a former which is surrounded by an iron core.

Next we come to the voltage divider, VD, which consists of a comparatively high resistance. The purpose of this resistance is twofold. It is intended to stabilise the voltage output from the power-pack by placing a small current drain on the rectifier (the current has to complete the circuit to the centre-tap of the high voltage secondary winding by flowing through (VD to earth). It also provides a convenient means of tapping off any fraction of the maximum voltage for use in different parts of the receiver. For example, say that the rectified output of the power transformer mentioned was 420 volts (at all reasonable current drains the output voltage is higher than the A.C. input voltage, although the former falls as the current drain increases). Assume that 410 volts are delivered at the C2 side of the voltage divider, VD, and that 250 volts are required for the operation of one of the valves in our receiver. This potential would be tapped off VD at a point a little less than half way down the voltage divider. Lower potentials would be tapped off at points correspondingly nearer the earthed end.

WIRE TABLES

B. & S. No.	Diameter (mils) *Enam.	Diameter (mils) D.C.C.	Turns per inch (exact winding) Bare	Enam.	S.C.C.	D.C.C.	S.C.C.	D.S.C.
8	130.6	142.5	7.78	7.65	7.32	7.01	—	—
9	116.5	126.4	8.74	8.58	8.23	7.91	—	—
10	104.0	112.9	9.81	9.61	9.26	8.85	—	—
11	92.7	100.2	11.02	10.7	10.4	9.98	—	—
12	82.8	90.3	12.37	12.0	11.6	11.07	—	—
13	74.0	81.5	13.89	13.5	12.9	12.27	—	—
14	66.1	73.6	15.60	15.1	14.4	13.59	—	—
15	59.1	66.6	17.52	16.9	16.1	15.0	—	—
16	52.8	60.3	19.68	18.9	17.9	16.5	18.9	18.2
17	47.1	54.8	22.1	21.2	19.8	18.2	21.1	20.2
18	42.1	49.8	24.8	23.7	22.0	20.0	23.6	22.5
19	37.7	45.4	27.8	26.5	24.4	22.0	26.3	25.0
20	33.8	41.5	31.3	29.5	27.0	24.1	29.4	27.7
21	30.2	38.0	35.1	33.1	29.8	26.3	32.7	30.7
22	27.0	33.8	39.4	37.0	33.5	29.5	36.6	34.1
23	24.1	31.1	44.3	41.4	36.9	32.1	40.6	37.5
24	21.5	28.6	49.7	46.5	40.6	34.9	45.2	41.4
25	19.2	26.4	55.8	52.0	44.6	37.8	50.0	45.6
26	17.1	24.4	62.7	58.4	49.0	40.9	55.8	50.0
27	15.3	22.7	70.4	65.3	53.4	44.0	61.7	54.9
28	13.6	21.1	82.8	73.5	58.4	47.3	68.4	60.2
29	12.2	19.8	88.8	81.9	63.2	50.5	75.1	65.3
30	10.8	18.5	99.7	92.5	68.9	54.0	83.3	71.4
31	9.7	17.4	112.0	103	74.6	57.4	91.7	77.5
32	8.7	16.5	125.8	114	80.0	60.6	100	83.3
33	7.7	15.6	141.2	129	86.2	64.1	109	90.0
34	6.9	14.8	158.6	144	92.5	67.5	120	97.0
35	6.2	14.1	178	161	99.9	70.9	131	104
36	5.5	13.0	200	181	111	76.9	142	111
37	4.9	12.5	224	204	117	80.0	153	117
38	4.4	12.0	252	227	125	83.3	166	125
39	3.9	11.5	283	256	133	86.9	181	133
40	3.5	11.1	318	285	140	90.0	196	140
41	3.05	—	363	327	—	—	—	—
42	2.64	—	400	378	—	—	—	—
43	2.37	—	444	421	—	—	—	—
44	2.12	—	500	471	—	—	—	—
45	1.91	—	571	523	—	—	—	—
46	1.72	—	666	581	—	—	—	—

S.W.G. No.	Diameter (mils) *Enam.	Diameter (mils) D.C.C.	Turns per inch (exact winding) Bare	Enam.	S.C.C.	D.C.C.	S.S.C.	D.S.C.
10	132	142	7.81	7.63	7.35	7.04	—	—
11	120	130	8.62	8.33	8.07	7.69	—	—
12	108	118	9.62	9.26	8.93	8.48	—	—
13	96	106	10.87	10.42	10.00	9.43	—	—
14	84	94	12.50	11.90	11.36	10.64	—	—
15	75.5	84	13.89	13.25	12.66	11.90	—	—
16	67.5	76	15.63	14.81	14.08	13.16	14.93	14.71
17	59	68	17.86	16.95	15.87	14.71	16.95	16.67
18	50.7	59	20.83	19.72	18.18	16.95	20.00	19.61
19	42.6	51	25.00	23.47	21.28	19.61	23.81	23.26
20	38.5	47	27.78	25.97	23.81	21.28	26.32	25.64
21	34.3	43	31.25	29.15	26.32	23.26	29.41	28.57
22	30.0	39	35.71	33.33	29.41	25.64	33.33	32.26
23	25.7	34	41.67	38.91	34.48	29.41	38.46	37.04
24	23.6	32	45.45	42.37	37.04	31.25	42.55	40.00
25	21.5	30	50.00	46.51	40.00	33.33	46.51	43.48
26	19.4	28	55.56	51.55	43.48	35.71	51.81	48.78
27	17.7	26.4	60.98	56.50	46.73	37.88	56.50	52.91
28	16.0	24.8	67.57	62.50	50.51	40.32	62.11	57.80
29	14.8	23.6	73.53	67.57	53.76	42.37	67.11	62.11
30	13.4	22.4	80.65	74.63	57.47	44.64	72.99	67.11
31	12.6	21.6	86.21	79.37	60.24	46.30	77.52	70.92
32	11.7	20.8	92.59	85.47	63.29	48.08	82.64	75.19
33	10.9	20.0	100.00	91.74	66.67	50.00	88.50	80.00
34	10.0	19.2	108.7	100.0	70.42	52.08	95.24	85.47
35	9.1	17.4	119.0	109.9	80.65	57.47	103.1	91.74
36	8.3	16.6	131.6	120.5	86.21	60.24	112.4	99.01
37	7.4	15.8	147.1	135.1	99.21	63.29	123.5	107.5
38	6.6	15.0	166.7	151.5	100.0	66.67	137.0	117.6
39	5.7	14.2	192.3	175.4	108.7	70.42	153.8	129.9
40	5.3	13.8	208.3	188.7	113.6	72.46	163.9	137.0
41	4.8	—	227.3	208.3	—	—	178.6	151.5
42	4.4	—	250.0	227.3	—	—	192.3	161.3
43	3.9	—	277.8	256.4	—	—	208.3	172.4
44	3.5	—	312.5	285.7	—	—	227.3	185.2
45	3.1	—	357.1	322.6	—	—	250.0	200.0
46	2.65	—	416.7	377.4	—	—	277.8	217.4
47	2.25	—	500.0	444.4	—	—	312.5	238.1
48	—	—	—	—	—	—	—	—

*Nominal Value. Actual dimensions vary slightly.

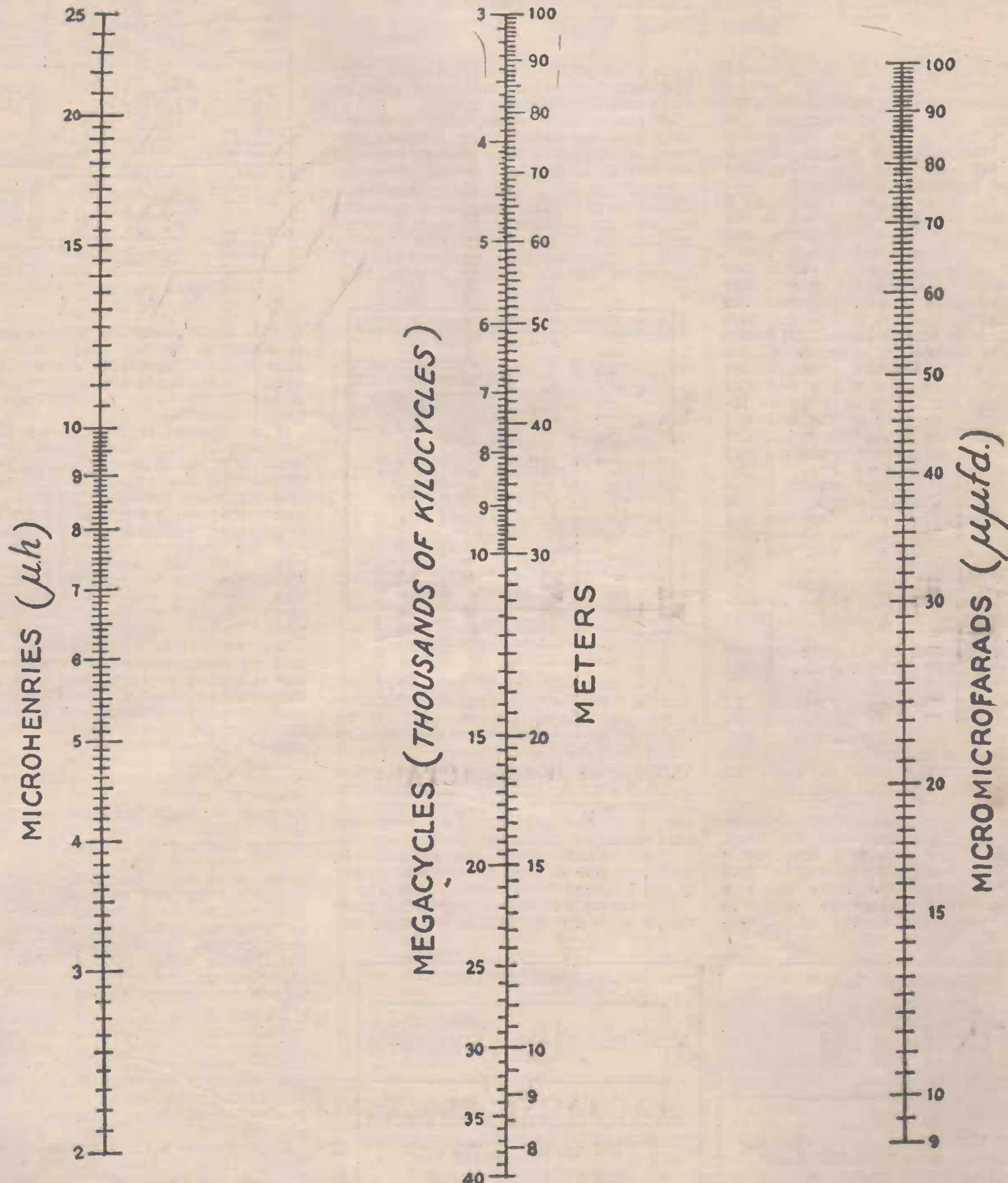
INDUCTIVE REACTANCE IN OHMS

Inductance (Henries)	50 cycles	100 cycles	1000 cycles	5000 cycles	175 K.C.	465 K.C.	1000 K.C.
250	78,500	157,000	1,570,000	7,850,000	—	—	—
100	31,400	62,800	628,000	3,140,000	—	—	—
50	15,700	31,400	314,000	1,570,000	—	—	—
25	7,850	15,700	157,000	785,000	—	—	—
10	3,140	6,280	62,800	314,000	—	—	—
5	1,570	3,140	31,400	157,000	—	—	—
1	314	628	6,280	31,400	1,100,000	2,920,000	6,280,000
.1	31.4	62.8	628	3,140	110,000	292,000	628,000
.01	3.14	6.28	62.8	314	11,000	29,200	62,800
Micro-H.							
1,000	.314	.628	6.28	31.4	1,100	2,920	6,280
200	.0628	.1257	1.257	6.28	220	484	1,257
100	.0314	.0628	0.628	3.14	110	292	628

CAPACITATIVE REACTANCE IN OHMS

Capacity Micro-Fds.	50 cycles	100 cycles	1000 cycles	5000 cycles	175 K.C.	465 K.C.	1000 K.C.
.00003	—	—	—	1,060,000	30,000	11,400	5,300
.0001	—	—	1,590,000	318,000	9,100	3,420	1,590
.00025	—	—	637,000	127,000	3,600	1,368	637
.0005	—	—	318,000	63,700	1,800	684	318
.001	3,180,000	1,590,000	159,000	31,800	910	342	159
.006	530,000	265,000	26,500	5,300	150	57.0	26.5
.01	318,000	159,000	15,900	3,180	91	34.2	15.9
.1	31,800	15,900	1,590	318	9.1	3.42	1.59
.25	12,700	6,370	637	127	3.6	1.368	.637
.5	6,370	3,180	318	63.7	1.8	.684	.318
1	3,180	1,590	159	31.8	.91	.342	.159
2	1,590	796	79.6	15.9	.45	.171	.08
4	796	398	39.8	7.96	.23	.086	.04
8	398	127	12.7	3.98	.11	.043	.02
25	127	63.5	6.35	1.27	.04	.0136	.006

The Relationship Between Inductance, Capacity and Frequency



With this chart and a ruler one of the above quantities can be determined if the other two are known. For example, if a condenser has a minimum capacity of 15 mmfd and a maximum capacity of 50 mmfd, and it is to be used with a coil of 10 microhenries inductance, what frequency range will be covered? The ruler is placed between the 10 on the left-hand scale and the 15 on the right-hand side giving 13 megacycles as the high frequency limit. Keeping the ruler at the 10 on the left-hand side, the other end is moved to the 50 on the right-hand side giving a low frequency limit of 7.1 megacycles. The centre scale also serves to convert frequency to wavelength.

The inductance of a single layer coil is given by the formula:—

$$L = \frac{r^2 \; n^2}{10 \; (r + l)}$$

Where L is the inductance in microhenries.
r is the radius of the coil in inches.
n is the number of turns.
l is the length of the winding in inches.

For example, assume a coil having 35 turns of No. 30 d.s.c. wire on a coil former having a diameter of 1½ inches. Consulting the wire tables shows that the 35 turns will occupy a space of ½ an inch.

Therefore,

$$r = \frac{\frac{3}{4} \times \frac{3}{4} \times 35 \times 35}{10 \; (\frac{3}{4} + \frac{1}{2})}$$

$$= \frac{\frac{3}{4} \times \frac{3}{4} \times 35 \times 35}{10 \times 1\frac{1}{4}}$$

= 55.1 microhenries.

OHM'S LAW FORMULAE

How to determine the voltage, current or resistance of any given circuit.

AMONGST the many things which he meets in the course of his radio experimenting, hardly anything gives the beginner so horrible a feeling as to be obliged to find out: "What is the voltage drop if a resistor of such and such a number of ohms is applied to a circuit?"

We all know, of course, that there is an excellent formula which solves the problem without great difficulties and that this formula is called "Ohm's Law." When the letters E, C and R, which are the internationally accepted symbols for voltage, current and resistance, are juggled by the person conversant with the working of Ohm's Law it all seems fantastically simple. However, when we come to use the formula ourselves we run into difficulty and finally come to believe that Ohm's Law is a devil's invention fit for use only by the initiated.

As we shall see later, this opinion of Ohm's Law is prejudiced because every one of us can understand it.

To prove that this is correct, let us look over the facts actually involved in the relations which exist between the three fundamental units of electric power: the volt, the ohm and the ampere.

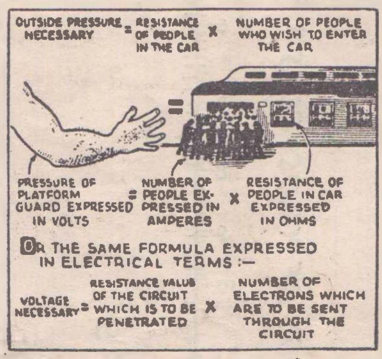
Scientists tell us that electricity consists of electrons—minute pieces of matter which move at a speed of 186,000 miles a second.

For a moment let us take one of these tiny electrons and think of it as a human being.

Carrying our imagination further, let us think of a crowded Flinders Street railway platform at 6 o'clock at night. A packed mass of travellers (electrons) is waiting for the train to come in. When it does, we find that it is already packed to the doors and nobody is leaving it. Despite this, the people on the platform try to get into the train. At the doors where only a few people are they ma-- enter without a great deal of pressure, but at the doors where a great many newcomers are eager to penetrate the thick masses of passengers already in the compartment they find considerable resistance and only by force are they able to get in.

In some cases, even, this does not help, and the more or less friendly services of a porter, who pushes with all his might, is required to get them in.

About the same situation occurs when electrons of which electricity actually consists) try to force themselves from an accumulator battery (platform) into a resister (crowded train compartment). If the value of the resistor is very high

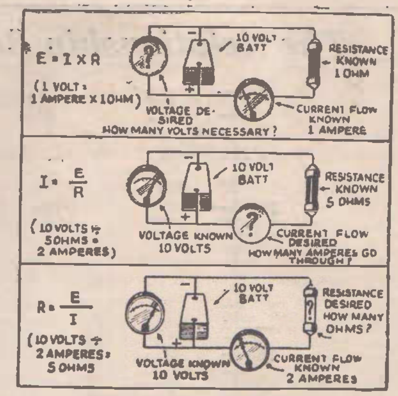


A pictorial illustration of one of Ohm's Law Formulae.

(if the compartment is very crowded) and only one battery is applied, the electrical pressure or tension will not be high enough to press all the desired electricity through the resistor.

The porter at Flinders Street solves the difficulty by pushing the people into the compartment with all his might. Engineers do the same thing by increasing the electrical pressure (increasing the voltage) which affects the electrons in the same way as does the pushing power of the Flinders Street porter. See Fig. 1.

The example of the railway train, compared with the description of what engineers do to overcome the resistance of an electrical resistor, has shown us very clearly that, regardless whether human beings or electrons are involved, a large resistance can only be overcome by a heavier pressure.



Ohm's law formulae.

If we desired to write down this experiment in very short form we could write it in the following way: The more people that are waiting on the platform and the more crowded the train is, the more pressure is required to crowd the newcomers into each compartment.

If we speak in electrical terms we could say: The higher the resistance through which we wish to send a current the more electrical pressure (the more "tension" or "volts") must be applied.

But even this description is clumsy and, by compressing our experience into a much simpler form, we come to the formula (see also Fig. 2):—Outside Pressure necessary equals Resistance of people in the compartment X number of people who wish to enter it.

Since voltage is internationally expressed in volts (abbreviation for volts equals E) and the unit of electrical resistance is the Ohm (abbreviation for Ohm equals R) there remains only to explain the unit of electron flow.

The accepted way to do this is in terms of a current, as electrons themselves are too tiny to be practicable for this purpose. In quite the same way we do not speak of the drops of water which flow through a pipe, but speak rather of the flowing water current. The unit of electrical current is the Ampere (abbreviation for Ampere equals E or I).

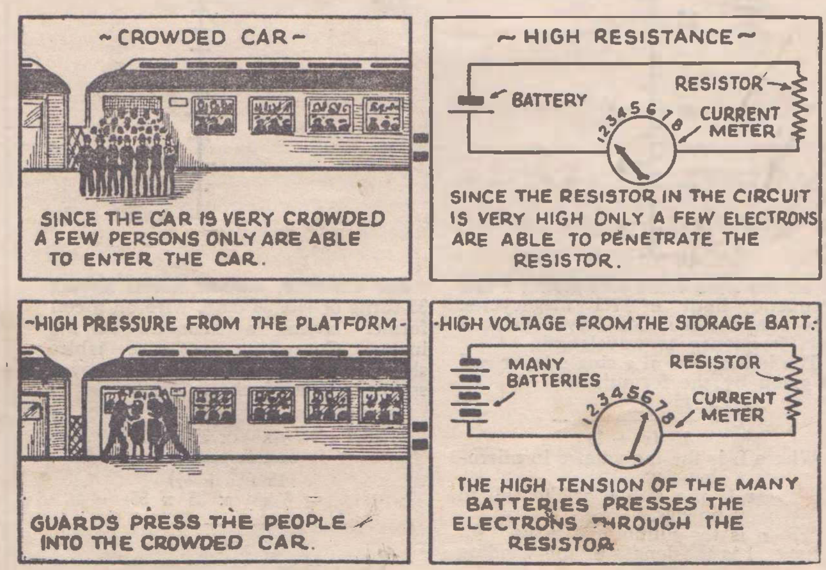
Having discussed these details, there remains only the fact that the essential rule governing Ohm's Law is found on the experience that, when we have 1 volt available we are able to send an electrical current of one ampere through a circuit having an electrical resistance of 1 ohm.

Since this is a clumsy way of writing Ohm's Law, another method has been devised and today, all over the world, Ohm's Law is written as shown in Fig. 3. If we enlarge the resistance to 5 ohms the formula tells us we need 5 volts to conquer the electrical resistance. If the resistance remains constant at 1 ohm, but we want to send through the resistor a current amounting to 6 amperes, the formula tells us that the voltage necessary is 6 volts, and so on.

A Current

The formula given by Fig. 3A enables us only to figure the necessary voltage to be applied if we know the resistance and the current to reckon with. How-

(*Continued on page 49*)



These illustrations show the remaining two formulae of Ohm's Law.

CONDENSERS AND RESISTORS

Theoretical and practical information on capacitive and resistive components.

TWO of the most important groups of components in a radio receiver are condensers and resistors. The first are used in their various forms for tuning, by-passing, coupling and filtering. The second are used for voltage division, filtering, and for audio coupling circuits. We propose now to discuss each type of condenser and resistor, to give hints on the selection of components for specific purposes, and to detail the pitfalls to be avoided.

Variable Condensers

This class of condenser includes all types in which mechanical movement is responsible for a variation in capacity. The most commonly used variable condensers are those which are possessed of two sets of plates, one of which is mounted on a spindle and arranged mechanically so that it can be enmeshed with the fixed plates.

The two sets of plates are separated from each other by air which is the dielectric. The more the surface area of the moving plates of the condenser which is brought into relationship with that of the fixed plates, the greater the capacity of the unit.

Variable condensers used for tuning broadcast receivers may be obtained in two or three capacities. The most common of these is .000375 mfd., .00042 mfd., and .00045 mfd. These small differences in maximum capacity permit a greater tuning sweep to be obtained; in other words, the large capacity condensers will tune over a greater wave-range than will the small ones.

For use in modern single control circuits the tuning condensers are gauged, i.e., the sets of movable plates are assembled on a common shaft whilst each fixed plate section is insulated from its neighbor. Two and three gang condensers are commonly used. Each gang unit is provided with what is known as a "trimmer" condenser, which is a compression type mica condenser, the capacity of which is controlled by an adjustment screw.

The purpose of these condensers is to balance up any circuit inequalities which otherwise would make it impossible for the various sections of the gang condenser to track, i.e., to keep in step with one another.

Gang tuning condensers should be carefully selected, attention being paid to see that no mechanical displacement has taken place in the common shaft. The shaft should move freely, but there should be no play in the bearings. The condenser plates should be smoothly finished and their edges should be free from metal burrs. The trimmer condenser screws should be firm in fit, and the spring brass, which forms one of the plates of each trimmer condenser, should be resilient.

The gang condenser should be selected to suit the particular coils to be used. If these call for the use of a condenser of .000375 mfd. capacity, use this capacity condenser and no other.

The next type of variable condenser is the compression type. We already have come in contact with this type of condenser in the trimmers of the gang type. The compression condenser usually consists of a number of sheets of brass foil, which are interleaved, and are separated from one another by mica. Pressure on the foil sheets flattens them out, and brings them close together, with the result that the condenser capacity is increased. This squeezing of the plates is usually effected by means of a set screw.

These condensers are also known as Pre-Set condensers, for they do not change their adjustment when once set.

The most general uses to which pre-

A drawing of a paper-type condenser.

set condensers are placed are as trimmers on gang condensers, and, in tuning circuits, as coupling condensers in radio frequency tuner units, and as padding condensers in super-heterodyne receivers. They should be selected with an eye to mechanical strength, particularly insofar as the adjusting screw is concerned.

Fixed Condensers

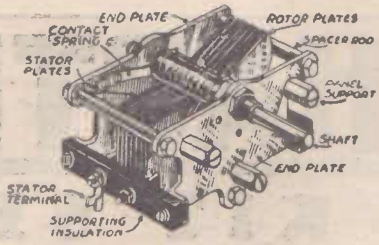
There are three chief types of fixed condensers. These are the paper dielectric type, the mica dielectric type, and the electrolytic type. The first-mentioned are to be found either in rectangular form, in which case they usually are enclosed in metal containers, or in the more recently developed tubular type.

The metal-clad condensers are usually very reliable, but, unless it is necessary to go to high working voltages, the space they occupy in the average receiver does not make them a practicable proposition. These condensers are provided either with terminals or with solder lugs, to which connections should be made.

The tubular type of condenser consists of a unit in which the paper and tinfoil, which go to make it up, are rolled up together. Two wire pig-tail connection leads are provided. These condensers are of what is known as the non-inductive type, and usually the lead which should be joined to the earth or low potential side of the circuit is indicated. They are made in capacities ranging from .0001 mfd. to .5 mfd.

The metal-clad type of paper dielectric condenser ranges in capacity from .001 mfd. to 8 mfd. In selecting either of these types of paper condenser for a specific service, be sure that it will not be exposed to a direct current potential of more than its working voltage.

Most condensers are branded with the voltage at which they have been tested



A typical variable tuning condenser with each section marked.

to work. For example, it may be found that a given condenser is branded "400 Volts Working." This does not mean that it should be placed on a circuit in which a stress of 400 volts will be applied to it.

The maximum safe working voltage of a 400 volt condenser is between 250 and 275 volts.

A word regarding the capacities of condensers used in various parts of the circuit may not be amiss. For cathode by-pass purposes the maximum useful capacity is .1 mfd., but this should not be reduced on the score of economy. In automatic volume control circuits the actual capacity will depend upon the circuit design, although .05 mfd. and .1 mfd. condensers will be generally used. For by-passing the screening grids and plates of radio frequency valves, condensers of either .1 or .5 mfd. capacity will be needed. A .5 mfd. condenser will be necessary to by-pass the screen of a detector valve.

In the usual r.f. and first stage audio circuits decoupling may be effected by means of a .5 mfd. condenser and the usual resistor. For audio coupling condensers in resistance coupled circuits capacities from .01 mfd. to .1 mfd. may be used. Tone compensation networks across the output of a power pentode will necessitate the use of capacities ranging from .004 mfd. to .1 mfd.

In none of these applications is it likely that the plate potentials will exceed 275 volts, so that standard 400 volt working condensers of reliable make will prove quite satisfactory.

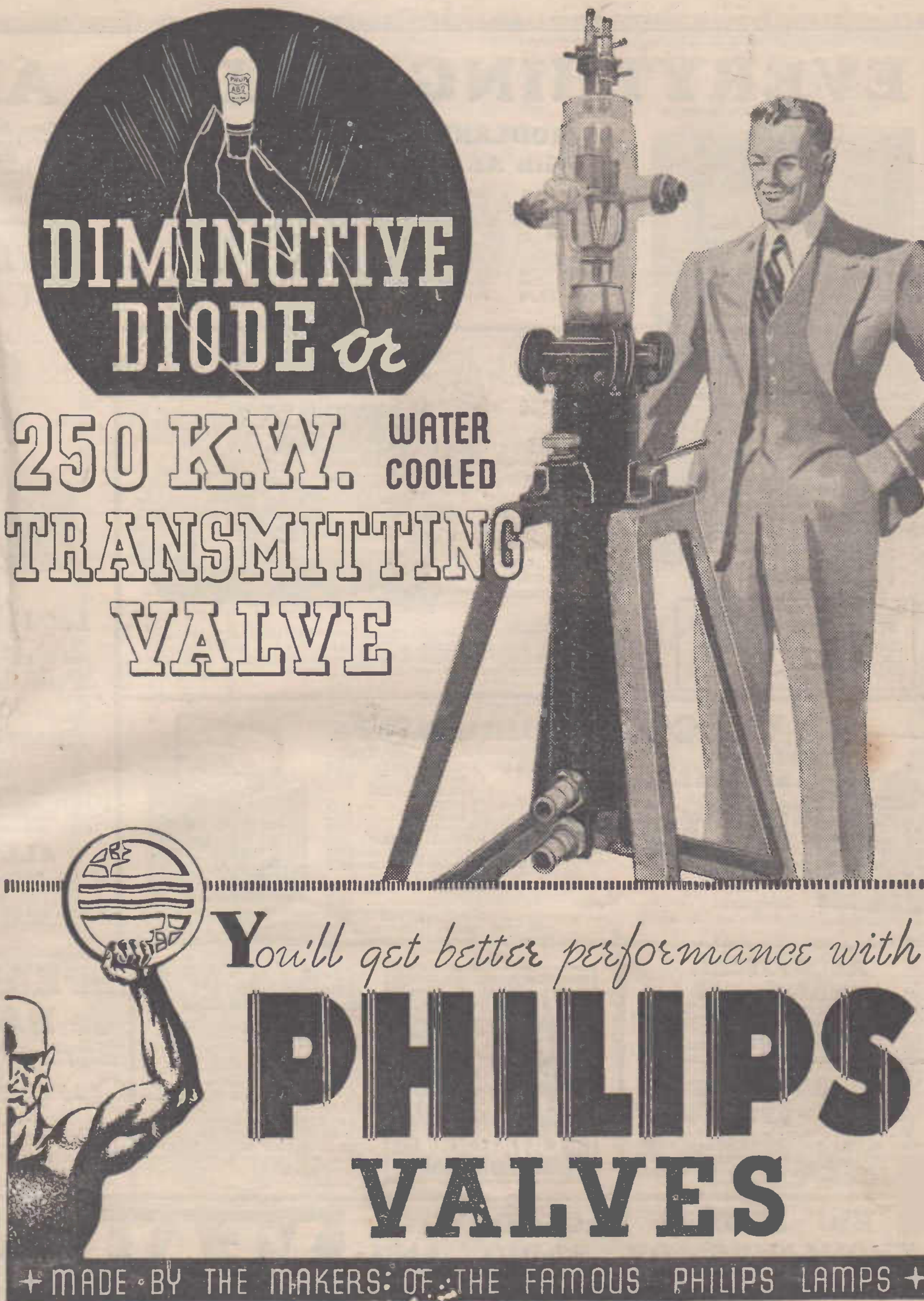
Electrolytic Condensers

We come now to the third class of condensers, electrolytic condensers. In these condensers use is made of a chemical action which produces a thin insulation over one plate of the condenser. Their chief claim to fame is that they are able to compress high capacities into a very small space.

Today we find that the chief uses to which electrolytic condensers are put are in filter circuits and in the by-passing of cathode bias resistors. In the first application they must be tested to withstand a very high voltage, which in the modern all electric receiver may reach 500. Although, unlike the paper dielectric condenser, the electrolytic type possesses the faculty of re-sealing after it has broken down under a severe voltage stress, it is unwise to bank on this action when installing the condensers in a receiver. The breakdown causes a short-circuit across the power supply source, and in an all electric receiver this short-circuit may be responsible for severe damage to the power transformer and associate equipment.

Electrolytic condensers, designed for power filtration purposes, are usually rated to work at 450, 500 or 600 volts. To be on the same side, it always is

(*Continued on page* 40)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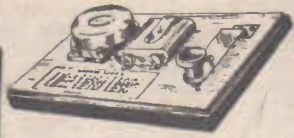
MORSE CODE KEY AND BUZZER OUTFITS



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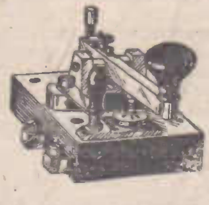

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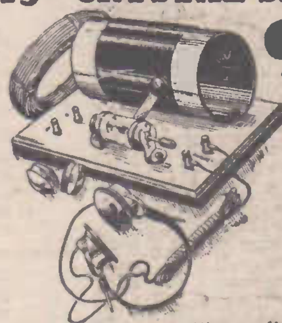

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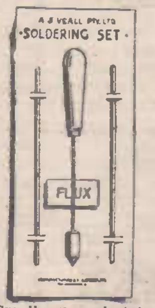

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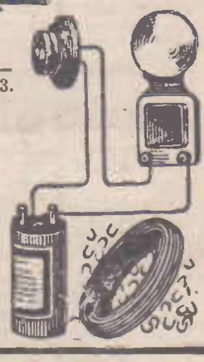

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Condensers and Resistors—

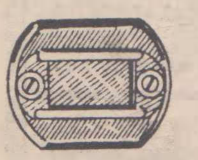
(*Continued from page 36*)

advisable to install the highest working voltage condensers. This type of electrolytic condenser has a capacity of 8 mfd. It should be pointed out. at this juncture, that there are two types of electrolytic condenser. The first is known as the wet type In it the chemical compound responsible for the condenser action is in a liquid form. In the dry type of electrolytic condenser the compound is in the form of a semi-liquid paste.

The dry type condensers are usually employed for low voltage applications, whilst the wet type are used in filter circuits and similar heavy duty circuits. Both are capable of re-sealing when once the over voltage which caused their breakdown is removed.

Electrolytic condensers of all types have a definite polarity. The positive element of the condensers is marked, and should always be connected to the positive side of the circuit.

The low voltage electrolytic condensers usually are employed as by-passes across "C" bias resistors. They range from 10 mfd. 35 volt types to 25 mfd. 75



Another mica condenser which is encased in bakelite.

volt types. All should be used with care, and should preferably not be placed in circuits in which alternating currents are flowing.

This form of current, in addition to direct current, flows in the cathode circuits of valves, but in this case we have to take the chance. On no account, however, place an electrolytic condenser across a circuit in which a high voltage alternating current is flowing.

Mica Condensers

The mica condenser is one of the most valuable of the condenser family to the radio set-builder. Whilst paper condensers have a certain amount of leakage and electrolytic condensers have considerably more, the good quality mica condenser is absolutely above reproach when used within its voltage ratings. Even the voltage rating is generous, for most modern mica condensers are capable of functioning on circuits carrying up to 1000 volts of direct current.

Mica condensers are made in capacities ranging from .00005 mfd. up to .02 mfd. They are used as grid condensers —.0001 to .00025 mfd., as radio frequency feed condensers—.00005 to .002 mfd., as radio frequency by-pass condensers—.0001 mfd. to .01 mfd., and as audio frequency coupling and tone control condensers—.004 mfd. to .02 mfd.

One of their chief uses is as audio frequency coupling condensers in resistance-coupled circuit.

The leakage of the paper dielectric condensers in audio circuit is quite serious. In addition to withstanding the stresses of applied direct current voltages, these coupling condensers have to withstand audio frequency peak voltages which often run into very high figures.

The combination of the two can wreck even the best of condensers, so it is best to be on the safe side and use the highest grade mica types.

A point which should be borne in mind when soldering condensers into circuit is to keep them as free from solder flux as possible. This applies particularly to the bakelite-encased mica condensers. Any flux getting on the condensers is likely to provide a high resistance leakage path. and the very purpose of the condenser, i.e., the blocking of direct current, is defeated by this leakage path.

Two types of mica fixed condensers.

Fixed and Variable Resistances

There are two types of resistance used in radio receivers. One is fixed, whilst the other is variable. The first type is generally employed in voltage dividing and feeding circuits, in the coupling circuits of audio frequency amplifiers, and in automatic volume control circuits.

The second type is almost exclusively used for volume and tone control purposes. The resistance elements are themselves divided into two classes—carbon or metallised types and wire wound types. The latter are mechanically more robust, but the difficulty and cost of making high resistance wire-wound resistors places them beyond the bounds of possibility in the average radio receiver.

Notwithstanding their cheapness, the carbon and metallised resistors are exceptionally robust and can be counted on to give long and trouble-free service.

Let us start off by analysing the requirements of wire-wound fixed resistances. We have two sub-divisions of the wire-wound resistor. The first is the low resistance type which, in practice, rarely exceeds 2500 ohms, whilst the second is the high resistance type ranging from 10, to 25,000 ohms.

The first class is employed exclusively for cathode bias resistors, whilst the second is used as a voltage divider and current stabiliser across the output of power packs.

Wire-bound resistors must be carefully selected with a view to their ultimate employment. Fortunately the two types generally available now are rated to carry 50 and 100 milliamperes of current respectively. For use as bias resistors, the wire-wound units are never asked to carry more than 50 milliamperes current when a single valve is being biassed. When more than one valve is biassed through the same resistor, its value may be proportionately decreased —to one half for two valves and to one-third for three valves — and its current rating increased to take care of the added drain. Resistors of a given current rating should be doubled in value and connected in parallel to enable twice the amount of current to be passed through them.

The usual "C" bias resistor will need only to carry a moderate current, but in push-pull circuits this juggling with resistors may be necessary. Voltage dividers should be selected to have a resistance which will suit their current carrying capacity

For example, a given divider will safely carry a current of only 10 milliamperes and must be connected across the 500 volt output of a power unit; it must have a resistance of 50,000 ohms to ensure that no more than 10 milliamperes of current will flow through it. Remember, too, that where a voltage divider is used to tap off potentials for various parts of the circuit, the current drain of the particular circuit point must be added to the "bleeder current" drain on that particular part of the divider through which the current flows.

For example, in our 50,000 ohm. resistor we shall assume that it is desired to draw a current of 5 milliamperes from the 100 volt tap on the divider. Then from the 500 volt positive end of the divider down to the 100 volt tap we would be drawing not only the 10 milliampere bleed current, but an additional 5 milliampere current for the receiver.

This point wants watching, for it often is responsible for the burning up of voltage dividers which are well constructed. but which are being grossly overloaded.

All resistors, whether of the wire-wound type or the carbon or metallised type, should run cool. If they warm up to any extent it is a sure sign that they are being overloaded and steps should be taken to replace them with resistors of greater current carrying capacity

In purchasing wire-wound resistors, inspect them to see that the connection of the pigtail connecting wire to the wire of the resistor itself is properly made. Poor mechanical construction in this respect will give rise to endless trouble and will give the constructor a few headaches before he finally clears up the matter with a soldering iron.

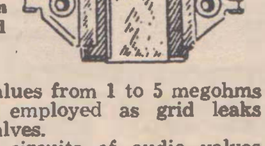
Carbon and Metallised Resistors

It should be clearly understood that the metallised resistor is the Rolls Royce of the high resistance fixed resistances. Unfortunately it is more expensive than the carbon type, and for that reason the latter is more generally used by set-builders and experimenters.

These resistors are made in various ratings known as the One-Watt, Two-Watt and Five-Watt types. The latter are not generally used and it is only in a few circuits that Two-Watt resistors are called for.

The resistance ranges which are in general use extend from 200 ohms to

This illustration shows another design used for fixed condensers.



5 megohms. Values from 1 to 5 megohms are generally employed as grid leaks for detector valves.

In the grid circuits of audio valves the usual values are 250,000 and 500,000 ohms. Plate circuit resistors vary in value, depending upon the particular type of valve, from 50,000 to 250,000 ohms, with 100,000 ohms as the generally used value.

Of the lower values, 200 ohm resistors are used as suppressors to prevent undesired oscillation in the grid circuits of r.f. amplifiers and to prevent the generation of harmonics from the oscillator tubes in super-heterodynes.

Valves from 1000 to 10,000 are used as stabilising resistance in the plate circuits of r.f. amplifier tubes. In the screen grid circuit resistances from 100,000 to 1 million ohms are used to reduce the applied potential to the desired figure.

Other uses for resistors include those of audio de-coupling for which values of from 15,000 to 250,000 ohms are employed; for tone control—20,000 to 50.00 ohms;

(*Continued on page 49*)

AUTOMATIC BIAS

An interesting discussion on how to apply a negative bias to a radio receiver.

ONE of the features associated with indirectly-heated valves is that their cathode structure permits a bias voltage to be obtained without the use of a "C" battery or other source of potential.

As we learned from a study of Ohms Law, the passage of a current through a resistance causes a voltage drop across that resistor. The higher the resistance and the greater the current, the greater the potential drop across the resistance.

It will be remembered that, in our discussion of the valve and its functioning as an amplifier, we explained that the grid had to be kept at a more negative potential than the cathode. Now, if we connect a resistance between the cathode and earth and make current flow from earth to cathode through this resistance, we produce a potential drop across the resistance.

Assuming that earth is true negative, as it is in practically every case, we find that the cathode is less negative than earth and therefore is positive with respect to earth by the amount of voltage drop which takes place across the resistance.

To bias a valve automatically, we connect a resistor between cathode and ground. The negative side of the high voltage supply system is fed to ground. Now if we return the grid circuit, be it through the secondary of an audio transformer or through the coupling resistor of a resistance-coupling unit, to earth the grid automatically is placed at the same potential as earth, which in the present case is full negative.

In these circumstances the grid is full negative, whilst the cathode is less negative than the grid by the amount of voltage drop which takes place across the cathode resistor.

A little thought will show that the cathode is thus positive with respect to the grid by the amount of voltage drop. Conversely, the grid must be negative with respect to the cathode by the same amount of voltage drop.

The drop which takes place across a given resistor is governed by the plate current drawn by the valve. If a valve draws 40 milliamperes, and has a cathode resistor of 1000 ohms, 40 volts drop will take place across the resistor and thus, when the grid circuit is returned to ground, a negative bias of 40 volts will be applied to the valve's grid.

The formula for calculating the correct resistance for a "C" bias resistor is quite simple and should be easily memorised by the experimenter. It is:—

$$R = \frac{E \times 1000}{C}$$

where R equals the required resistance, E equals the desired voltage drop or "C" bias voltage, and C equals the valves plate current in millamperes.

Remember, when dealing with a pentode valve, to include the total of the plate and screen grid currents.

The beauty of the automatic bias resistance is that, as the plate potential falls and the plate current of the valve decreases, so does the voltage drop across the bias-resistor decrease. The result is that proportionately lower bias voltages are applied as the plate voltage reduces, a fact which tends to increase the working life of the valve and to maintain it always at a correct operating condition

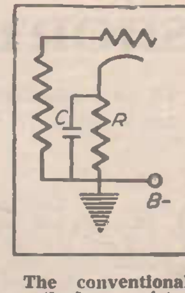
Similarly, an increase in the plate voltage brings about an increase in plate current with a corresponding increased voltage drop across the bias-resistor and an increased negative bias.

It is important to remember, however, that the resistor in the cathode circuit has a certain impedance to the flow of alternating currents. To permit an absolutely free flow of current through the circuit, it is necessary to by-pass the resistance with a condenser which will pass alternating currents but block direct currents. In radio frequency amplifiers and detector circuit this condenser should have a capacity of .1 mfd. maximum.

In audio frequency circuits, however, it must have a much greater capacity because the lower the frequency the greater the reactance of a condenser or, in other words, the more opposition it offers to the passage of alternating currents.

Radio frequency cathode by-pass condensers have a capacity of from .5 mfd. to 25 mfd., the latter value being used in the output stage.

Generally speaking, the higher the cathode resistance the lower the capacity of the by-pass condenser which must be used. Remember when connecting electrolytic condensers across cathode biassing resistors, that the cathode side of the resistor is positive and should carry the positive connection to the electrolytic condenser.



The conventional cathode resistor method of biassing a valve.

It also is possible to employ automatic "C" bias on battery-operated receivers. To do this, it is necessary to know the current drain of all valves in the receiver. Suppose, for example, we have a three valve receiver employing a screen grid r.f. stage, a screen grid detector and a pentode output tube.

At the rated plate voltage the current for the plate and screening grid of the r.f. valve might total 2 milliamperes, the current for the plate and screening grid of the detector 1 milliampere, and for the plate and screen of the output pentode 6 milliamperes, or a total of 9 milliamperes for the receiver.

Now, we find that at the rated plate voltage the pentode requires a negative bias of 4½ volts. Using the formula previously given, that R = E over C x 1000, we find that we require a resistance of 500 ohms to develop the 4½ volts bias required for the final stage.

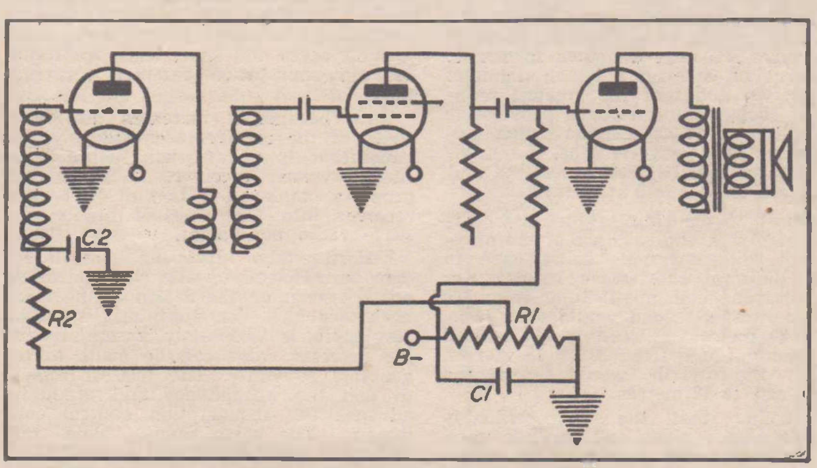
However, it also is desired to place a 1½ volt bias on the r.f. valve. To do this we must fit the 500 ohm resistor with a clip which can be slid along the bias resistor until it is one-third of the way from the earthed end and thus provides the 1½ volt bias required.

The circuit diagram shows how the automatic bias system is wired into a receiver. The main bias resistor, R1, is connected between the "B" negative supply lead and chassis. The "B" negative lead does not connect to earth or to any other part of the receiver. The other end of the resistor is earthed. The bias for the output tube is taken from the "B" negative end of the resistor which must be by-passed with a 25 mfd. low voltage type electrolytic condenser.

In order successfully to feed the r.f. valve with bias we must resort to decoupling. For this reason a 100,000 ohm resistor, R2, is connected in series with the 1½ volt bias tap on R1 and the grid return end of the r.f. coil. At this point of connection it is by-passed to earth by means of the .1 mfd. condenser, C2.

This automatic bias system will be found to work very well with battery sets. It overcomes the necessity for a separate "C" battery and prolongs the useful life of the "B" batteries by permitting them to be used down to the last few volts without introducing distortion.

Remember, when calculating "C" bias resistors for battery or A.C. valves, always to take into consideration the currents drawn by screening grids and other auxiliary elements. Remember also that every current must flow through the valve cathode so that it will contribute to the voltage drop which takes place across a given cathode resistor. When two valves are used in push-pull or in parallel, the current drawn by them is doubled so that a resistance of half the normal value may be used as a common bias-resistor for the two valves.



This skeleton circuit diagram illustrates how a bias potential can be obtained without the necessity of a "C" battery.

SHORT-WAVE RECEIVERS

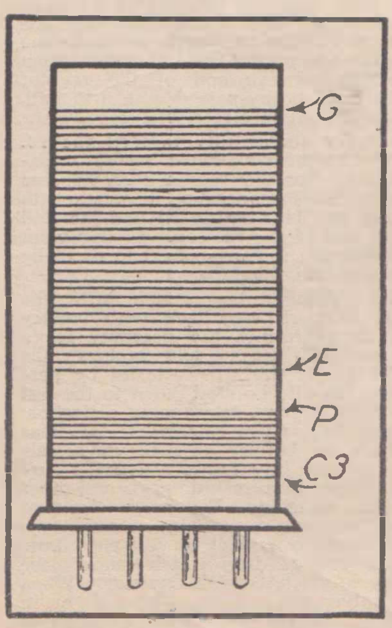
In this introduction to short-wave listening we have dealt with both the theoretical and constructional sides of this fascinating experimental field.

ONE of the most fascinating branches of radio reception is that of the short-wave stations. Even with the very simplest of equipment it is possible to tune into short-wave broadcasting stations in all parts of the world. Regular programmes broadcast from England, France, Germany, Italy, Russia and America provide the short-wave listener with plenty of thrills. If he has a knowledge of the Morse code, the short-wave enthusiast can listen to the Morse messages of amateur and commercial stations, hear a great deal of news, and generally eavesdrop on the world's airways.

The building and operation of short-wave receivers is not difficult. Providing that a little common sense is used in their construction, short-wave receivers are very easy to get going. In this introduction to short-wave listening we propose only to deal with the very simple types of receivers. Other more elaborate designs will, of course, give better results, but it is amazing what a good aerial system will do for a small short-wave set.

It should be explained at this juncture that short-waves, within the range from 100 to 10 metres, are chiefly notable for the great distances they cover. When broadcast stations operating between 200 and 550 metres have great difficulty in being heard at distance above 1500 miles, short-waves regularly bridge 10,000 and 12,000-mile gaps.

Fundamentally, the short-wave receiver is identical in design with that of the broadcast receiver. The only difference is that smaller coils and condensers are used in order adequately to tune through the short-wave range.



This drawing shows how a short-wave coil is wound. In this particular illustration it will be seen that the reaction winding is wound in the reverse direction.

At this juncture, we must diverge in order to clear up the question of wavelength and frequency. It is generally accepted that radio waves travel at the rate of 300,000 metres per second. This velocity is unchanging, no matter what wavelength is used. Velocity divided by wavelength gives us frequency, i.e., the number of changes of polarity which take place per second in an alternating current. A broadcast wavelength of 200 metres has a frequency of 1,500,000 cycles or 1500 kilocycles per second. A 500 metre broadcast wavelength has a frequency of only 600 kilocycles per second. A short wavelength of 100 metres has a frequency of 3000 kilocycles per second, whilst one of 15 metres has a frequency of 20,000 kilocycles per second.

From this it will be seen that, if we divide the wavelength into 300,000, we obtain the frequency in cycles per second.

Now it is a fairly simple matter to tune over a broadcast frequency range which extends only from 1500 to 545 kilocycles (200 to 550 metres), but if we attempt to tune over the short-wave frequency range from 3000 to 30,000 kilocycles (100 to 10 metres) with a single coil and condenser our tuning will be so sharp that it will be almost impossible to tune in any stations.

On the broadcast band we had a frequency range of 955 kilocycles, whilst on our short-wave band we have a range of 27,000 kilocycles.

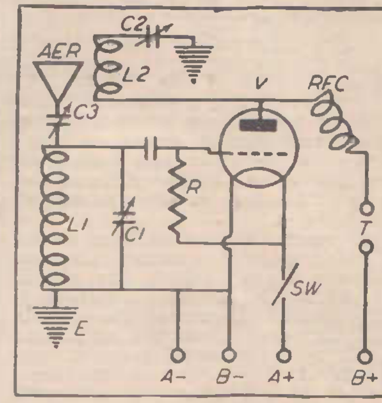
The first thing to do, then, in planning a short-wave receiver is to reconcile one's self to the fact that a very small tuning condenser and a number of coils will be required to tune throughout the short-wave range.

There is another reason for the employment of a small capacity condenser. At all frequencies or wave-lengths there is a definite ratio between the tuning capacity and the coil inductance which gives best results. This is known as the LC ratio. Generally speaking, the larger the inductance and the smaller the capacity the better will be the efficiency of the tuned circuit.

When on broadcast wave-lengths we use coils which vary from 50 turns of wire on a 2¾-inch diameter former to 130 turns of wire on a 1-inch diameter former, we find that the greatest number of turns required for a short-wave coil will be 20 to 25. On the higher frequencies lower wave-lengths, the number of turns will be greatly reduced and will reach from 3 to 5 at 15 metres.

In most of the simple types of short-wave receivers, the coils are of the plug-in type, different coils being used to cover different short-wave bands. For example, one coil might tune from 100 to 50 metres; a second would tune from 50 to 30 metres; a third would extend the tuning range from 30 to 18 metres, whilst the fourth would extend the range, say, to 12 metres.

Remember that the sweep which is possible with a given coil depends upon the maximum and minimum capacities of the tuning condenser. If the condenser has a high minimum capacity the tuning range will be compressed greatly by the cutting off of the bottom end, due to the fact that the condenser has no very great capacity range.



Circuit diagram of a simple one valve regenerative receiver.

For example, take two condensers and a given coil. Condenser A has a capacity range from 100 to 5 micro-micro farads (.0001 to .00005 mfd.), whilst condenser B also has a maximum capacity of 100 mmfd., but has a minimum of only 50 mmfd.

Naturally, condenser B will tune over the range which condenser A would tune over if its plates were swung only from the full in to the half-out position.

Another thing which has a bearing on the minimum capacities of the tuned circuits of short-wave receivers are the internal capacities of the valves.

Valves with a low capacity from control grid to ground are desirable in short-wave receivers. For this reason, high impedance triode valves and screen grid valves are preferable as detectors and radio frequency amplifiers. The triode, of course, cannot be used as a radio frequency amplifier on short-waves. It also is necessary to keep the capacity of the grid and plate wiring to a minimum by making these leads as short as possible and by keeping them well clear of any earthed body such as the metal chassis of the receiver.

The grid leads should be so proportioned that they do not exceed two inches in length. The plate leads, in receivers which employ a radio frequency amplifier, are of equal importance. Good, soldered joints, heavy connecting wires and short leads spell success in short-wave receiver construction.

Now, because it increases the sensitivity of the receiver tremendously, regeneration is always used with small short - wave receiver. Regeneration, properly employed, lifts the short-wave receiver into the class of highly-sensitive radio equipment.

Unfortunately, however, insufficient care is bestowed by the average short-wave listener on the design of the feed-back system. For anything like good results it is absolutely essential that the detector valve can be made to regenerate smoothly. The test of this is to don the headphones and gradually advance the regeneration control condenser The valve should "slide" into oscillation. There should be no "plop" as it is brought up to the oscillation point, but only a soft hissing or rushing sound should be heard. Until the detector valve behaves in this manner it is hopeless to expect anything like good results from the receiver.

The principles to be followed to attain this control of regeneration are: Keep the plate voltage on the detector valve to as low a point as possible. From 22½ to 30 volts should be adequate for the triode valve.

Wind the reaction coil so that it is separated by quarter-of-an-inch or more from the grid coil. Wind it on the earth end of the grid coil and let it consist of as few turns as possible.

The reaction coil should never have more turns than the grid winding, and only on the very highest frequency bands, lowest wavelengths, should the reaction coil turns equal the number of grid coil turns.

Pay particular attention to the capacity of the detector grid condenser and the resistance of the grid leak. Tests have shown that the ideal capacity for the grid condenser is .0001 mfd. (100 mmfd.) whilst the grid leak should have a resistance of not less than 5 megohms. Resistance up to 10 or 12 megohms can be used here with advantage. They improve the sensitivity of the detector and assist in obtaining a smooth control of oscillation.

In regard to oscillation, it should be possible. with a little experiment with grid leak values, reaction turns and spacing from the grid winding, and alteration of the detector plate voltage, to obtain a condition in which the detector cannot be heard to go into oscillation. The test for oscillation is to moisten the forefinger of one hand and to touch this on that connection of the grid condenser which joins to the grid of the detector valve. A "plop" should be heard on touching the condenser and another on removing the finger.

It will usually be found that the action of the regeneration control condenser has some effect on the tuning of the short-wave receiver. In tuning a short-wave receiver the usual thing to do is to throw the detector valve into a state of oscillation by advancing the regeneration control. Then the main tuning condenser is rotated and the whistles of the carrier waves of stations picked up.

When a steady whistle, unbroken by the dots and dashes of the Morse code—presuming that the listener is looking for a short-wave broadcasting station—is picked up the regeneration control is turned towards the position which brings the detector valve out of oscillation.

Almost always it is necessary to retune on the tuning condenser in order to find the station.

This interlocking effect can be overcome by experimenting with the spacing of the reaction coil from the grid coil.

A method which helps considerably is to wind the reaction coil in the opposite direction to the grid winding. This overcomes any coupling effects between the two windings and reduces the interlock considerably. The diagram shows how the connections should be made to the two coils.

We come, now, to a consideration of the coils and condensers to be used with short-wave receivers.

Let us take the condensers first. The maximum capacity of short-wave tuning condensers should not exceed 150 mmfd. (.00015 mfd.). Condensers of 100, 70, or 50 mmfd. can be used advantageously although the latter capacity necessitates the employment of a large number of tuning coils. Standard .0005 mfd. broadcast condensers can be used too if an electrical method of reducing their capacity is employed. This involves the connection of a fixed condenser of suitable capacity between the fixed plate plug of the variable condenser and the grid of the valve and the grid end of the tuning coil which are then not connected to the variable condenser itself. The capacity of the fixed condenser is worked out by cut-and-try methods from the formula:

$$\frac{C1 \times C2}{C1 + C2} = CX$$

Where C1 is the maximum capacity of the existing Variable Condenser,

C2 is the capacity of the fixed condenser connected in series, and

CX is the desired capacity of the combination.

This system works out very well for the man who does not wish to go to the expense of special short-wave condensers. For the small capacity variable condensers we suggest midget condensers. The 23 plate midget usually has a capacity of .00015 mfd. the 13-plate condenser has a capacity of .0001 mfd. the 11-plate condenser has a capacity of .000075 mfd., and the 7-plate condenser has a capacity of .00005 mfd.

These condensers are easy to mount, and, being small, permit a compact chassis lay-out and correspondingly short wiring.

Below is an approximation of the coil turns required for use with the various capacity condensers to tune over a given wave-range:

These coil dimensions are all calculated on the assumption that 1¼ inch diameter ribbed plug-in formers will be used. For round formers or for discarded valve bases the turns will need to be increased slightly. In all cases generous overlaps have been provided so that in practice the coil-winder will find it possible to remove one or more turns. This is better, however, than providing too few turns, for it is always easier to remove them than to add turns.

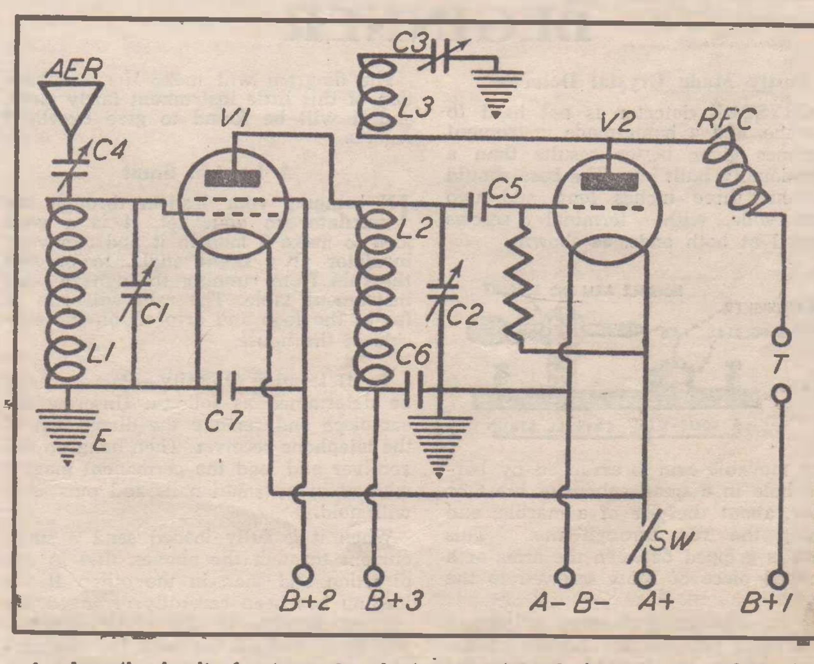
The spacing between the grid and reaction windings should be 1-8th of an inch for the high frequency bands up to around 25 metres, and one-quarter of an inch for the lower frequency bands. The 12 to 20 metre coils should be space-wound to one diameter of the wire being used. The other windings and all reaction windings are close wound.

We have three types of short-wave receiver from which to choose. The first embraces straight types of short-wave sets designed for S.W. reception and for nothing else. These receivers may be as simple or as elaborate as desired, and range from the one-valve regenerative type through the detector-audio combination to sets embodying r.f. amplification and to short-wave super-heterodynes.

The next type is the short-wave adaptor, which consists of a detector stage or an r.f. stage and detector so arranged that it can be plugged into the detector socket of a broadcast receiver, and thus draw its plate and filament power from this source and at the same time feed the detector's audio output into the audio frequency amplifier of the broadcast receiver.

The third type is the super-heterodyne—a converter which is designed to function ahead of a multi-stage tuned radio frequency receiver or ahead of a broadcast super-heterodyne. Each type has its merits, but the best all-round results will be obtained from the straight receiver.

For the present we propose only to deal with two types of short-wave receiver. The first is a one-valver, which is capable of excellent headphone reception. A glance at the schematic circuit diagram will show that only two coils, L1 and L2, are used. L1 is the main tuning coil, whilst L2 is the reaction winding. The aerial is coupled to L1



A schematic circuit of a two valve short-wave set employing one stage of tuned radio frequency and a regenerative detector.

through a variable condenser C3. This should have a maximum capacity of 50 mmfd. (.00005 mfd.).

It will be remembered that, in the coil data, we gave particulars of an aerial coil. Some short-wave set builders may decide to use an aerial coil, but a coupling condenser such as this gets over the tuning "dead spots" caused by aerial resonance and responsible for the detector valve going out of oscillation.

The condenser, C1, is the main tuning condenser and should be selected to suit the coil winding.

C2 is a 23 plate midget variable condenser and controls the amount of regeneration applied to the detector valve. C4 is the .0001 mfd. grid condenser, whilst R is the grid leak, which may have a resistance of between 5 and 10 megohms.

Note that this resistor is returned to the positive side of the valve filament for greater sensitivity. The headphones are connected in series with the plate of the detector valve through the radio frequency choke coil r.f.c.

The filament switch is connected in the positive filament circuit. For this receiver a triode valve such as a Type 30 and a 22½ or 45 volt "B" battery will be required.

The second circuit shows how a stage of radio frequency amplification may be added to the regenerative short-wave detector. The r.f. grid coil, L, is coupled to the aerial through the 50 mmfd variable condenser used in the previous circuit. L1 is tuned by C1 and has identical dimensions to L2, which is tuned by C2. C1 and C2 have the same capacity.

A screen grid valve is used as the r.f. amplifier, this being Tuned Anode coupled to the detector valve, V2. The by-pass condenser C6, which should be a .01 mfd. mica type, permits L2 to be tuned by C2. The rest of the detector circuit is identical with that of the single valve receiver.

The screening grid voltage applied to the r.f. valve should be 67½ volts. The r.f. plate should receive 135 volts and the detector plate 22½ to 45 volts through B plus 1.

This circuit is much more sensitive than the single valver because of the gain of the r.f. valve. It also is more selective, a feature which is not to be neglected on short-waves where conditions are becoming more and more crowded. Either of these circuits can have a stage of audio frequency amplification added to it in the conventional manner.

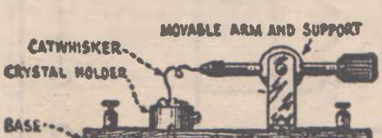
Short-Wave Coil Winding Data

Wave-Range.	Aerial.	Detector R.F.	Grid.	Reaction	Wire Gauge.
150 mmfd. Capacity					
12 to 19 metres	3	3	3	3	16 enamel
19 to 30 metres	4	6	6	5	24 enamel
29 to 51 metres	8	15	15	9	24 enamel
45 to 84 metres	10	26	26	11	24 enamel
70 to 110 metres	10	33	33	12	24 enamel
100 mmfd. Capacity					
12 to 17.5 metres	3	3	3	3	16 enamel
17 to 26 metres	4	7	7	5	24 enamel
25 to 38 metres	6	10	10	7	24 enamel
37 to 55 metres	7	16	16	8	24 enamel
54 to 85 metres	8	25	25	10	24 enamel
84 to 115 metres	10	34	34	12	24 enamel
75 mmfd. Capacity					
12 to 17 metres	3	3	3	3	16 enamel
17 to 24 metres	4	7	7	5	24 enamel
23 to 35 metres	5	11	11	7	24 enamel
34 to 51 metres	7	17	17	8	24 enamel
50 to 78 metres	10	26	26	10	24 enamel
77 to 100 metres	10	35	35	11	24 enamel
50 mmfd. Capacity					
12 to 16.5 metres	3	3	3	3	16 enamel
16 to 22 metres	4	6	6	5	24 enamel
21 to 32 metres	5	10	10	3	24 enamel
31 to 45 metres	6	16	16	10	24 enamel
44 to 65 metres	8	23	23	12	24 enamel
64 to 95 metres	10	36	36	12	24 enamel

HINTS FOR THE RADIO BEGINNER

Easily Made Crystal Detector

A CRYSTAL detector is not hard to make, and a home-made instrument sometimes gives better results than a professionally built one. The base should be about three inches long and two inches wide, with terminal screws mounted at both ends, as shown.



A HOME-MADE CRYSTAL STAND

The movable arm is arranged by boring a hole in a small sphere of brass or copper, about the size of a marble, and pushing the rod through this. This sphere is gripped between the arms of a U-shaped piece of brass screwed to the base.

The cat-whisker is soldered to the end and bent to play on the surface of the crystal which is clamped in a metal cup.

The diagram will make the construction of this little instrument fairly clear, and it will be found to give excellent results.

A Lead-in Stunt

IN bringing your lead-in through the insulator to your set, it is a good idea to make a loop in it and run your insulator at a slight angle, to prevent the rain from running through to your instrument table. The rain will run as far as the loop and drip off on the outside of the house.

To Determine Polarity.—Polarity may be determined as follows: Unscrew the ear-piece and remove the diaphragm of the telephone receiver. Then hang up the receiver and load the permanent magnet with as many small nails and pins as it will hold.

When it is fully loaded send a small current through the phones. first in one direction and then in the other. If the loading has been carefully arranged the current flowing in the right direction will assist to hold the load. but the current flowing in the wrong direction will cause it to fall.

Variable Condenser.—A simple form of variable condenser can be made from a number of old photograph plates and some pieces of zinc cut to the shape of a right-angled triangle. The assembly of a condenser made with these materials is shown in the diagram, and is fairly simple. All the moving plates are connected rigidly at one end and provided with a knob so that they can be adjusted. The fixed plates are placed alternately with the glass plates. Over the whole is placed a wooden box, provided with saw cuts to guide the moving plates.

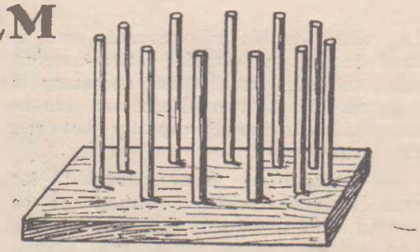
Phone Comfort.—Even the best of receivers is apt to become uncomfortable after many hours' use. To overcome this a soft cloth pad may be arranged under the head-bands to make them fit comfortably on the head. This takes the weight of the receivers and makes receiving much more comfortable.

Higher Efficiency Hints.—In connecting your instruments. the lengths of wire should be as short and of heavy gauge as possible. Have as few instruments in a circuit or set as possible. and learn to work them. Don't try new connections on your set every day. Get a standard circuit and learn to tune with it.

Care of Batteries. — Batteries or dry cells should be stored in a cool. dry place, and the terminals protected with some insulating material. so that there is no danger of a short-circuit.

COILS AND HOW TO MAKE THEM

The subject of inductance coils for use in radio work is of the utmost importance, and in this article the writer has touched on the salient points of each type and in addition dealt with the winding of coils.



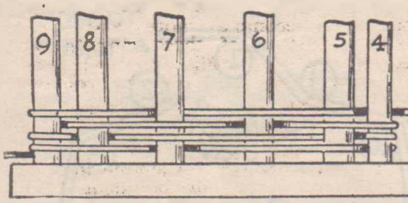
This diagram illustrates how the pegs should be assembled on a baseboard for the winding of basket coils.

THE tuning coils are the most important parts of a receiver. Without properly designed and efficient coils even the best set cannot be expected to function properly. Today there are many manufactured coils composed of special wires and wound in ways which cannot be duplicated by the home constructor.

However, even the best of these coils can be easily duplicated from the performance viewpoint by simply-wound home-made coils.

Certainly the size of the home-made coils must be larger than the efficient, commercially-made coils, but this is no drawback to the experimenter, who usually is interested only in the results he gets and not in the methods he must adopt to get these results.

One of the important things in coil design is to keep the distributed capacity low. In the diagram we see that distributed capacity is caused by the condenser effect existing between adjacent turns. Each turn is one plate of



A partly completed basket winding.

the condenser and the wire insulation—or spacing, if bare wire is used—constitutes the dielectric.

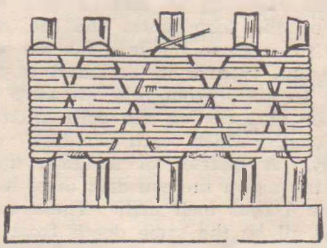
Honeycomb-wound coils, spiderweb coils and basket weave coils have a very low distributed capacity. Solenoid coils, i.e., single-layer coils in which the turns lie alongside one another, have a high distributed capacity, but have less resistance to radio frequency currents than other type coils.

Distributed capacity in a coil introduces certain losses, but in the solenoid coil these are made up by gains in other directions.

Of the coils which can be wound by the home-constructor, the solenoid is the simplest.

Next come the basket-weave and spider-web coils. The latter are of interest chiefly from the experimental viewpoint. Their size and general mechanical make-up does not lend itself to use in modern receivers. However, when we come to tell how coils can be wound, the three types will be dealt with.

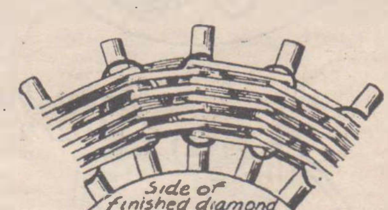
The next thing to consider in coil winding is the form factor. This is the relationship between the length of the winding and its diameter. Greatest inductance is obtainable from a given coil when the diameter is equal to 2.3 times the length of the winding. In practice, however, this can be varied considerably



The finished basket-winding with lacing in place.

without serious effect. From an efficiency viewpoint it is desirable to avoid small diameter coil-formers, which must be wound with a large number of turns of fine wire in order to obtain the desired inductance.

One of the best coils which the constructor can make for broadcast reception consists of a 2¾ inch diameter former wound with 50 turns of 26 gauge, double-cotton-covered wire. This coil will tune over the broadcast range with a .0005 mfd. condenser. Its efficiency, checked by measurements and under actual performance conditions, is as high as the best commercial coil of smaller dimensions. One point which should be borne in mind in constucting



Lacing the finished Diamond Weave spiderweb coil.

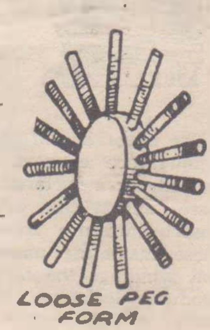
coils is that they should be wound on the highest quality formers. Cardboard and similar paper formers are not good. The best type of former is the yellow bakelite type which combines mechanical strength with high electrical efficiency.

Remember, if it is necessary to screen a coil, that the screening has an effect on the inductance of the coil. The more complete the metal shielding and the closer this shielding approaches the coil the more the coils inductance is reduced. To compensate for this, it is necessary to add more turns to the coil. The screening should be kept as far away from the coil as practical. If a screen is very close to the coil, say a quarter of an inch from it, the coil is heavily damped and its efficiency is lowered considerably.

The usual thing in fitting coils with metal screening cans is to arrange matters so that the screening can is twice the diameter of the coil which then is mounted centrally in the can.

In some types of sets screening partitions are used and the coils are otherwise left in the open. Providing that the coil is not nearer than one inch

A form for spider-web coil winding.



from the screening partition, the latter will have no measurable effect on the coils inductance or efficiency.

For this reason coils which are to be mounted on metal chassis should not be nearer than one inch from the chassis. This can be done if the coil winding is started one inch up from the bottom of the former.

Remember always to arrange the coil so that the grid end of the winding is at the top of the former away from the chassis and baseboard.

The coil winding tables provided here have been tabulated on the basis of cotton and silk-covered wires. It will be noticed that as the wire gauge decreases the number of turns required with a given sized former and tuning condenser is lessened. Furthermore, as the thickness of the insulation is reduced, i.e., when double silk-covered wire is used instead of double cotton-covered wire, the number of turns necessary is reduced. These two effects are due to increased distributed capacity between the turns.

No tables have been provided for enamel-covered wires, but they can be wound with two turns less than for the corresponding gauge silk-covered wire.

If a coil tunes higher than it is desired to go and will not tune down to the lowest wavelengths required it will be necessary to remove turns. This should be done carefully, one turn being removed at a time, until the correct wave-range is obtained. Coil dopes should be used sparingly.

Amyl-acetate and duco-lacquers are fairly satisfactory, but the best coil dope is made from a mixture comprising nine parts of beeswax to one part of resin. This should be melted and brought almost to the boiling point. Then the coils should be dipped into the mixture allowed to stay in it for a minute or two to drive out all the air bubbles, withdrawn and hung up to dry. This dope has the advantage of being impervious to weather conditions and is electrically efficient.

Space winding on single - layer type of coil.

The advantage of doping a coil is that temperature changes do not affect its capacity or inductance. Cotton, and to a lesser extent silk, are hydroscopic and absorb moisture from the air. When these insulating materials are used in coil windings the moisture they absorb produces leakages across the coil and makes it inefficient.

Don't use paraffin wax as a coil dope for this is hydroscopic.

Enamel insulated wire is impervious to weather conditions but still can be improved by doping with the beeswax-resin mixture.

When enamel-covered wire is used for coil winding, and it becomes necessary to wind a r.f. primary or a reaction winding over a grid winding, it is desirable first to wrap a piece of writing paper around the grid coil before starting the over-winding. This is because of the possibility of a voltage breakdown taking place between the over-winding which may be carrying potentials up to 250 volts and the grid winding which is at earth potential.

Sometimes, for example, with short-wave coils, it is necessary to space each turn of the winding. The degree of spacing will determine just how this is to be done, but when the spacing is equal to one diameter of the wire the simplest method is to wind on a pair of wires simultaneously and to remove one wire when the winding is completed.

The best way to wind solenoid coils singlehanded is to measure the length of wire required for one turn, calculate the total length of wire for the coil, and unreel this length. Allow a few inches for connection leads. Attach the far end of the wire to a support and fasten the near end to the coil-former. Then, keeping the wire taut but not straining it too much, gradually walk towards the far end of the wire, at the same time rotating the former, which should be held in both hands.

Cant the former slightly in the direction from which the winding started. This will ensure that each successive turn lies closely also alongside the preceding one. Keep the winding tight and the turns tightly against each other.

When planning to wind a coil, first look up the wire tables and see how many turns go to the inch for the wire gauge and type of insulation it is proposed to use. From this, knowing the number of turns on the coil, calculate the length which each winding will occupy. A quarter of an inch down from the top of the coil drill three holes with a 1/32nd inch drill. These holes should all be the same depth from the top of the coil, and may be a quarter of an inch apart.

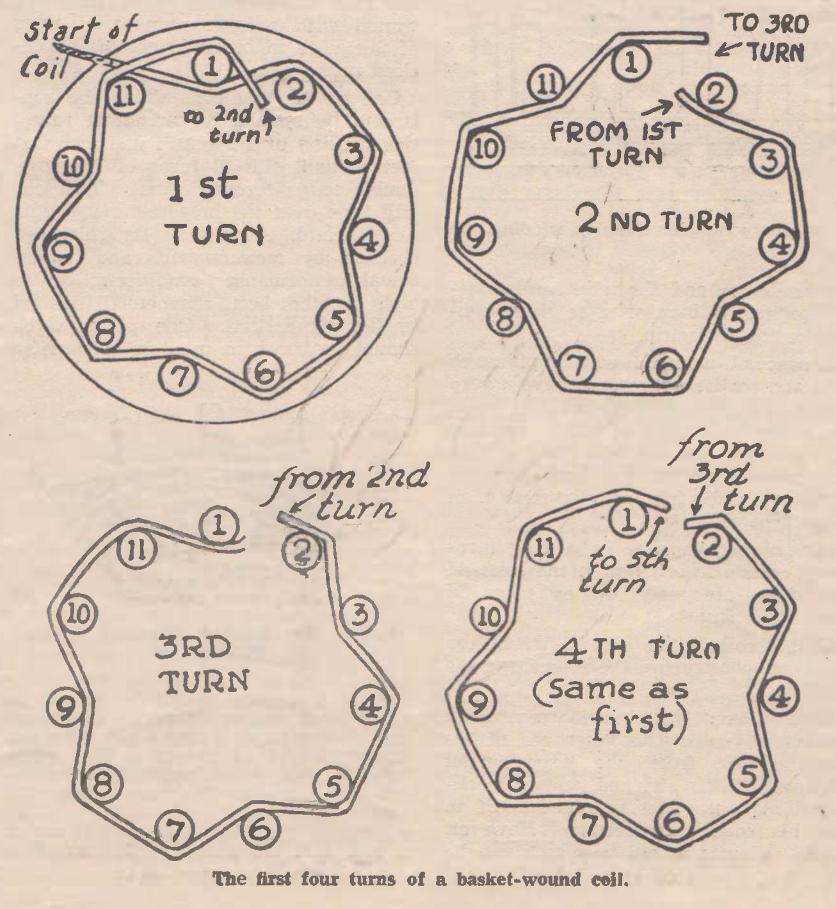
A similar series of three holes should be drilled at the point at which measurements and calculations have shown

The method of winding Diamond weave spider coils.

that the winding will finish. Other sets of three holes should be drilled as required for other windings on the former. It is best to drill all these holes before starting to wind the coil.

Now, holding the coil former vertically with its top end uppermost, thread the start of the wire down through the right-hand top hole for a distance of say 12 inches. Take the end up through the middle hole and down again through the left-hand hole. This will make a good anchor for the winding and one which will not slip. Now turn the former to the left so that the winding may be started with the wire feeding on to the former at the top.

With this arrangement it is easy to see what is happening during the wiring of the coil and to check any irregularities immediately. When a sufficient number of turns have been wound on, the winding should end at the left-hand of one of the bottom three holes. Holding the coil with the thumb and forefinger cut off the wire, leaving about 12 inches to spare. Thread it through the left-hand hole, up through the middle hole, and



The first four turns of a basket-wound coil.

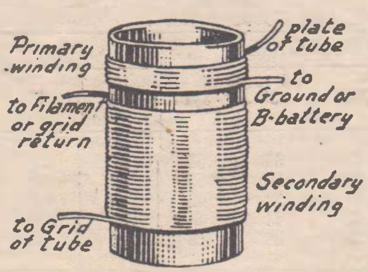
down through the right-hand hole. The same procedure should be followed with other windings.

These leads then can be soldered directly into circuit or can be terminated in a series of solder eyelets attached to the bottom of the coil. Remember, when winding coils, to take every care to see that the wire does not kink. Kinks in the wire weaken it and cause unsightly bulges in the finished coil.

Another way in which the coil-ends can be anchored is to cut a strip of linen tape quarter of an inch wide and two inches in length. Lay this down lengthwise on the coil-former so that the first turn of the winding crosses its midpoint. After the first turn has been wound over the tap, fold it back towards the centre of the coil so that succeeding turns are made at both ends of the loop so formed. When six or seven turns have been so wound. raise the top flap of the loop and continue winding as usual.

One inch from the point at which the winding is to end, lay down a second piece of tape and wind five or six turns over it. Then fold the tape back so that it will form a loop at the point where the last turn of the winding will fall, and continue to wind over both the upper and lower sections of the tape. This will leave about quarter of an inch of tape sticking out from the winding.

When the last turn is reached cut off the wire and thread it through the loop. Holding the coil so that the wire will not



The correct wiring connections for a standard loosely-coupled coil.

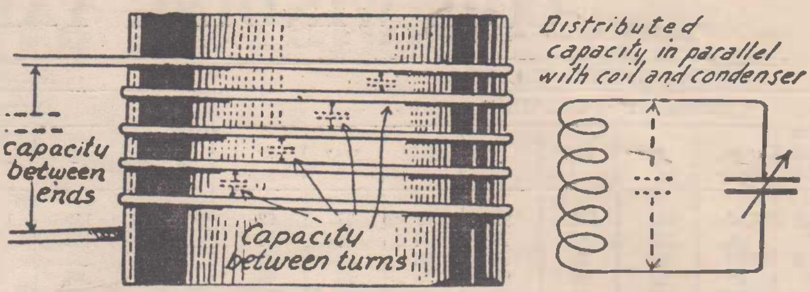
slip, pull hard on the exposed end of tape. This will cause the loop to tighten and hold the wire. The same tightening process should be applied to the loop at the top end of the winding.

Although a little more difficult, this form of coil anchoring is much neater than the hole type of anchor.

The other forms of coils which can be made by the home constructor include spider-web coils and basket coils.

Basket coils are wound on a former consisting of an odd number of pegs set around a circle drawn on a wooden base. The best way to make this former is to get some four or six inch nails, mark out the points at which they are to be inserted in the wooden base and drill holes which will not quite clear the nails. The latter then can be driven in without fear of splitting the base.

The base should be ¾ or 1-inch thick.



This illustration shows distributed capacity and its effect on a coil.

The diameter of the coil will depend upon the use to which it is to be put.

For example, a three-inch diameter coil of 35 turns will tune to the broadcast wave lengths. The smaller the diameter of the circle the more difficulty there is in winding the coil.

Wire gauges of from 16 to 24 will be found best for this type of coil which, when properly wound and laced, is quite rigid.

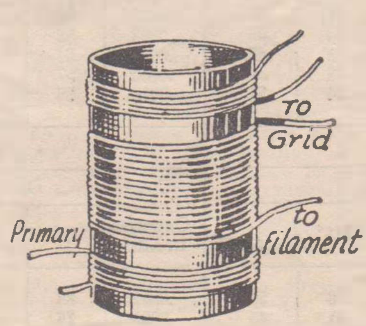
Suppose we take 11 pegs and space them equally around a three-inch diameter circle. The winding is started as shown in Fig. 2. The wire is run behind one peg then outside the next two, behind the fourth one, outside the fifth and sixth, and so on around the form following the rule of "one inside and two outside." The first turn is shown in the upper left-hand drawing of Fig. 2. The second turn, running from the end of the first one to the beginning of the third, is shown in the upper right-hand drawing. The third turn is shown in the lower left-hand drawing and the fourth turn is shown in the lower right-hand drawing.

It will be seen that the fourth turn is exactly like the first.

The winding is continued on from this point, and in the same sequence, until the desired number of turns has been wound on.

The appearance of the coil whilst still on its winding form, and as viewed from the side, is shown in Fig. 3. Whilst still on the former, the turns should be securely fastened with lacing, as shown in Fig. 4. If it is found more convenient the lacing may be dispensed with, and the coil doped with the beeswax and resin.

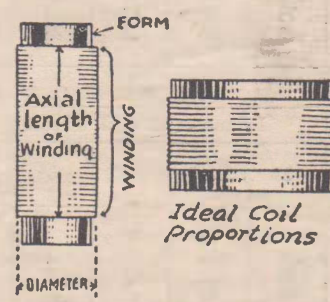
The spider-web coil is compact, and is easily constructed; also, it has spaced turns to reduce the distributed capacity. Aside from these three features, the spider-web is not a desirable type of coil, principally because of the large amount of dialectric directly in the field of the coil.



This diagram shows the winding and wiring connections to a conventional coil with a reaction winding.

The spider-web coil wound on the peg form is often called a diamond weave. It forms an efficient coil, doing away with the disadvantages of the flat spiral while retaining its advantages. The winding former consists of a central cylindrical disc, having holes bored radially around its circumference. Into these holes fit cylindrical pegs, either of wood or of metal. The number of pegs is always odd.

The construction of a diamond weave coil is shown in Fig. 2. The wire is fas-



The design proportions between length and diameter of coil windings.

tened around one of the pegs to start with, and as shown at the bottom of Fig. 2, the winding continues very much as with the basket weave coil, that is, over two pegs, under the next two, over the following two, and so on. The wire will build up, so that its appearance from the edge is as shown at the top of Fig. 2, this giving the diamond shaped appearance. When the winding has been completed, it will appear from the side as in Fig. 3. The wire may be fastened in place by a thin line of coil cement run along the wires where they come together along the length of each peg. If it is desiged to avoid the use of cement or binders, lacing may be run through the coil, as shown in Fig. 3, this forming a very secure fastening.

With the winding completed, and the wires secured either with lacing or cement, the pegs may be withdrawn. With the pegs out of the way, the finished winding will slide off the centre disc, and form a self-supporting space wound coil of compact form, good efficiency, and low resistance.

COIL WINDING TABLES

No. 20 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	166	121	103	93	87	77	68
.0003	143	103	89	79	74	68	59
.00035	126	91	79	71	66	61	53
.0005	93	68	60	54	50	46	40
.001	53	41	37	34	31	28	25

No. 22 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	141	107	94	84	79	72	60
.0003	116	92	81	72	67	62	53
.00035	108	82	72	65	60	56	48
.0005	82	61	55	50	46	43	38
.001	50	38	34	31	29	27	24

No. 24 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	132	98	87	78	72	66	49
.0003	114	86	75	68	63	58	44
.00035	101	76	67	62	57	53	41
.0005	76	59	52	47	44	41	34
.001	45	35	32	30	28	26	23

No. 26 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	121	89	80	72	67	62	53
.0003	114	78	70	64	59	54	46
.00035	93	70	63	57	52	48	42
.0005	70	53	49	45	41	39	35
.001	43	34	31	29	27	25	22

No. 28 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	112	88	75	70	66	61	53
.0003	97	74	67	61	58	54	46
.00035	87	67	60	56	53	49	42
.0005	67	53	48	44	41	38	33
.001	41	33	30	28	26	24	21

No. 30 D. C. C. Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	105	80	73	67	62	58	50
.0003	92	71	65	60	55	61	45
.00035	82	65	58	53	49	46	41
.0005	63	50	45	42	39	36	32
.001	39	32	28	26	24	23	20

No. 20 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	150	108	96	86	80	76	67
.0003	128	93	83	74	69	65	58
.00035	113	82	73	66	61	58	52
.0005	84	62	56	51	47	45	40
.001	48	39	35	32	30	28	25

No. 22 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	130	96	85	76	71	66	56
.0003	112	83	75	67	62	58	50
.00035	99	75	67	61	56	52	45
.0005	75	58	51	47	44	40	35
.001	45	35	32	30	28	26	23

No. 24 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	116	87	77	71	65	60	56
.0003	99	76	67	63	57	53	46
.00035	89	68	61	56	51	47	42
.0005	68	53	47	44	41	38	34
.001	41	33	30	28	26	25	22

No. 26 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	105	83	71	66	62	57	50
.0003	91	72	63	59	55	50	45
.00035	82	64	57	53	49	46	41
.0005	63	48	45	43	40	37	33
.001	40	34	30	28	26	24	21

No. 28 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	96	75	66	61	59	54	48
.0003	82	65	59	55	52	48	42
.00035	64	59	54	51	47	43	38
.0005	57	46	42	40	37	34	30
.001	36	29	26	24	22	21	18

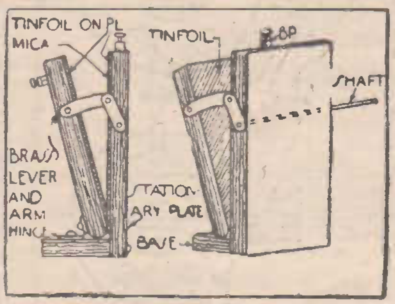
No. 30 Double Silk Covered Wire.

Condenser Capacity in Mfds.	Diameter of Coil Winding						
	2″	2½″	2¾″	3″	3¼″	3½″	4″
.00025	88	72	65	60	55	50	45
.0003	76	63	57	51	48	44	39
.00035	68	57	50	47	44	40	35
.0005	55	45	40	37	34	31	28
.001	35	28	26	23	21	20	18

AIDS FOR BETTER RECEPTION

Home-Made Variable Condenser — The size of this useful little condenser when making will depend on the capacity required. Only three main pieces are necessary, these being the base, the movable and the stationary plate, all of which are made from wood. The stationary plate is fastened in an upright position to the base.

The movable plate is fastened to the base with a small hinge, so that two plates will press solidly together and the movable may swing to and away from it. The two surfaces of the plates that press together are covered with tinfoil or metal (such as copper or brass). On the two plates are arranged two ter-



minals as shown. Each of these make contact with the metal or foil of the plate. On the stationary plate over the metal or foil is glued a piece of thin mica to keep the two plates from "shorting."

A brass lever and arm are cut in the shape shown and fastened to form a hinge, one piece being fastened to the shaft, so that when the shaft is turned the movable plate is moved to or away from the stationary plate.

Keep the 'Phones Clean. — Small particles of dust or dirt sometimes accumulate on top of pole pieces, destroying the maximum efficiency of the receivers. In such cases unscrew the cap and slide the diaphragm from the case and clean the poles with a camelhair brush. In reassembling follow the same procedure of sliding the diaphragm back and screwing down the ear cap tight. Care must be taken not to injure the fine wires soldered to the terminals, as these can only be resoldered with difficulty.

Valve Socket Hints. — The humble socket used to hold the valve and to provide the means of making an electrical contact between the prongs of the valve and the rest of the circuit receives less attention from the ordinary wireless user than it should.

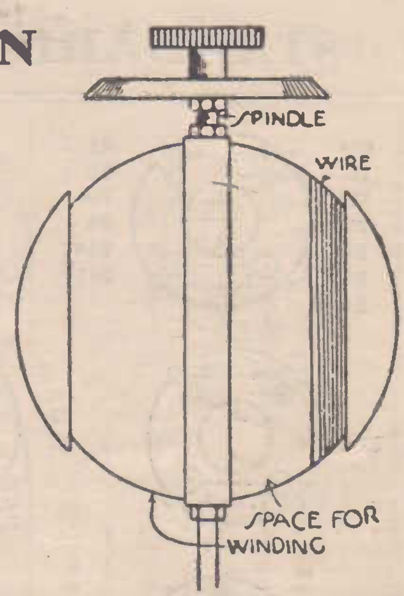
The socket should be carefully scrutinised, for it is at this point that the plate and grid wires and filament leads come very close to each other. If the socket is made of poor insulating material the current will leak across the base between the binding posts and become lost. The volume and distance of the set will suffer.

Do not accept a socket made of material that can be easily cut with a knife, or will leave a black mark when rubbed across a piece of white paper. Material that will do this has lampblack in it, which is a very poor insulating substance. As a rule this class of material will melt under the heat of a soldering iron.

Of next importance are the contact springs. Poor contact springs cause a great deal of the noise that is attributed to atmospherics.

Reviving the Sensitivity of Crystals.— One way of bringing a crystal back to its onetime usefulness is to immerse it in a saturated solution of alum and water for 20 minutes, and then remove and allow to dry. The alum solution should be made up warm and alum added gradually until it ceases to dissolve. The solution should be left over night, and if all the alum has dissolved by the morning still more alum should be added until the solution will take up no more.

A Tennis Ball Variometer Rotor.—A serviceable variometer which presents no difficulty in construction is shown at right. It is made from an old tennis ball. The method of preparing the tennis ball is to cut away, as shown, sufficient of the outer covering to accommodate the winding, which would be wound round the bare rubber. The wire can be fastened by means of pins pushed through the rubber. The fixing of the spindle presents little difficulty.



Ohm's Law Formulae—

(*Continued from page* 34)

ever, if we want to find out how many amperes will go through a particular resistor when a certain voltage is applied this formula will not do the trick, and Ohm's Law appears to be of restricted value. The same impression existed some 50 years ago, but "Mr. Ohm" dispelled it by providing us with the formula shown in Fig. 3B.

At first this formula appears forbidding because of its mathematical make-up. But since we know that "I" means current in amperes, "E" means electrical tension in volts, and "R" means electrical resistance in ohms, we shall try to use this formula.

Let us take a case where we have a voltage of 10 volts available, and the resistance of the circuit is 5 ohms. How many amperes will flow through the resistor? The answer is quite simple:—

$$10 \div 5 = 2$$

and we know a current of 2 amperes will flow.

However, some readers will say: "That is all right, but what can we do when we know only the voltage applied in a circuit and the current which flows through it but we do no know the value of the resistance?" This trouble occurred also long before we were born, and our good "Mr. Ohm" again came to the rescue, designing for our benefit the formula in Fig. 3C.

Now, if we have a voltage of 10 volts and a current of 2 amperes flows through the resistor, how great is the resistance of "R"? The solution of this problem is quite simple, since $10 \div 2 = 5$, we know that there is a resistance of 5 ohms in the circuit.

These formulae are of immeasurable value to the radio experimenter, for it does not matter how many volts, amperes or ohms are applied in a circuit, the formula will always help him to find their exact value when direct current is the medium with which he is dealing. It is of importance to remember that when the current C or I is in milliamperes this symbol must be multiplied by 1000.

Condensers and Resistors—

(*Continued from page* 40)

and automatic volume control—100,000 to 500.000 ohms.

A recently developed use for resistors of from 50.000 to 100,000 ohms has been as radio frequency chokes in the grid and plate circuits of detector and audio frequency amplifiers. In most applications a one-watt resistor will be found quite satisfactory.

In audio grid circuits, automatic volume control circuit and similar applications, the tiny 1/3rd and ½ watt resistors can be employed without trouble.

Remember, however, when purchasing resistors to buy the best available. They are all cheap, but some are slightly better than others. A poor resistor is responsible for a great deal of noise. Furthermore, when soldering them into circuit, don't smear the resistors with soldering flux or you will get into a great deal of trouble from noise.

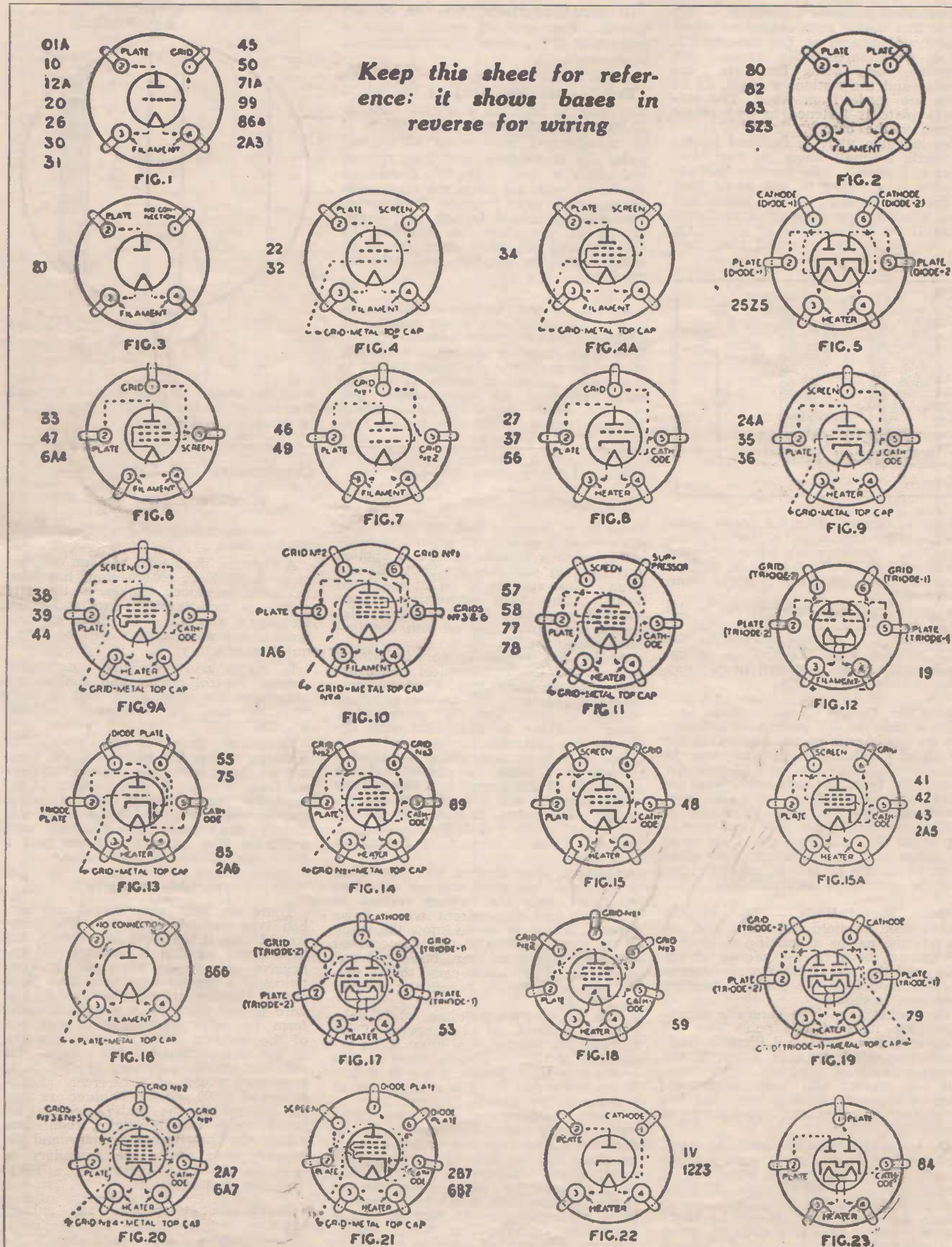
Variable Resistors

There are both wire-wound and carbon type variable resistors. The wire-wound type is the more satisfactory, but here again we find it difficult and expensive to procure wire-wound resistances of a greater resistance than 25,000 ohms. Usually it will be found that wire-wound resistors in a potentiometer form, i.e., with connections to each end of the winding and a third to the arm of the potentiometer, are used for volume control purposes in the radio frequency stages of a receiver. Resistances of 50,000 and 100,000 ohms are used for control in the audio circuits, the lower value usually being connected across the transformer primary and the higher value across the secondary or used as the grid resistor in a resistance-coupled stage.

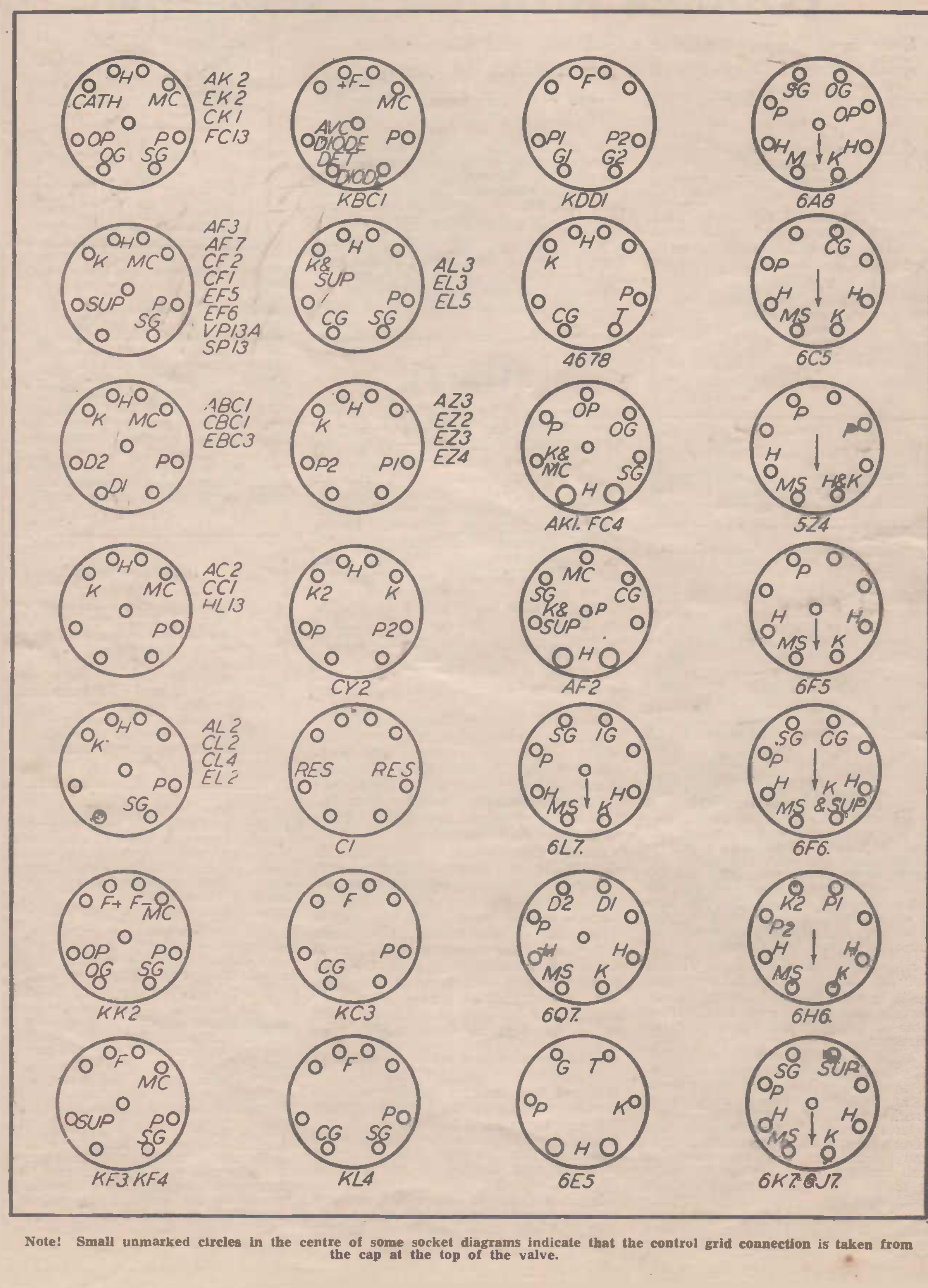
Don't attempt to feed any current through high resistance variable resistances. They are not designed for this service and will burn up.

STANDARD AMERICAN VALVE BASES

Keep this sheet for reference: it shows bases in reverse for wiring



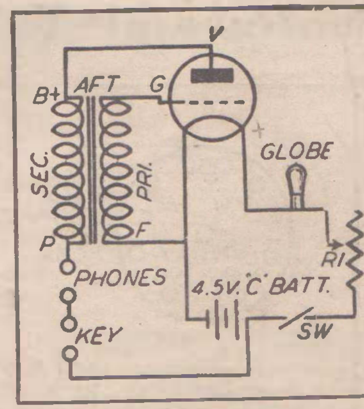
Continental Valve Bases As Viewed From Below



Note! Small unmarked circles in the centre of some socket diagrams indicate that the control grid connection is taken from the cap at the top of the valve.

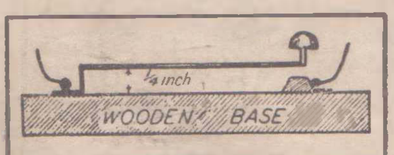
AN OSCILLATOR FOR MORSE CODE PRACTICE

Here is a simple oscillator which will give the amateur radio enthusiast hours of entertainment, and at the same time will allow him to practice the reading of Morse code signals.



Circuit diagram of the audio oscillator.

IN describing how to learn the Morse Code, we mentioned that the learner should practise sending with a key and buzzer This is a very cheap way of getting practice, but suffers from several small troubles. Usually Morse stations send with a high-pitched note, and buzzer notes are low; furthermore, most people listen with headphones, and it is not a very easy matter to connect a number of phones to a buzzer. Lastly, the sound of the buzzer can be heard all over a room, and may prove annoying to other people.



This drawing illustrates a simple home-made Morse code sending key.

A simple Morse practice oscillator overcomes these difficulties, and a device such as the one to be described is used in most instructional classes for teaching the Morse code.

The cost of such a device is very small, especially as most of the equipment can be found in the junk box.

Any type of battery triode valve can be employed, such as A415, A409, UX230. etc.

The circuit shows the oscillator with a type 30 valve, and slight modifications must be made if four-volt valves are employed. It will be seen that the oscillator consists mainly of an audio frequency transformer and a valve arranged to produce oscillations. Due to the inductance and self-capacity of the transformer windings, the oscillation occurs at audio frequencies, and can be heard in a pair of phones. The "A" battery of 4½ volts is also used as the "B" battery, and strong signals will be produced with this arrangement.

A rheostat is included in the circuit, and by its use the tone can be varied.

The layout of the components is not important, and they can be mounted on a piece of wood or bakelite to suit the constructor.

The Wiring

After assembling the various components, they should be wired by connecting the negative filament terminal of the socket to the F negative or C negative terminal on the transformer. The G terminal of this component is connected to the grid lug on the valve socket, and the plate lug on the latter goes to the "B" plus terminal on the transformer.

The free filament lug on the valve socket (positive) is joined to one side of the pilot light socket and the other side of this goes to the arm of the rheostat. The free terminal on the rheostat goes to one side of the switch.

The four terminals should be placed in line, and one of the outer ones connected to the P terminal on the transformer.

The other outer one connects to the free lug on the switch, and to this also connects a length of red wiring flex.

To the negative filament terminal on the valve socket join a length of black flex and then connect together the two centre terminals on the terminal strip.

If you are using a four-volt valve, the pilot light will not be needed, and the lead from the positive filament socket terminal goes straight to the arm of the rheostat.

Insert a valve in the socket, connect the red lead to the positive of the battery and the black lead to the battery negative.

A pair of headphones are then connected across the terminals marked "phones." Switch on the oscillator and short-circuit the key terminals. A sound should now be heard in the phones, and the tone of it can be adjusted by altering the rheostat.

To use the oscillator for Morse code practice, a Morse key must be connected across the "key" terminals.

A very simple key can be made by obtaining a piece of thin spring brass about half an inch wide and six inches long. Bend this as shown in the illustration, and screw it down to a piece of wood. Near the free end attach a small knob, and mount a small square of the brass on the wood, but underneath the end of the brass strip, so that when the knob is pressed the brass strip will make contact with the square.

The key is connected by making connections to the strip and to the square and connecting these to the "key" terminals on the oscillator.

It will be found that, as the resistance of the rheostat is increased, the pitch of the sound will increase up to a point where the emission of the valve falls too low and the oscillator will not oscillate.

If several people desire to use the oscillator, as in a class, several pairs of headphones can be connected in series.

It is possible to reproduce the output of this oscillator on a loud-speaker if a radio set is handy, and has provision for a gramo. pick-up. An audio transformer is connected to the phone terminals on the oscillator, instead of to a pair of phones, and the secondary of this transformer is joined to the pick-up terminals on the set.

LIST OF PARTS

- 1 audio frequency transformer.
- 1 valve.
- 1 four-pin valve socket.
- 1 100-ohm rheostat.
- 1 battery switch.
- 4 terminals.
- 1 2-volt 60 ma. pilot lamp and socket.
- 1 4½-volt "C" battery.
- 1 piece of bakelite or wood.
- Sundries. Wire, nuts and bolts.

Hints!

Rejuvenating the "B" Battery.—A run down dry battery may be brought to life and given considerable service if the paper cover be removed and the cell placed in water. Punch a few holes in the zinc so the water can soak in easily. An inexpensive container can be made from a quart vinegar bottle with its top cut off. Remove labels from the bottle and wrap three turns of ordinary cotton twine around the bottle where you wish to cut it, then saturate the string with kerosene. Don't use petrol. Set the bottle upright, then fire the string all round it as near the same time as possible. When the kerosene has almost burned from string, dip in cold water and the top will snap off. Be sure there is no cork in the bottle.

Dust and Dirt. — These are deadly enemies to radio apparatus, especially where valves are employed. The accumulator, used to heat the filaments, should be kept free of dust, likewise the variable condensers, the dirt from between the plates of these latter being removed with a feather.

Battery Connections. — Weak batteries should not be connected together with strong batteries in any combinations. Either in the series or the parallel arrangement the weak ones will be a drain upon the strong ones. In the series arrangement the strong batteries must force their current through the high resistance of the weak ones in the chain, and in the parallel arrangement the strong ones are apt to discharge their current through the weak ones.

SIMPLE SET TESTERS

With this reasonably inexpensive equipment the experimenter will find that it is possible to make most tests required for locating a fault in a modern radio receiver.

A VOLTMETER is the handiest instrument to have on hand when a receiver gives trouble. It must be a good instrument and should have several voltage ranges. For instance, it may read 0—5, 25, 50, 100, 500 and 1000 volts. Above all, it must be of the low current consumption type.

Usually voltmeters are rated at so many thousand ohms per volt, which means that a meter rated at 1000 ohms per volt has an internal resistance of 1000 times the maximum scale reading. That is, a meter reading to 100 volts full scale will have a resistance of 100,000 ohms and by Ohms law it will consume one milliampere of current at full scale deflection.

We have seen by Ohms law that the current that can flow in a circuit depends on the voltage and the resistance that is present, so it follows that, if the resistance is kept constant, any certain voltage will cause a definite amount of current to flow.

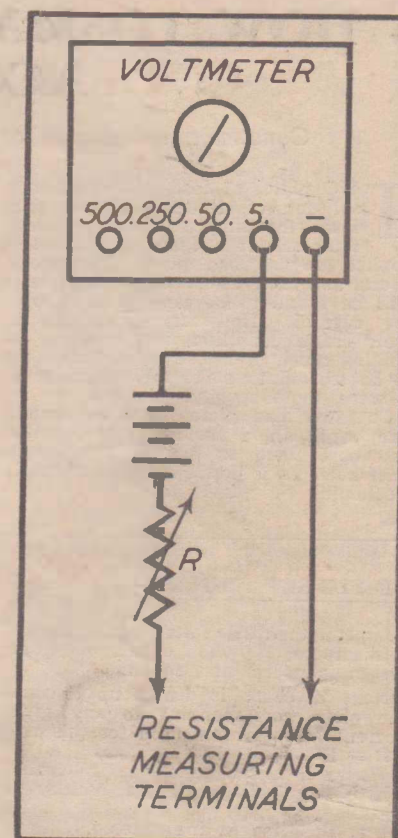
This is the operation of the voltmeter where the resistance is kept at a constant value for any one range of voltages, and by applying different voltages different amounts of current flow up to the point where maximum current is flowing. This, then, corresponds to the maximum permissible voltage for that range. Thus, when five volts is applied to a meter having an internal resistance of 5000 ohms and a maximum current consumption of one milliampere, the full scale deflection of the meter will be reached. If the same voltage is applied, but the internal resistance is increased to 10,000 ohms, only one half milliampere will flow. This will give a half-scale deflection. Thus the meter may have a full-scale reading on five volts on one range and ten volts on the next range.

On both ranges a five-volt battery will give a reading of five volts, but the current through the meter will be different for each range.

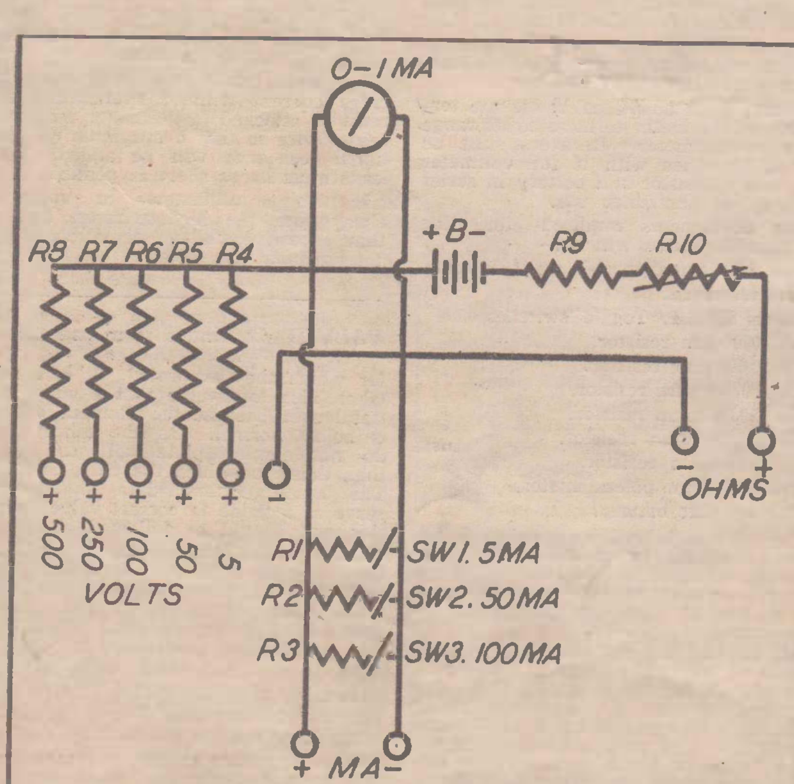
If such a meter is not used, inaccurate results can easily be obtained, for the current through the meter is added to the circuit being measured and the additional current can cause an incorrect voltage drop. Where the resistance of a circuit is high in comparison to the current flowing through it, this error is easier to make.

Next to the voltmeter, a resistance meter is the most useful. One can be made from a voltmeter without upsetting the functions of the latter as a voltmeter.

All that is necessary to convert a voltmeter to an ohmmeter is to place a battery and resistor in series with the low voltage range of the meter. For example, we will take a voltmeter having a full-scale reading of five volts on its lowest scale. This means that, when a potential of five volts is applied to the meter terminals, a current of one milliampere will flow to produce a full scale reading.



This diagram illustrates how a voltage meter can be used for measuring resistances.



Circuit diagram of a D.C. multi-meter.

Now, if a resistance is inserted in the circuit, the current will drop in accordance with Ohms Law, and it will be possible to calibrate the meter to read in ohms.

It is a simple matter to convert a five-volt voltmeter to measure resistance. Since a five-volt battery is not easily obtainable it will be necessary to use a six-volt one. This can be made up from torch battery cells, because the current drain is very light and the cells will last for a long time.

As six volts will be too much for the five-volt range of the meter, a resistance must be added to the circuit to obtain the full-scale deflection when the resistance measuring terminals are short-circuited.

The diagram shows the connections of the resistor and battery to the five-volt range of a voltmeter.

It is necessary to know the current drain of the meter in order to make the necessary calculations for an Ohms scale.

Because the battery in our example has a voltage of 6 volts, the total resistance in the circuit for full-scale deflection with the resistance terminals shorted must be 6000 ohms. The value of R should be 1500 ohms or 2000 ohms, and it must be of the adjustable type, such as a potentiometer.

To calibrate the meter first it will be necessary to draw up a chart converting the volts scale into a milliamps scale.

Knowing that 5 volts equals one mil-

(Continued overleaf)

HOW TO MAKE AN ACCUMULATOR

Constructional details of a simple storage battery.

TWO plates of lead, immersed in a solution of dilute sulphuric acid, form the simplest form of accumulator. If a charging current is applied to the lead plates for several hours, and then disconnected, the plates will be found to be capable of supplying current. However, the plates in their crude condition are incapable of holding much of a charge, so they have to be treated to make their surface, as it were, more spongy.

Cut two lead plates of a convenient size to fit in a handy glass retainer, and bore them as full of one-eighth-inch holes as is possible without unduly weakening the plates.

From a paint shop procure a small quantity of red lead and a similar amount of litharge. These are materials commonly used by painters. In a glass dish mix a stiff paste made by adding sulphuric acid to water in the proportion of one part acid to twenty parts water, and adding sufficient red lead to make a stiff mixture. One of the plates should then be "pasted" with this mixture—that is, the holes should be filled with it and then levelled up on both sides of the plate.

The second plate is similarly treated with a paste made from sulphuric acid and litharge.

When dry the plates should be stood in the glass retainer, care being taken to see that they do not touch. The glass is then filled with a solution of one part sulphuric acid and twelve parts water.

NOTE: The acid must be poured slowly into the water, and not the water into the acid, and none of the acid must be allowed to touch the clothes or flesh, for it will destroy anything with which it comes in contact.

The plates should stand opposite each other in the solution. If a current of not less than three volts be applied to the plates for a few hours they will be rendered in a condition to supply current for quite an appreciable time. Enough current may be generated during the night to last for experiments during the day. Each cell gives out slightly more than two volts when fully charged, and has an internal resistance which is so low that it need not be reckoned.

SIMPLE SET TESTERS— *(Continued from previous page)*

liampere, then 2½ volts equals one-half milliampere, 1¼ volts equals one-quarter milliampere, and so on.

Next a chart is drawn up to show the ohms corresponding to any given current. The formula used for this is:—

R = E/I minus 6000.

Where R is the resistance in ohms.

E is the voltage of the battery in volts.

I is the current in amperes.

In the particular instance given above the formula resolves itself into—

$$R = \frac{5 \times 1000}{I} \text{ minus } 6000$$

where I is the current in milliamperes.

When this chart is drawn up it can be converted into terms of volts by comparison with the voltage-milliamps chart.

It will be found that 100,000 ohms. is about the highest resistance that can be measured with this device. For higher ranges it will be necessary to use higher voltage ranges on the meter and higher voltages. Thus a 50-volt scale can be used if the battery voltage is a little over 50 and a series resistor R included, so that the correct adjustment can be obtained with the resistance measuring terminals shorted.

The fundamental formula is the same, but the 6000 ohms. is replaced by the total resistance of the circuit required to produce full scale deflection.

A battery of 55 volts would mean the internal resistance of the meter of 50,000 ohms., plus the 5000 ohms. in R required for full scale deflection.

In operating as an ohmmeter the resistance measuring terminals must be "shorted," and the resistor, R, adjusted to give full-scale deflection. The resistance to be measured is then connected across the resistance measuring terminals, the "short" having been removed. The scale will read in the opposite direction to that of the voltmeter, the lowest OHMS. being equivalent to the highest VOLTS.

In testing for faults, the various voltages should be checked and, if a discrepancy is noted, the power supply must be switched off and the ohmmeter brought into action to measure the resistance of the circuit to see if it is excessive or otherwise.

In checking condensers remember that somewhere in the receiver a resistor or coil may be connected across the condenser, and would indicate a breakdown in the condenser. Always disconnect one side of a condenser prior to testing. Remember, too, that a condenser may break down under high voltage, but not under the low voltage applied by the ohmmeter.

A milliammeter is a very handy instrument to have, since the current flowing in a circuit can be tested. It must be of the low resistance type.

A combination meter can be made up from a milliammeter having a full-scale reading of one milliampere.

Shunts must be placed across the terminals of the meter to increase its range as a milliammeter. Resistors must be placed in series with it for voltmeter use, and a resistor and battery in series with it for ohmmeter use.

The components required for this combination meter will be:—

One Milliammeter, 0-1 ma full scale.
Ten terminals.
Three S.P.S.T. Toggle switches.
R4. 5000 ohm resistor.
R5. 50,000 ohm resistor.
R6. 100,000 ohm resistor.
R7. 250,000 ohm resistor.
R8. 500,000 ohm resistor.
R9. 3000 ohm resistor.
R10. 2000 ohm potentiometer.
One 4½ volt battery.

The circuit is self explanatory. All resistors should be of the wire-wound type if accuracy is desired, but very accurate carbon resistors can be used for all but R9 and R10, which must be wire-wound.

R1, R2 and R3 are the shunts. They consist of very small resistors. The correct values for these can best be determined by trial by placing the meter in series with another meter of the desired range, and using a battery and resistor to adjust the current through the standard meter to the correct value. The shunts can then be adjusted until the correct readings are obtained on the milliammeter.

Care must be taken to see that the milliameter is not burnt out because the value of the shunt was too low for the range being calibrated. It is possible to calculate the resistances required but this means that you must know the internal resistance of the meter.

Thus—

N=I/Im

and Rs=Rm/ (N minus 1).

Where N is the multiplying factor;

I is the new maximum reading in milliamperes;

Im is the present maximum reading in milliamperes;

Rm is the internal resistance of the meter in ohms;

Rs is the value of the shunt resistor in ohms.

The shunt must be able to carry the extra current without overheating and must be attached to the meter with very heavy wire so that a minimum of additional resistance will be added. Such leads must be as short as possible.

In using a milliameter or voltmeter always use the highest range first so that excessive voltage or current will not burn out the meter.

VALVES—Continued from page 24

for which they are rated. It is a mistaken idea to assume that a valve will last longer because the filament voltage is below normal. On the other hand, do not employ plate voltages higher than those for which the valve is rated. The manufacturers' data sheets will serve as a guide to correct valve operation and should be followed closely.

Don't under-bias an audio amplifier tube, because this will cause distortion and overload. Over-bias is permissible when battery economy is desired, but this will affect reproduction unless special precautions are taken.

Above all, don't treat valves roughly. Remember they are quite delicate components and are likely to take serious harm from mechanical jarring.

When operating at plate voltages above 200 do not apply the plate potential until the filament voltage is on. This rule can be broken in the case of the indirectly heated type A.C. valves.

LOUD SPEAKERS

This article deals with the general theory, design underlying loud speakers.

THE loud speaker is the final link in the chain of broadcasting transmission and reception. In another part of this book it has been shown how sound waves are converted into electrical impulses because the sound waves cause the diaphragm of a microphone to vibrate. These vibrations cause either a current or voltage change in the microphone, depending upon its design.

There are several different types of electro-magnetic speakers, but all operate on the same principle. The illustration shows the balanced armature type. This type of speaker makes use of a very powerful horseshoe permanent magnet having specially-shaped pole-pieces attached to its ends. These pole-pieces provide two positive poles on one side and two negative poles. These are marked with a positive and negative sign in the illustration.

A small iron armature is pivoted in the centre between these two pole-pieces so that it can tilt backwards and forwards. One end of the armature is attached to a spring which is fitted with a tension screw. The other end of the armature is attached to a short rod, this in turn being connected to a reduction lever.

The other end of the reduction lever is attached to the framework of the speaker. To the centre of the reduction lever a stylus rod is attached to the other end of this rod, finishing at the apex of a cone.

Surrounding the armature is a coil of relatively fine wire. This coil is connected in the plate circuit of the output valve so that the audio frequency currents from this valve pass through the coil. As the current flows in one direction the upper end of the coil and the upper end of the armature become positive since the armature and the coil comprise an electro-magnet.

Because the current in the plate circuit of the output valve varies at an audio frequency rate the current through the coil will vary. This means that the magnetic flux also varies, and that the armature will move backwards and forwards in accordance with the current flowing in the coil.

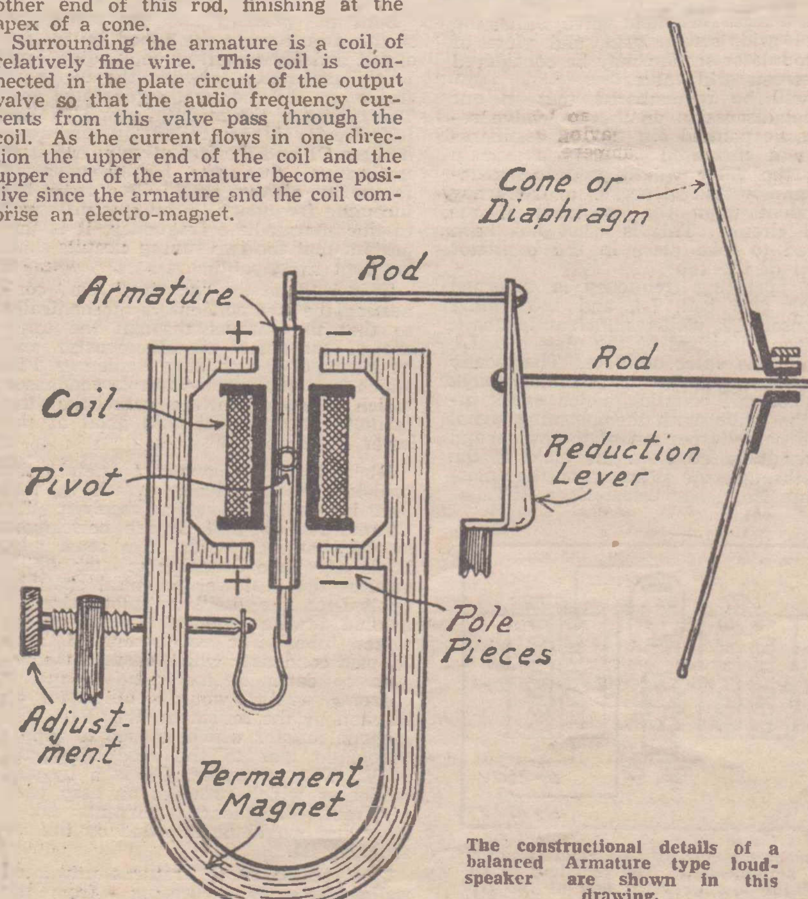
THE DYNAMIC SPEAKER

The dynamic speaker is totally different in construction from the electro-magnetic type of speaker. There are two types of dynamic speakers, the electro-magnetic and the permanent magnetic. The illustration shows a cross-section view of a typical electro-magnetic dynamic speaker.

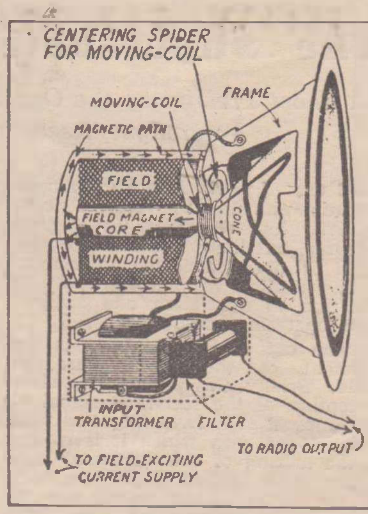
Magnetism for its operation is derived from an electro-magnet known as the field. The field is wound with a large number of turns of wire so that the magnetising effect will be as great as possible and this field is connected to some source of supply of direct current.

The average dynamic speaker field consumes about six watts of electrical energy.

It will be seen from the illustration that the field surrounds the field magnet core. A centre pole-piece is placed in the centre of the magnet system and separated from it by a few thousandths of an inch.



The constructional details of a balanced Armature type loudspeaker are shown in this drawing.



An illustration of an electro-dynamic loudspeaker showing the main features.

A frame extends from the speaker field system and carries a cone of relatively soft material, the apex of this cone being at the gap between the centre pole-piece and the rest of the magnetic system. Attached to the apex of the cone is a very small coil of wire which is free to move in the gap.

Across the apex of the cone is placed a thin spider of bakelite or other similar material with a hole in its centre. A bolt is passed through this hole and screwed into the centre of the pole-piece so that the voice coil, as the small coil of wire is called, will not be able to move laterally. However, the spider permits a certain amount of movement along the axis of the voice coil.

When a current of electricity is passed through the voice coil the latter becomes a magnet and is attracted into the gap or repelled from it depending on the direction of the current through the voice coil and that in the field winding.

The current in the latter is arranged to go in the one direction at all times so that an alternating current applied to the voice coil will cause the latter to move in and out of the gap depending on the direction of the current. The distance that the coil moves depends on the power of the current and its frequency of movement is dependent on the frequency of the current.

Because the voice coil is attached to the cone the latter moves in accordance with the voice coil, and sets up sound waves having the same frequency as the current passing through the voice coil.

As the voice coil consists of only a few turns of wire its impedance is very low and will not match that of a valve. Therefore an impedance matching transformer is used to connect the speaker to the valve. This transformer has a primary which matches the plate impedance of the output valve and a secondary impedance to match the voice coil of the speaker.

Sometimes an equaliser is added to the primary of the transformer, so that certain audio frequencies can be attenuated.

The permanent magnet type of dynamic speaker differs from the type just described in that a large permanent magnet is used to replace the field winding. This means that such a speaker can be used with battery-operated receivers be-

(Continued on Page 64)

The Super-heterodyne

A Short Treatise on the Operation of Super-heterodyne Receivers.

THE use of radio frequency amplification enhances the receiver's sensitivity and selectivity to a great degree, but there is a limit beyond which it is not practicable to employ radio amplification without running into trouble due to oscillation and kindred unstable operating conditions.

One way out of this difficulty is the employment of the super-heterodyne principle. Briefly, this principle involves the reception of the incoming signal at its fundamental high frequency and with the voice tones with which it is modulated; the mixing of this incoming high frequency with another high frequency signal which is unmodulated and of fixed amplitude or intensity. The "beat frequency" so formed is the arithmetical sum of or difference between the two frequencies.

For example, if the incoming signal has a fundamental frequency of 1,000,000 cycles and the locally-generated signal a frequency of 500,000 cycles, the resultant beat frequency will be either 1,500,000 cycles or 500,000 cycles.

Usually a frequency lower than the incoming frequency is selected. The beat frequency, together with the modulation frequencies, which have not been disturbed by this beating, are fed through an amplifier tuned to a fixed frequency corresponding to the difference between the incoming and the local frequencies. It is known as an "intermediate frequency amplifier," and consists of a radio frequency amplifier system operating at a comparatively low radio frequency. From this amplifier the beat frequency signal is fed to what is known as the "second detector" or de-modulator when it undergoes the same sequence of changes as take place with a signal received direct by a detector valve.

Thence the rectifed signal passes to the audio amplifier and loud speaker in the usual way.

Glance now at Fig. 1 whilst we explain brieflv the processes through which the signal entering the aerial circuit of a modern super-heterodyne receiver passes before it is transformed into an audio frequency signal capable of being heard in the loud speaker.

At the left (top) we find the modulator section which receives the incoming signal. Coupled to this is the oscillator section which generates the local frequency. Next we have the intermediate frequency amplifier which boosts up the resultant beat frequency. Then comes the de-modulator, which eliminates the beat frequency from the scheme of things and passes the audio frequency impulses on to the final stage, the audio frequency amplifier. After amplification here they are passed to the loud speaker, where they generate the sound waves which form intelligible speech.

A diagrammatic view of the various frequency changes which the signal undergoes is furnished by the sketch in the bottom section of Fig. 1. A "close up" of the action of the mixer valve is furnished in the schematic circuit diagram of Fig. 2, which depicts a "pentagrid" or "hexode" valve which has no less than seven distinct elements. Of these seven one is the filament or heater, one the cathode, and another the plate. The remaining four are grids.

Without going into an involved technical explanation we can say that the incoming signal is fed to the modulator grid coil, L2, via L1, and reaches the modulator grid of the valve V. Here it undergoes the series of operations dealt with in the description of the one-valve receiver except that, as this valve is not truly a detector, no grid leak and condenser is employed. The first and second grids from the filament of the valve are the oscillator grid and plate respectively.

In conjunction with the cathode, which is common to both sets of elements in the valve they may be said to constitute a separate triode valve whilst the control grid, screen grid, and plate of the modulator section may be considered as a screen grid valve.

It will be remembered that in our original discussion on the one valve receiver we pointed out that, if regeneration was increased beyond a certain point, the valve would go into oscillation and would generate a frequency dependent upon the constants of the tuned circuit. This is what has been allowed to take place in the oscillator section of the tube.

The operating frequency is governed by the grid coil, L4, and the tuning condenser, C2, whilst sufficient feedback has been furnished by the plate coil, L3, to make the valve oscillate. The locally generated oscillation is mixed, through the electronic coupling which exists inside the valve, with the incoming signal in the pentode portion of the valve and the result is fed from the plate of the tube through the primary of the intermediate frequency transformer, IFT.

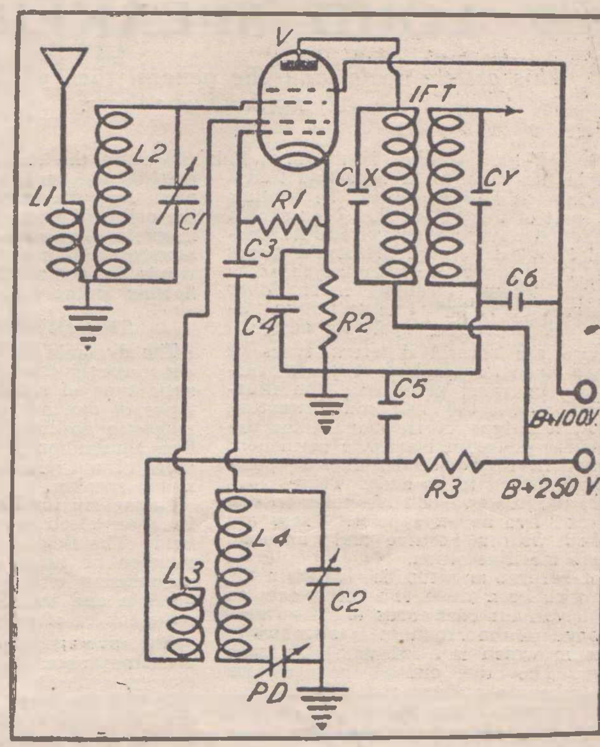
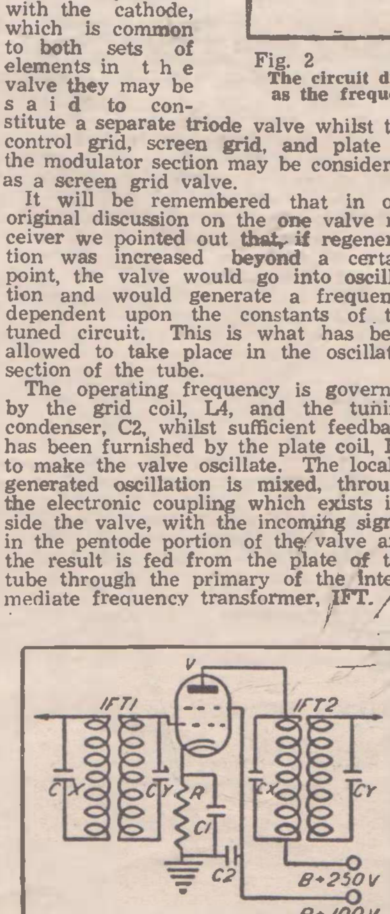


Fig. 2
The circuit diagram of a modern seven element valve, used as the frequency charger is a super-heterodyne receiver.



A theoretical circuit of a single stage of I.F. amplification. The junctions of CY and the low potential end of the IFT secondaries are connected to earth or to the AVC network depending on the design of the receiver.

Both the primary and the secondary of this transformer are tuned by means of CX and CY to a frequency equivalent to the difference between the incoming frequency and the locally generated one. The tuning of the modulator and oscillator circuits is controlled by the condensers C1 and C2 respectively. As it is imperative that the locally-generated frequency always shall differ from the incoming frequency by an amount equal to the intermediate frequency, it is important that the two tuning circuits shall be kept in step.

This is done by "ganging" (i.e., connecting the two condensers mechanically so that they travel through the same arc of movement simultaneously) and by means of the padding condenser, PD, which is a small semi-variable condenser which is set at such a value that the oscillator tuning will hold good at the lower frequencies.

R1 and C3 are our old friends the grid-leak and condenser which we met first in the single valve receiver. R2, C4 and R3, C5, and C6 are newcomers so we shall deal with them separately. R3 is a voltage dropping resistor which ensures that a lower potential shall be applied to the oscillator plate than is applied to the modulator plate of the mixer tube. The condenser, C5, is a by-pass condenser which ensures the return to earth of the radio frequency currents which would otherwise be blocked by the resistance, R3. R1 is the cathode resistor which is used to supply automatic bias to the modulator grid of V. The condenser, C4, is a by-pass condenser which provides an easy path for radio frequency currents which otherwise would be impeded by the resistance, R1.

The condenser, C6, returns unwanted radio frequency currents from the screening grid of the modulator section of V1 to earth so that they will not flow into the associated valve circuits and cause instability.

In Figure 3 we have schematically depicted a single-stage intermediate frequency amplifier. This is made up of the input and output transformers, IFT1 and IFT2, each of which consists of two windings, a primary and a secondary. Each of these windings is tuned by a semi-variable condenser which is set to the desired intermediate frequency and is not altered during the operation of the receiver. The valve, V, is a screen grid type known as a radio frequency pentode. Its chief characteristic is that of high amplification. Like the mixer valve the intermediate frequency valve, V, is self-biassed by means of a resistor R, which is provided with a by-pass condenser, C1, to permit the easy passage of radio frequency currents between cathode and earth. The by-pass condenser, C2, functions similarly to the condenser C6 in Figure 2.

To Renew Worn-out Dry Cells

WORN-OUT dry cells need not be thrown away. With a little trouble they can be made nearly as good as new. Strip off the outer zinc covering, which in the majority of cases, is corroded and full of holes, and stand the carbon element with its surroundings, in a jar of dilute sal-ammoniac solution.

A small leclanché zinc is then stood in the same solution alongside the remains of the dry cell.

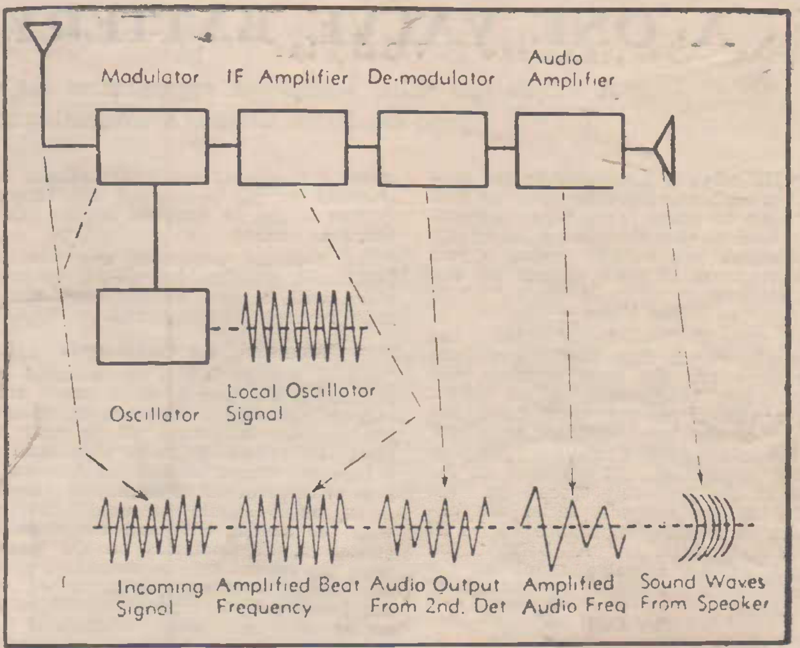


Fig. 1.—This diagram illustrates the operating principles of the superheterodyne type of receiver.

Aerials and How to Instal Them—

(*Continued from Page 20*)

termed a fog which extends upwards to a height of some 20 to 25 feet from ground level.

The average outdoor aerial, to be of any use in such circumstances must be erected at least 25 feet above the ground. The higher the aerial the more chance is there of getting out of the interference fog and the quieter will be radio reception.

Even if we erect an aerial well up in the clear, we still must bring the signals which this aerial collects to the receiver.

This is done by means of the lead-in which of necessity must come down through the interference fog before it can get to the receiver. Now the lead-in reacts to the tiny impulses of electrical interference in the same way as the aerial itself reacts to the broadcast signals, it collects them and feeds them to the receiver.

The design of the noise-reducing aerial aims at overcoming this defect. The aerial is mounted well in the clear and above the fog of interference. It is joined to the aerial by means of a twin-wire lead-in, only one wire of which joins to the aerial itself. The other wire is left free, but the pair are twisted together and brought down to the receiver. At the set the lead-in wire which has been soldered to the aerial, is attached to the aerial terminal. The other wire—free at the aerial end—is attached to the earth terminal on the receiver.

The operation of the noise-reducing aerial depends upon the fact that whilst only one wire of the lead-in is conducting the radio signal to the receiver, both wires are equally responsive to the interference signals. As both of the lead-in wires deliver the interference signals to the receiver at the same time but out of phase, i.e., step, the interference signals cancel out and leave only the broadcast signal.

This system is particularly effective, although it reduces signal strength to some small degree it absolutely eliminates the noise caused by electrical interference.

In order to raise the efficiency of the aerial system it may be resonated to some portion of the broadcast wave band —500 metres, for example—by proportioning the aerial so that this is some odd fraction of the desired wavelength. For example, we might take the 20th fraction of 500 metres or 25 metres. A metre being approximately 3¼ feet, the total aerial length, exclusive of lead-in, would be 81 feet three inches. The lead-in length does not matter materially, but the lead-in wires should be kept clear of earthed objects.

Ordinary enamel-covered 14 or 16 gauge wire can be used for the flat top and the twisted wire lead-in may consist of either twin lighting flex or two lengths of 3/20 rubber-covered wire twisted together.

Remember that any receiver can only be as efficient as its aerial will let it be. If you want real distant reception without electrical interference, erect a high aerial which is well insulated. For local reception an indoor aerial, a mains aerial or even the earth wire itself, will provide sufficient pick-up for normal needs.

Don't Handle Crystals

CRYSTAL sets give enormous trouble to many users. It seems utterly impossible for them to get the cat-whisker in such a position that good reception is obtained. Any good crystal should give good results at almost any point of its surface.

Some people seem to regard the careful envelopment of crystals in cotton wool when they are sold as a kind of ornamental fad, for they do not even take the precaution to wash their hands before inserting the crystal in the cup.

Don't, then, handle your crystal with the naked hands. Use metal tweezers.

How to Make Batteries—

(*Continued from page 8*)

the matter in the plates under the electrical action. After five changes, the maximum of surface will have been obtained, and the best results given. However, this alternation should not be continued longer, as the ribs will begin to decompose, and the mechanical strength will be so weakened that the plates will soon fall to pieces.

A battery of these cells may be constructed to deliver 150 to 300 volts for power amplifiers, and low range transmitters. Although such a battery would involve considerably tedious work, it would well repay the construction by the efficient operation obtained.

Distinguishing Polarity. — The centre terminal screw is positive, and the side terminal screw negative on a dry cell. Similarly, on a wet cell of the primary type, the carbon or copper plate is the positive and the zinc plate the negative.

Breaking-up Crystals.—Large pieces of crystal can easily be cut into several pieces by means of a pair of wire-cutters. A hammer should not be used. A large piece of crystal, broken up, sometimes yields a wealth of sensitive pieces.

Crystal Detectors in Series. — Don't attempt to wire two or more crystal detectors in series, or you will probably meet with failure. As many detectors as desired may be wired in parallel, with a multi-point switch arranged to switch each in as desired.

To Tell if Set is Oscillating. — To tell if the set is oscillating and causing interference to others, a damp finger placed on the grid terminal of the detector valve will, if the set is oscillating, produce a distinct click in the headphones.

When Wiring Up. — It is as well to refrain from lighting the filament of the valve until the connections of the "A" and "B" batteries have been checked.

A ONE VALVE BATTERY RECEIVER

A simple one valve headphone regenerative set which will provide good results on all local broadcasting stations.

THE receiver illustrated in the diagram is the simplest valve set that can be made. It employs regeneration, so that the utmost sensitivity is obtained, and it will operate a pair of headphones at good volume on distant stations.

The Valve

Any type of three-electrode valve can be employed, but those having a medium impedance are the best, as they will match the headphones a lot better. Power valves, on the other hand, are usually of the low-impedance type, and are not so satisfactory as those of slightly higher impedance. Valves such as the A415 in the four-volt types and the UX230 in the two-volt series are examples of medium-impedance valves. If you already have an "A" battery, you should choose a valve requiring the same filament voltage as the voltage of the battery.

The Coil

The coil for this set actually consists of three coils of wire wound on the same former. If a three-inch former is available, the aerial coil, L1, should be wound on first, using gauge 22 D.C.C. or enamelled wire. Wind on 15 turns, keeping the turns close to one another and passing the two ends of the coil through small holes that you have drilled in the former. This coil should be started near one end of the piece of former.

The start of L2, which is the secondary coil, is made half-an-inch down the former from the end of L1. Wind on 45 turns of the same wire, and be sure that the direction of winding is the same as that of the aerial coil.

The start of the reaction coil, L3, is made one-half-inch down the former from the end of L2, and is wound in the same direction as L2. This coil consists of 20 turns of the same wire.

When the three coils have been finished, a couple of small lugs should be attached to the bottom of the former so that it can be attached to the baseboard or chassis.

The variable condenser must be of 0.0005 mfd. capacity, and should be provided with a good vernier dial, which must be free from backlash.

Mounting the Components

All of the parts can be mounted on a wooden baseboard, or a small aluminium chassis can be made up. Mount the variable condenser, C1, so that its shaft is situated centrally, thus making a balanced appearance. If the baseboard type of construction is employed, a small metal panel should be used, together with the switch, SW, and the reaction condenser, C2, mounted on the panel. With the chassis type of assembly, these two components may be mounted on the front wall of the chassis. There is no necessity to insulate the shaft of the reaction condenser in either type of construction.

Mount the coil former on one side of the variable condenser, but one side of the baseboard or chassis. In the case of the latter it may be necessary to space the former off the chassis so that the finish of the reaction winding, L3, will not be closer than one inch to the chassis. Place the valve socket near the variable condenser and the coil-kit with the two filament lugs to the rear of the set.

The aerial and earth and the headphone terminals can be mounted on the rear of the set, the phone terminals being at the end away from the coil. Connections to the batteries is best made with long flex leads instead of terminals, particularly as only three wires are required.

The Wiring

Connect the aerial terminal of the set to the start of the aerial winding on the coil former, L1. The finish of L1 is taken to the earth terminal. Also connect the earth terminal to the frame of the variable condenser, C1, and the negative filament lug on the coil socket. This wiring should be done with a piece of bare wire and to it should be soldered the finish of the secondary coil, L2, and the rotary plates of the reaction condenser, C2.

Next solder one end of the grid leak, R, to the grid lug on the valve socket. Join the other end of R to the positive filament lug on the valve socket. Take the start of the secondary coil, L2, to the stationary plates of the variable condenser, C1. and to these plates also connect one end of the grid condenser, C3. The other end of C3 connects to the grid lug on the valve socket.

Connect the finish of the reaction coil, L3, to the plate lug on the valve socket. The start of the coil L3 joins to the fixed plates of the reaction condenser, C2.

To the plate lug on the valve socket also connect one end of the RF choke and take the other end of this component to one of the phone terminals.

A length of black wiring flex should be soldered to the negative filament lug on the valve socket. Join a similar length of red wire to one lug on the battery switch, S.W. The other lug on the switch goes to the positive filament lug on the socket.

Complete the wiring of the set by connecting a length of green wire to the unconnected headphone terminal.

As mentioned before, the voltage of the "A" battery and the filament voltage of the valve must be the same. Connect the black wire to the negative of the "A" battery. The positive of this battery is joined to the red wire. Now connect a small piece of wire to the negative of the "B" battery, and join the other end of this to the negative of the "A" battery. The red wire is then joined to the positive of the "B" battery.

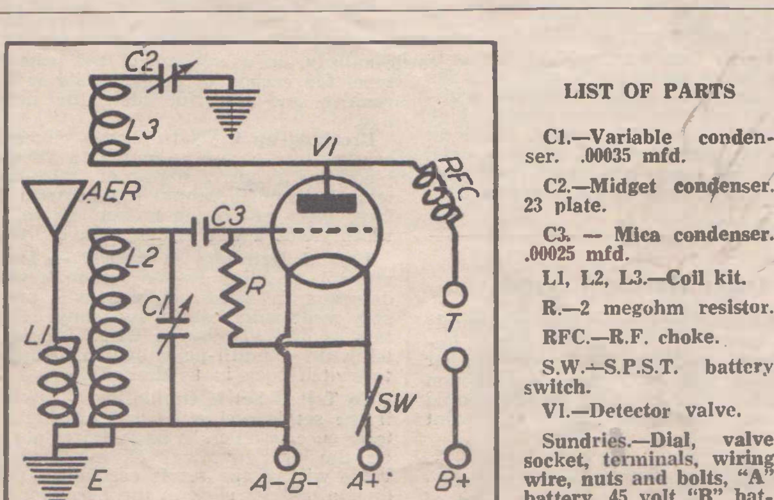
Now attach the headphones, the aerial and earth to their respective terminals and insert the valve.

Switch the set on with the battery switch and tune in a station by means of the variable condenser, C1.

If the reaction condenser, C2, is set so that the plates are fully in mesh, each station will be received with a whistle. The reaction should be reduced by slowly rotating the reaction condenser until the whistle ceases, as this will be the position in which the set is most sensitive.

If the set will not oscillate, try a very small aerial, since a large aerial will often prevent oscillation. If this does not cure the trouble, the plate voltage on the valve should be increased by adding to the "B" battery. It is assumed that all connections have been made correctly and that the valve is in good order.

The aerial should be about 50 feet long and 30 feet high, and must be clear of surrounding objects. Do not place the aerial ten feet above an iron roof and expect results, as the roof will most likely be earthed by down piping, so that the effective height of the aerial will be 10 feet.



Circuit diagram of a one-valve battery-operated receiver.

LIST OF PARTS

C1.—Variable condenser. .00035 mfd.

C2.—Midget condenser. 23 plate.

C3. — Mica condenser. .00025 mfd.

L1, L2, L3.—Coil kit.

R.—2 megohm resistor.

RFC.—R.F. choke.

S.W.—S.P.S.T. battery switch.

VI.—Detector valve.

Sundries.—Dial, valve socket, terminals, wiring wire, nuts and bolts, "A" battery, 45 volt "B" battery.

A Two Valve Battery Set

This Simple Receiver will give Loud Speaker Results from Nearby Stations

A SINGLE-VALVE SET will give good headphone reception of many stations, but it will not operate a loud speaker. A two-valve set will give speaker results from many stations, provided that they are not too far away. It is quite easy to build a two-valve set, since there are only two or three more components than in a one-valve receiver.

The audio frequency transformer should be of a good make if you want good quality reproduction. Poor quality transformers are useless when the best reproduction is required. The ratio should be about 3-1, although you can go as high as 5-1.

The valve sockets must be of a type in which the contacts make firm connection to the pins of the valve. Poor contacts in the sockets will cause weak reception, and possibly noise in the set.

The coil consists of the three windings—L1, L2 and L3—these being the aerial, secondary and reaction.

A piece of three-inch former is required, and the coil is to be made exactly the same as the coil for the One-valve Battery Receiver.

The various components can be mounted on a baseboard or on a metal chassis, depending on the preference of the constructor.

The variable condenser must be mounted so that its shaft will be in a central position, the coil to the right-hand side of the condenser, looking at the assembly from the rear, and the audio frequency transformer on the other side of C1 (variable condenser).

The valve socket for the detector, V1, is placed immediately behind the variable condenser and the audio valve socket, V2, to the left of the audio frequency transformer.

The reaction condenser is placed near the coil, and the battery switch, SW, placed in line with C2, but on the opposite side of C1.

With all components in place the wiring of the set can be commenced. A piece of bare wire is used to connect together the following points: The finish of the aerial coil, L1; the finish of the secondary coil, L2; the frame of the variable condenser, C1; the rotary plates of the reaction condenser, C2; the negative filament lug on V1, and the negative filament lug on V2; and the earth terminal of the set.

Now connect one lug on the battery switch to the positive filament lug on V1 and continue this wire to the positive filament lug on the V2 socket.

LIST OF COMPONENTS

AFT. Audio frequency transformer. 3-1 ratio.
C1. Variable condenser .0005 mfd.
C2. Midget condenser. 23 plates.
C3. .00025 mfd. mica condenser.
L1, L2, L3. Coil kit.
R. Two megohm resistor.
RFC. R.F. Choke.
SW. S.P.S.T. battery switch.
V1. Detector valve. (A415, UX230).
V2. Audio valve. (A409, UX330).
Sundries: Dial, two valve sockets, four terminals, wiring wire, nuts and bolts. "A" battery. Two 45 volt "B" batteries.

The start of the aerial winding, L1, is connected to the aerial terminal on the set and to the start of the secondary winding. L2 is connected to the stationary plates of the variable condenser, C1. Solder one end of the grid condenser, C3, to the grid lug on socket V1. A wire should be attached to the other end of C3 and connected to the stationary plates of C1.

Join one end of the grid leak, R, to the grid lug on valve socket, V1, and wire the other end of R to the positive filament lug on the valve socket, V1. To the plate lug on the V1 socket connect the finish of the reaction coil, L3, and one end of the RF choke, RFC. The start of the reaction coil, L3, is connected to the stationary plates of the reaction condenser, C2. Next attach the free end of the RF choke to the P terminal on the audio frequency transformer, AFT. The G terminal on the transformer is then wired to the grid lug on the audio valve socket, V2.

Attach a wire to the plate lug on V2 and connect this to one of the speaker terminals, T.

This now leaves only the battery leads to be attached. Connect about four feet of Red wire to the unconnected lug on the battery switch, SW. The same length of Black wire should be soldered to the negative filament lug on the V1 socket.

A length of green wire is then attached to the unconnected speaker terminal. To the B terminal on the audio frequency transformer solder a length of Blue wire. A length of Yellow wire is attached to the F or C terminal on the transformer.

This completes the wiring of the set.

The "A" battery should be of the same voltage as the filaments of the valves. The detector valve, V1, should be of the "detector" type and the power valve, V2, of the "power" class if speaker reception is wanted. For headphone reception a small power valve can be used. For instance, both valves could be of the 30 type for headphone work. If a four-volt battery is available, the detector could be an A415 and the power valve a B406.

The Red wire connects to the positive of the "A" battery and the Black wire is attached to the negative terminal of the "A" battery. Another length of wire should be attached to the "A" battery negative terminal and connected to the "B" battery negative terminal.

The "B" battery will consist of two 45-volt "B" batteries connected in series. That means that the negative of one battery will be connected to the negative of the "A" battery as just described. The negative of the second "B" battery will be connected to the positive of the first "B" battery. If the batteries have voltage tappings, the negative terminal of battery No. 2 should be connected to the 45-volt tapping on No. 1 battery. To this 45-volt tapping on No. 1 battery also connect the Blue wire from the set.

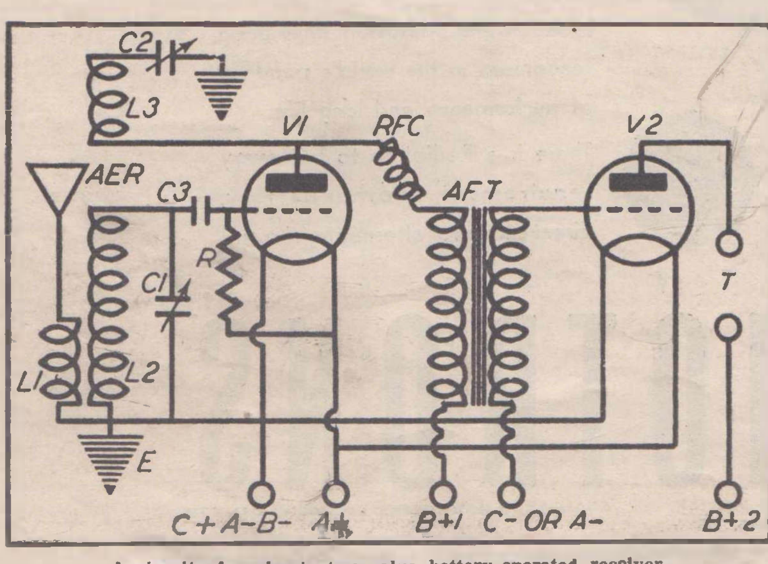
The Green wire from the set is connected to the 45-volt tap on the second "B" battery. (Since the batteries are in series the total voltage will be that of the two batteries added together, 90 volts.)

To the negative terminal on the "A" battery connect the positive of the "C" battery.

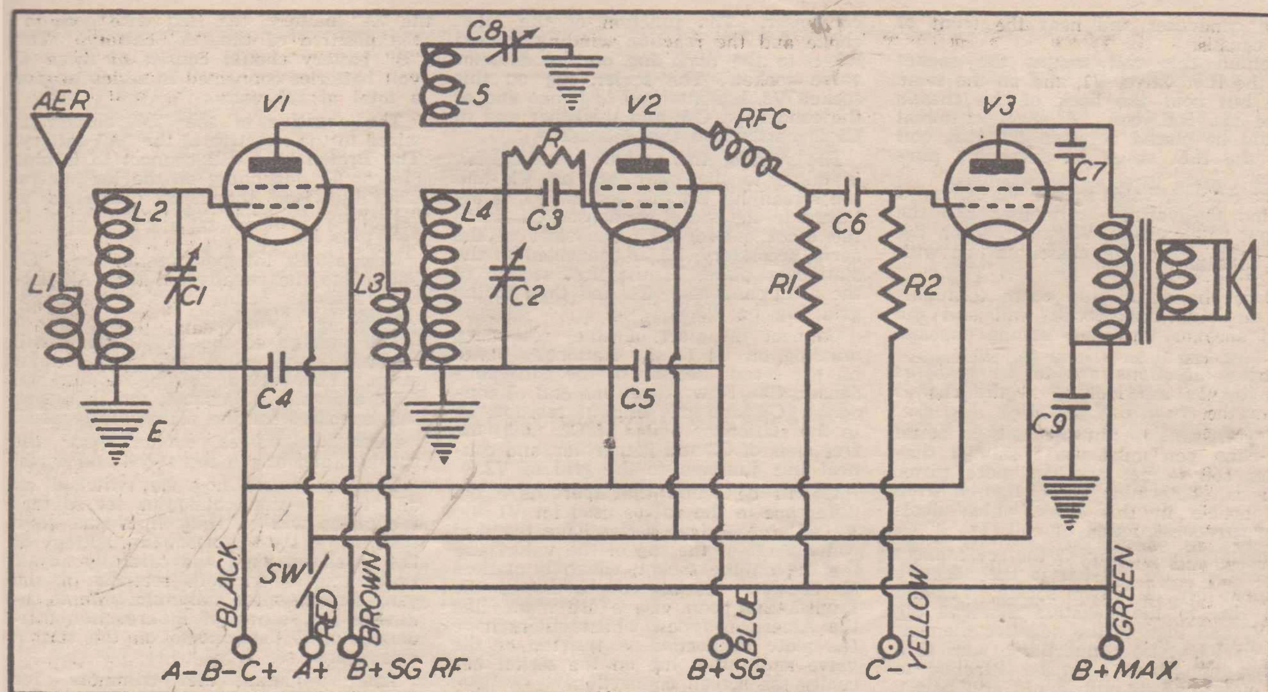
The negative of the "C" battery is connected to the Yellow wire from the set. The voltage of the "C" battery will depend on the valve, V2. This may range between 1½ volts and 15 volts. The correct voltage will depend on the plate voltage and can be determined from an inspection of the valve data sheets for the particular valve used. Thus the type 30 valve requires a "C" battery voltage of 4.5, when the "B" battery voltage is 90. If the voltage were increased to 135 the "C" battery voltage must be 9 volts.

With the batteries correctly attached, the valves should be plugged into their correct sockets, the aerial and earth attached, and the speaker or headphones connected up.

Switch on the set by means of the battery switch, SW, and slowly rotate the dial of the variable condenser, C1. When a station is heard the reaction condenser, C2, should be adjusted for maximum volume without any whistle. It will be found that the set will whistle as each station is tuned in if the reaction condenser plates are too far in mesh. At the same time the signals will be distorted.



A circuit of a simple two-valve battery-operated receiver.



Th_ theoretical circuit of a straight-forward three-valve receiver for battery operation.

A THREE VALVE BATTERY RECEIVER

This Receiver is Capable of Long Distance Reception at Full Loud Speaker Strength.

A THREE valve receiver using one stage of R.F. amplification and one stage of audio frequency amplification, together with a regenerative detector, will reproduce most of the broadcasting stations at reasonable strength on a loud speaker.

The diagram shows that the first valve, V1, is the radio frequency amplifier, and is of the screen grid type. One of the same type of valves is used as the detector, and a power type of penthode valve is employed as the output valve, V3.

This set should be built up on a metal chassis of suitable size. The variable condenser, C1, C2, and the coils are mounted on the top of the chassis and the other components placed underneath. The reaction condenser, C8, and the battery switch, SW, are placed on the front wall of the chassis, and the aerial, earth and speaker terminals mounted on the rear wall.

The variable condenser, C1, C2, is of the two-gang type. This consists of two variable condensers mounted in the one framework and operated by the one shaft.

The gang condenser must be mounted on the chassis so that when the dial is attached to the condenser the knob and scale of the dial will be centrally located.

The Coils

The coils can be purchased ready-made or the constructor can make his own. The aerial coil, as it is called, will consist of two windings, L1 and L2, and the RF coil will have three windings, L3, L4 and L5. If the variable condenser has a capacity of 0.0005 mfd per section, the coil formers can be 2¾ inches in diameter.

Start by winding on L2. This will comprise 50 turns of No. 26 D.C.C. wire with the turns touching one another. One-half inch away from the finish of this coil start the aerial winding, L1. This will consist of ten turns of the same wire. The former should be cut so that there will be at least half-an-inch to spare when the aerial winding is completed. Mount the aerial coil on the chassis by means of two or three small brackets. It must be mounted with the aerial winding nearest the chassis.

The R.F. coil is a little more difficult to make. A piece of the same sized former will be wanted. Start with the secondary winding, L4, and wind on 50 turns of No. 26 D.C.C. wire, keeping the turns close together. The start of this coil, like that of L2, should be near one end of the former. Half-an-inch from the finish of L4, start the reaction winding of 20 turns of the same wire.

The leads from both these coil ends can be attached to rivets or solder-lugs mounted near the base of the former, except in the case of the starts of L2 and L4, which must be taken out to lugs on the top of the former. Alternatively, the ends of the windings can be passed through small holes in the wall of the former and then passed down through the former for direct connection to the various components.

Over the bottom end of the coil, L4, place two thicknesses of paper. This strip should be two inches wide, and paper thickness. Wrap the paper around L4 and use a little glue only at the end of the strip. Do not glue the paper to the winding. Make a tight job, so that the paper will not slip off.

On this paper wind the primary, L3. This consists of 15 turns of the 26 D.C.C. wire, and, when completed, it should be given a coating of collodion to hold it in place. All coils must be wound in the same direction.

In mounting the coils on the chassis the aerial coil should be placed on the chassis on the right-hand side of the

LIST OF COMPONENTS

C1, C2.—.00035 mfd gang condenser.
C3.—Mica condenser. .00025 mfd.
C4, C5.—Tubular condenser. ! mfd.
C6.—Mica condenser. 0.02 mfd.
C7.—Mica condenser. 0.004 mfd.
C8.—Midget condenser. 23 plate.
L1, L2, L3, L4, L5.—Aerial and RF coils.
R.—2 megohm resistor.
R1.—0.25 megohm resistor.
R2.—0.5 megohm resistor.
RFC.—R.F. Choke.
SW.—S.P.S.T. battery switch.
V1.—R.F. penthode valve (Variable Mu).
V2.—R.F. penthode valve.
V3.—Penthode output valve.
Sundries.—Dial, valve sockets, wiring flex, nuts and bolts, "A" battery, three 45 volt "B" batteries, one "C" battery, terminals.

gang condenser and near the front of the chassis.

Behind this coil mount the socket for the R.F. valve, V1, and on the same side but near the back of the chassis place the R.F. coil. A sheet of metal should be placed between the R.F. coil and the R.F. valve for screening purposes.

The detector valve socket, V2, is placed behind the variable condenser and the output valve socket, V3, mounted on the left-hand side of the chassis in line with the R.F. valve.

Place the aerial and earth terminals on the right-hand back wall and the loud speaker terminals at the opposite end.

These directions are to be read as though you are looking at the chassis from the front.

If you want to put the coils in metal coil-cans, you must use a smaller diameter coil former and use more turns. You can determine these figures from the article in this book which deals with the construction of coils.

To start the wiring of the set connect a piece of bare bus-bar to the negative filament lug on valve socket, V1, and join this to the negative filament lug on V2 and then to the negative filament lug on V3. Also connect this wire to a solder lug which must be attached to the metal chassis with a nut and bolt.

The finish of the aerial coil, L1, the finish of the aerial secondary, L2, and the finish of the R.F secondary coil, L4, must each be connected to the chassis at the nearest point.

Next run a wire from one lug on the battery switch, SW, to the positive filament lug on V1. Also connect this lug to the positive filament lug on V2 and connect this lug in turn to the positive filament lug on V3. The earth terminal on the set must be connected to the chassis.

Next join the plate lug on the output valve, V3, to one of the speaker terminals. The screen lug on V3 is then taken to the other speaker terminal, which we will call the "B" plus terminal for purpose of identification. One end of condenser, C7, is connected to the B plus speaker terminal, and the other end of C7 is wired to the other speaker terminal. This condenser is used for purposes of tone correction, as without it that from the pentode valve appears to be very high.

Now join the start of the aerial coil, L1, to the aerial terminal of the set. Bear in mind that all terminals with the exception of the earth terminal must be insulated from the chassis.

Now run a wire from the "B" plus speaker terminal to the one end of condenser C9, which is of 0.5 mfd. capacity. The other end of C9 is joined to the chassis A lead is next taken from the "B" plus speaker terminal to the finish of the R.F. primary winding on the R.F. coil, L3.

Attach one end of condenser, C6, to the grid lug on the audio valve socket, V3, and to this lug also attach one end of the grid resistor, R2. One end of the R.F. choke, RFC, and one end of the plate resistor, R1, are connected to the free end of the grid condenser, C6, and the free end of R1 connected to the "B" plus speaker terminal by means of a length of wire.

The free end of the R.F. choke, RFC, is wired to
the finish of the reaction winding, L5. The start of this winding is connected to the stationary plates of the reaction condenser. The junction of the R.F. choke and the reaction winding is next taken to the plate lug on the detector valve socket. The screen lug on this socket. V2, has attached to it one end of the condenser, C.5, and the other end of C5 is earthed to the chassis.

The start of the primary winding, L3, is taken to the plate lug on V1, and the screen lug on this socket, V1, is attached to one end of condenser, C4. Earth the other end of C4. The start of the aerial secondary, L2, is connected to the stationary plates of the first section of the gang condenser, C1, and then to the grid lug on V1.

Connect the start of the secondary winding on L4 to the stationary plates on the second section of the gang condenser, C2. Now attach one end of condenser C3, and one end of resistor, R. to the stationary plates of C2. Join the free ends of C3 and R together, and connect this junction to the grid of V2.

It will be found that there is a big difference in the valves used for V1 and V2. The American series have the grid coming out of the top of the valve, and the lug on the socket, which is marked G, becomes the screen. Some of the English-European valves are made like the American types, whilst others have the plate connection at the top of the valve and the P lug on the socket becomes the screen connection.

Some of the valves, too, may have a metal coating on them, and this is connected to a separate lug on the socket. This lug must be earthed

Other valves may have a suppressor with external connection, and this must be earthed to the chassis.

The Battery Leads

A length of black wire is connected to the negative filament lug on V1, and a length of Red wire to the unconnected lug on the battery switch. To the screen lug on V1 attach a length of Brown wire. The lead to the screen lug of V2 should be colored Blue, and that to the B plus speaker terminal should be Green.

To the free end of the resistor R2 attach a length of Yellow wire. The Black wire is connected to the negative of the "A" battery, the Red wire goes to the positive of the "A" battery. The "B" battery should consist of three 45 volt batteries connected in series to give a total of 135 volts.

The negative of the "B" battery is wired to the negative of the "A" battery. The Brown lead will connect to B plus 67½ or 90, depending on the R.F. valve. The Blue lead should be connected to "B" plus 45, and the Green wire to "B" plus 135.

Now attach the positive of the "C" battery to the negative of the "A" battery, and the Yellow wire to the negative of the "C" battery.

The voltage of the "C" battery will depend on the valve used in the output stage. This value can be determined from the valve data sheet, and should be that specified for the plate voltage used.

Insert the valves, connect up the speaker, and attach the aerial and earth.

The set should now be switched on and the reaction condenser set so that the plates will be fully in mesh. Now tune in a station near the bottom of the broadcast band and carefully adjust the trimmers on both sections of the gang condenser for maximum volume reducing the setting of the reaction condenser until the whistle on the station disappears.

After adjusting the trimmers for maximum volume on this station, tune to another station, and see if any alteration to the trimmers is necessary to bring in the station at greater volume. If so, this means that the coils are not properly matched, and it would be advisable to remove both trimmers from the gang condenser and mount a five-plate midget condenser on the chassis.

The stationary plates on this trimmer must be wired to the stationary plates on the C1 section of the gang condenser. When tuning in a station this trimmer can be adjusted for maximum volume on each station.

The reaction condenser should be adjusted to make the set as sensitive as possible, but once a station is tuned in the reaction condenser must be adjusted so that there is no whistle on the station, as this distorts the reception.

A Four Valve Battery Set

Good Quality Reproduction is the Main Feature of this Receiver.

THE three-valve receiver is capable of giving good speaker reception of most of the broadcasting stations, but a four-valve set will give much better results, particularly as far as tone is concerned. This is because the pentode type of valve accentuates the high notes. The triode valve does not do this and, although correction can be applied to pentodes, the tone is never so good as with the triode.

On the other hand, the triode takes far more driving for the same audio output. This means that in most sets the pentode can be driven directly from the detector, whereas the triode requires a driver stage after the detector.

In this receiver this arrangement is used. The complete receiver consists of a stage of radio frequency amplification, a screen grid type of detector, a triode driver audio stage and an audio output stage.

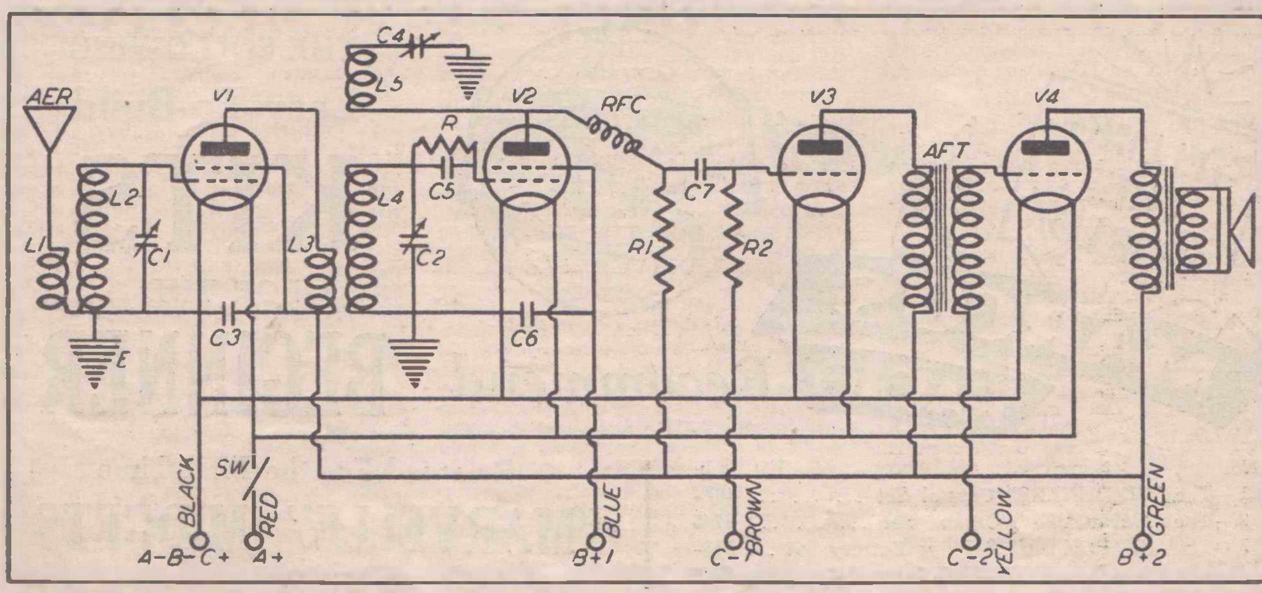
THE COILS should be made up exactly in accordance with the specifications for the coils for the Three Valve Battery Set.

THE VARIABLE CONDENSER should be the same as that specified for the Three Valve Set.

THE VALVES.—The R.F. and Detector Valves are the same as for the Three Valve Set. The driver valve, V3, should be of the medium impedance type such as the A409 or the 230. The output valve, V4, is of the power output type such as the B406.

THE SPEAKER can be of the magnetic type or of the permanent magnetic dynamic type. Make sure that the speaker impedance will match that of the output valve. This is because speakers designed for pentodes usually will not match a triode valve.

(Continued on Page 64)



The Circuit Diagram and List of Components

AFT. Audio frequency transformer. Ratio 3-1.

C1, C2. Two gang variable condenser. 0.00035 mfd.

C3, C6. Tubular condensers. 0.1 mfd.

C4. Midget condenser. 23 plates.

C5. Mica condenser. 0.00025 mfd.

C7. Mica condenser. 0.02 mfd.

L1, L2, L3, L4, L5. Aerial and RF coils.

R. 2 megohm resistor.

R1. 0.25 megohm resistor.

R2. 0.5 megohm resistor,

RFC. R.F. Choke.

SW. S.P.S.T. battery switch.

V1. R.F. Pentode valve (variable mu).

V2. R.F. Pentode.

V3. Audio valve.

V4. Audio power valve.

Sundries. Dial; terminals; wiring flex; nuts and bolts; "A" battery; three 45 volt "B" batteries; "C" battery.

A FOUR-VALVE BATTERY SET—

(Continued from Page 62)

The components should be mounted on an aluminium chassis about 2½ inches deep. The layout can be the same as that for the three-valve receiver with the addition of the output valve V4 being placed near the first audio valve, V3.

Wiring

With all the components in place, the wiring can be commenced. First connect all the following points to the chassis: The finish of the aerial coil, the finish of the secondary coil, L2, the negative filament lug on each valve socket, the finish of the secondary of the RF coil, L4; also earth the frame of the gang condenser and the reaction condenser, C4.

Connect together each of the positive filament lugs on the valve sockets and connect one of these to one lug on the battery switch, SW.

The start of the aerial coil, L1, is then taken to the aerial terminal on the set. The start of L2 connects to the stator of the first section of the gang condenser, C1, and to the grid of the RF valve, V1. The plate of V1 is connected to the start of the R.F. primary coil, L3. To the screen lug on V1 connect one side of condenser, C3, and take the other side of this condenser to the chassis. Also connect the screen lug on V1 to the finish of the primary coil, L3.

If the valve you are using for V1 requires a lower screen voltage than plate voltage, a resistor of the corect value must be connected between the screen lug on V1 and the finish of L3 instead of the direct wire.

Next connect the start of the R.F. secondary, L4, to the stator plates of the second section of the gang condenser and to one side of the grid condenser, C5. The other side of the grid condenser is joined to the grid of V2. Wire the grid leak, R, across the grid condenser, C5.

One side of condenser, C6, is soldered to the screen lug on V2 and the other end of this condenser earthed to the chassis.

The plate of V2 is connected to one side of the R.F. choke, RFC, and to the finish of the reaction coil, L5. The start of this coil is wired to the stator plates of the reaction condenser, C4. The free end of RFC goes to one end of condenser, C7, and one end of resistor, R1. The free end of C7 is joined to the grid of V3 and to one end of resistor, R2.

The plate of V3 should be wired to the P terminal on the audio frequency transformer, AFT, and the G terminal on this unit connected to the grid of V4. Now take the plate of V4 to one of the speaker terminals. The other speaker terminal will be referred to as the "B" plus terminal and to it are connected the finish of the R.F. primary winding, L3; the free end of R1; and the "B" plus terminal on AFT.

To the negative filament lug on V1 connect a length of black wire. A similar length of red wire is connected to the free lug of the battery switch, SW. To the screen lug on V2 join a piece of blue wire and to the "B" plus speaker terminal wire a length of green wire. The free end of resistor R2 has a piece of brown wire attached to it and to the "C" terminal on AFT is connected a piece of yellow wire.

The red wire goes to the negative of the "A" battery; the red wire to the positive of the "A" battery; the green wire to "B" battery positive 135 volts; the blue wire to "B" positive 45 volts. The negative of the "B" battery should be connected to the negative of the "A" battery. The positive of the "C" battery connects to the negative of the "A" battery and the yellow lead to "C" negative max. The brown lead is joined to a tapping on the "C" battery.

The connections of the brown and yellow leads must be that which gives the correct bias voltage for the particular valves used at the specified plate voltage.

The operation of the set is exactly the same as that of the three-valve battery set and readers are referred to the description of that set for operating details.

LOUD SPEAKERS—

(Continued from Page 55)

cause there is no power loss in energising the field.

This type of speaker is also very popular in public address systems, as there is no necessity to run long wires to carry the field supply.

All dynamic speakers must be used in conjunction with a baffle if the correct tone is required. Such a baffle can be made from a large piece of wood about one inch thick. It should have an area of at least four square feet.

The older types of horn speakers are not used nowadays, because of their poor performances. Essentially they consist of a unit similar to a single headphone attached to a large horn.

AN ALL-ELECTRIC THREE VALVE RECEIVER

A Simple Loud Speaker Set which Operates from the Electric Power Mains.

HERE is a receiver that can be used on the electric light or power mains thus being independent of batteries for its power supply. This set is only suitable for those areas which have an A.C. supply . The usual A.C. supply in Australia is 230 volts 50 cycles, but in some towns the voltage and frequency may be different.

In another portion of this book the method of converting the A.C. power into a form that can be used in a radio set is fully described. The heart of any electric receiver is the power transformer, P.T., and when ordering one be sure that it is suitable for your supply mains. Most transformers have tappings to allow for quite a range in voltages, but practically all are wound for 50 cycles. If your supply frequency is different, you must specify it when ordering the transformer.

This simple all-electric receiver will bring in all the local stations at good loud-speaker volume, and in country districts will provide good entertainment from most of the more powerful city broadcasters.

The components are laid out on an aluminium chassis, care being taken to see that the electrolytic condensers, E1 and E2, are not placed near the rectifier valve, V3. This is because the heat from this valve may damage the condensers. In most sets the power transformer is placed between the condensers and the rectifier valve, this spacing being quite sufficient.

The variable condenser is placed so that the dial will be in the centre of the chassis and the reaction condenser is placed underneath the chassis in line with the shaft of the variable condenser so that the two shafts are one above the other.

THE COIL will be exactly the same as that described for the Two Valve Battery receiver.

THE SPEAKER must have a field resistance of 2500 ohms and the transformer must match the output valve, V2.

THE ELECTROLYTIC CONDENSERS. —Condensers having a capacity of 8 mfd. and a peak voltage rating of 500 volts will be satisfactory.

RESISTORS.—The resistors R, R1, R2 and R3 should be of the carbon type rated at 1 watt. R4 must be of the wire-wound variety and able to carry the normal plate current of V2 without overheating.

The Wiring

Connect all of the following points to the chassis: The finish of the aerial coil, L1; the finish of the secondary coil, L2; the cathode lug on V1; the centre-tap on the 6 volt heater winding on the power transformer, and the HT centre tap on the transformer.

If the 6 volt winding is not provided with a centre-tap, one of the lugs must be earthed. If you are using valves for V1 and V2 that have heaters of a different voltage to that given above then the transformer must have a winding of that voltage instead of the 6 volts.

The aerial terminal on the set goes to the start of the aerial winding, L1. Then take the start of the secondary winding to one side of the grid condenser, C3, and to the stationary plates of the variable condenser, C1. The other side of C3 is joined to the grid of V1. Wire the grid resistor, R, across the grid condenser, C3. Now connect one of the heater lugs (6 volt) on the power transformer to one of the heater lugs on V2, and then to one of the heater lugs on V1. Connect the other heater lug on the transformer to the remaining heater lug on V2, thence to the free heater lug on V1.

One side of the rectifier filament winding on PT (5 volt) is connected to one of the filament lugs on the rectifier socket, V3, and the other 5 volt lug on Pt is taken to the free filament lug on V3. Next wire one of the HT lugs to one of the plate lugs on V3 and next join the remaining plate lug on V3 to the remaining HT lug on PT.

One of the filament lugs on V3 is soldered to the positive terminal of electrolytic condenser E1.

The positive terminal of electrolytic condenser, E2, goes to the screen lug on the output valve socket, V2. To this screen lug also attach one end of condenser C6, the other end of which goes to the plate lug on V2.

Connect one end of resistor, R4, to the cathode lug on V2 and connect the other end of the resistor to the chassis. The positive of E3 is joined to the cathode of V2 and the free end of E3 taken to the chassis.

To the plate of V1 connect one end of the RF choke, RFC, and a lead going to the start of the reaction winding, L3. The other end of L3 is wired to the stator plates on the reaction condenser, C2.

Attach one end of the condenser, C5, and one end of resistor, R2, to the free end of the RF choke. The other end of C5 goes to the grid lug on V2 and to one end of the resistor R3. Earth the other end of R3.

To the screen lug on V1 attach one end of condenser, C4, and one end of

The List of Parts and Schematic Circuit Diagram to build this Receiver.

C1. — Variable condenser, 0.00035 mfd.

C2.—Midget condenser, 23 plates.

C3.—Mica condenser, 0.00025 mfd.

C4.—Tubular condenser, 0.1 mfd.

C5.—Mica condenser, 0.02 mfd.

C6.—Mica condenser, 0.004 mfd.

E1, E2.—8 mfd electrolytic condensers.

E3.—25 mfd, 35 volt electrolytic condenser.

L1, L2, L3.—Coil kit.

PT.—Power transformer.

R.—2 megohm resistor.

R1.—L megohm resistor.

R2.—0.25 megohm resistor.

R3.—0.5 megohm resistor.

R4.—Bias resistor to suit valve.

RFC.—R.F. choke.

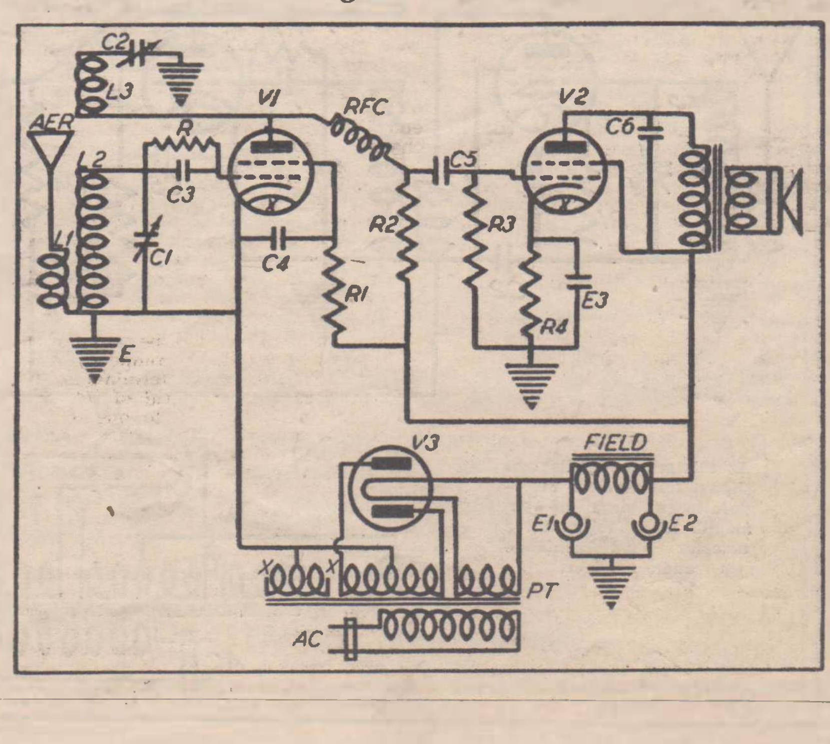
Speaker.—Field, 2500 ohms. Transformer to match V2.

V1.—R.F. Penthode valve and socket.

V2.—Penthode output valve and socket.

V3.—Rectifier valve and socket.

Sundries. — Dial, chassis, wiring flex, nuts and bolts.



resistor, R1. The free end of C4 is taken to the chassis, and the free end of R1 to the free end of R2, this junction then being wired to the screen lug on V2.

THE SPEAKER CONNECTIONS.—One of the transformer lugs on the speaker is wired to the plate lug on V2, and the other lug on the speaker transformer is connected to the screen lug on V2. One of the field lugs on the speaker goes to the positive of electrolytic condenser, E1, and the positive of electrolytic condenser, E2, is taken to the remaining field lug on the speaker.

A power cord should then be connected to the lugs on the power transformer corresponding with the voltage supply in your district.

The value of resistor, R4, is calculated from Ohm's law. R equal 1000 E/I where R is the resistance in Ohms, E is the desired bias voltage, and I is the cathode current in milliamperes.

This formula applies to bias resistors for all types of valves where this system of bias is applied.

It must be borne in mind that I is the cathode current, which consists of the plate current and the screen current if a valve has a screen.

The wiring of the set should be checked over to see that there are no wrong connections, and, after the valves have been inserted, the set can be connected up to the mains. Allow the set a few minutes so that the valves can warm up, and then tune in a station with the condenser, C1. The reaction condenser, C2, is used to control the sensitivity of the set. Do not allow the set to oscillate, as this is detrimental to reception.

The power transformer should have a winding for a type 80 rectifier and a heater winding to suit the other valves. The high tension winding should be 375 to 385 volts per side, and rated at 60 milliamps.

AN A.C. FOUR VALVE SET

High Sensitivity and Good Quality are the Main Features

THIS four-valve electric receiver is an improvement on the three-valve receiver in that it incorporates a stage of radio frequency amplification. This means that this set is more selective and will get distant stations much better than the three-valve receiver.

THE COILS are identical with the coils for the three-valve battery receiver.

THE SPEAKER must have a field of 2500 ohms and a transformer to suit the output valve, V3.

THE POWER TRANSFORMER. — The requirements for this are the same as those for the three-valve electric set.

The whole of the major components are mounted on an aluminium chassis with the power transformer, the electrolytic condensers, the gang condenser and the coils.

The R.F. and Detector valves, V1 and V2 should be provided with shields.

It would be best to mount the coils in small shield cans rather than use a piece of shielding between them.

The wiring is commenced by connecting the rectifier filament lugs on Pt. to the rectifier filament lugs on the rectifier socket, V4. One of the filament lugs on this socket is also connected to the positive terminal of electrolytic condenser, E1.

The HT outers are wired to the plate lugs on V4 and the HT centre-tap connected to the chassis. Next connect the heater lugs on V1, V2 and V3 to the heater lugs on Pt. One of these lugs must be earthed to the chassis.

Now connect the following points to the chassis: The finish of the aerial coil, L1; the finish of the aerial secondary coil, L2; the finish of the RF secondary, L3; the cathode of V2.

The start of the aerial coil, L1, goes to the aerial terminal on the set and the start of L2 is connected to the stationary plates of the first section of the gang condenser, G1. A connection is also taken from this position to the grid of the R.F. valve, V1.

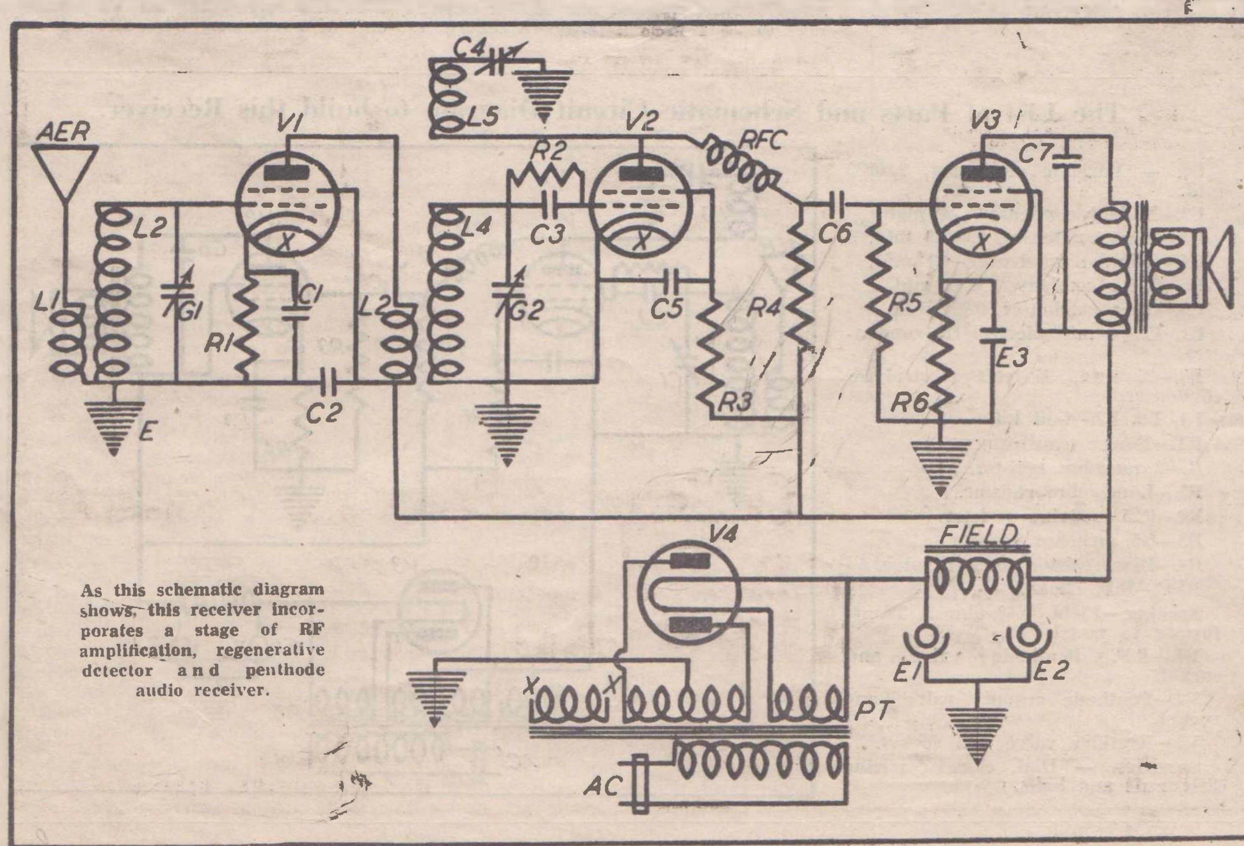
Join one end of the cathode resistor, R1, and one end of condenser, C1, to the cathode lug on V1. Earth the free ends of R1 and C1. To the screen lug on V1 connect one end of condenser, C2, and earth the other end of this condenser. Attach the plate lug on V1 to the start of the primary winding, L3, and to the finish of this winding connect a lead which goes to the screen lug on V1.

If this valve requires a lower screen voltage than plate voltage a resistor of the correct size must be connected between the screen lug on V1 and the finish of the R.F. primary, L3, instead of the wire mentioned above.

The start of the RF secondary, L4, is taken to the stator of G2 and to one end of the grid condenser, C3, and one end of the grid resistor, R2. The free ends of these components are joined together and wired to the grid of V2.

To the plate of V2 attach the finish of the reaction winding, L5, and one end of

(*Continued on Page 68*)



As this schematic diagram shows, this receiver incorporates a stage of RF amplification, regenerative detector and penthode audio receiver.

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An A.C. Four-Valve Set—

(Continued from Page 66)

the R.F. choke. The other end of L5 is taken to the stator of the reaction condenser, C4.

To the free end of the R.F. choke, RFC, attach one end of the grid condenser, C6, and one end of the plate resistor, R3. The other end of C6 is wired to the grid of V3 and to one end of the grid resistor, R5. The free end of R5 is then earthed.

To the cathode lug on V3 attach one end of the bias resistor, R6, and the positive of electrolytic condenser, E3. The free end of R6 and the negative of E3 are earthed.

To the plate lug on V3 attach one end of condenser, C7, and take the other end of this condenser to the screen lug on V3. Also attach the screen lug on V3 to the positive of electrolytic condenser, E2. Now wire the finish of the R.F. primary, L3, and the free end of R4 to the screen lug on V3. The junction of this wire and R4 should be connected to one end of resistor, R3, the other end of which is connected to the screen lug on V2. To this lug also attach one end of condenser, C5, and earth the free end.

One of the field lugs on the speaker is connected to the positive of electrolytic condenser, E1, and the other field lug to the positive of electrolytic condenser, E2.

One of the input transformer lugs on the speaker goes to the screen lug on V3 and the other transformer lug is taken to the plate lug on V3.

The value for the bias resistors, R1 and R6, is calculated by the formula given in the description of the three valve electric receiver.

Now attach a power cord to the correct primary lugs on the power transformer.

The operation of the set and its alignment is the same as that for the three valve battery receiver, and this description should be referred to for these particulars.

LIST OF COMPONENTS

C1, C2, C5.—Tubular condensers. 0.1 mfd.
C3.—Mica condenser, 0.00025 mfd.
C4.—Midget condenser, 23 plate.
C6.—0.02 mfd. mica condensers.
C7.—0.004 mica condensers.
E1, E2.—8 mfd. electrolytic condensers.
E3.—25 mfd. 35 volt electrolytic condenser.
G1, G2.—Two gang condenser, 0.00035 mfd.
L1, L2, L3, L4, L5.—Aerial and R.F. coils.
Pt.—Power transformer.
R1.—Bias resistor for V1.
R2.—2 megohm resistor.
R3.—1 megohm resistor.
R4.—0.25 megohm resistor.
R5.—0.5 megohm resistor.
R6.—Bias resistor for V3.
RFC.—R.F. choke.
Speaker.—Field 2500 ohms. Transformer to match V3.
V1.—R.F. pentode (variable mu) and socket.
V2.—R.F. pentode and socket.
V3.—Pentode output valve and socket.
V4.—Rectifier valve and socket.
Sundries.—Dial, chassis, terminals, nuts and bolts, wiring wire.

A 5 VALVE A.C. SUPER-HET

This Modern Receiver is Capable of Receiving Interstate Stations at Full Loud Speaker Volume.

The modern trend in radio receiver design is for multi-valve dual and all-wave receivers, but despite this a large number of listeners favor a straight-out local receiver, selective enough to separate the powerful local stations and yet not so selective as to prevent the higher musical frequencies from being reproduced.

Another very necessary rquirement of a receiver of this type is that it be fitted with an efficient automatic volume control system to prevent the output valve from overloading on the powerful local signals.

Taking into consideration the above requirements, we believe that a simple type of five-valve super-heterodyne fills the bill admirably. Whilst not designed for the reception of interstate stations, a receiver of this type will, under favorable conditions, receive the majority of the higher-powered interstate stations at fair loud speaker strength.

The receiver described here has been designed with the idea that home-constructors should have little difficulty in building a chassis identical in layout and construction, and capable of providing real musical entertainment from the local stations.

In order that the automatic volume control would not reduce the strength of weak interstate signals, a small amount of delay was arranged. This was provided by tapping the cathode bias resistor for the diode-triode valve and returning the load resistor for the A.V.C. diode to this point.

This results in a slight negative voltage on this diode, and the incoming signal has to be powerful enough to overcome this before the A.V.C. functions.

A glance at the circuit diagram will show that the receiver is a five-valve super-heterodyne consisting of a mixer stage followed by a stage of intermediate frequency amplification operating on the intermediate frequency of 462 k.c. This, in turn, is followed by a diode-triode valve performing the functions of diode second detector, delayed automatic volume control, and first stage audio-frequency amplifier. The demodulated output of the triode section of this valve is fed to the output penthode, where it is amplified further and fed to the input transformer of the dynamic speaker.

It will be noticed that the receiver employs three of the latest metal valves in the mixer, I.F., and output stages respectively, and that ordinary glass valves are used in the remaining sockets. If desired, metal valves can be employed throughout in which case a type 6Q7 could take the place of the 75, and a type 5Z4 rectifier could replace the 80.

The valves employed in the various stages of the original model are a type 6A8 as the oscillator-mixer, a type 6K7 as the intermediate frequency amplifier valve, a type 75 as the diode second detector, a type 6F6 penthode as the output tube, and a type 80 as the rectifier.

An intermediate-frequency of 462 k.c. was selected because of the greater band width, i.e., slightly broader tuning of the I.F. stages and consequently improved reproduction. Another thing which influences the choice of 462 k.c. is the elimination of the necessity for a preselector stage ahead of the mixer valve.

It will be noticed that great care has been taken to see that none of the R.F. component of the rectified signal is allowed to penetrate into the audio section of the receiver. This is prevented by the inclusion of a suitable filter consisting of the radio frequency choke, R.F.C., and the by-pass condensers, C12 and C13, in the plate circuit of the triode section of the second detector valve.

So much for the technical highlights of the receiver. The first step in its construction is to obtain a suitable chassis. This may be constructed of aluminium, steel, copper, or other suitable material depending on the constructor's requirements. The original chassis was constructed of aluminium and newcomers to the field of radio will find this the most suitable material for their initial experiments.

The two-gang condenser is mounted centrally on top of the chassis assembly with the aerial and oscillator coils bolted in position on its right-hand side. The oscillator coil is the one nearer the front edge of the chassis.

These coils should be placed as near the gang condenser as is possible so that the leads to the condenser are short and direct. In the front right-hand corner of the chassis is the socket for the 6A8 mixer valve, V1, whilst towards the rear of the chassis and in line with the aerial coil is the first I.F. transformer, IFT1. The intermediate frequency amplifier valve, V2, is situated in the rear right-hand corner of the assembly with the second I.F. transformer, IFT2, bolted in place to the left of this valve along the rear edge of the chassis.

The power transformer, PT, occupies a position to the left of the gang condenser with the two electrolytics, E1 and E2, mounted in the front left-hand corner of the chassis.

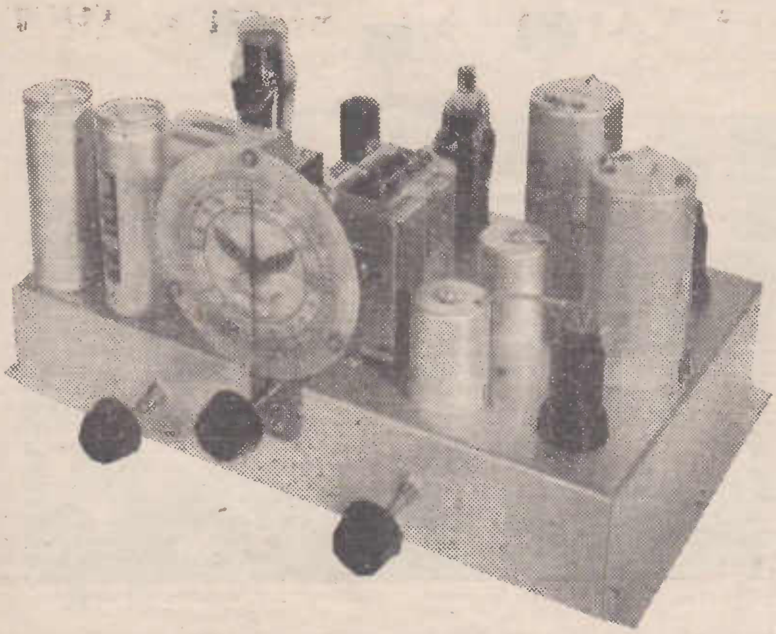
In line along the rear edge of the chassis are the sockets for the rectifier valve, V5, the output pentode, V4, and the diode triode second detector, V3. The socket for the rectifier, V5, is the one at the extreme left of the assembly.

The aerial and earth terminals are mounted on the back edge of the chassis directly below the socket for V2. The speaker output socket also mounts on the back of the chassis between the rectifier socket, V5, and the pentode output socket, V4.

The volume control potentiometer, VC, bolts in position to the right of the main tuning control, whilst the tone control occupies a position on the left of the main tuning control.

Below the chassis the radio-frequency choke, RFC, is bolted to the back of the chassis between the sockets V3 and V4. The padder condenser, PD, may be seen bolted in place between the two tuning coils with its adjustment screw arranged so that it may be adjusted from on top of the chassis.

Having completed the assembly of the parts, the wiring may be commenced by wiring the filament contacts of the sockets V1, V2, V3 and V4 by means of a twisted pair to the 6.3 volt winding of the power transformer, PT. Similar twisted pairs join the filament contacts of the rectifier socket, V5, to the 5-volt winding on PT, and the plate contacts of the rectifier socket to the high voltage secondary on PT. The centre-tap of the high-voltage secondary joins to earth.



This photograph clearly shows the symetrical front of the completed receiver.

The centre-tap of the 6.3-volt winding and the astatic shield contact of PT also join to earth.

Before commencing the remainder of the wiring, a suitable tinned wire should be soldered to convenient solder-lugs placed under the holding nuts of the sockets and I.F. transformers. To this tinned wire should be soldered all of those leads designated as connecting to earth. It is important to see that a solder-lug is placed under the holding nut of each of the coil cans, and that these lugs are soldered to the moving plate wipers on the gang condenser.

Having soldered these earth wires in place, the wiring may be continued by wiring in the coils. The number four contact of the aerial coil connects to the aerial terminal, whilst the number five contact of this coil joins to earth. The number one contact of the aerial coil connects to the fixed plate contact of the section G1 of the gang condenser, whilst the number two contact of this coil is left unconnected for the moment.

The number four contact of the oscillator coil connects to the oscillator plate contact of VI and the number five contact of this coil is left unconnected for the time being. To the oscillator grid-lug of the socket VI solder one side of the grid condenser, C2. To the remaining side of this condenser solder the lead from the number one contact of the oscillator coil, while the number two contact of this coil solders to the fixed plate contact of the padder condenser, PD. The moving-plate lug on this component joins to earth. Join together the shield and cathode lugs of V1 and to them solder one lead each of R3 and C3. The remaining leads of these components join to earth.

The oscillator grid leak, R2, should now be connected between the oscillator grid and cathode lugs of V1. The Red lead of IFT1 solders to the plate contact of V1, whilst the Green lead of IFT2 solders to the corresponding lug on the socket, V2. Join together the shield and cathode lugs of V2 and to them solder one lead each of R5 and C6. The remaining leads of these components join to earth.

Join together the screen lugs of the sockets, V1 and V2, and connect the condenser, C7, from this position to earth. Returning to the power supply side of the receiver wire one side of the rectifier filament to one of the large pins of the speaker socket. To this pin also connect the positive contact of the electrolytic condenser, E1.

The remaining large pin of the speaker socket joins to one of the small pins of the same socket and to the positive side of the electrolytic condenser, E2. The remaining contact of the speaker socket connects to the plate of the pentode socket, V4. The two lugs which were connected together on the speaker socket will be termed the "B" positive lug of that socket.

To contact number five of the oscillator coil solder one contact of the resistor, R4. Solder one lead of the resistor R6, to the screen-lug on the socket, V1, and join the vacant lugs of the resistors, R4 and R6, together. To the junction of these resistors solder a lead from the "B" positive lug on the speaker socket.

The "B" positive leads from IFT1 and IFT2 also join to this point. The .1 mfd. condenser, C4, may now be soldered in place from the number five contact of the oscillator coil to earth. The grid-lead of IFT2 solders to one of the diode plates of the socket V3, and the earth lead of this component should be replaced with one of shielded wire long enough to connect to one of he outside contacts of the volume control potentiometer, VC. The remaining outside lug of this component connects to the cathode-lug of the socket, V3.

One contact, each of the resistors, R9 and R10, solder together. The remaining contact of R9 solders to the cathode-lug of the socket, V3, whilst that of R10 joins to earth. The electrolytic condenser, C11, may be connected between the cathode lug of V3 and earth.

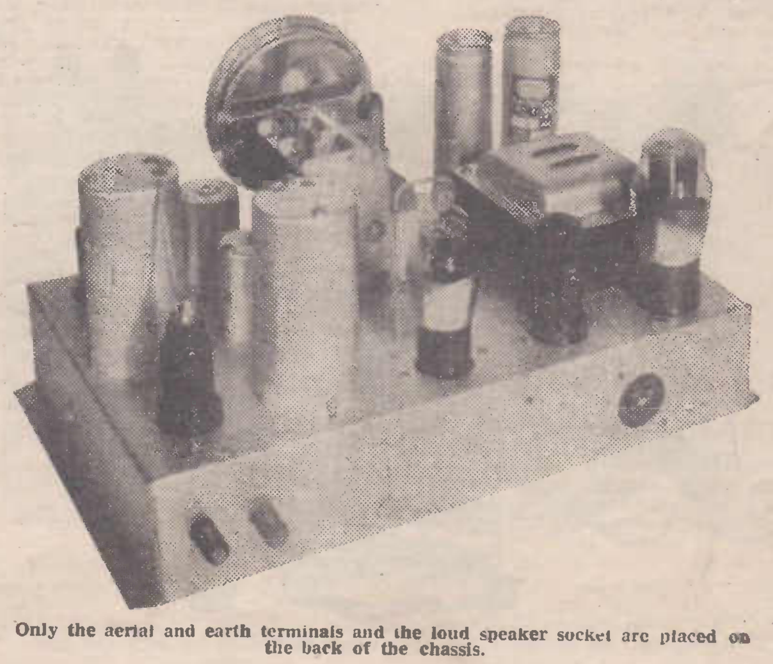
Solder one contact of the condenser, C8, to the plate of the socket, V2, and connect its remaining lug to the remaining diode plate of the socket V3. From this position the resistor R8 solders to the junction of the resistors R9 and R10.

To this same diode plate of V3 solder one side of the resistor, R7, and, using the shielded wire, take a lead to the earth lead of IFT1.

It must be understood when using this shielded wire that the outside metal covering is pushed back and wound with fine gauge wire to prevent it from "shorting" to the inside push-back wire. Then the outside metal covering is securely soldered to earth.

From the junction of this shielded wire and the lead of IFT1 a .1 mfd. condenser, C5, joins to earth.

Solder to the number two contact of the aerial coil one side each of R1 and C1. The remaining lug of C1 joins to earth, whilst that of R1 is connected with the shielded wire to the contact of R8, to which the other shielded lead has been joined.



Only the aerial and earth terminals and the loud speaker socket are placed on the back of the chassis.

Solder one lug of the condenser, C9, to the centre-contact of VC and solder the resistor, R11, from the remaining lug on VC to earth. A shielded wire connects to the junction of C9 and the centre contact of VC. It must be taken through a hole in the chassis drilled near the socket, V3, to the grid of the 75 valve. The condenser, C10, solders between the lug of VC, which connects to the earth lead of IFT2 and earth. The lead from the fixed plates of the section G2 of the gang condenser may now be connected to the number one contact of the oscillator coil.

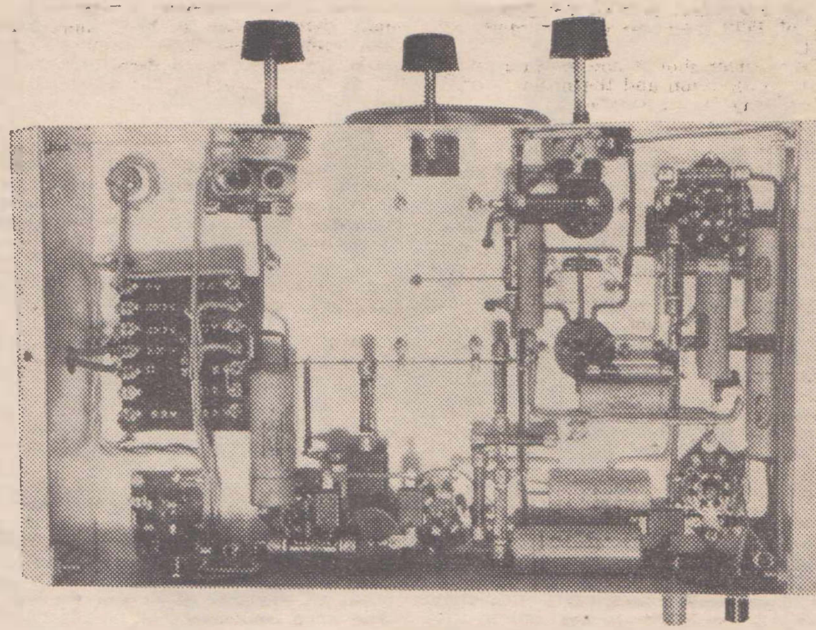
Solder a lead to the plate lug of the socket V3, and connect it to one side of RFC. The remaining lug of RFC connects to one side of the coupling condenser, C14. The remaining side of this condenser connects to the grid lug of the socket V4. The resistor, R13, connects between the grid side of this coupling condenser, and earth. Solder one side of the condenser, C12, to the plate side of RFC, and one side of the condenser, C13, to the other side of RFC. The remaining lugs of C12 and C13 join to earth.

Solder the resistor, R12, between the "B" positive lug on the speaker socket and that side of RFC to which C13 is connected. Connect one side each of R14 and C15 to the cathode and shield-lugs of the socket V4 and solder their remaining leads to earth. The screen-lug of the socket V4 solders to the "B" positive lug of the speaker socket.

Solder a lead to the arm of TC and connect it to the positive lug of E2. Connect together one lead each of the condensers, C16 and C17. The remaining lug of C17 connects to one of the outside contacts of TC. The resistor, R15, connect between the vacant lug of C16 and the "B" positive lug of E2.

To complete the wiring solder the three grid-clips to their respective leads and wire in the dial lights to the 6.3-volt winding on PT. The power leads should be attached to their correct terminals and knobs fitted to the three tuning controls.

This completes the actual construction of the receiver chassis. The next step is the aligning of the tuning and intermediate frequency circuits.



The positions of the components underneath the chassis can be seen in this illustration.

One very important thing when aligning by ear is to keep the signal on which the alignment is being carried out at a low level. The reason for this is that it is much easier to discriminate between changes in low signal-levels than between changes in high signal-levels.

The first requirement, therefore, is to reduce the signal-level by means of the volume control each time an adjustment is made which raises the output signal.

Bearing this in mind switch on the receiver and attach the aerial and earth wires to their correct terminals. Tune a station on the high-frequency end of the broadcast band say 3XY, and adjust the trimmers on the gang condenser.

If a calibrated dial such as that used on the original receiver is employed the trimmer on the section G2 of the gang condenser should be screwed down until the station on which the alignment is being carried out is received at the correct position on the dial. It is important, however, that this be done on one of the higher frequency stations such as 3AK or 3XY.

Having located this station at its correct place on the dial the trimmer on the section G1 of the gang condenser should be adjusted for maximum signal strength.

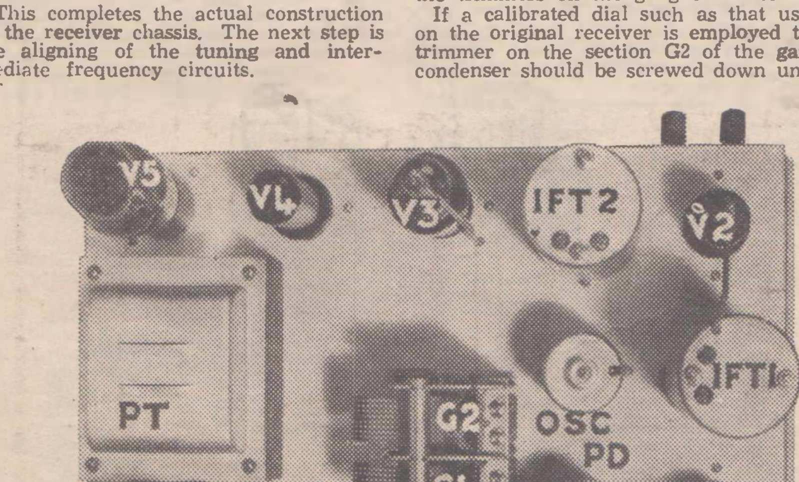
It may be desirable if, with the aerial used for the alignment, the volume control has to be turned nearly off, to attach a short piece of wire to the aerial terminal in place of the normal aerial whilst these adjustments are being made.

Having adjusted the trimmers for maximum results, re-tune the receiver to a station at the low-frequency end of the band, says 3AR, and adjust the padder condenser for maximum signals on this station. As the adjustment of the padder condenser affects the tuning of the station it will be necessary to swing the dial over two or three degrees of its scale to make certain that the condenser is tuned to the peak of the station's carrier wave.

With this operation performed return once more to the high-frequency end of the band and try the effect of a slight re-setting of the trimmer on the G1 section of the gang condenser. On no account should the G2 trimmer be touched after the padder has been set as this will throw the whole alignment out.

With these adjustments completed the receiver should be functioning fairly well, but, in almost every case, results may be still further improved by adjusting the trimmer condensers on the intermediate frequency transformers.

First tune in a station in the centre of the band, and, again working on a weak signal, adjust the diode trimmer of IFT2 for maximum results. The same procedure is adopted with the remaining trimmers. Work in the following order:



In this illustration the parts are key-lettered in accordance with the text.

the plate trimmer of IFT2, the grid trimmer of IFT1, and the plate trimmer of IFT1.

The receiver should now be in a fairly sensitive condition and the normal aerial system may be re-connected.

As stated previously, the sensitivity of the receiver will be still further improved by alignment on a signal generator or service oscillator.

Used in the suburban area on a comparatively inefficient aerial system the receiver has given excellent results, not only from local stations, but also from the more powerful interstate stations. The tonal quality of the receiver has been remarked upon many times by people well able to judge the musical value of its reproduction. A tone control is fitted, which, when turned to the full off position, is calculated to give more or less a flat response. However, as many listeners like to hear more bass than treble from their receivers the treble notes can be suppressed by turning the tone control to the full-on position.

This receiver can be recommended to those in search of a quality local receiver capable of separating any of the local stations from one another and yet of receiving many of the more powerful interstate broadcasters with excellent clarity and strength.

For the home-constructor it is ideal. Very few parts, all of which are readily obtainable, are required. The receiver is simple to build neat and attractive in appearance, and, above all, is capable of outstanding results without the complications usually associated with this type of set.

A GOOD VARNISH

This Mixture is also an Excellent insulator

A GOOD varnish for instruments, woodwork, etc., will be found very useful for those who are fond of making things. A recipe which will result in a good varnish and an insulator when used for electrical work is given hereunder:—

Liquid shellac (white), one 4oz. bottle.

One tablespoonful of black aniline dye.

The shellac should not be very thick, whilst the aniline dye should be soluble in alcohol only. Mix and shake well, painting the mixture on with a soft brush. A very pleasing result can be obtained from one or two thin coats of this varnish.

THE LIST OF COMPONENTS AND SCHEMATIC DIAGRAM

Of the Five-Valve A.C. Super-Het.

Chassis—Measuring 13½ inches by 8½ inches by 2½ inches.

Coil Kit—Consisting of type BC aerial and oscillator coils for 465 K.C. to suit 6A8.

C1, C3, C4, C5, C6, C7—.1mfd. tubular condensers.

C2, C8, C12, C13—.001 mfd. mica condensers.

C9, C14—.02 mfd. mica condensers.

C10—.0002 mfd. mica condenser.

C11, C15—25 mfd. low voltage electrolytics.

C16—.01 mfd. tubular condenser.

C17—.05 mfd. tubular condenser.

DS—Dynamic speaker 2500 ohm field to suit 6F6.

E1, E2—8 mfd. 500 volt test electrolytics.

G1, G2—Type G Stromberg Carlson two gang condenser.

IFT1, IFT2—465 K.C. I.F. transformers.

PT—Power transformer 385-0-385 80 milliamperes, 5 volt two ampere, 6.3 volt two ampere.

R1—100,000 ohm 1 watt resistor.

R2—50,000 ohm 1 watt resistor.

R3—300 ohm wire wound resistor.

R4—20,000 ohm 1 watt resistor.

R5—350 ohm wire wound resistor.

R6—30,000 ohm 1 watt resistor.

R7, R8, R11—1 megohm 1 watt resistors.

R9—1000 ohm 1 watt resistor.

R10—5000 ohm 1 watt resistor.

R12, R13—.5 megohm 1 watt resistors.

R14—400 ohm wire-wound resistor.

R15—10,000 ohm 1 watt resistor.

RFC—Radio frequency choke.

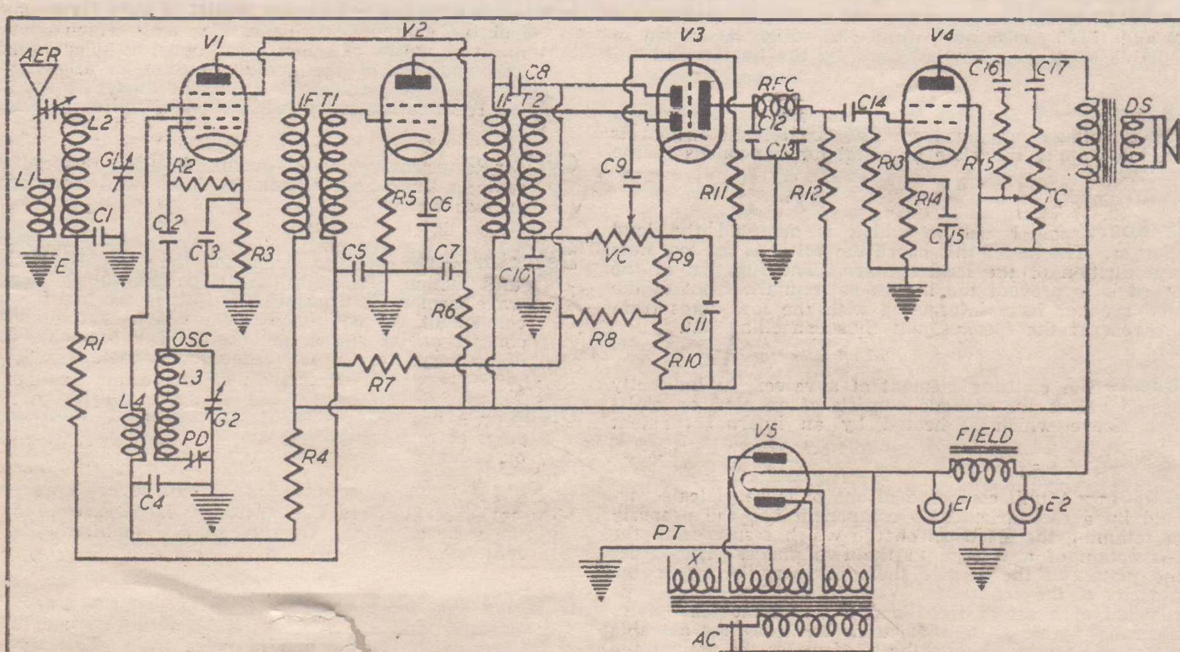
Sockets — 3 octal sockets, 1 6-pin socket, 2 4-pin sockets.

TC—50,000 ohm tone control potentiometer.

VC — 500,000 ohm volume control potentiometer.

Valves—1 each 6A8, 6K7, 75, 6F6 and 80.

Sundries — Wiring flex, nuts and bolts, aerial and earth terminals, small quantity of tinned wire, 1 yard of shielded wire, 465 k.c. padder condenser, 1 Radiokes dial, 3 grid clips, knobs and power flex.



A GLOSSARY OF TECHNICAL TERMS

With the assistance of this chart the amateur radio enthusiast will be able to obtain the meaning of all radio and electrical terms used in this handbook.

"A" Battery—The battery which supplies filament current to the valve. This may be either a dry cell or a re-chargeable accumulator battery.

A.C.—Alternating Current. Current which changes its direction of flow periodically. The number of times per second that this reversal of flow takes place is known as the frequency and is referred to in terms of "cycles per second."

A.V.C.—Automatic Volume Control. An electrical system incorporated in modern receivers which ensures that the output volume shall remain constant irrespective of fluctuations of the input signal strength.

Adaptor—A unit which consists usually of a detector stage plugged into the audio frequency amplifier of a receiver to permit the tuning in of short-wave signals which otherwise could not be heard on the broadcast set.

Aerial—The collector system which picks up the transmissions of broadcasting stations and feeds them to the input circuits of the receiving set. The aerial may be of various designs, each of which has its particular advantages.

Amplification—The electrical boosting or increasing of signal strength, usually carried out by means of transformers.

Arrester, Lightning—A device connected between the aerial and earth leads and so designed that, whilst it has no effect on signal currents, it provides a "flashover" path for lightning surges which thus are directed to earth.

Audio Frequency—Alternations of a frequency between 20 and 15,000 cycles per second and which, when fed in suitable apparatus, can be heard by the human ear.

"B" Battery—A dry cell or accumulator battery which has a voltage ranging from 22½ to 180, and which is used to supply the plate potential for the valves in the receiver.

Baffle-Board—A board on which is mounted the loud speaker. The larger this board the better is the low note reproduction of the loud speaker. The function of the board is to prevent the low notes from the front of the loud speaker from interacting with the low notes from the rear of the speaker and thus cancelling out.

Cathode—The emitting element of a valve. In indirectly heated valves the cathode consists of an electron emitting sleeve which is heated by an internal filament wire.

Condenser—A unit composed of one or more plates separated by a dielectric. This component has the property of retaining the electrical charge which results from the connection of a voltage to the two plates. The larger the plates, or the greater their number, the larger the capacity of the condenser. Variable condensers are constructed of a set of fixed and a set of movable plates separated by air as the dielectric. The more the movable plates are enmeshed with the fixed plates the greater the capacity of the condenser.

"C" Battery—A small battery, usually of the dry cell type, which is used to supply the bias voltage for amplifier valves. As no current is drawn from this battery its cells may be of the smallest physical dimensions.

Chassis—The steel or aluminium framework upon which the components of a radio receiver are assembled.

Coils—Usually known as inductances. these components consist of a number of turns of wire on a non-conducting former. The actual number of the turns of wire and the diameter of the former on which they are wound is dependent upon the tuning range it is desired to cover and the capacity of the tuning condensers. Coils which are untuned are called "aperioic," and their design follows a different law.

Conductor—A material which provides an easy passage to the flow of electric current. Materials such as silver, copper, and brass are the best conductors, although most metals will conduct electricity without great loss.

Converter (Short-Wave)—A unit which operates on the super-heterodyne principle and changes the frequency of the incoming short-wave signal to a lower radio frequency and one with which the broadcast receiver is capable of dealing.

Counterpoise—An alternative "earth" arrangement which depends for its operation on the capacity effect existing between it and the aerial. The counterpoise is usually erected about 10 feet above ground level and consists of a number of wires arranged underneath the aerial and insulated from contact with the earth.

Crystal Detector—Usually consists of a substance such as galena, iron pyrites, silicon, etc., with which contact is made by means of a fine wire known as a "cat-whisker." The property of the crystal detector in allowing only the one-way passage of a current makes it useful for the rectification or de-modulation of radio signals.

Cycle—Recurrent period of events. Usually referred to in radio as the change of polarity from positive to negative, or vice versa.

Detector—The popular name for the "de-modulator," or unit which eliminates the high frequency "carrier" wave from radio transmissions leaving the low frequency component or modulated wave which is the electrical counterpart of speech or music. The two chief forms of detectors are the valve and the crystal.

Diode—A two-element valve which is chiefly used for purposes of rectification. It consists of an emitting element, or cathode, and a plate.

D.C.—Direct Current. A current which always flows in the same direction. Opposite of A.C. or alternating current.

Doublet Aerial—A special form of aerial developed particularly for short-wave reception. Also has advantages in the elimination of noise from electrical interference.

Dynamic Loud Speaker— A loud speaker in which the audio frequency signal current flows through an exceedingly light cylindrical coil of wire, called the moving coil, which is attached to the cone of the instrument. Movements of this coil, brought about by varying magnetic intensities, impart movement to the loud speaker cone, and thus produce audible speech or music.

Electric Receivers—Known also as All-Electric Sets, or A.C. receivers. Sets which derive their power supply entirely from the alternating current supply mains and are fitted with rectifiers which change this current into Direct Current for use on the plates of the valves.

E.M.F.— An abbreviation for Electromotive Force. The force necessary to make a current flow through a circuit. The unit of E.M.F. is the Volt.

Fading— The waxing and waning of the strength of the received signal due to varying reflections from the Heaviside Layer.

Fault Finding— The location of the cause of unsatisfactory operation of radio receivers.

Field (Loud Speaker)—The winding of many turns of wire around a soft iron core, which, when energised by a direct current, forms an electro-magnet and provides a static balance for the loud speaker voice coil.

Filter— A combination of capacity and industance which impedes the passage of currents of undesired frequencies.

Frequency— The period of alternation of a current, i.e., the number of times it changes its direction of flow per second.

Gang Condenser—Two or more variable tuning condensers, the moving or rotor plates of which are mounted on a single shaft and are rotated simultaneously through the same arc of movement.

Ganging— The electrical alignment of the combination of the gang condenser and the associated tuning coils. This is usually assisted by means of a small semi-variable condenser units mounted on each section of the gang.

Grid—The control element of the radio valve. It usually consists of an open-mesh wire screen.

Ground—The earth or neutral point of an electrical circuit.

Heaviside Layer—The non-conducting but reflecting layer of ionised gases which is believed to exist at distances beyond 60 miles from the surface of the earth.

Indirect Heater—A valve which functions by the electron emission from a cathode which is indirectly heated by a pair of current-carrying wires embedded in it.

Inductance—The self-induction effect of a coil of wire by which it tends to prevent any change in the current flowing through it. A coil of wire used for tuning purposes.

Insulator—A material which opposes the flow of electric current. Mica, oil, glass, air, porcelain, bakelite and similar materials are good insulators.

I.F.—Intermediate frequency. A frequency used in superheterodyne receivers, which actually is a low radio frequency.

Kilocycle—1000 Cycles. Most broadcasting stations are referred to as transmitting on a frequency of —— kilocycles. On the short-waves the term used is the mega-cycle, mega meaning 1,000,000.

Lead-In—The wire connecting the aerial proper with the receiving set. This wire should be heavily insulated and should be kept clear of earthed objects.

Lightning Arrester— (See Arrester.)

Loop Aerial—An aerial wound on a frame or loop. Noted particularly for its directional properties. Not much used for broadcast reception today.

Loud Speaker—A device for rendering the received speech or music audible to a number of people.

Microphone—The electrical ear which translates the air impulses of the speaker's or singer's voice into electrical impulses, which can be used to modulate the carrier-wave of a radio transmitter.

Megohm—One million ohms. An ohm is the measurement of resistance to the passage of current.

Oscillation—Broadly—the generation of high frequency current.

Pentode—A five-element valve, which may be used either for radio frequency or audio frequency amplification. Its outstanding characteristic is the ease with which it responds to weak signals and the high amplification it can provide.

Permanent Magnet—A hardened steel or steel alloy which retains is magnetism after it is once magnetised. Cobalt steel and similar alloys are used in the best permanent magnets.

Pick-Up (Gramophone)—An electro-magnetic device which changes into alternating currents, suitable for amplification and subsequent loudspeaker reproduction, the mechanical variations caused by the undulations in a gramophone record.

Plate— One of the elements of the valve. Is usually in the form of a flattened metal tube.

Plug-In Coils—Tuning coils which are plugged into circuit to permit the tuning over different wavebands. Mainly used in short-wave receivers.

Power Amplifier—An audio frequency amplifier which is capable of delivering very loud signals to the loudspeakers. Used mainly in circumstances where large volume is required.

Power-Pack—The unit which supplies the plate, grid and filament power of the all-electric receiver.

Pre-Selector— An additional tuned circuit in front of the main input tuning system used to increase the selectivity of the receiver.

Radio Frequency—Inaudible frequencies lying between the range from 15,000 cycles per second to 30,000,000 cycles per second and upwards.

Receivers—The assembled components which make possible the reception of radio transmissions.

Rectifier—A device which is capable only of passing one-half of the alternating current cycle. The valve, the crystal, some chemical, and some mechanical, rectifiers are used for various purposes.

Reaction—See Regeneration.

Regeneration— The feeding back of energy from the plate to the grid of the valve. In circumstances wherein it is controlled, regeneration can be a valuable asset to the receiver.

Resistance— The opposition offered to the flow of current by non and semi conductors.

Screen Grid— An auxiliary grid connected in radio fre-frequency valves with the object of increasing the valve's stability, and at the same time of increasing its amplification.

Selectivity— The capability of a receiver to discriminate between two or more stations operating on adjacent frequencies.

Self-Bias— The provision of negative bias voltages by means of the voltage drop which takes place through a cathode resistor.

Sensitivity—The measurement of the capability of a receiver to respond to the very weak signals of low-powered or distant stations.

Series—Electrical devices connected one after another in such a way that all of the current flows through each of them. Batteries are said to be connected in series when the positive terminal of one cell is connected to the negative terminal of another.

Shielding—The enclosure of tuning coils, condensers, transformers and valves in metal housings for the purpose of absorbing stray electro-magnetic fields which may emanate from any of these components and would cause instability or kindred troubles in the receiving set. Shields are usually constructed of aluminium, although copper, brass and iron also are used.

Short-Waves—Wavelengths, the frequency of which lies between 3,000,000 and above 30,000,000 cycles per second. Noted chiefly for their capability of covering long distances and for their use for international broadcasting services.

Socket—The receptacle into which a radio valve is plugged. The socket is provided with terminal lugs which carry the connections to and from other parts of the circuit.

Static—The natural electrical interference which is picked up by a receiver in the form of crashes, crackles, and bangs.

Super-Heterodyne—A type of receiver in which the incoming signal is mixed with a locally generated one and the resultant intermediate frequency amplified before demodulation or detection in the usual manner.

Symbols—Radio's "short-hand," in which diagrams are used to represent the various components of a receiving set.

Television—The art of seeing by radio.

Tone Control—An electrical device which permits the tone or timbre of the receiver to be altered at the will of the listener.

Triode—A three-element valve containing a filament, grid and plate.

Transformer—A device consisting of a primary and secondary winding which is used to transfer energy from one circuit to another. Radio frequency transformers consists of two coils separated by an air dielectric, whilst in audio transformers the coils are surrounded by a laminated iron core.

Tuned Circuit—A circuit which is tuned or resonated to a desired frequency by means of a capacity made up of either a fixed or variable condenser.

Tuned Radio Frequency—A radio frequency amplifier which is provided with tuned, as distinct from aperiodic, or untuned, circuits.

Ultra Short-Waves— The wavelengths lying in the region of 10 metres and extending down below 1 metre. Mainly used for short distance communication, for television transmission, and for radio lighthouse beacons.

Valve—The electronic device which possesses the capability of permitting alternating or direct currents to pass only in one direction.

Variable Condenser—(See Condenser).

Voice Coil—A small, exceedingly light cylindrical coil, so mounted that it "floats" in the intense radial magnetic field in the small gap between the central core and housing of powerful electro-magnet of a dynamic loud speaker. Alternating voice currents cause a piston like movement of the voice coil to which is attached the loud speaker cone.

Voltage—The electrical force or pressure existing between any two bodies which have a different intensity of charge or a different polarity of charge. Sometimes called "potential difference."

Watt—The unit of electrical power. A pressure of one volt at a current of one ampere results in a power of one watt.

Wave Band—The frequency range over which a receiver, or a given combination of inductance and capacity will tune.

Wavelength—The distance between each successive train of impulses released by a radio frequency oscillator. For example, radio waves travel at the rate of 300,000,000 metres per second. If one million groups are emitted every second from the transmitter, corresponding to a frequency of 1000 kilocycles, then each group will have travelled 300,000,000 divided by 1,000,000 or 300 metres per second. Sometimes referred to as the distance between the crests of succeeding radio waves. Wavelength decreases with frequency.

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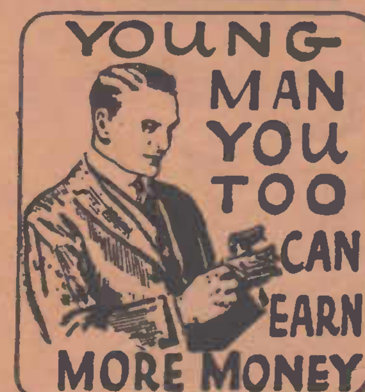

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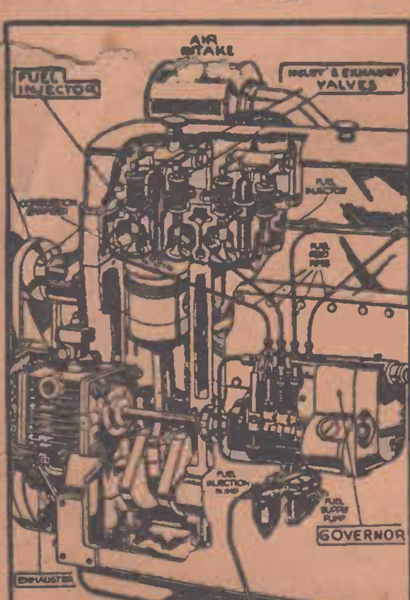

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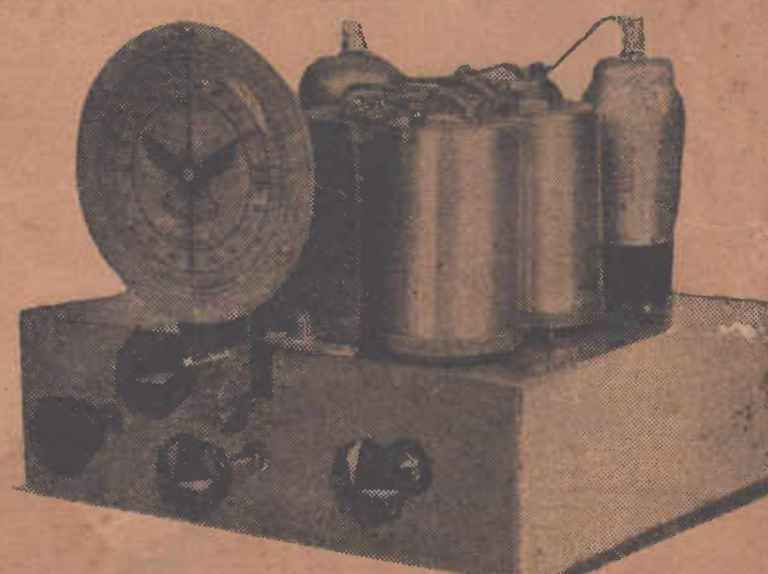

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