

The Wireless Constructor's Encyclopædia

A Complete Guide, in alphabetical order, to the Construction, Operation, Repair, and Overhaul of all types of Wireless Receivers and Components. Containing a special section on Television

WITH 490 ILLUSTRATIONS

BY

F. J. CAMM

*Editor of
"Practical Wireless"*



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PREFACE

ALTHOUGH the fascinating hobby of wireless receiver construction is rather more than twenty years old (for wireless telegraphy transmitters and receivers were in operation long before the war), this volume, specially produced for the home constructor, represents the first effort at the collation, in encyclopædic form, of the practical knowledge and data which have resulted from two decades of experiment. The rapid development and perfection of wireless telephony since 1922 have given a terrific fillip to the science, and brought into existence the present truly colossal army of listeners, totalling five millions or more, nearly 50 per cent. of whom are interested in the construction of, and experiments with, home-built receivers.

The number of listeners has increased enormously year by year since 1922, with the natural corollary that the number of amateurs has increased in direct proportion. There can now be no dubiety that home construction is here to stay; and it is therefore thought that the arrival of **THE WIRELESS CONSTRUCTOR'S ENCYCLOPÆDIA** has provided the amateur with a source of information and reference similar to that already in existence for the electrical and mechanical industries.

It will be noted that, whilst the normal encyclopædic style of definition has been followed, appropriate items have been expanded to include constructional and practical details. Additionally, to avoid repetition, cognate subjects have been grouped. Thus *Grid* will be found under *Valve*, although the reader is guided to that fact by first consulting the word in its correct alphabetical

PREFACE

order in the volume. Tables, too, have been inserted in their correct alphabetical position, instead of in the more usual position at the back. The standard abbreviations and symbols will be found on the opposite page.

A complete series of circuits has been included, and the section on television includes instructions on the making of a simple television receiver. "How to make" instructions and diagrams have been generously distributed through the pages. Television, in view of recent developments, has been accorded space.

I must express my thanks to the Technical Staff of *Practical Wireless* for their assistance in preparing some of the sections.

F. J. CAMM.

ABBREVIATIONS

A.—Anode, or plate.	I.C.—Intermittent current.
A.C.—Alternating current.	I.C.W.—Interrupted continuous waves.
AE.—Aerial.	I.F.—Intermediate frequency.
A.F.—Audio frequency.	I.P.—In primary (of transformer); start of primary.
A.T.C.—Aerial tuning condenser.	I.S.—In secondary (of transformer); start of secondary.
A.T.I.—Aerial tuning inductance.	kw.—Kilowatt.
B.A.—British Association.	L.F.—Low frequency.
B.O.T. Unit—Board of Trade unit.	L.R.—Low resistance.
C.C.C.—Closed circuit or secondary condenser or S.T.C.	L.S.—Loudspeaker.
C.C.I.—Closed circuit or secondary inductance or S.T.I.	L.T.—Low tension.
cm.—centimetre.	mfd.—micro-farad.
C.P.—Candle power.	mhy.—microhenry.
C.W.—Continuous waves.	mm.—millimetre.
D.C.—Direct current.	O.P.—Out primary (of transformer); end of primary.
D.C.C.—Double cotton covered.	O.S.—Out secondary (of transformer); end of secondary.
D.E.—Dull emitter.	P.—Plate, or anode.
D.P.—Potential difference.	P.D.—Potential difference, same as D.P.
D.P.D.T.—Double pole double throw.	Pot.—Potentiometer.
D.P.S.T.—Double pole single throw.	P.V.—Power valve.
D.S.C.—Double silk covered.	R.F.—Radio frequency (same as high frequency).
D.X.—Long distance.	R.M.S. Value—Root-mean-square value.
E.—Earth.	S.C.C.—Single cotton covered.
E.M.F.—Electro-motive force.	S.I.C.—Specific inductive capacity.
F.—Filament.	S.P.—Series parallel.
G.—Grid.	S.P.D.T.—Single pole double throw.
G.B.—Grid battery or grid bias.	S.P.S.T.—Single pole single throw.
G.C.—Grid condenser.	S.S.C.—Single silk covered.
G.L.—Grid leak.	S.W.G.—Standard wire gauge.
H.F.—High frequency (same as radio frequency).	T.T.—Tonic train.
H.P.—Horse power.	
H.R.—High resistance.	
H.T.—High tension.	

SYMBOLS

QUANTITIES		Reactance		X
Amplification Factor	μ	Self-inductance	L	L
Capacity	C	UNITS		
Current	I	Ampere	A	A
Conductance	G	Ampere-hour	Ah	Ab
Dielectric Constant	ϵ	Coulomb	C	C
Efficiency	η	Farad	F	F
Energy	W	Henry	H	H
E.M.F. (voltage)	E	Ohm	Ω	Ω
Frequency	f	Volt	V	V
Impedance	Z	Watt	W	W
Magnetic Flux	Φ	Watt-hour	Wh	Wh
Magnetic Flux Density	B	PREFIXES		
Magnetic Field	H	Mega	M	M
Power	P	Micro	μ	μ
Period Time	T	Milli	m	m
Phase Angle	ϕ	Kilo	k	k
Quantity	Q			
Resistance	R			
Resistivity (Specific Resistance)	ρ			

THE SHORTHAND OF WIRELESS

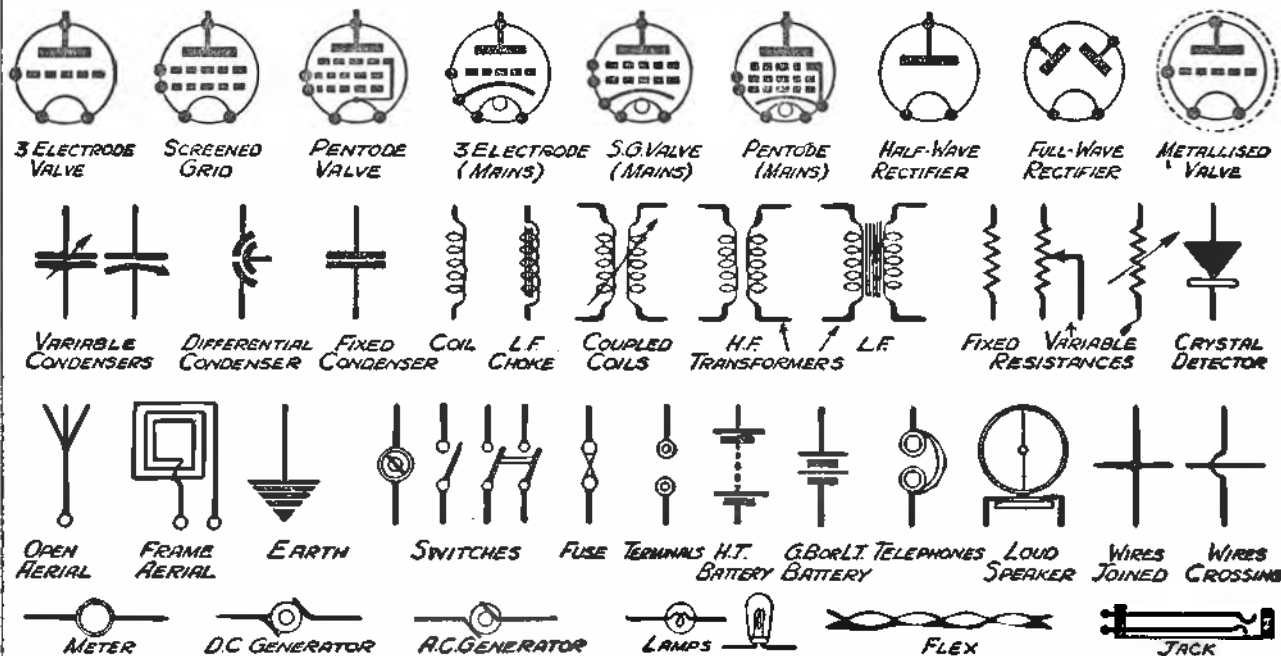


FIG. 1.—Diagram of the conventional signs used in drawing a wireless circuit, which merely consists of a number of these signs joined together. Pictorial diagrams showing the actual components represented are given in the book in their correct alphabetical order.

WIRELESS CONSTRUCTOR'S ENCYCLOPÆDIA

A

ABAC.—A graphical diagram which enables results of formulæ to be obtained by using a ruler. The most complicated formulæ may thus be used by the non-mathematical constructor. The basis of the Abac system is d'Ocagne's theorem, published in France in 1899.

ABSCISSA.—The horizontal distance of any ordinate from the axis of a graph. Refer to ordinate.

ABSOLUTE UNITS.—The units of the centimetre-gramme-second system of measurement, in which the unit of length is the centimetre, the unit of mass the gramme, and the unit of time 1 second. Thus the C.G.S. unit of force is the force that can so move a body weighing a gramme that at the end of a second it will have a velocity of 1 centimetre per second.

A.C.—Abbreviation for alternating current (which see).

ACCEPTOR CIRCUIT.—A tuned circuit consisting of inductance and capacity so designed that a certain band of frequencies is accepted in preference to all other frequencies. An instance is given in the Acceptor

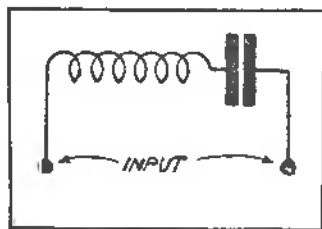


FIG. 2.—Acceptor Circuit.

Wave-trap, where a coil with series condenser is arranged in series with the aerial lead to the receiver. When the acceptor circuit is tuned to the frequency of an interfering station that frequency is accepted, or absorbed, and therefore is not received by the wireless receiver.

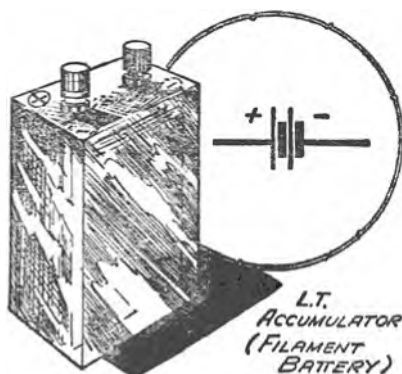


FIG. 3.—Theoretical and actual diagram of an Accumulator.

ACCUMULATOR.—A device for storing electricity. It consists of a container of either glass or celluloid, in which are fitted two sets of plates. These plates are made up of pastes (see under *Accumulator Types*) immersed in a solution known as electrolyte. This consists of dilute sulphuric acid in either liquid, paste or jelly form. It was Galvani, who in 1793, whilst conducting some experiments with a Leyden jar, observed that the legs of a frog began to twitch when they were used as a conductor

ACCUMULATOR

for the discharge of this well-known form of condenser. Later on Volta discovered that by using two different metals to touch the leg of the frog an increased twitching effect resulted. The famous Volta-pile, which was

terminal of its neighbour. By this means the voltages of the cells are added together to give any value desired. In wireless high-tension batteries, for instance, about seventy dry cells may be connected in series to give about 100 volts.

The number of the cells will govern the voltage, whilst the size of the individual cells will decide

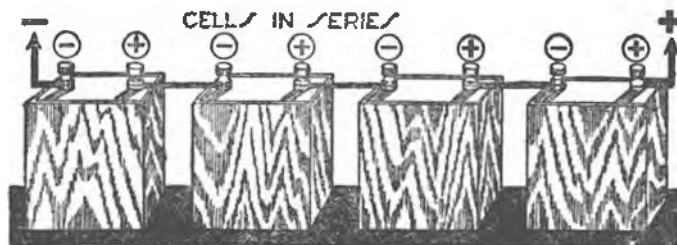


FIG. 4.—Accumulators connected in Series.

the precursor of the modern primary cell, was developed by him from this discovery.

A *primary* cell is one which gives an electric current by the immersion of two dissimilar plates (usually carbon and zinc) in a chemical solution. An accumulator, or secondary cell, must have an electric current passed through it, a proportion of which it stores. An accumulator is rated according to its voltage, and its capacity for storing is known as its ampere-hour capacity.

Cells in Series. Most single-cell batteries have a voltage between one and two or perhaps a fraction over two, but to obtain a higher voltage one may connect any number of cells in series (see Fig. 4), that is to say, by joining the negative terminal of one cell to the positive

the extent of the total capacity.

Cells in Parallel.—A bigger dry battery will have a lower resistance; therefore, although size does not affect the voltage, the larger battery will be capable of supplying a greater current. The equivalent of a large battery may also be obtained by connecting a number of smaller ones in parallel, this being accomplished when all the positive terminals are connected together and also all the negative terminals, as shown in Fig. 5. The voltage will not be increased, however, so it will be seen that series

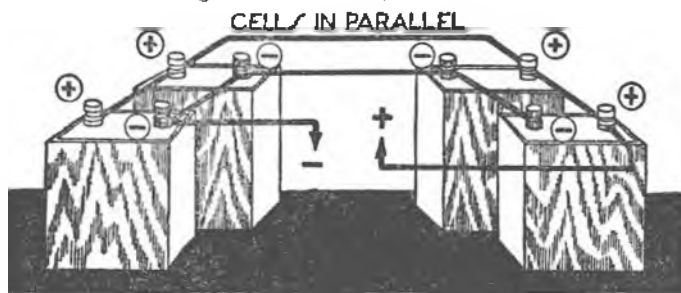


FIG. 5.—Accumulators connected in Parallel.

connection (referred to earlier) gives increased voltage, but parallel connection gives lower resistance and

ACCUMULATOR ACID

consequently more current in the case of accumulators so connected.

Generally speaking, a dry battery is only useful for light duty, such as ringing bells or lighting tiny lamps, but an accumulator of quite a moderate size will satisfactorily accomplish such heavy duty as starting up a motor-car engine.

ACCUMULATOR ACID AND PASTE.—The acid solution consists of pure brimstone sulphuric acid diluted with distilled water to the required specific gravity; acid of the correct specific gravity can be purchased. A good quality should be obtained. Instructions regarding the correct specific gravity are usually attached to the battery, and should be carefully followed. The density specified has a direct bearing on the battery condition, and acid of too low a density will reduce the capacity, whilst too high a density decreases conductivity and sets up heating and local action in the plates. The specific gravity is affected by a rise or fall in the temperature of the acid solution, and an appropriate correction must be made before using the acid (see p. 4).

Density is normally stated as at 60° F. To correct for temperatures above 60° F. add .002 to the specific gravity for every 5° F. For temperatures below 60° F. deduct .002 for every 5° F. to obtain the requisite equivalent at 60° F.

For cells in which the separators are wood, it is necessary to make an allowance for the moisture content of the wood, this type of separator being kept in a wet condition for storage.

How to dilute Acid. Pure brimstone sulphuric acid is supplied in carboys, and can be obtained broken down by any specified density required for battery electrolyte, but as this density may alter owing to evaporation, it is preferable to dilute

the acid as and when required. In mixing the solution, glass, glazed earthenware, or lead vessels should be used. The water must be poured in first, and the acid added gradually, stirring meanwhile with a glass rod. Violent and dangerous splashing of the acid is liable to occur if water is poured into acid.

A new battery should not be filled with solution until ready for charging, and before filling the acid should be cooled to atmospheric temperature. After filling, the battery should be allowed to stand for twelve hours before charging. The acid should be tested periodically, as impurities in it may lead to self-discharge, heating, and other battery troubles.

First Charge. The first charge is of critical importance to the life of a battery, and the manufacturers' instructions should be followed implicitly. The usual period is thirty-six hours, and the charging rate that of about half this period. The period and rate vary with different makes of cell, and depend on the formation of the plates and the density of the solution used. During the charge the temperature of the electrolyte should be kept below 100° F., and if this figure is exceeded the charging rate should be reduced or the charge suspended until normal temperature is regained. High temperatures cause the active material in the grids to expand and to loosen, resulting in flaking, loss of capacity, and shorting of the plates.

Batteries will give much better service and last longer if the temperature during charge or discharge periods is kept within the limits of 70° F. and 90° F. At the end of the charging period the cells should be gassing freely and the density of the acid have attained a maximum value. The vent plugs should be removed during the first charge to allow the gas generated to disperse.

ACCUMULATOR CHARGING

This gas is highly inflammable and explosive, and on no account should a naked flame be allowed to be brought near to the cells.

USING ACID OF 1.840 SPECIFIC GRAVITY

Required Specific Gravity at 70° F.	Water.	Acid, 1.840 Specific Gravity.
	Parts by Volume.	Parts by Volume.
1.400	14	10
1.350	18	10
1.300	21	10
1.250	27	10
1.225	29	10

USING ACID OF 1.400 SPECIFIC GRAVITY

Required Specific Gravity at 70° F.	Water.	Acid, 1.400 Specific Gravity.
	Parts by Volume.	Parts by Volume.
1.300	4.5	10
1.280	5.5	10
1.275	6.25	10
1.265	6.4	10
1.255	6.65	10
1.250	6.75	10

ACCUMULATOR CHARGING FROM ALTERNATING CURRENT.

—The fact that so many electrical undertakings are changing over from

direct current to alternating current renders necessary information on charging accumulators from this source of supply. It is impossible to charge an accumulator from alternating current until it has been rectified or converted into unidirectional or direct current by one of the methods now to be described.

Fig. 6 illustrates the difference between direct and alternating current. It will be observed that alternating current derives its name from the fact that the current "alternates"; it consists of a series of pulses flowing first in one direction and then in another, and if used without rectification would be continually doing and undoing its work. The usual means adopted for rectifying alternating current is by means of a chemical rectifier, a rotary converter, a vibrating reed rectifier, the Tungar rectifier, a motor generator, the mercury-vapour rectifier, the valve rectifier, and the copper-oxide rectifier. It will thus be seen that rectification may be brought about in three ways—chemically, mechanically, and electrically. For amateur purposes, the chemical method is the most suitable.

The Motor Generator. There are on the market a number of motor generators consisting of an induction motor driven from the alternating-current mains, and coupled to a direct-current dynamo. This system has much to recommend it, but unfortunately it is expensive. There are other

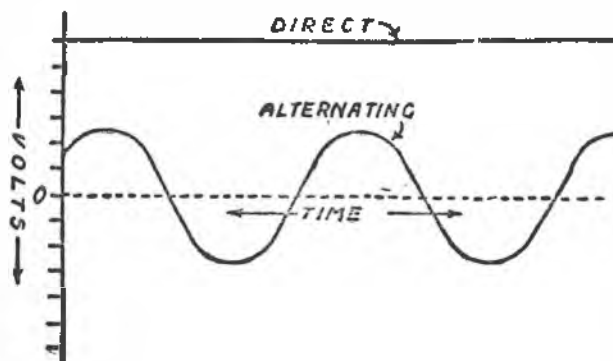


FIG. 6.—Graph illustrating difference between Direct and Alternating Current.

ACCUMULATOR CHARGING

motor generators somewhat similar but differing in principle, having rotary transformers incorporated in the frame of the motor. The mechanically driven rectifier makes use of an A.C. motor (synchronous)

reed itself should first be tuned to that frequency. Fig. 8 shows a typical circuit diagram for the vibrating reed method of charging from A.C. It will be seen that the A.C. mains are connected across the pri-

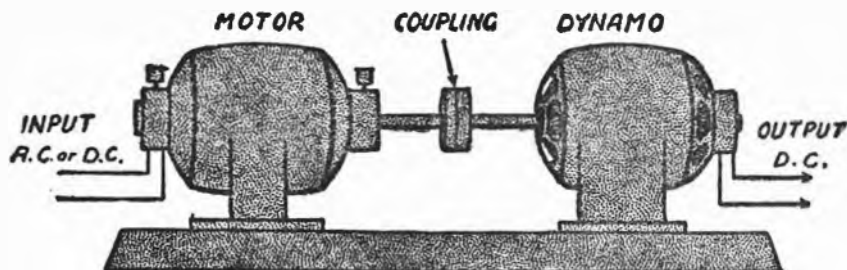


FIG. 7.—Diagram showing the principle of the Rotary Converter and Rotary Transformer. A motor, either A.C. or D.C., is driven from the mains and coupled to a D.C. generator which charges the accumulators. In practice one machine acts both as motor and dynamo.

coupled to a commutator fed by the alternating current, and from it is delivered the direct current (see Fig. 7). The chief defect of this type is the commutator sparking, necessitating frequent renewal.

The Vibrating Reed. This type of rectifier is chiefly of use when only a small current is required, and for this reason it is particularly suitable for the home charging of accumulators. Its principle is that of a reed which makes and breaks the alternating-current circuit by its vibration. In order that the vibrations of the reed should coincide with the A.C. cycles, it is essential that the

frequency of the reed should be tuned to that frequency. Fig. 8 shows a typical circuit diagram for the vibrating reed method of charging from A.C. It will be seen that the A.C. mains are connected across the pri-

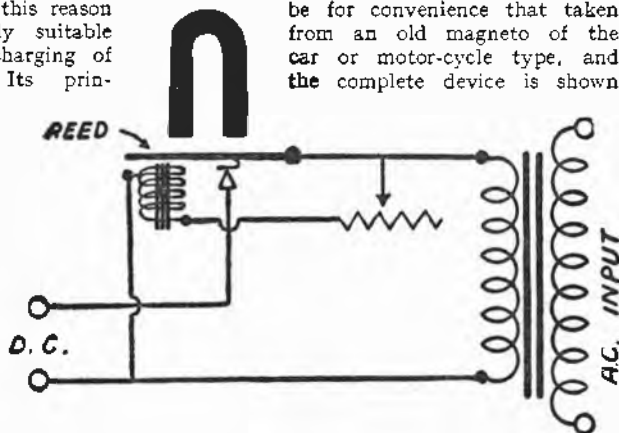


FIG. 8.—Circuit of vibrating reed method of charging from A.C.

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in wiring diagram form in Fig. 9. Two tumbler switches are used, one to control the direct-current output and the other the alternating input. The transformer itself

of aluminium immersed in a solution of ammonium phosphate. The action is electrolytic; gas forming at one of the electrodes prevents the flow of current in one direction.

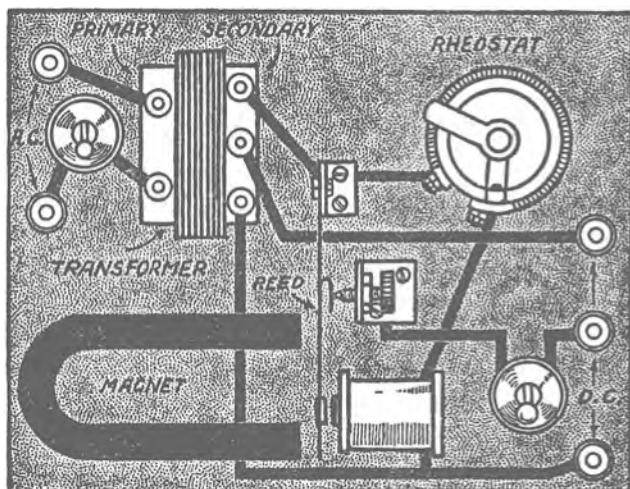


Fig. 9.—Practical layout of vibrating reed Rectifier with Transformer: Secondary tapped giving two D.C. voltages.

can be purchased quite cheaply. The vibrating reed can, for convenience, be a piece of clock spring about $\frac{25}{1000}$ in. thick, and $\frac{5}{8}$ in. wide by 5 in. long. It may be necessary to experiment a little with this reed so that its vibration synchronises with the A.C. ripples. Use magneto platinum contacts. If you wish to make the transformer, use the commercial transformer iron laminations, $\frac{20}{1000}$ in. thick; five hundred turns of 22 D.C.C. copper wire should be used for the primary, and fifty-two turns of 16 D.C.C. for the secondary.

Chemical Rectification. The chemical rectifier is perhaps better known under its correct name—the Nodon valve—and essentially it consists of a glass or stoneware container or jar, with a plate of lead and a rod

the following way: four half-gallon glass or stoneware jars are half-filled with a solution of ammonium phosphate, made by dissolving the commercial salts in hot water. About $2\frac{1}{2}$ lb. of salts to the gallon of water will be required. When the solution becomes cold, it should be neutralised by the addition of a little liquid ammonia until there is no acid reaction. The test for this latter can be made with a piece of blue litmus paper, which will turn red if there is any acid present.

A piece of wood across the top of each jar will serve to support the metal elements. The lead element can suitably consist of a sheet of $\frac{1}{8}$ -in. lead, rolled in the form of the letter C and to fit easily the jar. The other element, which is alumin-

Except for very small currents of about $\frac{1}{2}$ ampere, it is usual to use more than one cell, otherwise the rectifier is liable to heat, and, if the temperature exceeds 80° , the action will stop.

Making a Nodon Valve. A Nodon valve may be made in

ACCUMULATOR CHARGING

ium, may be a rod or a plate. Rod $\frac{3}{8}$ in. thick will be quite suitable, and it is easily obtainable. It only remains now to connect the elements up, and the wiring diagram (Fig. 10) will make it quite clear how this is done. It will be observed that a

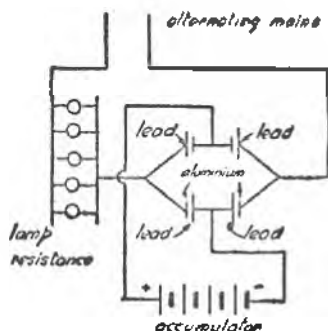


FIG. 10.—Diagram of connections for multi-cell electrolytic Rectifier.

pair of leads and a pair of aluminiums are connected together, and from these connections the leads are taken to the cells to be charged. The remaining two pairs of lead and aluminium plates are coupled together, and leads are brought to these from the alternating-current mains.

In order to limit the charging current to an amount suitable for the cells that are being charged, lamps

may be used as a resistance, as explained in the section dealing with direct current, the number being determined in exactly the same way.

Improving the Action of the Rectifier. The action of the rectifier can often be improved by treating the aluminium element so as to render the surface matt. This may be accomplished by immersing it for a few minutes in a strong and boiling solution of ordinary washing soda.

Fig. 11 shows the necessary arrangements when only one cell is used, when it is not desired to use a current in excess of $\frac{1}{2}$ ampere. An elementary arrangement, again using one cell, is shown in Fig. 12, although with this simple arrangement only half the wave is rectified. The usual method of obtaining full-wave rectification is shown in Fig. 13, where four cells or valves are used. This system is known as the Graetz, by whom it

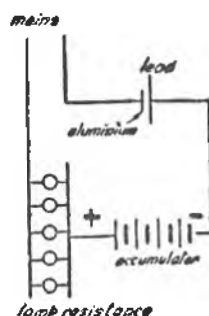


FIG. 11.—Connection diagram for single-cell Rectifier.

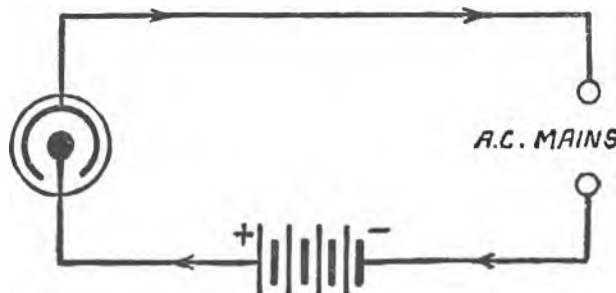


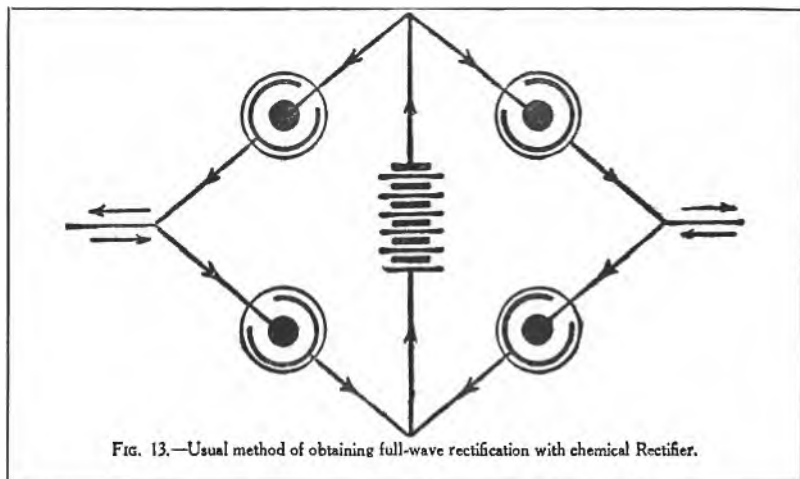
FIG. 12.—Simple circuit for chemical Rectifier. With this arrangement only half the wave is rectified.

was invented. It will be understood that the centre rods are of aluminium, and the part circular plates of lead. Alternating-current supply is connected to that part of the circuit indicated by the

ACCUMULATOR CHARGING

arrows (right and left portions of the diagram).

induction coil is necessary, and it must be connected across the A.C.



It is not absolutely necessary to use ammonium phosphate as the electrolyte, which needs to be neutralised occasionally by the addition of a weak ammonia solution. Magnesium in ammonium fluoride solution and ammonium carbonate are sometimes used; but ammonium phosphate gives best all-round results. Similarly, carbon or steel is sometimes used in place of lead.

The Mercury-arc Rectifier. Another cheap and fairly efficient method of charging accumulators is the mercury arc, which automatically converts A.C. into D.C. It consists of an electric lamp containing mercury vapour, which, when the A.C. current is passed through it, becomes incandescent. The two anodes (Fig. 14) are connected to the A.C. supply, and the cathode (sometimes spelt kathode) to the direct-current part of the circuit. A starting electrode is included to form an arc by means of which the rectifier is started. With this type of mercury-arc rectifier (there are many other types) an

source of supply. The connection

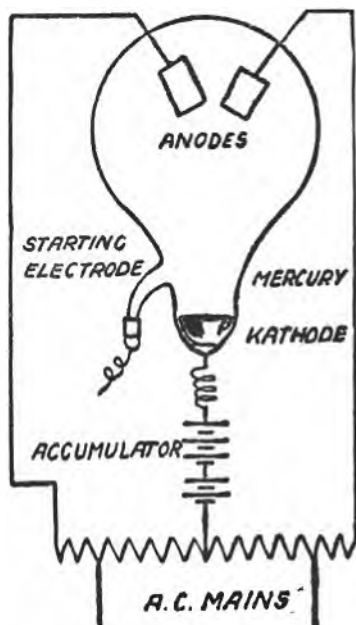


Fig. 14.—Circuit of mercury-vapour Rectifier.

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from this inductance to the battery is the negative side of the D.C. portion of the circuit, and the connection from the cathode of the mercury-vapour rectifier is the positive side.

Such a rectifier will give a 30-ampere direct current at between 80 and 120 volts. Other rectifiers of this type can, of course, be obtained with larger and smaller outputs. They are simple to operate, but their life is comparatively short—about 450 hours.

The Tungar A.C. Rectifier. The Tungar rectifier is a complete rectifying outfit supplied for alternating-current charging, and its components consist of a transformer, a rectifying bulb, and a reactance.

These parts are suitably cased to form a compact unit, and it can be recommended as a thoroughly reliable outfit.

The bulb resembles a wireless valve, and its purpose is to permit current to flow only in one direction. The filament is of tungsten, and the anode is of graphite. When a current passes through the filament, therefore, there is a flow of electrons between it (the cathode) and the anode, in exactly the same way as in a wireless valve. The valve action is obtained by means of the heater filaments and the inert gas, known as argon, with which the bulb is filled. This valve action also precludes the possibility of the battery discharging back. This Tungar rectifier makes use of only half of the A.C. wave, although full-wave rectifiers of the same make are available. They all operate on voltages of from

250 volts down to 100 volts, with outputs varying from 25 ampere up to 60 amperes. Fig. 15 shows a circuit diagram of a typical Tungar rectifier.

Metal Rectifiers. This type of rectifier, although not so efficient as those already described, is none the less quite reliable, and has the advantage of being trouble free. Its principle is, briefly, this: a piece of

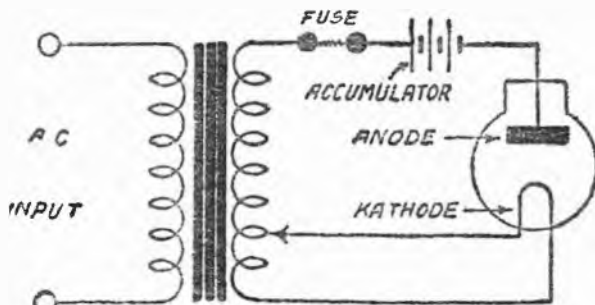


FIG. 15.—Circuit of Tungar type of Rectifier.

copper (pure) when in contact with a certain oxide allows current to flow more easily in one direction than another. Lead, being soft, permits of a great degree of contact, and is therefore used as one of the elements. A number of these elements are mounted concentrically on a non-conducting tube, the elements consisting of a lead disc, a copper washer, and some form of cooling disc. These units in any number may be suitably connected in series or parallel according to input and output requirements. A circuit diagram of a typical commercial metal rectifier is given in Fig. 16.

All the parts, enabling the amateur to construct his own metal rectifiers, are available quite cheaply from most electrical stores. Whilst such a system of rectification is chiefly of value in districts remote from towns, and has the great advantage

ACCUMULATOR CHARGING

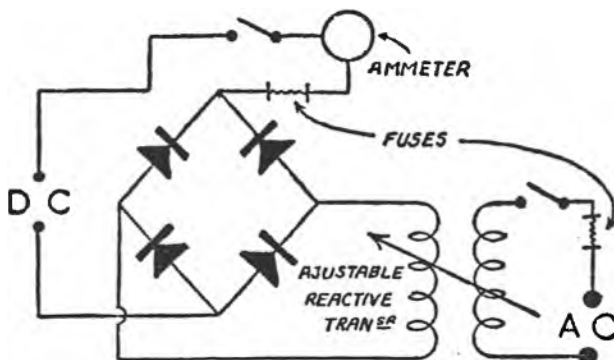


FIG. 16.—Circuit of metal Rectifier.

of simplicity, it is naturally a slow method of charging. Complete metal rectifiers, which are sometimes referred to as copper-copper-oxide or all-metal rectifiers, are made by the B.T.H. Co. and others.

Transforming Alternating Current. Unlike direct current, alternating-current voltage can be transformed to higher or lower potentials without the use of rotary converters. This means that a simple piece of apparatus can be used in place of the resistance, the advantage being that the excess voltage need not be dissipated and, therefore, wasted. Transformers can be purchased quite cheaply, and they are obtainable for all voltages of supply and with any output voltage.

The Charging Rate. The charging current should be limited to the correct rate in amperes, as specified on the makers' instruction label. Those accumulators, having approximately the same charging rate, should be grouped together in series and connected to the pair of charging leads which will supply the requisite current. If the exact charging rate for one particular accumulator cannot be obtained, remember that it is always advisable to charge below rather than

above the given rate. For example, an accumulator to be charged at 2 amperes should be placed on the 1-ampere circuit rather than on the 5-ampere circuit.

Filler plugs may be left in during charge, but it is as well to make sure that the vent hole in the plug

is not stopped up, otherwise the gases generated in the cell will not be able to escape. These gases, by the way, are highly inflammable, and the charging-room should be well ventilated in order to facilitate their dispersal. Never bring a flame or

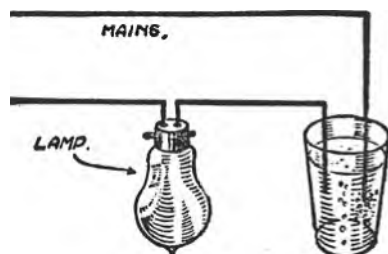


FIG. 17.—Dissolve a teaspoonful of salt in a glass of water and dip the ends of the charging wires in the solution. Bubbles of gas will form on the negative wire. (See also Figs. 26 and 27.)

spark—such as a match or lighted cigarette—near the accumulators during or shortly after charge.

Avoid high temperatures when charging, as these tend to increase the chemical activity of the plates and the electrolyte, and help to shorten the life of an accumulator. The temperature should never exceed 110° Fahrenheit (100° F. for cells in celluloid containers).

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Cleanliness is another very important factor in accumulator management. Dirt and dampness on an accumulator permit the current to leak away, in addition to attracting and holding small quantities of acid. This is liable to cause corrosion and rotting of wooden crates, etc.

It is also advisable to use rubber in place of leather for carrying-handles of accumulator crates.

Neutralising Spilled Electrolyte. If electrolyte is spilled, it should be immediately treated with a neutralising solution, such as sodium carbonate (soda) and water, or ammonia and water. Either of these liquids is excellent for checking the effects of acid on clothing. Benches, trays, and other fittings which have become acid-sodden should be treated with a solution of 1 lb. of soda to 1 gallon of water, and then allowed to dry thoroughly before coating with acid-proof paint.

Polarity of the Mains: First Method. Connect the positive pole of a direct-current voltmeter to the (supposed) positive main, and allow a wire from the negative terminal of the meter to momentarily touch the (supposed) negative main. If correctly connected, the hand of the meter will swing in the proper direction. If reversed, the hand will tend to swing backwards. Make sure that the connection is broken immediately, for a reversed connection might bend the hand of the meter.

Second Method. Dip the ends of the two wires into a glass containing a weak solution of salt and water. Bubbles of colourless gas will be formed on the negative wire. Be sure that the wires are not allowed to touch, and it is advisable to connect a lamp of "mains" voltage in series with the wire to avoid the danger of short circuits (see Fig. 17).

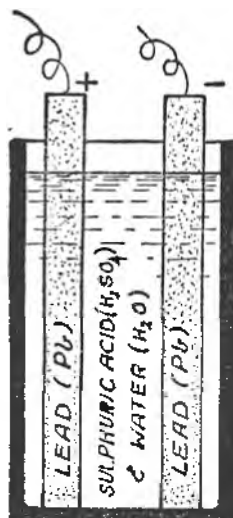


FIG. 18.—Primitive cell ready for charging.



FIG. 19.—State of cell when charged.

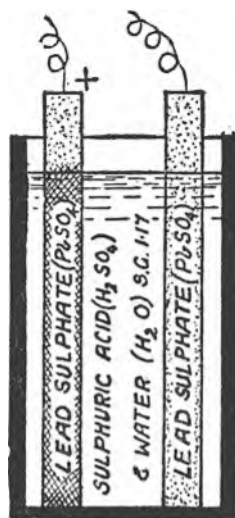


FIG. 20.—State of cell when discharged. Note the acid becomes weaker, having been used up in forming lead sulphate.

ACCUMULATOR CHARGING

CHARGING ACCUMULATORS FROM DIRECT CURRENT.—Unlike alternating current, which, as has been explained earlier, needs to be rectified or made uni-directional before it can be used for accumulator charging, direct current does not need any special apparatus other than that necessary to restrict the flow of current to the correct charging rate—a comparatively simple matter. This present section deals with direct-current charging from lighting mains. The other methods will be dealt with later in this section. Should any doubt exist regarding the nature of

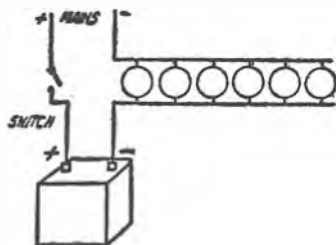


FIG. 20A.—A typical arrangement of Lamp Resistances.

the supply, this may be easily ascertained on application being made to the offices of the supply company.

Mains Voltage for Accumulator Charging. The voltage of the current for accumulator charging is immaterial, providing that it is in excess of the total voltage of the cells to be charged and (this is most important) that the current that is allowed to flow is restricted to a suitable amount by means of a resistance. Voltage or potential, as it is sometimes termed, is not capable of producing a heating or chemical effect, but it has the power of forcing current through a conductor, and as it is the actual current flowing that counts, it is the volume of this that must be restricted to a suitable amount. A good deal of misconception exists on this point.

The Safe Charging Rate. The maximum safe charging rate of an accumulator is approximately one-tenth of its actual capacity. For instance, the charging rate of a 60-ampere-hour cell would be 6 amps. Any excess would cause heating and disintegration of the plates.

Determining the Resistances to be Used. It will be apparent that the resistances to be used will differ with different voltages of charging supply and also with cells of different capacity. The ideal voltage for charging a 6-volt battery would be approximately 8, as in this case there would be no necessity to interpose a resistance, the difference of the voltage of supply and that of the battery being charged not being sufficient to cause an excess amount of current to flow. With increase of the voltage of supply, however, such as by the use of lighting mains, suitable resistances are necessary, and the higher the voltage the greater must be the resistance. Incidentally, high voltages are wasteful, inasmuch as no use is made of the excess, though it figures in the total cost of the units used. Carbon filament lamps are used for charging purposes chiefly because they take almost four times as much current per candle-power as do metal-filament lamps (see table below).

CURRENT PASSED BY CARBON FILAMENT LAMPS

Current in amperes per Lamp.	Voltage of Supply.			
	25.	50.	100-200.	200-250.
$\frac{1}{2}$	—	—	8 c.p.	16 c.p.
$\frac{3}{4}$	—	8 c.p.	16 c.p.	32 c.p.
1	6 c.p.	16 c.p.	32 c.p.	60 c.p.
2	12 c.p.	32 c.p.	60 c.p.	100 c.p.

At 4 watts per c.p.

Example 1. Suppose the battery has to be charged at 10 amperes and the voltage of supply = 250.

ACCUMULATOR CHARGING

Total watts required = $250 \times 10 = 2,500$.

Divide this value by the wattage of the lamps available to get the number required. Thus the number of 60-watt lamps required = $\frac{2,500}{60} = 42$ approx.; 100-watt lamps = 25, etc.

Example 2. To find the current which a certain number and value of lamps will allow to flow.

Four lamps of 60 watts each are available and the town supply is 250 volts.

Current flowing =

$$\frac{\text{Number of lamps} \times \text{wattage of each}}{\text{Voltage of supply}}$$

$$= \frac{4 \times 60}{250} = \frac{240}{250} = .96 \text{ ampere.}$$

A Typical Charging Arrangement.

In practice the first essential is to

find out what the charging rate of the accumulator is, a fact which, as a rule, is stated on the label, though, as mentioned earlier, it is approximately one-tenth of the capacity. The next matter is to provide a suitable arrangement for holding the lamps. A simple way of doing this is to mount a number of batten-type lamp holders on a board, as shown in Fig. 20A. The method of connecting the lamps and the accumulator is clearly shown, and from a study of this it will be apparent that the current can be regulated to a particular amount by the removal or insertion of lamps. Any number of lamps up to the maximum can be used, but it must be understood that the fewer that are used the longer will the charging time be, owing to the reduced amount of current pass-

RESISTANCE WIRE DATA

S.W.G.	Eureka.			German Silver.		
	Resistance per yard.	Yards per lb.	Current Capacity.	Resistance per yard.	Yards per lb.	Current Capacity.
18	0.37	48	3.5	0.117	51	3.5
20	0.66	85	2.5	0.315	90	2.5
22	1.10	140	1.5	0.520	147	1.5
24	1.77	227	1.0	0.844	238	1.0
26	2.65	340	0.5	1.26	349	0.5
28	3.91	502	0.25	1.85	527	0.25
30	5.58	714	0.2	2.65	750	0.2
32	7.35	943	0.15	3.50	984	0.15
34	10.13	1,300	0.1	4.82	1,360	0.1
36	14.84	1,905	0.5	7.06	2,000	0.5
38	23.81	3,060	—	11.33	3,295	—
40	37.18	4,761	—	17.70	4,920	—

CURRENT-CARRYING CAPACITY OF WIRES

S.W.G.	Current Capacity (Amps.).	S.W.G.	Current Capacity (Amps.).	S.W.G.	Current Capacity (Amps.).	S.W.G.	Current Capacity (Amps.).
10	19.305	19	1.8855	28	.258	37	.0545
11	15.855	20	1.527	29	.218	38	.0425
12	12.7425	21	1.206	30	.1812	39	.0318
13	9.872	22	0.9237	31	.1586	40	.0272
14	7.5405	23	0.6786	32	.1374	41	.0228
15	6.108	24	0.5702	33	.1178	42	.0189
16	4.8255	25	0.4793	34	.0998	43	.0153
17	3.6045	26	0.3818	35	.0831	44	.012
18	2.715	27	0.3168	36	.0681	45	.0093

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ing. A table giving the amount of current that different lamps will pass on different voltages is given on an earlier page, and the worked examples which follow it should make the calculation clear.

Whilst the accumulators are being charged, the light from the lamps,

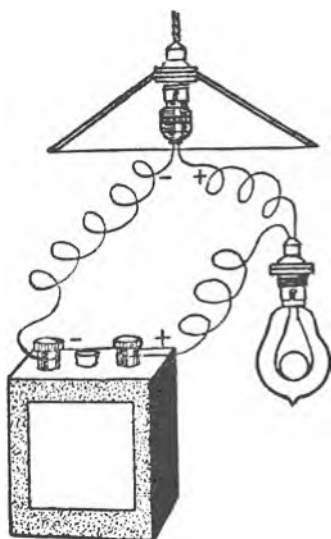


FIG. 20a.—Simple Charging Arrangement from D.C. Mains.

which is only slightly less brilliant than usual, is being wasted, and this suggests a method of charging whilst the lamps are in use. One method of doing this is clearly shown by Fig. 20B.

In this case one lead to a single pendent lamp is cut and a wire joined on to each end. These wires are then simply connected to the accumulator, observing, of course, the correct polarity as detailed before. Another method, which is applicable to either a single or three-light fitting, is to remove the screw-

on cover of a switch and connect a wire to each of the contacts. The two wires, after their polarity has been determined, are then connected to the accumulator in the usual manner.

When it is desired to adopt this latter method as a permanent fitting, it is essential that the two wires from the switch should be attached to some form of insulated board, and the terminals, or other attachments for the accumulator, should be protected so that they will not be short circuited or touched when no accumulator is connected to them.

Determining Resistance Values. Ordinary metal filament lamps are one of the most popular and convenient forms of resistance obtainable. The actual value of charging resistance required will vary, as already explained, according to the voltage of the charging supply, the voltage of the accumulator to be charged, and the charging rate required.

To determine this, connect a bank of lamps and an ammeter in series with the battery, as suggested earlier, and increase or decrease the number of lamps until the correct rate of charge (as indicated by the ammeter) is obtained. Fig. 20c shows the complete charging circuit.

Charging from a Dynamo. Those who are not so fortunate as to have electricity in their homes may be interested in another method of accumulator charging. This consists of a small dynamo driven by a small petrol engine. The dynamo should have an output of 100 volts at 35 milliamps., and 4 volts at 2 amps.

Charging Hints. If it is intended to charge accumulators on a large scale, have the charging-room well ventilated in order to dispose of the gases generated in the accumulator. Never bring a flame or spark near to an accumulator during or shortly

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after charge, as the hydrogen given off is highly inflammable.

Avoid high temperatures. The temperature of any accumulator on charge should be kept below 110° F. If this is exceeded, the charge should be suspended for a time, otherwise the life of the accumulator may be shortened.

Never charge at rates greater than those specified by the makers of the accumulator. Continue the charge until all the cells are gassing freely and at an even rate, and the specific gravity of the electrolyte will not rise any higher. For testing the gravity of the electrolyte, use a hydrometer with a graduated float, showing the actual strengths of the acid.

CURRENT-CARRYING CAPACITY OF LAMPS

Carbon-filament Lamps

Candle-power.	Voltage.	Current passed.
8	110	.254
16	110	.509
32	110	1.018
8	220	.127
16	220	.254
32	220	.509

Metal-filament Lamps

Candle-power.	Voltage.	Current passed
8	110	.09
16	110	.18
32	110	.36
8	220	.049
16	220	.09
32	220	.18

Charging Accumulators from the Lighting Mains. It is here presumed that more than one accumulator is to be charged. It has already been explained that only direct current can be used for charging accumulators, and where the source of supply is alternating current, it must be rectified in accordance with the instruc-

tions, and by one of the methods described earlier.

The reader has a choice of several methods. The simplest method where many accumulators are to be charged is to arrange a number of them, totalling in voltage that of the mains (or slightly less than that of the mains) in series and connect them direct to the house supply, making suitable arrangements in the form

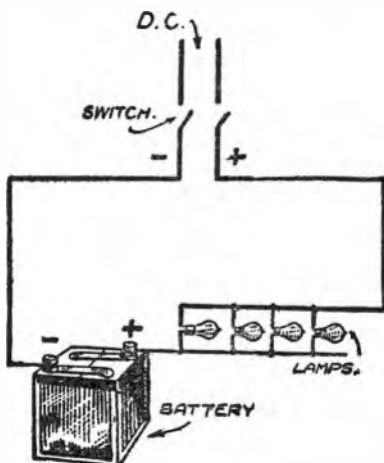


FIG. 20c.—The complete Charging Circuit.

of a slab of slate or marble on which to support the cells during charge.

This method is, however, hardly practicable in the majority of cases, and even where it would be it is recommended that the local electrical company be consulted first. Amateurs can, with advantage, rig up a lamp resistance board, using batten-mounting lamp holders, for by this means (using lamp resistances of a voltage to suit the mains supply, but of various wattages or candle-powers) it is a comparatively simple matter to arrange a series of lamps to suit

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the charging rate and voltage required. No ammeter is required, and the only disadvantage is the cost of charging (the installation itself is extremely low in cost), for the current dissipated through the lamp resistances, whilst having to be paid for, is wasted.

It is also possible to charge accumulators by means of a motor generator, but this does not come within the scope of this section.

If it is desired to charge a small number of cells, say one or two, by means of the lamp-resistance method,

connect this wire to the negative accumulator terminal, making quite sure that the wire is of the correct current-carrying capacity (see page 13), and the other wire to the positive accumulator terminal. These terminals are marked + and - on the top or sides of the accumulator. Positive is red and negative black. Do not put the switch in the "on" position whilst the accumulator is being charged. Otherwise you will short circuit it, and it will be ruined. Leave the accumulator on charge until the plates gas freely, that is, until bubbles issue freely from them.

The arrangement just described is shown diagrammatically in Fig. 20D.

Using Lamp Resistances. The following simple example will clearly illustrate the use of lamp resistances for accumulator charging.

Let it be supposed that it is required to charge a 2-volt accumulator from 150-volt D.C. mains, and that the charging rate is to be 2 amps. Connect a number of lamp resist-

ances in circuit until, by taking ammeter readings, the correct charging rate is obtained.

Connecting Cells. If it is convenient to do so, the accumulators may be connected in series groups and parallel groups. For example, if twenty cells are to be charged, you may arrange two groups of ten cells, each connected in series, and then connect the two groups in parallel or *vice versa*. This system is known as series parallel, and its chief advantage lies in the fact that it permits cells of assorted capacities to be charged at the same time and without risk of over-charging.

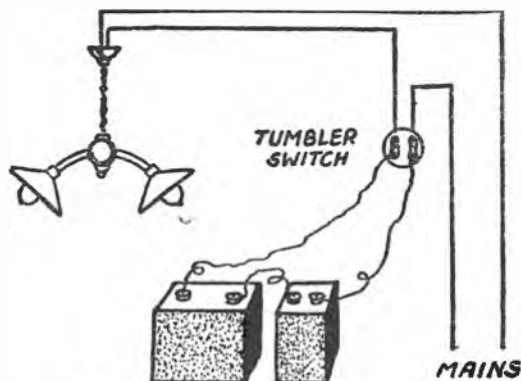


FIG. 20D.—Charging from House-lighting Switch.

the first thing to do is to remove the switch cover, after having wired the lamp resistance in parallel. Next determine the polarity of the mains by connecting a length of wire to the switch terminals (taking care to keep the switch in the "off" position), baring the other two ends, and then immersing them in a *cup* (non-metallic) of water to which a few drops of vinegar have been added. Keep the two ends of the wire as far apart as possible. Bubbles will issue from the wire connected to the negative terminal as already explained.

It is now only necessary to con-

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Corrosion. To prevent corrosion, wipe with a rag, wet with ammonia, and then coat with pure vaseline. Once corrosion has started, it must be removed from all metal surfaces by scraping, filing, or with a wire brush. Ammonia and vaseline should then be applied as before. Pay particular attention to keeping the top

therefore very necessary to make up the water lost by evaporation, but quite unnecessary to add acid. Fresh acid should only be added when some of the original electrolyte has been lost through spillage, and it should then be carefully adjusted to the correct strength before adding. Never allow the level of the elec-

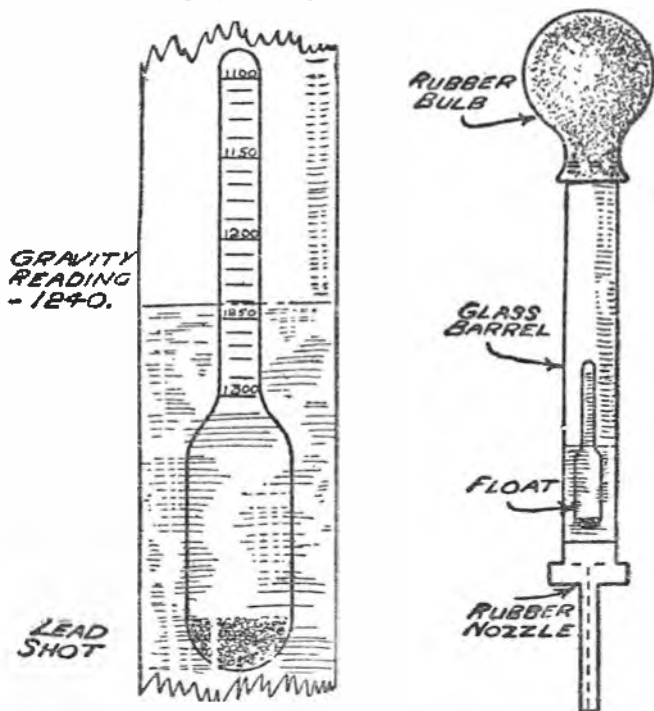


FIG. 21.—Hydrometer.

of the affected accumulator clean and dry. Vaseline is specified as a preventive of corrosion, because ordinary grease contains animal or vegetable fats which increase rather than prevent the evil.

Use Distilled Water only. Under normal conditions, nothing but pure distilled water should ever be added to an accumulator. Water evaporates, sulphuric acid does not. It is

electrolyte to fall below the tops of the plates. The best time to add distilled water is just before charging, as the gassing of the accumulator ensures the liquid being well mixed. Never carry or store water in any metallic vessels other than lead. Glass, earthenware, or lead-lined vessels are the most satisfactory, and they should be kept clean and well covered to keep out impurities.

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Precautions. When handling and mixing acid, the precautions already given and here tabulated should be observed:

(1) Use glass, china, earthenware, or lead-lined vessels.

(2) Pour the acid carefully into the water—not the water into the acid, as this may cause spluttering and possible personal injury.

(3) Stir very thoroughly and use a wooden spoon or paddle.

(4) Allow the liquid to cool before taking hydrometer readings.

Chemical Action Explained. Before proceeding further, it would, perhaps, be as well to explain the chemical action which takes place in a cell during charge and discharge. In a fully charged cell (Fig. 19) the negative plate is spongy lead (Pb) and the positive plate lead peroxide (PbO_2), while the electrolyte is a mixture of sulphuric acid and water (H_2SO_4 and H_2O). This electrolyte is now at its maximum strength.

When the cell is placed on discharge, the acid splits up into H_2 and SO_2 . The H_2 combines with some of the oxygen in the lead peroxide and forms H_2O , while the SO_2 combines with the liberated Pb to form lead sulphate ($PbSO_4$). As the discharge continues the gravity of the electrolyte falls, both plates become entirely sulphated, and the current finally ceases to flow. The strength of the acid is now at its minimum (Fig. 20).

Direct current must now be passed through the cell in order to recharge it. When this is done, a reverse action to the above will take place. The lead sulphate on the plates is converted into lead peroxide and spongy lead, while the acid which has combined with the active material in the plates is driven back into the electrolyte.

Having obtained a clear understanding of the above facts, it will

now be apparent why specific gravity readings are the most reliable means of ascertaining the state of charge in an accumulator. It has been explained that the density of the electrolyte increases on charge and decreases on discharge. This density or specific gravity is measured by means of a hydrometer (Fig. 21). This hydrometer should have a graduated float showing the actual strengths of the acid as in the enlarged view (Fig. 21). Another type is shown in Fig. 54.

Use of the Hydrometer. Hydrometers of the "floating ball" type are practically useless to the accumulator man, as they give no indication when the acid is too strong or too weak. Electrolyte fifty points in excess of the strength specified by the makers is quite sufficient to ruin the plates in most accumulators.

Hydrometer readings can sometimes give a false indication. If, for instance, acid has been added to an accumulator instead of water, a hydrometer reading might incorrectly indicate the accumulator to be fully charged.

To correct such false readings, the accumulator should be placed on charge until the gravity will not rise any higher. The electrolyte should then be adjusted by removing some of the liquid and replacing with distilled water until working strength is obtained.

To adjust low specific gravity, charge until no further rise takes place, then empty out the electrolyte and replace with the correct strength. Charge again until the accumulator gasses freely and leave it so gassing for one hour, and then make any further slight adjustments that may be necessary.

Additional causes of false hydrometer readings are:

(1) An inaccurate or cracked hydrometer float.

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(2) Taking readings when freshly added water has not had time to mix with the acid.

(3) Wide variations in electrolyte temperatures.

Hydrometer readings may always be supplemented by means of voltage tests. Use an accurate moving-coil voltmeter, reading 3.0-3 volts, and take all readings while the cells are on discharge. Voltmeter readings taken on open circuit are liable to be misleading. Low voltages registered on open circuit indicate that the cells are exhausted or unhealthy, but high readings do not always mean that the cells are in good condition.

Having discussed the charging and general treatment of a normally healthy accumulator, let us now consider the various unhealthy cells which every accumulator man is called upon to handle from time to time.

Overcharging. A furred or blistered appearance of the negative plate is often an indication of over-discharging. If hydrometer readings suggest the presence of strong acid, charge fully, and then make the necessary adjustments or change the electrolyte entirely. Over-discharging cannot be remedied, but it should be checked at once, and the accumulator given a long, slow charge at a reduced rate. If the evil has gone unchecked for a considerable period, the accumulator may require new plates.

Excessive frothing on charge and discoloration of celluloid boxes is another indication of too strong acid. Frothing is sometimes caused by the presence of an impurity in the electrolyte, and in this case the accumulator should be treated as for strong acid. Wash thoroughly with distilled water before adding the fresh electrolyte.

Swollen or broken positive plates are often a sign of over-charging at

too high a rate. Ill-treatment of this nature causes high temperatures and subsequent "growing" of the positive plates. It is impossible to cure, and a seriously affected accumulator generally requires new plates.

A small deposit of sediment in the bottom of a cell is no cause for alarm, as there is a slight deposit in even a brand-new cell. Excessive deposit, however, indicates that the active material is being forced out of the plates—probably through over-charging.

White deposits of lead sulphate or hydrate are caused by leaving the accumulator standing in a discharged condition or allowing the level of the electrolyte to fall below the tops of the plates. Small deposits may often be removed by means of a long, slow charge at, say, half the normal rate, but a seriously sulphated cell will often require new plates and separators.

Reversed Charge. It sometimes happens that an accumulator is "reversed"—i.e. connected to the charging board so that the current flows through in the wrong direction. In this case an attempt should be made to recondition the accumulator by means of a prolonged, slow charge in the right direction. This treatment is generally successful unless the reversal has been going on for a considerable period.

Choosing a Wireless Accumulator. The average wireless set to-day requires an accumulator capable of giving a small supply of current over an extended period. A few years ago radio valves were exceptionally "greedy," but nowadays their current consumption is comparatively small. Accumulator makers have kept pace with these changes, with the result that the thick-plate type of accumulator has been evolved.

These cells have exceptionally thick and robust plates, specially designed

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to give a small flow of current for a considerable period. Moreover, they are not so liable to deteriorate if left standing in a discharged or semi-discharged condition for any reasonable length of time.

For about 12s. it is possible to purchase a splendid 2-volt accumulator of this type, which will work the average three-valve set for about a hundred and fifty hours. Using the set five hours per day, this gives a period of one month between recharges, and is about the cheapest and most satisfactory form of low-tension supply for wireless receivers obtainable.

For these reasons, the owner of any set taking $\frac{1}{2}$ ampere or less is strongly advised to consider the thick-plate type of accumulator, which will prove very satisfactory for his requirements.

There are, of course, a number of enthusiasts with much larger sets requiring a low-tension current of 1 ampere or even more. For them, the thin-plate type of accumulator is still the best proposition. Thin-plate cells are constructed to stand a far higher rate of discharge than the massive-plate type, but they are, as a rule, more expensive to operate, as they require more frequent charging. The purchaser of one of these cells must remember that, to keep the accumulator in first-class condition, it is essential to recharge at least once a month—whether it has been in use or not.

The first question to be asked will almost inevitably be—"Wet or dry?" For all-round satisfaction a good wet accumulator is unbeatable. The main argument in favour of the wet accumulator is that it gives a fairly constant supply of current until the voltage drops below 1.7 volts per cell.

The moment you put a dry battery on your set, the voltage begins to fall

slightly—and this gradual fall continues until the battery is useless. Now the voltage drop in a wet accumulator is not gradual—it is rapid, but it does not take place until the end of the charge is reached. This ensures a steady flow of current during discharge and improved reception.

There is, unfortunately, always the question of expense to be considered. Not all can afford to lay out the money for a new set of wet accumulators. Dry batteries are cheaper to buy, but in the long run will probably prove the more expensive.

For about £3 10s. one can obtain a splendid large-capacity 100-volt wet accumulator (fully charged). This, with reasonably good care, should give at least four years' service, and the only expense after the initial outlay will be for occasional recharge.

The Size of an Accumulator. Many wireless amateurs purchase accumulators far too small for the sets they use. It is necessary, when purchasing an accumulator, to estimate how much current in ampere-hours is to be taken from it. Most accumulator manufacturers clearly state on the label affixed to the accumulator its discharge rate, which should not be exceeded. For example, suppose you have a three-valve set using three 25-amp. valves, the total current consumption per hour will be .75 amp., and it is no use purchasing an accumulator which will not stand this rate of discharge. Another factor is that you require the accumulator to work the set for at least a fortnight on one charge. In selecting an accumulator, proceed on the following lines: total up the current consumption of the valves used in your set; assume this to be .75 amp., and that you wish to use the set for three hours every evening. If you use the set for three hours every evening it will be consuming .75 amp. for

ACCUMULATOR CHARGING — REPAIR

twenty-one hours a week, equal to approximately 16 ampere-hours. In a month this would total 64 ampere-hours, and to allow a slight margin to meet the case an 80 ampere-hour accumulator should be purchased.

Whether the accumulator is required for a wireless set or for any other purpose it is necessary, in order that you should choose the correct type, to know what current is to be taken from it.

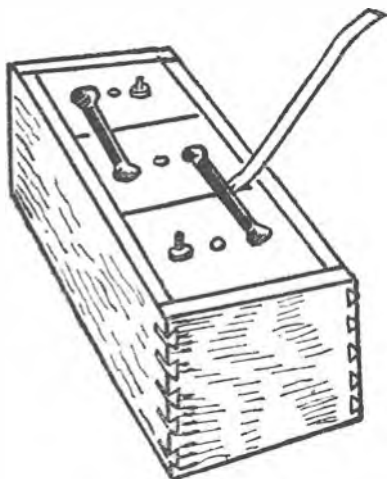


FIG. 22.—Prising off the connecting bar after drilling the posts to separate the bars.

ACCUMULATOR PASTES.—The following ingredients are required: 4 parts by weight redlead (Pb_3O_4), 1 part by weight litharge (PbO), 1 part by weight sulphuric acid (1.12 specific gravity). Add the acid gradually to the mixture of redlead and litharge, stirring well until a fairly stiff paste has been formed. Thorough mixing is essential, and care must be taken not to make the paste too thin.

How to Apply. Place the grid on a flat board and use a scoop to place the paste in the grid. A wooden spreader should then be used to force

the paste into the pockets of the grid. A piece of newspaper is then placed on top of the plate, and another flat board on top of that. This enables the plate to be turned over so that it can be pasted on the opposite side.

Drying. Stack the plates carefully in a warm room to dry. After three or four days dip the plates in sulphuric acid (1.25 specific gravity) and re-dry.

Paste for Negative Plates. Use the following ingredients: 5 parts by weight litharge, 1 part by weight of 1.10 specific gravity sulphuric acid. Mix, apply, and dry as for positive plates.

For a high-rate discharge cell, the paste for the negative plates can be varied as below:

Litharge, 99.96 per cent.; lamp-black, .03 per cent.; wood flour, .01 per cent. One-sixth of the total weight of the above of 1.10 specific gravity sulphuric acid.

Use acid of 1.12 specific gravity, charge at the rate of about .02 amp. per square inch of the plate area, counting both sides of the plate.

ACCUMULATOR REPAIR.—Accumulator failures and troubles are usually due to one of the following causes: sulphated plates, short circuits inside the battery, low level of acid, wrong specific gravity of acid, buckled plates, shedded plates (that is, plates from which some of the paste has fallen out), loose connectors between the cells, faulty terminal connections. The usual voltage and specific gravity tests of individual cells will indicate the faulty cells and the probable cause of the trouble, but it is possible for a battery to have a comparatively low output or capacity whilst the voltage and specific gravity readings are apparently correct.

Examination of the Battery. Open the case and scrape away as much

ACCUMULATOR REPAIR

dust and dirt as possible by means of a brush; then clean off all grease and acid with a cloth moistened in a solution of washing soda or a brush dipped in petrol. Do not allow the soda to mix with the electrolyte. Examine the terminal connections. If they are loose, tighten them; if they are badly corroded, scrape them clean. Examine the connections to the battery and make sure that they are not frayed. Look for cracks in the sealing compound, test the level of the electrolyte, and if the level is low fill up with pure distilled water so that the level is about $\frac{1}{2}$ in. above the top of the plates. After the battery is fully charged test the specific gravity of each cell after it has gassed freely for some time. If the battery is in good condition, the reading should be 1.250 to 1.300.

Dismantling and Repair. Accumulators of the bitumen type are usually made up of single containers in a wooden case with both lower and top covers burnt on to the connecting straps and terminals. Before any repair can be undertaken the accumulator should be drained and thoroughly washed out.

Removing Connecting Bars. Use a drill of the same size as the post, and drill a hole partly through strap and terminal. Place a piece of bar iron on the edge of the case, and with a screwdriver prise off the bars (Fig. 22), removing the cover and compound. The compound softens at about 200° F. It should be heated up with a blowlamp, after the vent plugs have been removed and all gas blown from the inside of the cell by means of a pair of bellows. It has been known for explosions to occur through failure to observe this precaution. Keep the flame on the move, and then with a large screwdriver, which has been heated, clean out the compound along the edges of the case and work it about until the cover is free. It will

then be found possible to remove the plates by means of two pairs of pliers gripping the terminal posts. In cases where a blowlamp cannot be used, immerse the battery in boiling water.

Examining the Plates. Gently prise the plates open and make a preliminary examination. If the condition is fairly good remove any visible short circuit and insert a small piece of ebonite to prevent the trouble re-

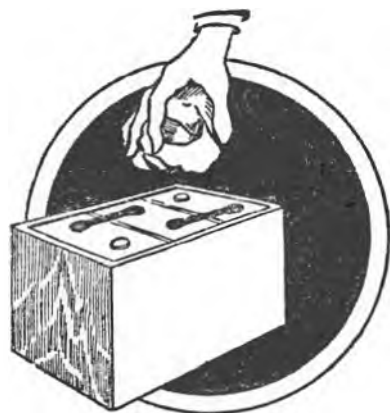


FIG. 23.—Clean the surface of the Accumulator with a cloth dipped in strong soda water.

curing. Now place the group of cells back in the container, fill up to the correct level with acid, replace the connecting straps, and charge at about one-third of the normal rate until the colour of the plates is good, and see that they are gassing freely. No attempt should be made to straighten the plates or replace the separators until this charge has been given, as this charge anneals them and renders them soft and workable. After charging, drain and remove for further examination. Open out the plates, remove a few separators, and joggle the plates free of each other and the separators. It will be found that positive plates suffer more than negative. A slight

ACCUMULATOR REPAIR

rub with the finger on the negative plates should produce a shiny lead appearance. If they are hard, bulged, and have a rough granulated appearance, and if the positives are cracked, soft, or brittle or thin, due to shedding, the plates are useless, and new ones should be obtained. If the positives and negatives are hard, white with sulphate, and dry, do not waste further time upon them. If the plates are usable wash them under the tap, and interleave wooden boards of the correct thickness, finally pressing them between wooden cramps in the jaws of a vice. Charged negatives should not be kept out of acid or water for more than a few minutes at a time.

The Positive Plates. Now attend to the positive plates. These are rather more delicate; if they are buckled they may be straightened in the vice in the same manner as the negatives, or the edges may be gently gone over with a pair of parallel jaw pliers.

Lead Burning. This requires considerable experience and apparatus. Plates of different ages or types should not be used for the repair of any particular group, but a positive group need not necessarily be of the same age as the negative group used with it. If all the plates are bad it is cheaper to buy a new set, but if only one or two require replacing this may be attempted.

If the plates to be replaced are on the outside, saw them off just below the connecting strap. If one or two inner plates are to be replaced, break them off at the lug close to the junction with the connecting strap by bending backwards and forwards with a pair of pliers.

Saw slots in the strap to receive the lugs of the new plates with a good fit.

A burning rack is now required to hold the plates firmly in position.

An oxy-coal, gas, or acetylene flame is required for burning. The parts to be joined should be thoroughly cleaned by scraping, and heat being applied carefully by a small pointed jet, lug and connecting strap are melted together, lead being added as required.

Renewing the Separators. Always renew the separators after the plates are removed, when they are made of wood. Hard rubber and ebonite separators can usually be used again. After replacing the assembled plates and separators in the cell, immediately fill with electrolyte of specific gravity 1.300 to $\frac{1}{4}$ in. above the tops of the plates. Scrape the inside clear of compound ready to receive the covers. Clean these with boiling water. The covers can be fitted over the plate posts before or after fitting in the boxes. When the cover has been fitted, pour sufficient compound around the edges to effectively seal the top, and level off by application of the gas flame or a piece of hot iron. If the cover is a loose fit, a piece of asbestos string can be inserted to stop the compound from running through. The compound is heated in a plumber's ladle on an ordinary gas-ring. Next charge the battery at about one-third of its normal rate, and if at any time during this period the temperature exceeds 100° F. reduce the charging current. Continue the charge until no further rise in voltage or specific gravity takes place for a space of four hours, after which the charge may be considered complete.

Adjusting the Electrolyte. Various changes will have taken place in the newly added electrolyte, due to the action of sulphate soaking into separators and plates, and the effect of charging. At the end of charge, if the specific gravity of any cell is above 1.300 draw off some of the electrolyte and replace to correct level

ACCUMULATOR REPAIR

with distilled water. Use good-quality acid when necessary to replace it.

If the specific gravity is below 1.300 draw off some of the electrolyte and make up with acid of 1.400 or 1.350 specific gravity. Charge the battery again to mix the electrolyte thoroughly, and test again. Continue the adjustment, until with the electrolyte at the correct level the specific gravity is 1.300. Never add any but distilled water. Tap water should never be used. Refer to the tables on page 4.

Correction for Temperature. The values given on page 4 are correct for a temperature of 70° F. A correction must be made if the temperature differs from this. To obtain the actual specific gravity at 70° F. add one point to the reading obtained for every 3° the temperature is above 70°, subtracting one point for every 3° below this temperature. Some makers prefer a lower specific gravity, and in such a case the table given here should be used.

Condition of Cells.	Actual Hydrometer Readings at Temperatures shown below to give 1.280 at 60° F.						
	40°F.	50°F.	60°F.	70°F.	80°F.	90°F.	100°F.
Fully charged	1.288	1.284	1.280	1.276	1.272	1.268	1.264
Half dis-charged	1.207	1.204	1.200	1.196	1.193	1.189	1.186
Fully dis-charged	1.115	1.113	1.110	1.107	1.104	1.101	1.098

To ensure satisfactory working the battery should now be charged at its normal rate until fully charged, when it should be discharged through a coil or water rheostat at its normal discharge rate until the voltage equals an average of 1.8 per cell. This discharge current should be kept at a constant value by varying the rheostat, and the number of hours for which the battery will give out this current should be noted. The pro-

duct of hours and amperes gives the capacity in ampere-hours.

Effects of Overcharging a Battery. Except in the case of a sulphated cell, when gassing takes place at the plates at all times, gassing on a large scale only occurs when the chemical changes at the plate are nearing completion. Consequently, continued gassing after such completion of charge has taken place is simply wasting energy. In any case, the charge should be reduced so that gassing is not excessive. If continued in excess the gas which is being produced in the pores of the plate causes disruption of the paste, loss of capacity due to shedding, and perhaps short circuiting. A battery is kept in better condition if at some periodical time, say once per week or fortnight, it is given a prolonged gassing charge, as this ensures all the active material being in a healthy condition. This will give an efficient battery, but overcharging generally is of no value, and may be detrimental both to the life and capacity of the cells. It is indicated by high specific gravity at all times.

Effects of Under-charging. Habitually under-charging, on the other hand, is bad policy. It is not good practice to get as much out of a battery as possible nor to use it without sense or reason. Nothing undermines the efficiency of a battery so much or reduces its useful life to such a degree as persistent under-charging. If the voltage per cell is allowed to fall below 1.8 repeatedly, and discharge is continually drawn from it at this or lower values, sulphation invariably occurs. The sulphate so formed is the same as that produced when a battery is left for long periods in a discharged state, and is of the hard, greyish crystalline kind, which is an insulator, and is so hard to get rid of. Under-charging is indicated by low specific gravity.

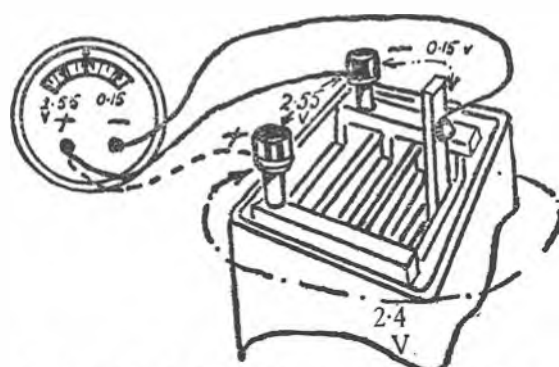


FIG. 24.—Testing a fully charged Accumulator with a Cadmium Tester.

The Cadmium Test for Faulty Plates. An instrument known as a cadmium tester is really a voltmeter with a central zero reading on its scale, an arrangement which permits of polarity tests. Two flexible leads are attached to it. The positive lead is of the ordinary type, but the negative lead has a piece of cadmium about 4 in. long by $\frac{3}{4}$ in. diameter soldered to it. This cadmium extremity has a perforated rubber covering or ebonite tube covering, so that when used the metal cannot make direct contact with the plates.

This negative lead is placed through one of the vent holes into the liquid between the two plates, and preferably in the centre of the section. It will readily be perceived that the cadmium is

really another electrode which forms two other cells with the positive and negative plates and the acid.

To make a cadmium test, place the cadmium between the plates and the centre sections as described, and make

contact with the other voltmeter terminal on + and - lead terminals of the cell alternately. The reading with the contact on the + terminal should be to the right of zero and about 2.4 to 2.5 volts. The reading with the contact on the - terminal should be to the left of zero and about -0.15 to -0.2 volt. This is obviously equal to a voltage of $2.4 + 0.15 = 2.55$ volts between battery terminals. If the positive reading is appreciably less than 2.4 volts, or the negative near zero or even on the + side of zero the posi-

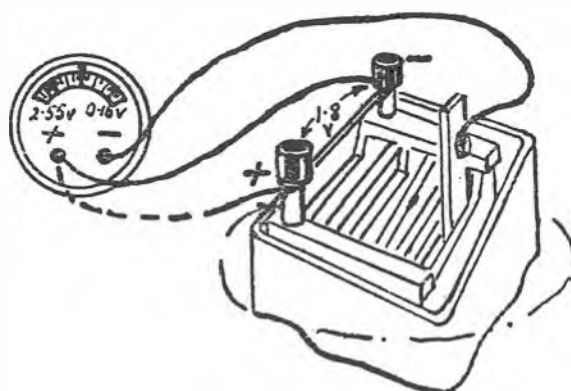


FIG. 25.—Testing a discharged Accumulator with the Cadmium Tester.

tive or negative plates respectively are defective. Towards the end of charge the cell voltage is obviously the sum of the two readings obtained.

Celluloid Accumulators. Celluloid cases are either moulded or built up. Plastic celluloid is made from a mixture of nitrate cellulose and gum camphor in amylacetate, pressed in a mould or rolled into sheets. The sheets, cut to size, have their edges stuck together with a paste made of celluloid and amylacetate.

The only advantage of the celluloid jar is its transparency. Its great disadvantage is its inflammability.

Examination of plates can be made without opening out. To open out, when necessary, insert the blade of a knife in the join between cover and side of jar and prise open.

To repair case after overhaul of plates, scrape the edges of case and cover with a knife. Dissolve some scrapings of celluloid in amylacetate to form a thick solution and apply this to the edges to be joined. Clamp in position by clips until set. Keep all terminals and connectors coated with vaseline to prevent corrosion.

Nickel-iron Cells. Top up with distilled water to level indicated above plates; never add acid or use it in any way in dealing with this type of battery. Keep filler plugs tight, and do not expose electrolyte to air longer than necessary.

Keep cells clear of dust and moisture. The specific gravity of the electrolyte falls with age and must be completely renewed when it falls below a certain value. Nickel-iron cells are worked at specific gravity 1.190 and are considered exhausted when this falls to 1.160. The cells can be stored for any length of time if charged and then partially discharged. Before being put in service again charge fully. To prepare the liquid electrolyte from the solid, in

which form it is supplied, add 1 lb. of solid to 2 lb. of distilled water, or by volume 1 gallon of water, which is about equal to 10 lb., to 5 lb. of solid. Do the dissolving in perfectly clean iron, glass, or earthenware receptacles. Galvanised or soldered vessels should not be used. The slightest trace of lead battery acid in the electrolyte will lower the capacity of the cell, and greater quantities will destroy it.

The Nickel-Iron-Alkali Accumulator. In this type of cell the positive plate is a stout steel frame in which are fixed a great number of perforated steel tubes filled with alternate layers of nickel hydroxide and nickel. The negative plate, also of steel, binds together a large number of rectangular pockets filled with powdered iron oxide.

The electrolyte is a solution of potassium hydrate having a specific gravity of 1.400. This alkali does not attack the steel grids or containers, but if exposed to the air it combines with carbon dioxide and forms useless potassium carbonate, so that the containers must be almost airtight, in order that gas may escape from the inside. The electrolyte is necessary to bring about the transference of oxygen from one plate to the other on charge and discharge, but does not change in composition or specific gravity value during the working of the cell. Voltage readings, therefore, form the only means of determining the state of the cell.

The voltage of any cell depends on the materials used for the plates. That of the nickel-iron type is found to be 1.25 when fully charged, and about 1.1 volts when discharged. Its great advantages over the lead-acid type are its smaller weight, greater robustness or mechanical strength, absence of acid, and freedom from troubles caused by short circuiting. The nickel-iron-alkali accumulator

ACCUMULATOR REPAIR

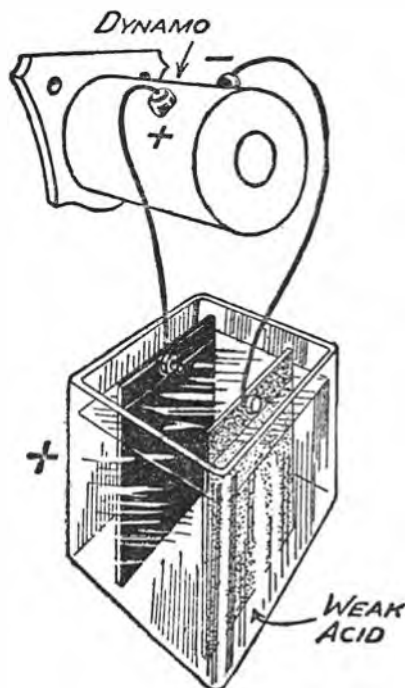


FIG. 26.—Method of testing a Dynamo for Polarity.
(See also Fig. 17.)

has been used with marked success for motor-cycle lighting.

Capacity of a Cell. Capacity depends on the amount of active material available, the charge put into the cell, the rate of discharge, the temperature and the state of the cell as regards sulphation, and short circuit. The *condition* of the plates has a great deal to do with the capacity of a cell and its ability to hold a charge.

The amount of active material available depends on the quantity upon the plates and the acid which has access to it. At slow rates of discharge, the acid can circulate into the pores of the plates, and thus the greater portion of the paste will be chemically active. At high rates of

discharge only the surface of the plates is acted upon, and acid diffusion being limited, the capacity suffers temporarily. A sufficiency of charge must, of course, have been given to the plates to convert the paste to chemically active material in the first case. If a lead-acid cell be discharged below 1.8 volts per cell, this is not all. The conducting sulphate of the discharged negative plate is converted to hard non-conducting sulphate, which is so difficult to reconvert to useful spongy lead, and covers up areas of useful paste from the action of the acid. The capacity therefore decreases when such sulphate is produced, and in the endeavour to get rid of it, shedding of paste, with consequent loss of

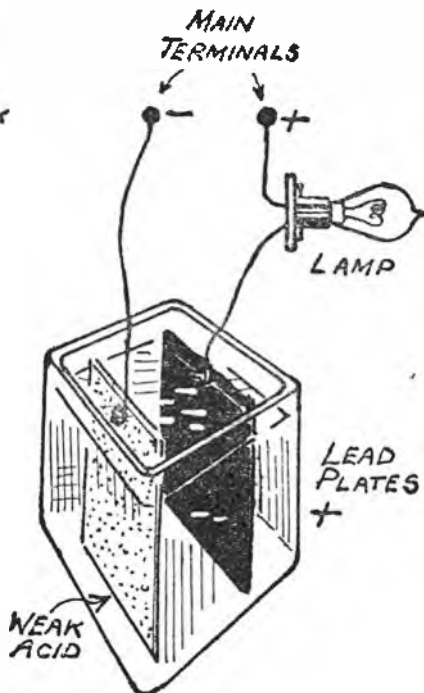


FIG. 27.—Method of testing Mains for Polarity.
(See also Fig. 17.)

ACCUMULATOR REPAIR

capacity or internal short circuiting of plates, results with decreased capacity, and still more sulphating. Temporary loss in capacity therefore always results from too-rapid discharge, whilst prolonged discharges below 1.8 volts, or leaving the cells in a discharged state results in sulphation and permanent injury, which it is almost impossible to rectify.

Removing Sediment and Sludge.

If only one cell of a battery is deficient, and it is required to empty the box of acid and sludge after the plates are taken out, this should be done by a syphon or sludge pump. The case should not be tipped, or the deposit in the good cells gets mixed with plates and separators to their detriment, considerably shortening their life.

A syphon can be made from a piece of lead tubing to which is attached a longer length of flexible rubber tubing. The syphon, filled with water and with both ends closed, should be placed with its lead end below the liquid level in the box, and the other hanging to a lower level outside, and then the ends opened. Acid will then be drawn over, and the sludge, stirred about by the piece of lead tubing, will come over with it. Meanwhile, water is run into the box for so long as is necessary to rid it of all traces of sediment.

Battery Charging by Rotary Machines. A number of single machines of the rotating type for rectifying A.C. are available when accumulator charging is to be done on a large scale. Connections at one end are to the A.C. supply, whilst from the commutator end of the shaft connections are made through an automatic cut-in and cut-out to the batteries on charge. In larger sizes a transformer is used, connected between the A.C. supply and the slip rings or terminals. The machine

works with very little attention and has an output of 50/60 volts, 30 amperes. This would charge up ten 6-volt or five 12-volt batteries in series, or a larger number at a lower amperage than 30 in parallel.

A wall-type series resistance regulator enables the set to be used for charging as low as one 6-volt battery alone, or more in series, according to the value of the resistance inserted in the rheostat.

For large garages and charging equipments, larger types of rotary converters or motor-generator sets are perhaps more convenient. These may be ordered for any given output on the D.C. side, and suitable for connection to any A.C. supply at any voltage and frequency. The particulars required are the number of phases, single-, two-, or three-phase, of the A.C. supply, the voltage and frequency; and the output in volts and amperes required on the D.C. side for charging the maximum number of batteries at once. Reckon about 3 volts per cell when calculating the D.C. voltage.

Portable Accumulators. One of the many difficulties with which the designers of portable wireless sets have had to contend is the question of the low-tension accumulator. An ordinary dry battery can, of course, be used for the high-tension supply, but the standard low-tension accumulator is quite unsuitable for use in a portable set owing to the danger of spilled acid.

As a result of this, nearly all portable sets are fitted with special unspillable cells of either the "free acid" or "jelly acid" type. These small unspillable cells require rather more careful handling than the ordinary low-tension accumulator, and some practical hints on their maintenance now follow.

Firstly, the average unspillable cell is very often too small for the job!

ACCUMULATOR REPAIR — TROUBLES

The fault lies, not with the battery makers, but with the designers of the sets, who leave a ridiculously inadequate space for the housing of the low-tension battery. It is obviously false economy to fit a four- or five-valve set with a cell of only 15 to 20 ampere-hours' capacity, as the cell will spend as much time at the charging station as it will on the set!

It is this smallness of many unspillable cells that gives rise to a large percentage of our battery troubles during the summer months. These cells are not designed to hold their charge over a long period and, even when fully charged, they should never be allowed to stand for more than a month without a freshening charge. If this precaution is neglected, the cells show a tendency to sulphate, and soon become quite useless.

Sulphation takes place much more rapidly if the cell is left in a discharged or partially discharged condition, and this is, unfortunately, all too frequently the case with unspillable accumulators. Let us suppose that the portable has been used in the garden during the week-end and then closed up and forgotten for perhaps a couple of weeks. The cell has been left in a half-charged state and, when wanted, will probably be found to have the plates covered with a white deposit of lead sulphate.

Slight traces of sulphate may be removed by slow and careful charging, but a seriously sulphated cell will require extensive repairs, costing about half the price of a new accumulator.

Another point in connection with these small-capacity portable cells is that they require more careful treatment at the charging station. If we are using a 60 ampere-hour cell, and are getting about 50 ampere-hours from it, we scarcely notice the deficiency. But a drop of only 5 am-

pere-hours in the capacity of a 20 ampere-hour cell is a serious loss, and charging bills begin to mount up at an alarming rate. It is advisable to take your batteries to the best charging station and to ensure that they are always returned in a fully charged condition.

The following few simple rules will enable you to obtain better service from your unspillable cells.

Charge whenever the specific gravity falls to 1.100 or the voltage to 1.8. *In any case*, charge at least once a month.

Unspillable cells of the "free acid" type may be tested in the usual way by taking hydrometer readings of the specific gravity of the electrolyte. It is, however, impossible to test the gravity of a "jelly acid" cell, and the only way to ascertain the state of charge is by taking voltage readings.

Maintain the acid level by adding distilled water only, but be careful not to fill above the "danger line." Even an unspillable cell may leak if the correct volume of electrolyte is exceeded.

Keep all terminals and connections clean and well coated with vaseline, and make sure that the filling plug is screwed up *tight*.

ACCUMULATOR TROUBLES—CAUSE AND CURE.—One of the most common causes of battery failure is over-discharging and then leaving the battery in a discharged condition. During the autumn and winter months the risk is, of course, greatly reduced, as the battery (particularly when employed for multi-valve sets) is often in almost constant use, and is therefore charged and discharged at fairly frequent intervals.

In the summer, however, the wireless set or radiogramophone is no longer in such demand.

Therefore, it is necessary to take precautions that the wireless accumu-

ACCUMULATOR TROUBLES

lators (and also wet high-tension batteries, when such are used) are not left discharged and neglected, or sulphation will inevitably follow and, unless immediate steps are taken to check it, the affected batteries soon become beyond repair.

Sulphation. It is worth repeating that certain types of batteries are far better equipped to withstand sulphation than others. Most battery manufacturers market—under various names—cells of the “slow-discharge” type. They are generally assembled in glass containers, and have exceptionally thick and robust plates. These plates are so constructed as to give a small supply of current over a long period, and are admirably suited for the average two- or three-valve set, or for bell work.

If the batteries are of this type, the risk of sulphation—even if the battery is to stand idle for several months—need cause no alarm. Merely see that the cell is given a long, slow discharge, clean and vaseline the terminals, and it should stand for a period of quite six months without the slightest ill effect. It is advisable to examine the cell from time to time to ensure that white specks of lead sulphate are not forming on the edges of the plates.

Celluloid Cases. Batteries capable of standing a much higher rate of discharge than the above are frequently assembled in celluloid cases, and consist of a large number of thin plates with wooden or ebonite separators. While suitable for being charged and discharged more quickly than the thick-plate type, these cells require more careful treatment when not in use.

Stopping Acid from Creeping. When the acid in a high-tension battery begins to “creep,” the wireless enthusiast is placed in a decidedly unpleasant situation. Unless the problem is tackled correctly and im-

mediately, the nuisance will persist, until eventually the acid will spread all over the cells, connectors, and even down to the battery box and to the floor. This acid “creeping” is more common in batteries known as “open topped.” The prevention and cure may be carried out by any amateur with very little trouble and expense by adopting the procedure which is outlined below.

First of all, take the plates out of the cells and empty them of acid. Replace the plates and fill up the cells with pure distilled water to $\frac{1}{4}$ in. above the top of the plates. Now put on charge for thirty hours. At intervals, see that the water covers the plates. On no account must the tops of the plates be allowed to protrude the very slightest amount above the surface of the water.

After being thoroughly charged, empty the water out and wash the cells clean and then dry. Next, not quite boil them in ammonia water for five minutes. Clean and then dry thoroughly.

When handling the plates in this condition, the utmost care should be exercised that the paste is not dislodged.

Melt a sufficient quantity of paraffin wax in a dish. Take great care not to tip the wax into the flame. Take each cell and dip the top about $\frac{1}{4}$ in. into the wax. The connecting bars of the plates must be treated in the same way.

Allow the wax to harden and then re-assemble the battery. Fill up with fresh acid of correct specific gravity and charge in the manner already described.

What is the Electrolyte? It consists of a mixture of pure sulphuric acid and distilled water. If you are filling your own batteries and “breaking down” strong acid to the required strength, the precautions already given should be observed;

ACCUMULATOR TROUBLES — TYPES

When refilling the accumulator, use a small celluloid or glass funnel, taking care not to spill or splash the acid over the top surface of the accumulator, for carelessness of this

over-discharged, and immediately recharged, very little damage will be done.

ACCUMULATOR TYPES.—The accumulator is obtainable in a number of different types, the principal differences being in the container or disposition of the plates. The most common form consists, of course, of the celluloid container with thin plates having a large discharge rate. The glass container usually has the thick-plate arrangement giving slow discharge rates but large capacity. In addition, there are of course the larger moulded case accumulators used for cars, etc.

The accumulator of to-day consists primarily of a number of positive and negative plates bunched together and immersed in a dilute solution of sulphuric acid. Each set of plates is connected to a common terminal, and the individual plates are kept apart by means of wood or ebonite separators. The outside plates are always negatives, so that there is always one more negative than positive (Fig. 28).

The positive plates are of lead peroxide while the negatives are composed of spongy lead. These active materials, as they are called, are imprisoned in the plate grids in

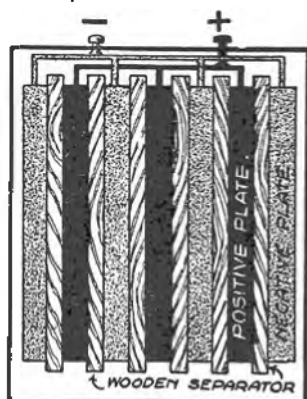


FIG. 28.—Section of a Heavy-duty type of Accumulator.

description is the chief cause of corrosion of terminals.

Corrosion is best prevented by removing all traces of acid from terminals and connections (by wiping with a rag moistened with ammonia) and then coating all metal parts with pure vaseline.

Once corrosion has started, it is necessary to scrape the affected parts clean, remove all traces of acid as before, smear with vaseline, and then carry out the instructions given on earlier pages.

Rate of Discharge. No harm is done to the plates if the battery be discharged at any rate of current that it will deliver. The higher the rate of discharge, however, the faster the drop in voltage, and if a battery is discharged at higher than the "normal" rate the full number of ampere-hours will not be obtained. A high rate of discharge should not be confused with overcharging (too many ampere hours taken out of the battery). If a battery be accidentally

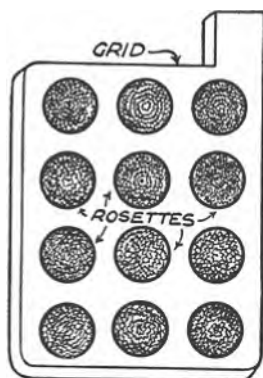


FIG. 29.—A Positive Accumulator Plate of the Rosette type.

ACCUMULATOR TYPES

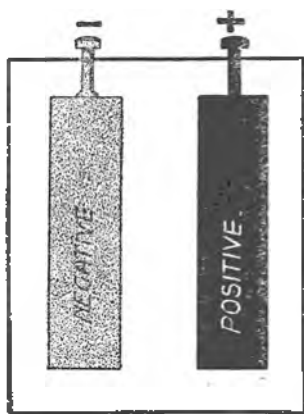


FIG. 30.—Section of a Slow Discharge type of Accumulator.

a number of different ways. The grids are merely supports for the active material, and are generally made of an alloy of lead and antimony—this being harder than pure lead.

In many accumulators the active material is "pasted" on to the grids, while others employ the "box" type of plate, consisting of a narrow, perforated box filled with active material. Again, the active material is sometimes forced into the grid in the form of rosettes of gimped lead tape (Fig. 29).

Thick-plate Cells. There is, of course, a very popular type of accumulator which often has only two plates. These are known as the slow-discharge or thick-plate type, and are particularly suitable for working bells or supplying the low-tension current for wireless sets. These cells have exceptionally thick and robust plates specially designed to give a small flow of current over an extended period (Fig. 30).

Thick-plate cells are intended for small discharge rates only, say up to 2 amperes, and the rate of charge should be kept correspond-

ingly low. The robust design of the plates renders them singularly free from sulphation, and the cells are therefore able to stand for considerable periods without recharging.

Plates of similar design are employed in the modern high-tension battery, and in any accumulator where the discharge is slow or intermittent, and where recharging may only be carried out at infrequent intervals. Slow-discharge cells are particularly suitable for operating bells, telephone, electric clocks, and burglar, or fire, alarms.

Thin-plate Cells. Thin-plate cells, as shown in Fig. 28, are recommended for heavier duty than the "slow-discharge" type. The construction of the plates renders frequent recharging essential, as they are more susceptible to sulphation. These cells will give comparatively heavy currents over long periods, but should be recharged at least every three or four weeks. They stand up to a quick charge, and discharge better than the "thick-plate" types, and are suitable for multi-valve radio sets, model driving, and similar tasks. These cells are assembled in both glass and celluloid cases, but owing to its heat-resisting properties the glass-case type is always recommended for use in tropical climates.

The thin type of plate is also fitted in the small unspillable cells supplied for portable wireless sets and electric hand lamps. These cells have

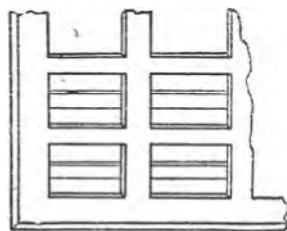


FIG. 31.—The Grid ready for pasting.

ACCUMULATOR TYPES

an acid trap which permits the gases to escape, yet renders the spilling of electrolyte impossible. Another im-

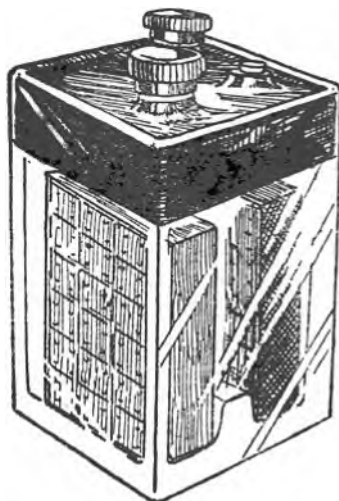


FIG. 32.—2-volt Cell for Radiopurposes. The moulded glass container obviates the use of separators.

portant feature of their design is that the plates are always immersed in the acid even when the receiver is in either the carrying or operating position. Many of these portable cells are rendered doubly unspillable by filling them with "jelly" electrolyte; although their capacity for holding a charge is considerably reduced.

Thin-plates are also employed in the construction of the modern car starting and lighting battery.

These batteries are assembled in non-conducting composition containers, or ebonite boxes in wooden trays. They have a large number of plates per 2-volt cell (sometimes twenty-five, or more), and are designed to withstand exceptionally heavy rates of charge and discharge (see Fig. 23).

When the electric starter of a car

is pressed, the current from the battery drives the starting motor, and this in turn "cranks" the engine. While the engine is running, it drives a charging dynamo and generates current for recharging the battery.

This rate of recharge is very high—anything from 8 to 20 amperes under normal running conditions—while the strain placed upon the battery during the actual start is truly tremendous. A standard car battery of 100 ampere-hours capacity will deliver a starting current of about 260 amperes for five minutes, or 120 amperes for twenty minutes.

Motor-cycle batteries, while not called upon to deliver such large currents as car batteries, are of similar robust construction. Head and tail lamps and an electric horn place a very heavy strain upon the battery, which has to be particularly strong to withstand the abnormal vibrations to which all motor-cycle accumulators are subject.

For the lighting of trains and buses and the propulsion of electric vehicles a special type of battery is again necessary. One method of accomplishing this is to enclose the active positive material in slitted ebonite tubes instead of the customary grid of lead or lead alloy. These slitted tubes allow the electrolyte free access to the active material, yet hold the latter in position more satisfactorily than the ordinary flat lead grid. This gives a longer life, and enables the battery to withstand the abnormally heavy demands made upon it from time to time.

Plante and Faure. In the large batteries for house-lighting and similar work, various types of plates are employed, but all are modifications of the two principal methods named after their inventors—Plante and Faure.

In the Plante type of plate, the

ACCUMULATOR TYPES

active material is "formed" in a thin layer on the lead grid, and a large surface is therefore necessary in order to get sufficient volume of active material. This difficulty is usually overcome by grooving or laminating the plate, and thus procuring a surface area of about ten times that of a plain lead sheet of similar size. The Faure type of plate is generally a pasted grid or a lead grid containing pellets of active material. Box-type negative plates are often used in conjunction with Plante positives, and the whole assembled in large glass containers.

Tremendous batteries of this type are built up (some have a capacity of over 2,000 ampere hours), and are used for a variety of purposes—house, yacht, and factory lighting, or supplying the extra power required by electric sub-stations during "rush hours." They are also installed as emergency equipment (automatically coming into operation when the normal supply fails) in banks, hospitals, cinemas, large stores, and public buildings.

Edison or Nickel-Iron Accumulators. It will be noticed that the foregoing types of accumulators are all of the lead-acid type, but this volume would be incomplete without some reference to the Edison or nickel-iron type of battery—the only practical accumulator that does not embody the use of lead.

The plate grids of the Edison accumulator are of steel, and carry perforated steel tubes or pockets containing the active material. The positive plate is packed with alternate layers of metallic nickel and nickel hydrate, while the negative is packed with iron oxide. All containers, terminals, and connectors are of steel, and the electrolyte is a solution of potassium hydrate.

These cells are remarkably strong, and the absence of any corrosive acid

is a great advantage. Furthermore, they do not deteriorate if left standing in a discharged condition, and the plates do not buckle or sulphate—serious defects in the lead-acid accumulator. The only disadvantage of the Edison type of accumulator is its low voltage, which is only about 1.3 volts per cell.

Unspillable Accumulators. As already stated, there are instances, as with portable wireless sets, where it is necessary that the accumulator should be unspillable. Most manufacturers now list an accumulator of this type, and it is marketed in two forms. The first consists of the usual acid-filled accumulator with a non-leaking valve fitted in place of the usual vent, and the second consists of an accumulator with either a glass-wool or jelly electrolyte.

An accumulator filled with jelly electrolyte has one very obvious advantage over the more common or acid type—it is unspillable. In addition to being of special value for portable wireless sets, jelly acid cells eliminate the possibility of damage to furniture and carpets through spilling or leaking.

Jelly electrolyte consists of sulphuric acid to which a given proportion of sodium silicate has been added. Jellification takes place at varying speeds according to the proportions in which the two chemicals are mixed. A suitable mixture which jellifies in five or six minutes is—1 part of pure sodium silicate (1,200 specific gravity) to 3 parts of cold sulphuric acid (1,400 specific gravity).

As jellification takes place fairly rapidly it is essential to arrange that the entire operation may be carried through without any hitch or delay. The cell to be filled with jelly acid should be given a first charge, using ordinary free sulphuric acid. This acid should then be poured off, and

ACETONE — AERIALS

the cell inverted and allowed to drain for about half an hour.

ACETONE.—A colourless liquid smelling something like pear drops. Chiefly used in wireless for jointing and repairing celluloid. Used as a solvent for fats, camphor, and resins, for making chloroform. Also known as dimethyl-ketone and methyl-acetyl. It is very inflammable.

ACIDOMETER.—Apparatus for measuring the strength of acids. A hydrometer (which see).

ACLINIC LINES.—Any line on a diagram or map which represents the magnetic equator.

ACOUSTIC.—The sense of hearing; the science of sound is known as acoustics.

ACOUSTIC WAVES.—Sound waves.

ACTINOMETER.—A p p a r a t u s which measures the actinic value of light.

ADMIRALTY UNIT.—The unit of capacity known as the Jar (which see).

ADMITTANCE.—Anything which aids current flow in a circuit. May be calculated by dividing 1 by the impedance—the reciprocal of the latter.

AEO LIGHT.—A lamp used in the production of sound or "talkie"

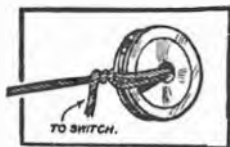


FIG. 33.—The wire passed through the insulator to form a double bight.

films, and yielding a glow which has greater actinic value than a neon lamp. A microphone is employed to turn the speech and music into electrical vibrations, which are changed

into light variations (through the medium of the Aeo Light), and are thus recorded on the film.

AERIALS AND EARTHS.—The two most important factors in the efficiency of an aerial are insulation and height. The energy collected by the aerial is quite small, and, consisting of "high-frequency currents," takes the shortest path to earth. One must therefore take care that the

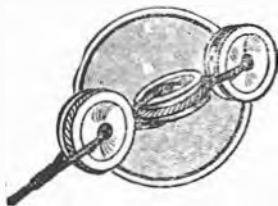


FIG. 34.—For a Single-wire Aerial three insulators should be fitted at each end.

shortest path to earth is through the tuning coil of the set, and not via the mast or house to which the aerial is fixed. For the same reason the actual aerial wire should be suspended in such a position that it does not run parallel with any earthed body, such, for instance, as a wall or roof. Three feet should be considered the very minimum distance which should be allowed between the aerial and any other earthed body. For most listeners the simplest aerial to erect will be one which is suspended from a pole at the bottom of a garden, and a chimney stack or pole fixed to the side of the house.

The Mast. The most satisfactory mast consists of sections of steel tubing screwed together, with the bottom section about 2 in. in diameter, and the top about 1 in. Lengths of the timber known as 2-in. quartering may also be bolted together to form quite a good strong mast. A pulley should be fixed at the top to enable

the aerial to be lowered periodically in order that the insulators may be cleaned. The mast should be supported by guys at either side and at the back. These may be of either rope or galvanised wire, and should each be broken in two places and insulators inserted.

Where a total length of 60 ft. can be obtained, use a single-wire aerial, but if the amount of space at your disposal will only allow a run of about 30 ft. or less, then use a double-wire aerial with the two wires spaced by means of a bamboo stick, with a separation of 3 ft. Do not have the wires closer than this.

Egg and Reel Insulators. Insulators of either the egg or reel variety are both cheap and efficient, and in the case of a single-wire aerial, six should be the minimum to use, three at either end. They should be joined together to form a chain, as shown in Fig. 34, and at the lower (or garden) end one end of the chain should be attached to a length of good quality rope threaded through the pulley. One end of the aerial should be securely fixed to the other end of this chain. At the house end, the other chain of three should be fixed to a pole, or a length of galvanised wire attached to a staple in the wall or chimney stack, so that when the aerial is attached to the end of this chain the down lead will hang about 3 ft. from the wall, and, if possible, directly above the window through which it is eventually to be led.

The Aerial and Lightning Switch. The best material for an aerial is the stranded copper wire, known as 7/22s. This consists of seven separate strands of No. 22 gauge copper wire, twisted together like a rope, and is quite cheap. At the house end, the aerial wire should be passed through the hole in the end insulator to form a double bight, as shown in Fig. 33.

In this way the aerial and lead-in are all in one, with no connection to become corroded. If, however, owing to your having insufficient wire or any other reason, a joint has to be made, it should be thoroughly soldered, and then bound with insulation tape of the rubber variety, or painted, to avoid corrosion.

Outside the window a lightning switch should be fitted, and this should be of the type known as "double-pole-double-throw" (unless,

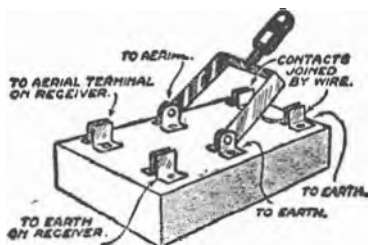


FIG. 35.—The method of connecting up the Lightning Switch.

of course, you can afford one of the proper lightning arresters). The method of connecting up the switch is shown in Fig. 35, and if wired up in this manner the aerial is completely disconnected from the house when the switch is in the "off" position. The wire to earth should be of the same material as the aerial proper, or of some thicker wire. Do not use anything thinner.

The Earth Connection. There is no doubt that the ideal earth connection is a buried plate of metal. This should be as large as convenient (a 7-lb. biscuit tin is quite good), and the earth wire should be securely soldered to it. Dig a hole about 3 ft. deep, place at the bottom a layer of coke or some similar rubble, put the earth plate on this, and cover with another layer of coke. Fill in the hole and well water. Remember that the earth connection should be kept

INDOOR AERIALS and EARTHS

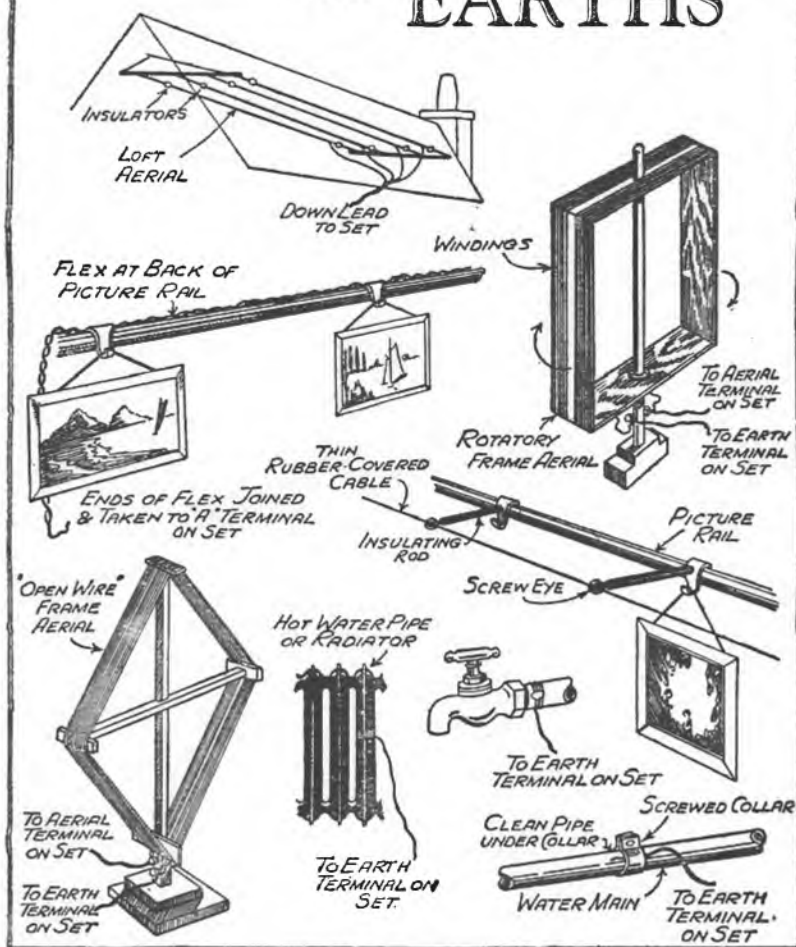


FIG. 36.

OUTDOOR AERIALS

and

EARTHS

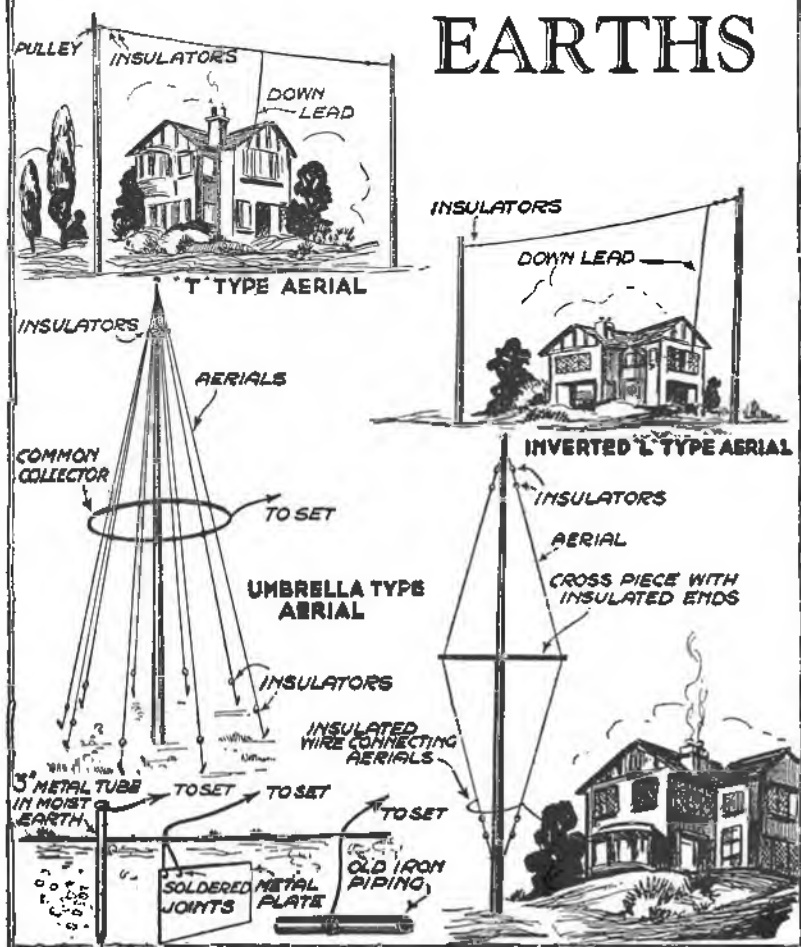


FIG. 37.

AERIAL HINTS

SOME ALTERNATIVE METHODS

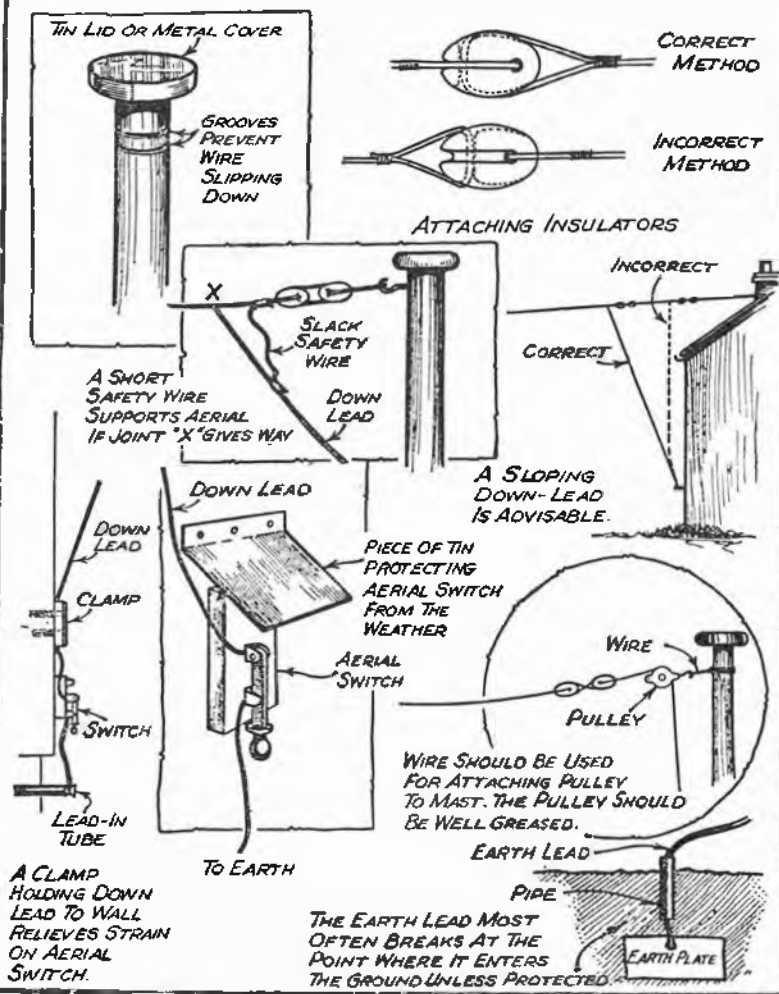
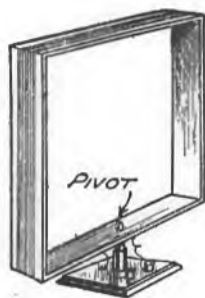
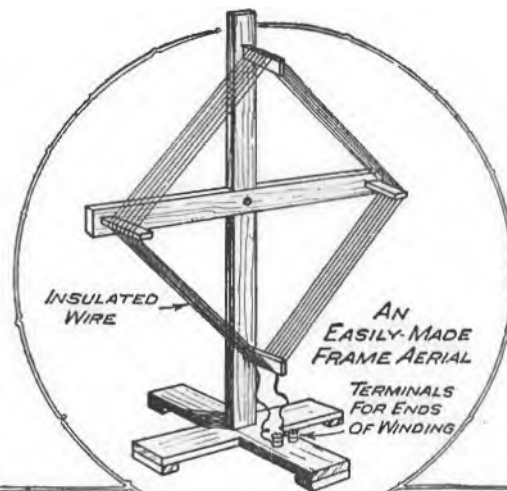


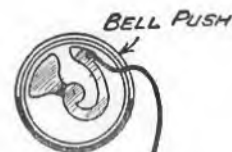
FIG. 38.



*DIRECTION-FINDING TYPE
OF FRAME AERIAL.*



*AN
EASILY-MADE
FRAME AERIAL*

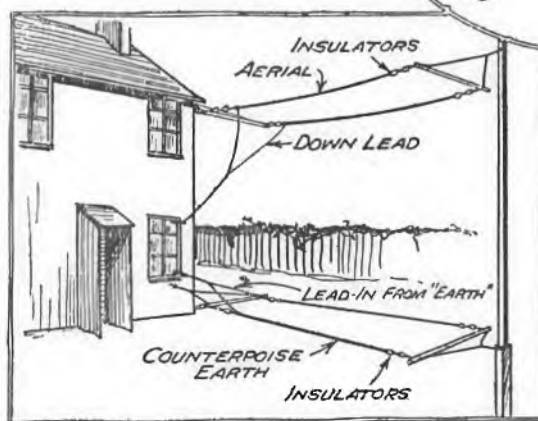


*VARIABLE
COND'S'R.*

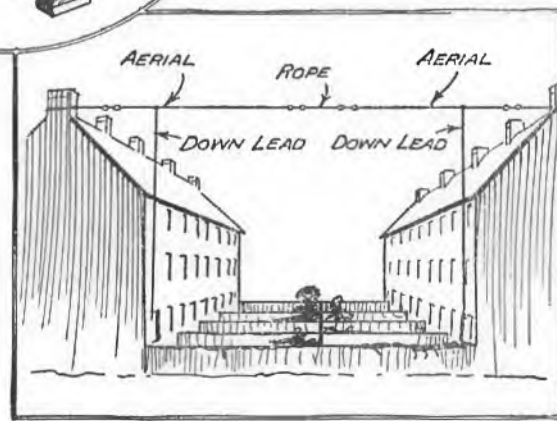


*TO RECEIVING
SET.*

*UTILISING A BELL CIRCUIT
AS AN AERIAL.*



*AN "L" TYPE AERIAL WITH A COUNTER-
POISE EARTH.*



*TWO AERIALS ERECTED AS SHOWN ABOVE,
OBTAIN THE USE OF A MAST.*

AERIALS

as damp as possible to keep the resistance low. Of course, if a buried earth is inconvenient, a connection to the water pipe may be made, but this should be a main pipe, if possible, and connection made by means of a proper earth clip. Whatever type of earth is employed, keep the lead to it as short as possible. Do not let it travel all round the house, but take it by the most direct route.

Gas pipes are not recommended for the earth, not so much on account of the danger which exists, but because most of the joints are painted, and, therefore, if this has been well done, the sections of pipe are insulated from one another.

An Aerial Earthing Switch. A common practice with many amateurs is to use a single-pole switch for earthing the aerial when their wireless set is not in use, the earth terminal of the set being directly connected to earth all the time. A much better arrangement is to use

a switch which entirely isolates the receiver from the aerial and earth when placed in the earth position.

A simple switch, which answers the purpose very efficiently, is shown in Figs. 43 and 44. The materials required to make it consist of a piece of $\frac{3}{16}$ -in. ebonite, $4\frac{1}{2}$ in. long by 3 in. wide, four stout terminals with clamping nuts, a strip of sheet brass $5\frac{1}{2}$ in. long by $\frac{3}{8}$ in. wide and $\frac{1}{16}$ in. thick, two brass screws 2 in. long, and a wooden bobbin.

Construction Details. Mark out the ebonite as indicated in Fig. 45 and drill six holes through, the two to take the fixing screws being counter-sunk.

To make the switch arms, cut the brass into two pieces of equal length, and set out the position of the holes and slots according to the dimensions given in Fig. 46. The slots are made by first drilling holes in the centre lines, and then with a hacksaw cutting away the metal not re-

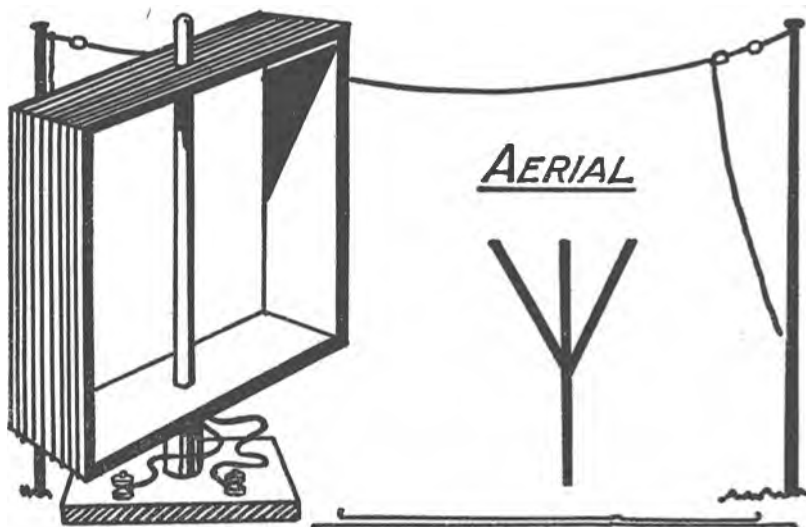
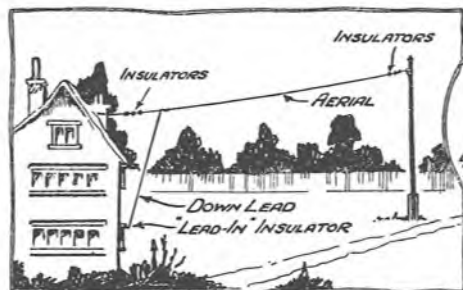
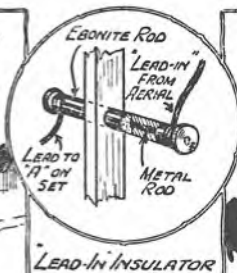


FIG. 40.—Conventional sign for an Aerial, shown also pictorially.



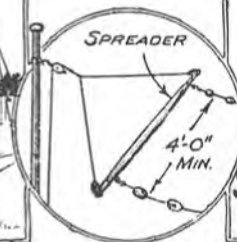
"L" TYPE AERIAL. KEEP FREE OF TREES. SEE THAT DOWN LEAD IS CLEAR OF GUTTERS, ETC.



"T" TYPE AERIAL. DOWN LEAD TAKEN FROM CENTRE OF AERIAL WIRE, CLEAR OF ROOF, TO "LEAD-IN".



TWIN "L" TYPE AERIAL WITH WOODEN SPREADERS.



TWIN "T" TYPE AERIAL.

FIG. 41.—Various Aerial Systems.

AERIALS

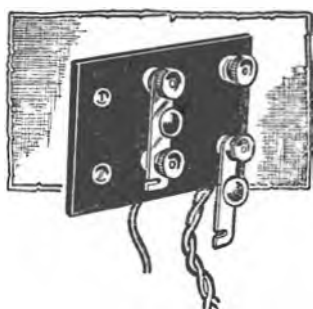


FIG. 42.—The Switch in earthed position.

quired. Clean out the slots and round the ends of the arms with a fine-cut file.

Having screwed the four terminals in position, slip on the two arms and see that the slots engage smoothly with their respective terminal stems. Any tendency to bind can be put right by slightly filing the inside of the tight slot. A small ebonite or erinoid knob can be screwed to the centre of each arm as shown.

The supports for the ebonite base are made from a wooden bobbin of the kind that instrument wire is wound on. Select one that is about $2\frac{1}{2}$ in. long over the ends, and cut it across the centre of the core with a tenon saw. File the sawn ends square, and proceed to screw the base of the switch in position on the side of the window frame, having previously made holes in the latter to receive the fixing screws. After passing the screws through the base piece, the half bobbins are slipped on the screws, and on screwing home the latter tightly quite a rigid fixture results.

It will readily be seen that the wooden distance pieces provide ample clearance behind the base for the terminal stems and connections. In making the connections with the various leads, the ends of these can either be placed between washers and clamped by the end nuts, as shown in Figs. 43 and 44, or they can be soldered to the terminal stems before

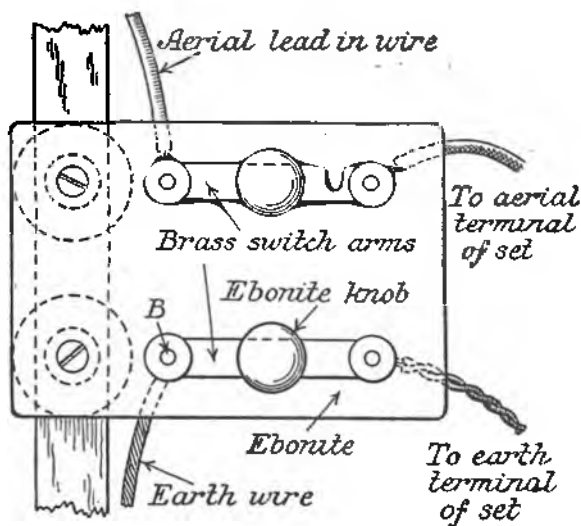


FIG. 43.—A front elevation.

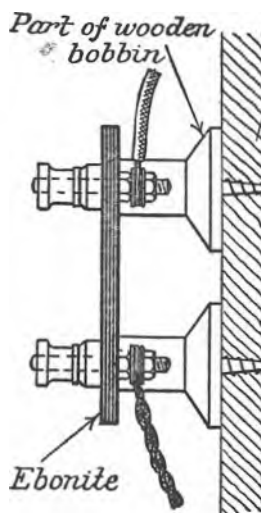


FIG. 44.—A side elevation.

AERIALS

finally screwing the switch in position.

Operation. As shown in the illustration (Fig. 42), the switch is in the earthed position, the receiver being

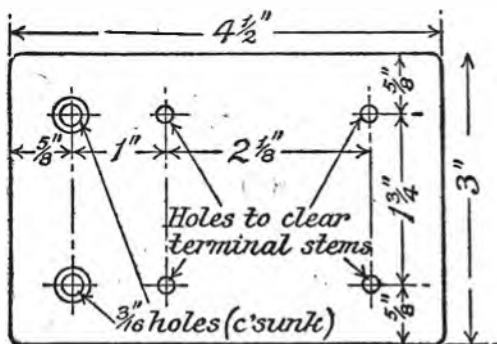


FIG. 45.—How to mark out the Ebonite Base.

completely isolated. When the set is to be used, each terminal head is given a slight turn, and the top switch arm moved round, until the end slot engages with terminal stem (Fig. 43). The lower switch arm is moved upwards until the slot near the end engages with terminal stem B, after which the terminal heads are screwed down.

One advantage of this type of switch is that a positive contact is maintained, not only when the receiver is in use, but also when the aerial is earthed.

It will be noticed, with reference to Fig. 43, that different kinds of wire are indicated leading to the switch terminals. The aerial lead-in wire and the lead to the aerial terminal of the receiver are of heavy rubber-covered stranded wire. The earth wire to the switch is 7/22 copper wire, and the earth lead from the switch to the receiver is ordinary twin flex. This arrangement has been found to work very well in practice, reception being much better than when smaller wire was used.

The Length of the Aerial. If you are situated close to a broadcasting station the aerial need be no longer than 25 ft., and an outdoor aerial under such circumstances is not necessary. In fact, it is desirable to use an indoor aerial if you are using a three-valve set, or a set employing more valves, close to a broadcasting station. The tendency in wireless design is to get rid of the outdoor aerial altogether. Whilst, however, we are compelled to use them, they should be made as efficient as possible, for too often the set is blamed when a poor aerial or a poor earth is at the root of the trouble. An outdoor aerial should be

erected as high as possible, and the earth lead should be as short and direct as possible.

Aerial Types. Figs. 36 to 41 show various systems of aerial erection, from which it should be possible to select a system to meet your particu-

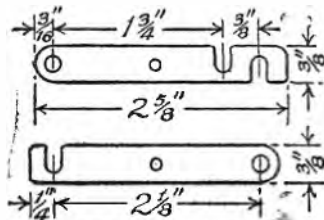


FIG. 46.—Details of the Switch Arms.

lar requirements. The most common forms of outdoor aerials are the "L" type and the "T" type. For maximum volume these aerials should be erected in a direct line with the nearest broadcasting station, if that is the main station one desires to listen-in to. If you are using a twin-wire aerial it is important to ensure that each wire is of the same length,

AERIALS

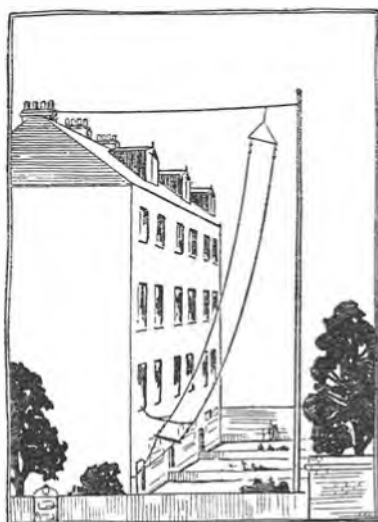


FIG. 47.—Aerial for use in restricted area.

otherwise sharp tuning will be out of the question.

The "T" aerial will receive stations at about equal volume in both directions, that is to say, if the aerial is running from east to west the reception from an eastern station will be equal to that from a western station, proving that the stations are of equal distance from the receiving set. Cage aerials are not advised, as they are of use only for transmission purposes, since they have a very high self-capacity.

Wire for Aerials and Earths. Stranded 7/22 insulated copper wire is best for both aerial and lead-in. It is not generally known that high-frequency currents travel on the surface of the wires; therefore, the more wires included in the aerial, within reason, the greater will be the surface on which these currents can travel and the lower will be the resistance to their passage. The earth should be for preference as short as

possible and, as stated earlier, be of at least the same gauge as the aerial.

The earth should have as low resistance as possible, and to ensure this a soldered connection should for preference be employed.

Useful Hints. The lead-in should be kept as far as possible from any earthed objects. The aerial itself should be situated at right angles to any adjacent telephone wires or overhead tramway cables. If the aerial is fixed parallel to them it will be screened and the reception will be difficult, and the set will suffer from considerable interference.

A vertical aerial, that is to say, one suspended from the top of the pole, is extremely efficient, although it is often not possible to erect a mast of the desired height. It is not necessary to-day to use multiple wire aerials. It is important to note that local authorities object to the erection of an aerial passing over a street or other highway. The electric bell

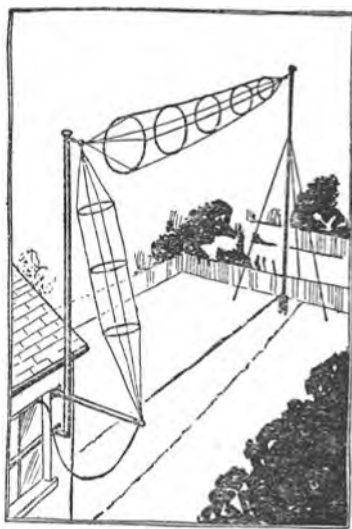


FIG. 48.—Cage-type Aerial.

AERIALS

system may be used as an aerial if a variable or fixed condenser of suitable capacity is connected between it and the set.

The Earth Connection. As already stated, the earth lead should be as short as possible. A main water pipe makes the best earth, but if it is not convenient to make such a connection an earthing tube driven into the soil may be used. It is important with this sort of earth to keep the soil around the earthing tube moist. In any damp district trouble due to dryness will not arise. The connection to the earth tube frequently corrodes and needs periodic attention. When dismantling it scrape the contacting surfaces quite bright, and after re-assembling coat the connection with paint.

It is stressed that the principal feature of the earth connection is dampness, and therefore any chemical or other device which will retain the earth in that connection should be used as a guarantee that the resistance of the earth is low. There are a number of chemicals which may be used for the purpose, the chief of which are sal-ammoniac and ordinary washing soda. A large quantity of either of these commodities buried beneath the earth will ensure that the ground is kept damp. It is, of course, necessary to renew the chemical from time to time.

Another form of earth consists of soldering the earth-wire connection to a sheet of zinc or an old galvanised-iron bath and burying it at least 3 ft. beneath the surface.

Provision should be made for protecting the set from lightning. An aerial and earthing switch may be purchased quite cheaply. If such is not fitted, the aerial and earth terminals should be disconnected from the set, and the two ends twisted together.

Aperiodic Aerial Coil. The effective

length of the aerial can be modified by including a small untuned coil in series with the aerial and earth. This is placed near the secondary coil (which is the coil that is tuned by the tuning condenser), and the signals in this way are induced into the coil instead of being conducted into it. Here is the way to make the coil. Obtain a quantity of No. 26 D.C.C. wire. About 2 oz. will be enough.

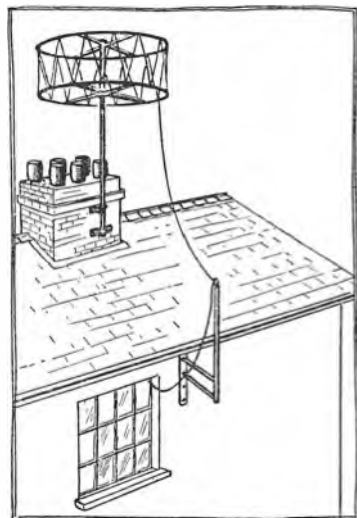


FIG. 49.—Birdcage-type Aerial.

This must then be wound in a hank of the same diameter as the coil to which it is eventually to be coupled. The simplest way to do this is to wind it round a bottle or some similar object and then slip it off afterwards. Wind on a total of thirty turns, making tapping loops at the fifth, tenth, fifteenth, twentieth, and twenty-fifth turns. Now tie this finished hank on to the present coil, and connect one end of it permanently to the earth connection. From the aerial terminal a short length of flex should be connected, and this

AERIALS — ALUMINIUM

must be joined to one of the tapping loops, the particular one to use depending on the degree of selectivity required.

AERIAL TUNING CONDENSER.

—The variable condenser by means of which the aerial tuning inductance (the aerial coil) is tuned to a required wavelength. Usual capacity .0005 mfd. (See also *Condensers* and *Variable Condensers*.)

ÆTHER.—See *Ether*.

A.F.—Audio Frequencies (which see).

AIR CHOKE.—A coil of wire of such a size that it has a large impedance and therefore offers a high resistance to high-frequency oscillating currents, and therefore prevents the passage of such currents. (See also *Chokes*.)

AIR CONDENSER.—A condenser with air space as dielectric, e.g. a variable condenser which is not of the solid-dielectric type. (See also *Variable Condensers*.)

ALPHABET, WIRELESS PHONETIC.—The phonetic alphabet gener-

ally used for wireless telephone call signs is as follows: A, Ack; B, Beer; C, Charlie; D, Don; E, Edward; F, Freddie; G, George; H, Harry; I, Ink; J, Johnnie; K, King; L, London; M, Monkey; N, Nuts; O, Orange; P, Pip; Q, Queenie; R, Robert; S, Sugar; T, Toc; U, Uncle; V, Vic; W, William; X, X-ray; Y, York or Yorker; Z, Zebra.

ALTERNATING CURRENT.—A current whose direction of flow surges first in one direction and then in another, and at a regular period (see Fig. 6).

ALTERNATION.—A complete movement of an alternating-current cycle from zero point of one wave to zero point of the next.

ALTERNATOR.—A type of dynamo in which alternating current is delivered through slip rings, as against the usual method of using a commutator.

ALUMINIUM.—An extremely light and white elemental metal, much used for chassis in commercial receivers. (See also *Chassis*.)

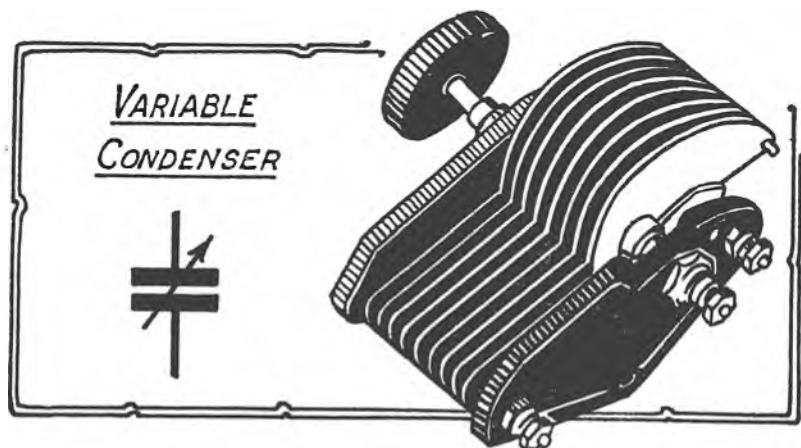


FIG. 50.—Variable Condenser with air dielectric.

ALUMINUM — ANELECTRIC

ALUMINUM.—American term for aluminium.

AMBROIN.—Insulating material consisting of a mixture of fossil copal and silicates.

AMMETER.—An instrument for measuring the current (in amperes) flowing in a circuit. It must be connected *in series* with the circuit. Usual and cheapest type is the moving iron. Other types: the *hot wire* and the *moving coil*, which see. (See also *Meter*.)

AMP.—Abbreviation for ampere.

AMPERE.—The unit of measurement of current. The current which will flow through a resistance of 1 ohm under a pressure of 1 volt. With small currents, such as that taken from a H.T. battery in wireless circuits, the milliamperere is the unit used. This is equal to one-thousandth of an ampere. Even smaller currents are measured in micro-amperes, which equals one-millionth of an ampere.

AMPERE-HOUR.—This unit, chiefly used in connection with accumulators, is equal to 1 coulomb per second for 3,600 seconds, or 3,600 coulombs.

AMPERE TURNS.—The number of turns in the coils of an electromagnet, multiplied by the current flowing through them.

AMPLIFICATION.—In an amplifying valve the overall amplification is to be measured by comparing the signal voltage applied to the grid of the valve with the voltage developed across some piece of apparatus, termed the "load," included in the anode circuit of the valve. By studying Ohm's Law (given on a later page) it will be observed that, for a given value of anode current, the voltage drop across the load will be proportional to the im-

pedance of the load. It would therefore appear that the higher the load impedance the greater the voltage drop across it, and hence the greater the degree of amplification.

To an extent this is correct for the actual formula for the total stage gain in a resistance-capacity coupled stage:

$$\text{Gain} = \frac{\text{Resistance of load} \times \text{amplification factor of valve}}{\text{Anode resistance of valve} + \text{resistance of load}}$$

AMPLIFICATION FACTOR.—The ratio between change in plate current and change in grid potential.

AMPLIFIER.—A valve used in the amplifying stages of a receiver. A complete unit coupled to an existing receiver for increasing its output to the loudspeaker.

AMYL ACETATE.—Chemical compound used for dissolving celluloid; also for making celluloid jointing cement.

ANNEAL.—To soften (a metal) by heating and quenching or heating and gradual cooling. Brass may be annealed by the former method; steel is *hardened* by it.

ANELECTRIC.—Any body unaffected (i.e. does not become electrically charged).

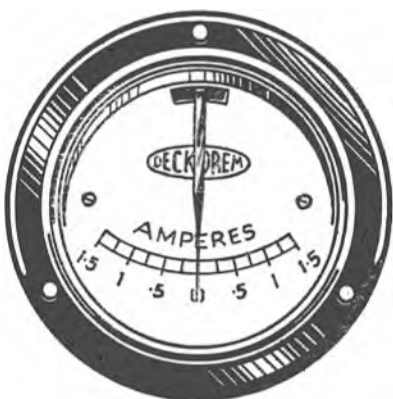


FIG. 51.—Ammeter.

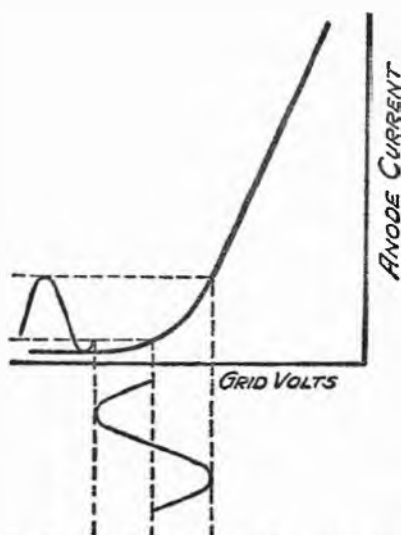


FIG. 52.—Grid Volts-anode Curve for anode bend rectification.

fied) by friction. The reverse of dielectric.

ANODE.—The positive voltaic pole. The point where, or the path by which, a voltaic current enters an electrolyte. The plate of the valve. The opposite of *Cathode*.

ANODE OF ACCUMULATOR.—The negative cell.

ANODE BEND RECTIFICATION.—A process of rectification which depends upon the bend in the lower part of the grid volts-anode current curve. If you examine such a curve (one is always supplied with a valve by the manufacturers) you will see that at the bottom of the curve it tends to become horizontal. The result of applying a large negative grid bias to the valve is to bring the working point to this bend. When oscillations are received by the grid of the valve the anode circuit can only increase at positive half cycles,

no change being recorded (theoretically) at negative half cycles. The result of this is to rectify the incoming oscillations, and owing to the fact that the anode current curve is so steep, a certain amount of amplification also takes place.

ANODE OF VALVE.—Terminal to which high-tension current is applied. The plate of the valve.

ANTENNAE.—Obsolete term for aerial (which see).

ANTINODES.—In a series of oscillations (waves) the points of greatest amplitude. Known also as loops.

APERIODIC.—A circuit which is untuned—or possesses high resistance, thus precluding oscillation.

ARC.—When a current “jumps” an air gap it is said to “arc.”

AREOMETER.—Another term for hydrometer, used to determine the specific gravity of a liquid. Some hydrometers of the “floating-ball” type are practically useless to the accumulator user, as they give no indication when the acid is too strong or too weak. Electrolyte fifty points in excess of the strength specified by the makers is quite sufficient to ruin the plates in most accumulators.

Hydrometer readings can sometimes give a false indication. If, for instance, acid had been added to an accumulator instead of water, a hydrometer reading might incorrectly indicate the accumulator to be fully charged.

To correct such false readings, the accumulator should be placed on charge until the gravity will not rise any higher. The electrolyte should then be adjusted by removing some of the liquid and replacing with distilled water until working strength be obtained.

ARMATURE — ATMOSPHERICS

To adjust low specific gravity, charge until no further rise takes place, then empty out the electrolyte and replace with the correct strength. Charge again until the accumulator gasses freely and leave it so gassing for one hour, and then make any further slight adjustments that may be necessary.

Additional causes of false hydrometer readings are:

- (1) An inaccurate or cracked hydrometer float.
- (2) Taking readings when freshly added water has not had time to mix with the acid.
- (3) Wide variations in electrolyte temperatures.

Hydrometer readings may always be supplemented by means of voltage tests. Use an accurate moving-coil voltmeter, reading 3.0-3 volts, and take all readings while the cells are on discharge. Voltmeter readings taken on open circuit are liable to be misleading. Low voltages registered on open circuit indicate that the cells are exhausted or unhealthy, but high readings do not always mean that the cells are in good condition. (See also *Hydrometer*.)

ARMATURE.—See *Loudspeaker*.

ARMSTRONG.—The circuit employing what is known as the super-

regenerative principle. The constants of the circuit were rather critical, and the arrangement does not function with modern valves. (See also *Circuit*.)

ARTIFICIAL AERIAL.—A non-radiating transmitting aerial. A "dumb" aerial.

ASTATIC.—Being in neutral equilibrium. An astatic coil is one wound in two sections, half the winding being on one coil and half on the other, but wound in the opposite direction. The "field" of each coil is therefore neutralised.

ASTATIC GALVANOMETER.—A galvanometer (which see) having an astatic pair of index fingers or needles.

A.T.C. — Aerial Tuning Condenser.

A.T.I. — The Aerial Tuning Inductance. The aerial tuning coil.

ATMOSPHERICS.—Crackling noises in the receiver. These do not occur in this country except during periods of thundery weather. What is often put down to atmospherics is

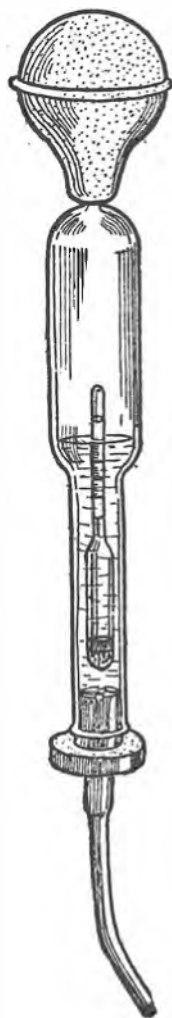


FIG. 54.—Another type of Hydrometer.

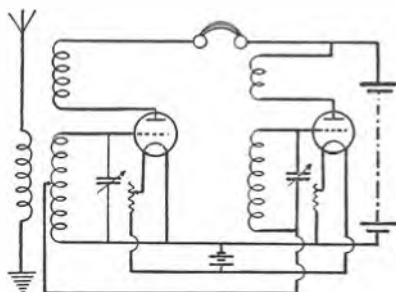


FIG. 53.—The Armstrong Circuit.

ATOM — AUTOMATIC GRID BIAS

nothing more than crackles caused by a worn-out H.T. battery or some faulty or dirty connection in the set. If you have any doubts as to the cause, disconnect the aerial temporarily. If the crackles cease they

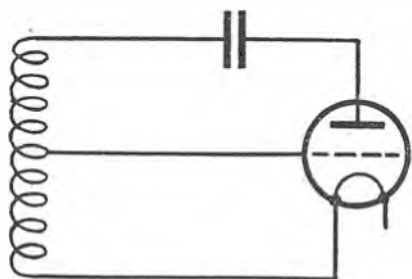


FIG. 55.—Autodyne Circuit.

are due to atmospherics. A cure is practically out of the question at the present time. (See also *Interference and Noises*.)

ATOM.—The smallest part of matter capable of existing alone or in a chemical combination.

ATOMIC WEIGHT.—The weight of one atom of any element, as compared with an atom of hydrogen. Atomic weight of hydrogen is unity.

ATTENUATION.—A lengthening out, or a thinning. The term is applied in wireless to a weakening of the frequency response at the ends of the scales. For instance, if the constants of a circuit are designed in such a manner that the high notes are cut off, we say that the high notes are attenuated.

AUDIO FREQUENCIES.—Frequencies of less than 10,000 cycles per second are assumed to be audible, and so are described as of audible frequency.

AUDION.—The de Forest and Fleming types of valve. The main feature is the second plate, which makes it a rectifier as well as an amplifier.

AUTODYNE.—Where the inductances of the grid and plate are part of a common coil in a circuit, that circuit is of the autodyne type.

AUTOMATIC CALL DEVICE.—An arrangement used chiefly on ships for giving an audible signal when distress calls are made. It usually consists of a selector so designed that when the three letters of the distress signal, S.O.S., are received a bell is rung, even if the operator is receiving a message on another wavelength, or has left the receiver.

AUTOMATIC GRID BIAS.—The object of biasing a valve is to render the potential of the grid less than that of the cathode, that is, the filament in battery-fed valves. With ordinary battery bias, the cathode is at a potential equal to the potential at the negative end of the high-tension supply, and by connecting the positive pole of the grid-bias battery to the same spot, the grid potential is equal to the voltage of as much of the grid battery as is included in the grid circuit. In order to bias the valve, it really does not matter in the least whether the cathode is at zero voltage and the grid at some negative potential, or whether the grid is at a zero potential and the cathode at some positive potential. This latter condition is that which usually obtains when automatic bias is used. In most of these arrangements, the grid is maintained at the same potential as the negative terminal of the high-tension supply, while the cathode is raised to a higher potential by the inclusion of a resistance in the lead connecting the cathode to the high-tension negative terminal.

Voltage Drop. This will be made clear by a reference to Fig. 56, which shows the essential connections for automatic bias to an indirectly heated low-frequency output valve. In this

AUTOMATIC GRID BIAS

diagram, certain refinements, such as the decoupling arrangements, are omitted for the sake of simplicity. It will be seen that the full high-tension voltage exists between the points A and B, the point B being at zero potential. It is obvious, therefore, that there will be a drop of voltage, equal in all to the total high-tension voltage, along the complete valve circuit. This drop of voltage will consist of three portions: (1) the drop across the load in the anode circuit (*i.e.* the output choke); (2) the drop across the cathode-anode path of the valve (*i.e.* between the points C and D); and (3) the drop across the biasing resistance (*i.e.* between the points C and B).

Thus, the point A is at a higher potential than point D; D is at a higher potential than the point C; and C is at a higher potential than point B. But the grid of the valve is connected to point B, so that the point C, the cathode, is at a higher potential than the grid, or, in other words, the grid is at a lower potential than the cathode, which is the condition desired for successful operation.

Advantages of Automatic Bias. The advantages of automatic or self-biasing are many. In the first place, if the value of the biasing resistance is correctly calculated, there is no possibility of under biasing or over biasing the valve. Also the biasing resistance automatically controls the value of the anode current, for should the anode current rise, due, perhaps, to an increase in anode voltage, the drop through the biasing resistance will rise in proportion, the negative bias will be increased, and the anode current again reduced to its normal value. Further, the biasing resistance does not deteriorate as does a grid-bias battery, does not vary in value, and needs no replacement. If desired, the biasing resistance can be

made variable, or semi-variable, so that adjustments can be made while the set is in operation, without any risk of an abnormal rise in anode current.

There is, of course, one slight disadvantage. Any biasing voltage applied in this way is definitely subtracted from the total H.T. voltage. However, this makes no practical difference to the efficiency of the average mains set where 200 or 250 volts H.T. is available from a mains

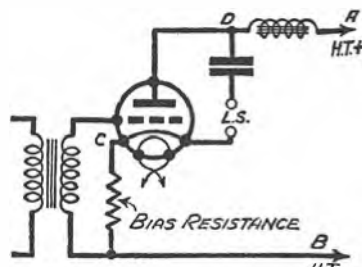


FIG. 56.—A Resistance inserted in the cathode lead of an indirectly-heated valve.

unit, and the maximum bias voltage required does not exceed 20 or 30 volts. In the case of some of the bigger output valves, however, which are designed to operate at about 400 volts on the anode, as each valve requires over 100 volts grid bias, the loss, if this amount of bias were subtracted from the available 400 volts H.T., would be serious. In this case, therefore, it is necessary to design the high-tension unit to give an output voltage equal to the normal anode voltage plus the bias voltage.

Biasing Resistance. Biasing resistances generally should be of the wire-wound type, and must be capable of carrying the full anode current of the valve continuously without overheating. In the case of early stage low-frequency amplifiers and screened-grid valves, ordinary spaghetti re-

AUTOMATIC GRID BIAS

distances are quite suitable, but for output valves, where a certain amount of preliminary adjustment of grid bias is usually necessary, it is advisable to use a variable resistor, or, preferably, a fixed resistor and a variable resistor in series. This allows of adjustment, but at the same time prevents the valve from being run entirely without bias if, by mistake, the variable portion is reduced to zero. For variable- μ valves, where continuously adjustable bias is required, the resistance must naturally be of the variable type. The cal-

anode current being 30 milliamps. The correct resistance for self bias would be 32 multiplied by 1,000 and divided by 30, or 1,066.6 ohms. Actually, a total resistance of 1,250 ohms would be used, consisting of a 750-ohm fixed resistor in series with a variable resistor of 500 ohms maximum.

Decoupling Resistance. In addition to the biasing resistance itself, certain additional apparatus is usually required, by way of decoupling. If the anode supply is not efficiently smoothed, and a bad mains ripple is present, there is a risk that this may be transferred to the grid by the bias arrangement, when the anode current will be correspondingly modulated, and serious mains hum result. Moreover, there is always a chance that the biasing circuit may pick up mains hum from some other part of the apparatus, while any other low-frequency component in the anode current will have a similar effect. To reduce this risk, a grid decoupling or smoothing circuit may be employed. This consists of a high resistance, usually of about 50,000 ohms, included in the grid return, and bypassed to the cathode through a condenser which, in the case of most low-frequency valves, should be of 2 mfd. capacity.

Such decoupling is not essential, but should be added without hesitation if serious hum is noticed. The condenser value of 2 mfd. is ample, and in many cases, especially in early low-frequency stages, 1 mfd. may be sufficient. On the other hand, where a very bad hum is present, especially if the output valve is a pentode, it may be necessary to use a 4-mfd. condenser for decoupling the bias to the last valve. Different designers prefer different arrangements of the auto-bias circuit, but the circuits given are tried arrangements, and quite suitable for the types of valves

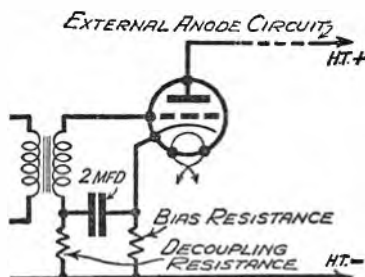


FIG. 57.—The arrangement of Fig. 56 with a Decoupling Circuit added.

culcation of the correct value of biasing resistance is a simple matter, and is merely the application of Ohm's law. The formula is:

Value of biasing resistance in ohms =

$$\frac{\text{Desired bias in volts}}{\text{Anode current in amps.}}$$

As the anode current is usually expressed in milliamps., the value of the biasing resistance is found by multiplying the desired bias voltage by 1,000 and dividing by the anode current in milliamps.

As a typical example, take an output valve requiring a grid bias of 32 volts at full anode voltage, the

AUTOMATIC GRID BIAS

for which they are recommended. Fig. 57 is the complete arrangement for an early stage indirectly heated L.F. amplifier, such as the input valve of a gramophone amplifier. It may also be employed where the de-

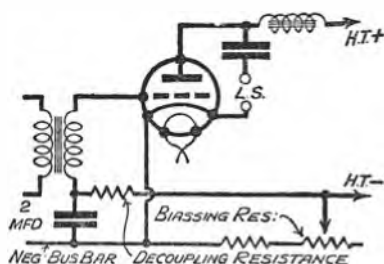


FIG. 58.—An alternative arrangement of Fig. 57, in which the cathode is maintained at the normal negative potential.

tor valve of a receiver is required to act also as first low-frequency amplifier with a pick-up.

Precisely the same arrangement may be used for a pentode output valve of the indirectly heated type, but for three-electrode output valves a slightly different system is preferable. For a triode, the value of the biasing resistance is usually of the same order as the resistance of the load, and the loss of power in the biasing resistance, if this resistance were included in the load circuit, would be serious. This is avoided in the circuit shown in Fig. 58, where the cathode is maintained at the common potential of the set, and a negative potential given to the grid by the biasing resistance connected between the common negative wire and the H.T. terminal.

Fig. 59 gives the variant of this circuit for use with

a directly heated triode or pentode output valve, a connection between the common negative wire and the centre-tap of the filament winding taking the place of the cathode lead in Fig. 58. For screened-grid high-frequency valves, the circuit is as shown in Fig. 60. This arrangement is similar to that in Fig. 56, but the decoupling arrangement for the high-frequency valve consists merely of a $\cdot 01$ -mfd. high-grade fixed condenser.

For Portable Sets. It should not be forgotten that automatic bias can just as simply be applied to battery-operated receivers. In general it is not economical, for the bias is definitely subtracted from that of the H.T. battery. Still, for portable sets and other special purposes, it has the advantage of compactness and light weight. The essential circuit is shown in Fig. 61. Here a wire-wound resistance capable of carrying the total H.T. current of the set is connected between H.T.— and L.T.—, and thus biases the output valve. It may be made variable for purposes of adjustment, and may also be suit-

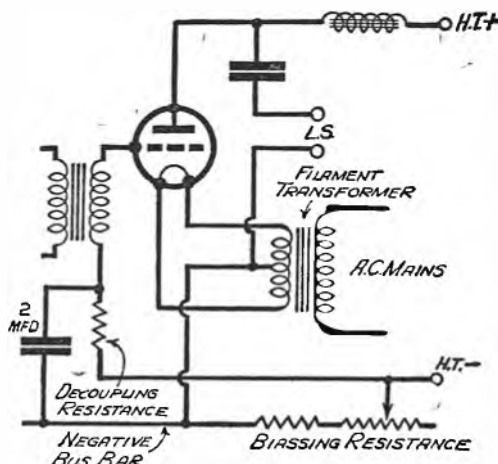


FIG. 59.—A Battery-heated Valve arranged in the same manner as Fig. 58.

AUTO TRANSFORMER — BAND-PASS TUNING

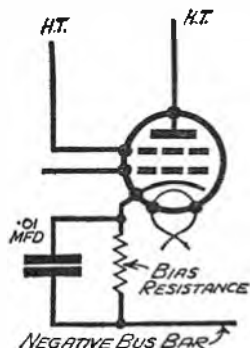


FIG. 60.—The Biasing Resistance arranged in the cathode lead of a S.G. valve.

ably tapped to provide bias to other stages. The value of the total resistance and of the intermediate tapings can be calculated in the way already described, and any home constructor can easily construct a suitable resistance unit, either by connecting spaghetti resistors in series, or by winding the resistance with high-resistance wire.

AUTO TRANSFORMER.—A transformer which is direct coupled.

AUXILIARY ANODE.—The third electrode of a valve—the grid.

B

B.A.—British Association — the screw-thread system used by the wireless and electrical industries.

BACK E.M.F.—Back or opposite electro-motive force. Back E.M.F. in an accumulator or battery is due to polarisation. Produced in a circuit by self-induction due to varying input current.

BAFFLE BOARD.—A board on which is mounted the cone of the cone-type of loudspeaker. Its use is to bring out the bass notes.

BALANCING CAPACITY.—A n y

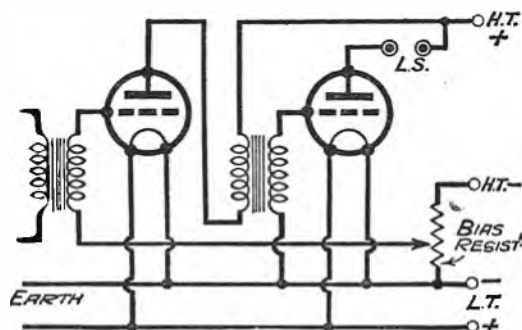


FIG. 61.—A common Resistance connected up to provide bias for two battery-heated valves.

artificial or capacity earth. Extra capacity inserted in the aerial circuit to replace the earth.

BALLISTIC GALVANOMETER.—

An instrument for measuring condenser discharges and similar currents of short duration.

BAND-PASS TUNING.—A system of tuning giving a high degree of selectivity. The regional broadcasting scheme has provided listeners in most parts of the country with alternative programmes, but in very many cases it is now impossible on the older types of receiver—especially those consisting of a simple detector, either alone or followed by L.F. stages—to separate the different stations. Wave-traps, in the majority of cases, serve a useful purpose in cutting out one station, but usually this is only carried out at a sacrifice of signal strength, and with receivers of the kind mentioned this is a great drawback. The best way out of the selectivity difficulty is undoubtedly by means of a two-circuit tuner, and provided this is arranged in a certain manner, practically no loss of signal strength is occasioned, but the separation of the stations can be reduced to that which is used by the transmitting stations of Europe, namely, 9 kcs.

There are three ways of arranging this band-pass tuning circuit, the differences being in the manner of coupling the two tuned circuits. For the aerial circuit, a coil of the ordinary size is tuned by a condenser as is usual, and a similar arrangement is used in conjunction with this tuned

tuning inductances. A combination of these two devices, with the coupling inductance arranged in a negative manner, produces the best signal strength, combined with the best selectivity, and this is the arrangement which is incorporated in the better commercial types of band-pass tuner. (Refer to Fig. 64.)

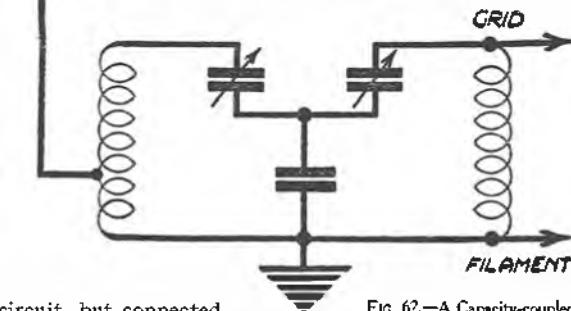


FIG. 62.—A Capacity-coupled Band-pass Tuner.

circuit, but connected in the grid circuit of the valve. The two tuning condensers may be ganged—that is, joined together on the same spindle so that the disadvantage of using two condensers is overcome by using only one tuning dial. To connect these two tuned circuits together, in some cases a fixed condenser having a value of .01 is used (Fig. 62). The drawback to this arrangement, however, is that the ganging of the two circuits does not hold over the entire range of the coil. This means that if a local station is tuned in at either end of the tuning dial, there will be a loss of strength due to unequal tuning on one of the stations.

In some cases an inductance or resistance is used to couple the circuits (Fig. 63), but this generally results in a loss of signal strength due to the coupling inductance being affected by the two

For the simpler detector types of receiver, especially for those listeners living very close to a main station, it is well worth employing. For instance, in the London area, near Brookman's Park, the two London stations can be easily separated, and

there are twenty or thirty degrees of complete silence between these stations on a .0005 tuning dial, which means to say, that if the receiver is sufficiently sensitive a number of foreigners are easily receivable during broadcasting hours in between these London stations, with no background whatsoever.

BANK.—A bank of condensers. A number of condensers self-contained

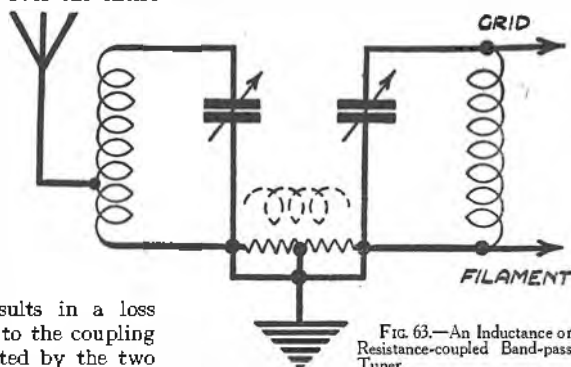


FIG. 63.—An Inductance or Resistance-coupled Band-pass Tuner.

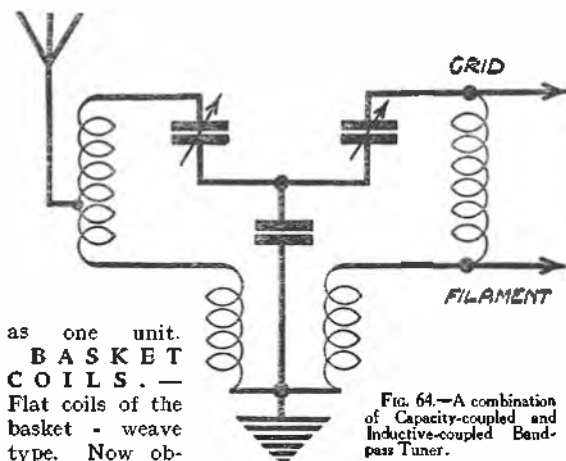


FIG. 64.—A combination of Capacity-coupled and Inductively-coupled Band-pass Tuner.

as one unit.
BASKET COILS.—Flat coils of the basket-weave type. Now obsolete.

BATTERY ELIMINATOR.—A device for connection to the house supply mains for obtaining high-tension supplies without the use of dry batteries. For D.C. supplies, this simply consists of a smoothing circuit and appropriate voltage-dropping resistances. The smoothing circuit consists of an iron-core choke having a large inductance value, and a large-capacity condenser joined across the smoothed side of the mains leads. For A.C. supplies it is necessary to rectify the alternating currents, and therefore some form of rectifying circuit is included before the smoothing circuit. For rectifying purposes it is possible to use metal rectifiers or valve rectifiers. The metal rectifier consists of a combination of metals which permit of a flow of current in one direction only, and the valve rectifier consists of a valve with two, or three, electrodes. The two-electrode valve gives "half-wave" rectification, and the three-electrode gives "full-wave" rectification. (See also *Eliminators*.)

BEAM WIRELESS.—A process in which ultra-short wavelengths in conjunction with directional aerials are

used. The result of this combination is to direct the wireless signals in a narrow channel instead of giving an equal radiation in all directions. Owing to this, only a very small power is necessary to cover large distances, as all the energy takes one line, which may be made to be a direct one from the transmitter to the receiving station.

BEAT RECEPTION.—One method

of detecting signals by making them interact with artificially produced oscillations, local to the receiver, but of different and higher frequency. This gives rise to a "beat," which represents the difference between the two frequencies.

BELLINI TOSI AERIAL.—A double-frame aerial, having the two sections arranged at right angles. This is wired up in such a manner that it is extremely directional, and is therefore used for direction-finding purposes.

B.E.M.F.—Back Electromotive Force.

BERNE BUREAU.—The broadcasting stations of Europe are subject to certain regulations laid down by a governing body having its headquarters in Berne. The most important duty of this body is that of settling the wavelength of each station, and this is done in such a way that no station may use a wavelength which is closer than 10 kcs. to any other station. Kilocycles equal the frequency of the oscillations, as distinct from the distance separating the peaks of the oscillations, this latter being measured in metres.

BICHROMATE CELL — BLUE PRINTS

BICHROMATE CELL.—A cell containing two plates or rods of carbon which are immersed in a solution of sulphuric acid, bichromate of potash, and water, with a zinc plate between the two carbon plates. Such a cell yields 2 volts, and is of low resistance (Fig. 65).

BIFILOR WINDINGS.—Windings which are non-inductive.

BILLI.—A synonymous term for millimicro (one billionth).

BILLI CONDENSER.—A tubular condenser consisting of two telescopic tubes—one metal and the other of an insulating material with a metallic lining. Used in the aerial lead. A series aerial condenser.

BINDING POST.—An American term for a terminal.

BINDING SCREW.—The American term for a terminal.

BIPOLAR.—Possessing two poles.

BLATTNERPHONE.—A system of recording sounds by means of the magnetic properties of steel. The apparatus consists, in essentials, of a powerful electro magnet with the two poles arranged opposite each other and with only a small gap separating them. At each end of the machine are two spools, one of which contains a length of thin steel tape. This is taken across through the gap of the magnets and so to the other reel or spool. The tape then feeds from one spool to the other when the mechanism is set in motion, in the same manner as a typewriter ribbon. The sounds which are to be recorded are fed into the electro magnet in the same manner as the wireless signals are applied to a loudspeaker, and the resulting magnetic variations are impressed on the steel tape. As soon as the sounds are recorded they may be reproduced by passing them back through a magnetic system in the same manner.

It is claimed that the results are quite permanent, and this is the apparatus which is employed by the B.B.C. for recording important items for re-transmission.

BLOCK CONDENSER.—A number of fixed condensers connected together. A bank of condensers.

BLOCKING CONDENSER.—A term which was employed in the early days of broadcasting for a "by-pass condenser."

BLUE GLOW.—A valve gives rise to the blue glow when excessive current is flowing from plate to filament. Blue glow also signifies that the valve is "soft"—that is, not completely exhausted of air.

BLUE PRINTS.—A photographic copy of a drawing. Probably the quickest way of building a set exactly to specification is to use a full-size blue

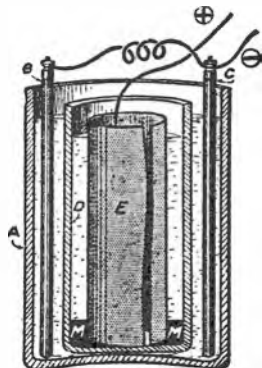


FIG. 65.—Section of the Bichromate Cell.

print. Although primarily intended for the guidance of the beginner, there is no doubt that even the expert home constructor will find his work greatly speeded up by using a blue print instead of relying on the usual small wiring diagram. Besides that, there is the question of accuracy. With some modern receivers of very compact design the accurate positioning

BLUE PRINTS — BOOSTER

of the components is of utmost importance.

First stand the components which are to be mounted on the baseboard direct on the blue print and have a good look at it. This will give you some idea of what the finished thing will look like, besides showing you if you have forgotten any of the parts. You can now either take them all off and stand them on the baseboard in approximately their right positions, and then make the final adjustments by careful measuring from the blue print, or you can stand them on the table while you mark the positions by placing the print on the baseboard and pricking through it with a sharp bradawl. The latter method is perhaps the better so long as you make the marks clear. The same method can be employed with the panel.

It may be that some of the components you are using are not the same make or quite the same pattern as those shown on the blue print. You may be using the alternatives to those specified in the list. In this case it is usual to mount the components with the terminals in as nearly the same position as those shown on the print. This may mean turning the component round. However, in the case of unshielded coils or chokes it is better to lengthen or shorten the leads rather than alter the position of the components in relation to others.

Do not necessarily mount all the components right away. If they are at all crowded you will find it best to fix them one by one, and complete as much of the wiring as possible each time. In the case of sets employing under-baseboard wiring, all holes for the wires to pass through should be drilled before mounting the components. In sets of this type you will usually find the underside of the baseboard will have to be

marked out as well as the upper. Any skirting to the baseboard should be fixed last of all. As you wire each component, cross off the corresponding wire shown on the blue print. When you have finished, all the wires should have been marked off. If any are not you know you have missed them out. At this stage, however, you will not have crossed them all off, since you still have to fix the panel to the baseboard and wire up any final points between the two. This is the best method, as if all the components and panel are in position first it is such a fiddling business making connections in the corners. The set also becomes unwieldy.

Do not spread your blue print on the baseboard and panel and fix the components directly on top of it with the idea of tearing it away when the parts are all fixed. It is difficult to clear it away properly from between each component. Also you will most likely want it as soon as it has been "scrapped." When drilling holes for chassis-type valve holders, etc., do not drill straight through from one side, but turn the work over as soon as the point of the bit comes through and drill from the underneath. This will give a clean edge to the hole. Do not be in a hurry to drill your panel till you have made certain that the components you are using will not foul one another. Alternative components may, for instance, need positioning slightly differently from those shown on the blue print.

BOARD OF TRADE UNIT.—1,000 watt-hours.

BOLOMETER.—A particular type of Wheatstone Bridge possessing quickly-heating resistance.

BOOSTER.—The booster is a piece of electrical apparatus for increasing voltage. A dynamo wired in series with it superimposes or

BOOSTER

adds its voltage to that of the mains. All methods of accumulator charging have certain drawbacks, which the booster entirely eliminates. For example, in electrical equipment, in which the battery is simultaneously on charge and discharge, the accumulator is arranged to be supplied from a shunt-wound dynamo, a portion of the current from which will pass to the lamps. Assume that the generator in such an installation gives 50 amps., and that the accumulator

lighting circuit irrespective of whether the battery is on charge or not, for the booster will impose its voltage sufficiently to charge all of the cells of the accumulator simultaneously and at an equal rate. A great advantage is immediately obvious, for it will not be necessary to run the generating plant to charge the battery so that, say, it can be used at night.

Another type of booster is the automatically reversible, and it is chiefly

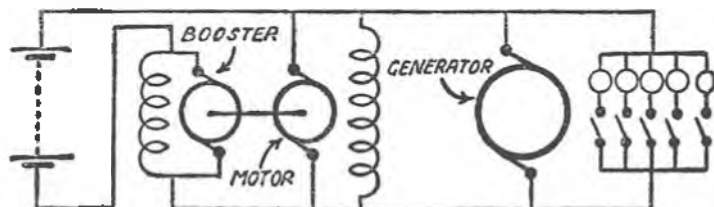


FIG. 66.—Circuit diagram showing how the Booster is connected.

is distributing 20 amps. to the circuit. It will readily be seen that the end cells will be charged at the normal rate, but the 20 amps. imparted to the circuit must be subtracted from the normal charging rate of the cell interposed between the negative end of the accumulator and the particular cell wired to the discharge switch. It follows that 80 per cent. of the cells will be charged at 20 per cent. lower rate than the remainder. For this reason the life of such cells is comparatively short. The booster entirely gets rid of this trouble.

A booster suitable for accumulator charging can conveniently consist of a shunt motor driving a shunt-wound dynamo. It may also consist of a small shunt-wound dynamo driven from an extension of the shunt motor shaft. It functions in the following way: the constant voltage generator will supply the amperage for the

used where an electrical load is imposed which is subject to considerable variations up or down. Such a case would be in starting an electric crane or a tramcar, and in such cases the plant must be capable of an output sufficient to deal with the heaviest current drain. The period between the load, therefore, necessitates running the plant very much below its maximum capacity. By connecting an accumulator in parallel with a shunt dynamo the latter would be aided by the discharge of the former when the voltage of the shunt dynamo dropped on account of electrical load. Pursuing this point further, it will be seen that once this load is imposed the voltage of the accumulator would also drop, thus rendering necessary some further aid. This assistance is forthcoming in the form of the reversible booster, which, wired in series with the accumulator, will increase the voltage to an amount equal

BOOSTER — BREAK THROUGH

to the voltage drop of the battery. This it does automatically and thus maintains at a constant voltage the booster and battery system.

Another type of reversible booster

versible, and the chief features of it are the carbon piles which act as regulators. A lever is situated between these two sets of piles, and a soft iron core is attached to one end of the lever. A solenoid surrounds the iron core. A spring is secured to the opposite end of the lever, the tension of which is adjusted to counteract the pull of the solenoid. Any required load on the generator can thus be adjusted to a nicety. Any variations cause a change in the carbon piles which, varying the resistance, thus controls the degree of field excitation in the booster. For example, if the electrical pull of the solenoid on the

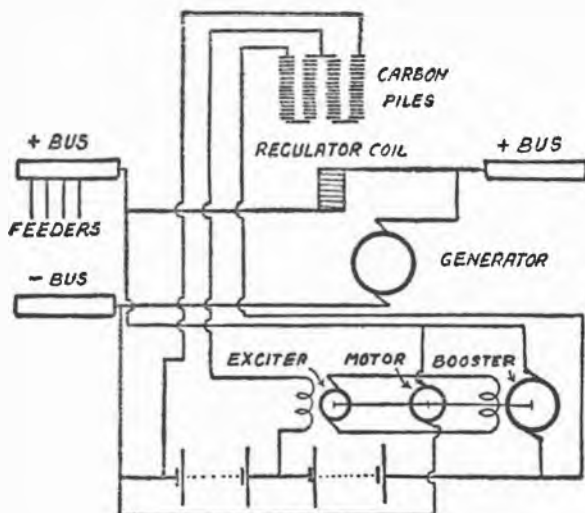


FIG. 67.—Arrangement of Automatic Reversible Booster.

depends for its operation on variations in its output and not at all on variations in dynamo voltage. It is claimed that this type maintains a more even load than the former. The diagram shows one of the most popular systems in use, known as the Entz. It consists of three cheap parts—the booster, the exciter, and the motor itself. The complete plant as sold is fixed to one bedplate casting. An examination of the diagram indicates a divided busbar, and between this division is placed the coil which carries the generator current. In series with the main busbars is connected the booster armatures, and the battery is connected to the chief busbar. Only one field coil is fitted to the armature of the booster.

The Entz booster is instantly re-

lever causes a deflection or extension of the spring, a compression and release of the carbon piles will take place, and if the spring conquers the thrust of the solenoid there will be a reversal of direction of excitation.

BORNITE.—An ore of copper. One of the elements of the Bornite-Zincite crystal detector.

B.O.T.—Board of Trade.

BRAUN TUBE.—The original name given to the Cathode Ray Oscillograph, a device for producing visible indications of oscillating currents. (See also *Cathode-ray Oscillograph*.)

BREAK THROUGH.—A troublesome form of interference sometimes met with in dual-range coils. It is the breaking through of one or more

BREAK THROUGH

powerful medium-wave local stations on to the long waves. In extreme cases the station or stations on the medium waves which are causing the trouble can be heard all over the dial when the set is switched on to the long waves. Usually, however, it is not quite so bad as this, the interference being most noticeable at the lower end of the tuning dial and very gradually decreasing towards the upper end.

Curiously enough, the cause of the trouble is usually due to an attempt on the part of the designer of the coil to obtain selectivity on the long-wave band. In order to do this it is usual to employ either a separate aerial coil of comparatively few turns coupled to the long-wave grid coil, or to tap the long-wave coil near the earthed end. This, of course, gives the desired selectivity as regards the long-wave stations themselves, but introduces break through with it from the medium waves.

Examine the diagram (Fig. 68), which shows a typical dual-range circuit. In this case when the switch

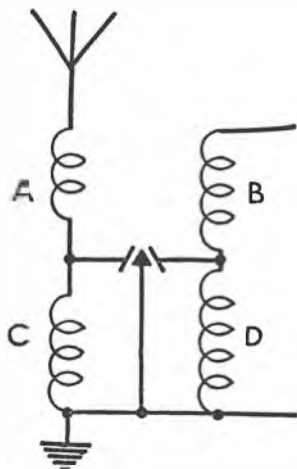


FIG. 68.—Circuit of a Dual-range Coil with which break through may occur.

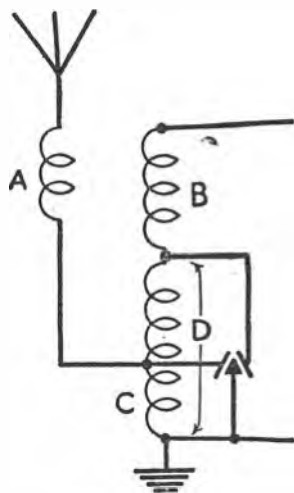


FIG. 69.—Another typical Dual-range Circuit.

is in the "in" position the medium-wave circuit consists of an aerial, or primary coil A, of from five to fifteen turns, and a grid, or secondary, coil B, coupled to it of about sixty turns. When the switch is "out" the windings C and D are included in series with A and B respectively so as to bring the total inductance up to that required for tuning in the long-wave stations. Now C may consist of twenty or thirty turns, and this, together with A, gives an aerial coil of about forty turns. This winding is not of itself very selective, and being of about the right wavelength, brings in the powerful medium-wave local sufficiently strong to impose the signal on to the grid coil BD. In other words, the medium-wave station "breaks through." In the case of the circuit shown in Fig. 69, which is another popular arrangement for a dual-range coil, the effect is similar. Here the long-wave primary circuit consists of windings A and C, but C this time is not a separate coil, but a tapped portion of D. The prac-

BREAK THROUGH

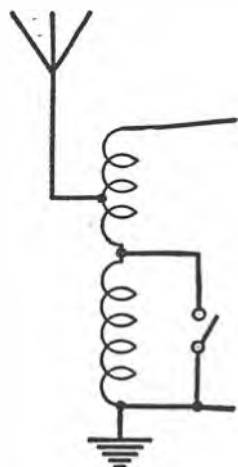


FIG. 70.—A very common circuit employed in commercial coils. Break through does not occur, but it is unselective on the long waves.

Fig. 70 shows a very popular circuit much used in commercial coils where only the medium-wave winding is tapped, but here, of course, there is no attempt at selectivity on the long waves. With the circuits given in Figs. 68 and 69 there are two courses open. One is to raise the natural wavelength of AC *above* the medium wave and the other is to take it well *below* it. The usual practice is to raise it. Fig. 71 shows one method. This consists of introducing a separate coil E in series with A and C. This raises the wavelength of the primary circuit sufficiently high to clear the medium band and at the same time does not decrease the selectivity. The coil E should consist of about fifty or sixty turns, and should be placed a little way from the tuning coil or with its axis at right angles to that of the tuning coil so as to prevent interaction. Screening is hardly necessary unless space is very limited. The design of the coil is not critical, and

pile winding is quite suitable, especially as this method tends to limit the external field. Fig. 72 shows a very simple and effective method which can be applied to the circuit of Fig. 68. A fixed condenser of .0003 mfd. or .0005 mfd. is placed across C. This again increases the wavelength of the aerial coil without increasing the coupling. In this way the selectivity on the long waves still remains good.

Taking the wavelength of the aerial winding *below* the medium band is not generally considered good practice, since it can only be done by making both A and C very small, and this naturally increases the selectivity on both the medium and the long waves to a degree which is not always desirable. However, it has been found that where great selectivity is necessary this method is admirable. The circuit is precisely the same as in Fig. 71, but A consists of about five turns tightly coupled to B, that is, wound on top of B, and C is a tapping of about fifteen turns.

There is one advantage in this

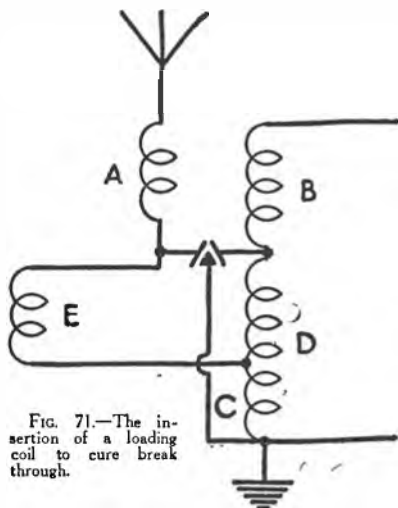


FIG. 71.—The insertion of a loading coil to cure break through.

BREAK THROUGH — BRITISH SYSTEM

method, and that is, there is no fear of trouble arising through the use of a condenser in series with the aerial as a selectivity control. It sometimes happens that when reducing the setting of such a condenser a

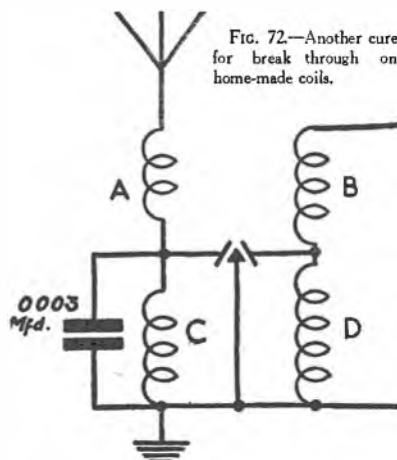


FIG. 72.—Another cure for break through on home-made coils.

point is reached where break through occurs. This is because the natural wavelength of the primary circuit, which in the particular coil used would normally be well above the break-through range, is lowered sufficiently to bring it into the danger zone. Obviously, this cannot occur with the second method, since the natural wavelength of the primary circuit is already below the medium-wave band, and the reducing of the condenser setting would only tend to lower it still further. Where, however, trouble of this sort does arise, the only cure is to increase the setting of the series aerial condenser and make up for the reduced selectivity by decreasing the coupling between the primary and secondary circuits. If the coil is a home-made one, this can easily be arranged, either by reducing the number of turns in the tapped portion C, in the case of Fig.

69, or by placing the windings C and D farther apart, in the case of Fig. 72.

BRIDGE.—A Wheatstone Bridge.

BRIDLE.—The rope which is attached to each end of a spreader for suspending an aerial.

BRITISH ASSOCIATION SCREW THREADS

(See also *Screws and Wood Screws*)
(Dimensions in Millimetres)

$$\text{Formula} \begin{cases} p = \text{pitch} \\ d = \text{depth} = p \times 0.6 \\ r = \text{radius} = \frac{2 \times p}{11} \end{cases}$$

No.	Pitch mm.	Outside Diameter mm.	Pitch Diameter mm.	Root Diameter mm.	Tap Drill Size.
0	1.00	6.0	5.400	4.80	7
1	0.90	5.3	4.760	4.22	16
2	0.81	4.7	4.215	3.73	22
3	0.73	4.1	3.660	3.22	29
4	0.66	3.6	3.205	2.81	31
5	0.50	3.2	2.845	2.49	37
6	0.53	2.8	2.480	2.16	43
7	0.48	2.5	2.210	1.92	46
8	0.43	2.2	1.940	1.68	48
9	0.39	1.9	1.665	1.43	54
10	0.35	1.7	1.490	1.28	54
11	0.31	1.5	1.315	1.13	56
12	0.28	1.3	1.130	0.96	59

BRITISH BROADCASTING STATIONS

Kcs.	M.	AW.	Station.
193	1,554.4	30	Daventry National.
625	480	50	North Regional (Manchester).
752	398.9	25	Midland Regional.
797	376.4	50	Scottish Regional (nr. Falkirk).
853	356	50	London Regional.
995	301.5	50	North National (Manchester).
1,040	288.5	1	Bournemouth.
		0.12	Plymouth.
		50	Scottish National (nr. Falkirk).
		0.12	Swansea.
1,147	261.6	50	London National.
1,400	214.3	1	Aberdeen.
1,420	211.3	1	Newcastle.

BRITISH SYSTEM OF UNITS.—

The foot-pound-second system

B.T.U. — CABINET CONSTRUCTION

(F.P.S.). The work done in raising 1 pound 1 foot in 1 second.

B.T.U.—British Thermal Units.

BUS BAR.—A bar connecting several cells or pieces of apparatus. An omnibus bar.

BUZZER.—A smaller trembler coil of similar design to an electric bell. Chiefly used for testing circuit continuity. The buzzer portion is a make-and-break arrangement.

B.W.G.—Birmingham Wire Gauge.

BY-PASS CONDENSERS.—A condenser inserted in a circuit to provide an alternative and easy path for some frequency which it is desired should not proceed to other parts of the circuit. A good illustration is in a decoupling circuit, where a resistance is inserted in the anode lead to prevent the passage of H.F. currents, and at the high potential end of the resistance a fixed condenser is joined to provide a bypass, or easy path, for these H.F. currents. This condenser is joined direct to the earth connection of the receiver.

C

CABINET CONSTRUCTION. —

The actual size is, of course, ruled

by the dimensions of the set itself, and it is impossible to begin until this has been decided upon. Then there is the material to use. Gener-

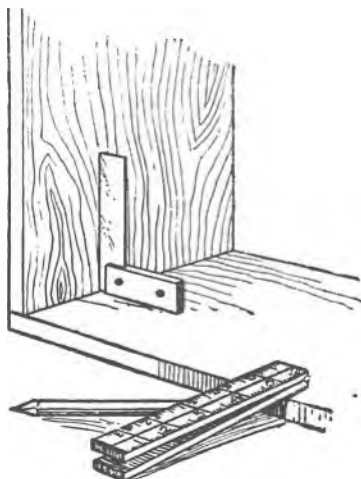


FIG. 74.—Test your wood and angles with a square and ruler to ensure accuracy.

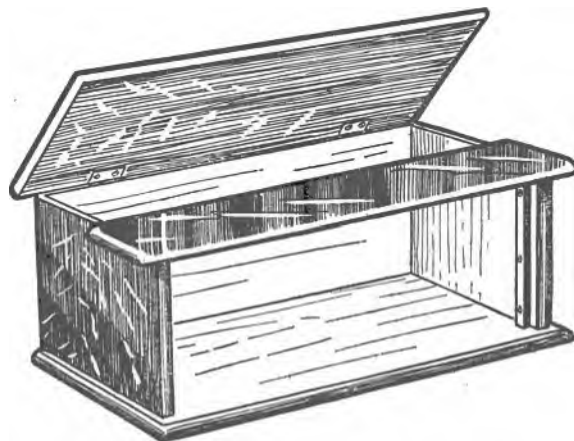


FIG. 73.—The American style of Cabinet.

ally speaking, cabinets are in either oak or mahogany, and boards of these materials are easily obtainable at quite reasonable cost. Either of these, too, is suitable for staining and polishing and finishing off like a normal piece of furniture, so it is merely a matter of personal taste as to which is used. The boards should be $\frac{3}{8}$ in. thick for the smaller sets—say, with a panel of 10×7 in.—and $\frac{1}{2}$ in. thick for the larger ones. The simplest method of construction is shown by the cabinet illustrated in Fig. 73, where it is seen that the two sides and a back are fixed to a baseboard and have a lid above. The open

CABINET CONSTRUCTION

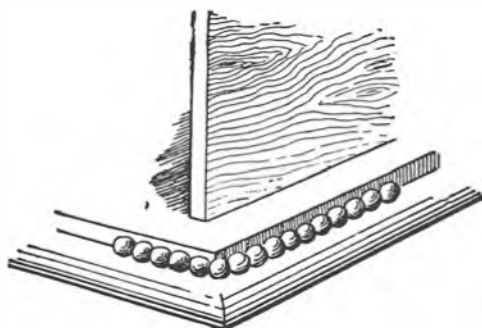


FIG. 75.—The base is improved by the addition of beading glued in the corner angle of the two parts.

front, of course, provides the space filled later by the panel.

Overlapping Parts. The base and lid, it will be noted, overlap the sides about $\frac{1}{2}$ in., and this allows the edges of the former parts to be rounded off nicely, at the same time reducing the possibility of the nails or screws splitting the material. The size of the panel is the inside measurement between the ends, the lid, and the base, and the depth will be the same as the width of the baseboard, plus the thickness of the ebonite panel on the front. The back of the set can

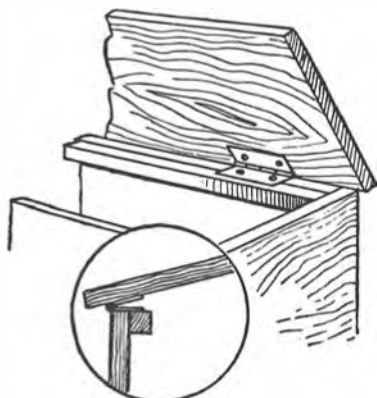


FIG. 76.—This is the simplest method of fixing the lid by means of hinges. The detail shows the extra strip for strength.

well be plywood, as that will not be seen, and, in marking it out, remember to make allowance for any terminal strips or leads which have to pass through.

The General Construction. Mark out the boards carefully with a square and ruler, being particularly careful to see that the two ends are exactly the same size. The three upright parts are glued and screwed to the base, and, if the lid

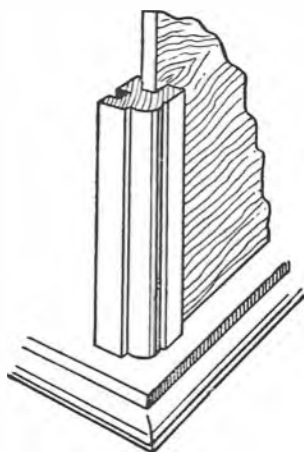


FIG. 77.—This shows plainly how corner moulding makes the construction easy.

is not ready to fit on, it is advisable to nail some thin strips to hold the top edges upright until that part is ready. Another good plan is to have a thin baseboard first, and then a larger and thicker one beneath. This bottom board can be glued entirely, and the angle of the two parts decorated by the corner ornamental beading, as shown.

The lid itself can be completed either as one piece or in two parts. This allows hinging, so the top may

CABINET CONSTRUCTION

be lifted to get at the "works." Another method, of course, is to screw and glue the top down entirely, but this necessitates the withdrawal of the set if anything goes wrong inside. If the lid is to be in two pieces (as in the cabinet shown), a thin strip is cut to hold the front edges of the ends together, whilst

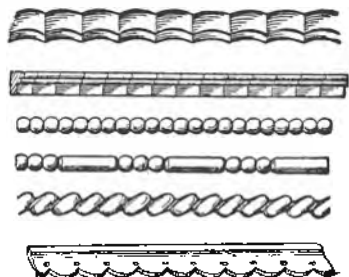


FIG. 78.—This is the fancy beading which is excellent for decorating the cabinet.

the main piece of the lid is hinged on at the back.

The Grain in the Lid. Use a complete board for the lid, and saw off the strip for the front. If two different boards are used, the grain of the top will vary and not look so well. A third method is to cut the lid into three, so that a strip is screwed and glued to the back edges, another to the front, and the movable lid hinged between. The method of hinging is illustrated (see Fig. 76), but it is also advisable to glue a strip of wood along the top inner edge of the plywood back, in order to provide greater strength for the flange of the hinge. All the way through the building of the cabinet tests must be made with the square to ensure that the parts are at right-angles, horizontal, and vertical, whilst sufficient room must be ensured for the putting in of the set itself. A more elaborate cabinet can, of course, be built by means of a built-up base of a box-frame style, whilst transfers or some of the wooden carved ornaments may

be added in order to decorate if so desired. In putting on these transfers or ornaments, do not overdo it, but add just one or two simple pieces which will lend dignity and a little colour to the job.

A more simple method of construction is, of course, by the use of the corner moulding. This moulding (see Fig. 79) has a groove into which the sides of the cabinet can slide, thus forming a pillar at each corner and providing strength as well as covering any bad joints which might otherwise be seen. This moulding is obtainable with a $\frac{3}{4}$ -in. groove, is cut to the height of the sides, and is glued and screwed at the corners through the base and top as before. All screws, of course, must be sunk well into the wood, so that their heads are below the surface, and the holes filled with plastic wood to render them invisible.

The use of this moulding certainly simplifies the construction of the



FIG. 79.—The shape and grooves of the corner moulding are clearly seen here.

cabinets in every case. Where it is used, the worker must allow a little greater width than the dimension of the baseboard between the ends. Thus, if the baseboard of the set is 14 in. long, a space of $14\frac{1}{2}$ in. must be allowed between the inside surfaces of the ends of the cabinet. The shape of the moulding on the corner turns over $\frac{3}{4}$ in. inwards, and this

space must be allowed so that the panel of the set can get between. The groove in this edge can either be filled with a small strip, or the ebonite panel so fitted that it comes in line and prevents the groove showing.

A professional finish is possible with these cabinets by the use of ordinary colour stains and Lightning Polish. Having temporarily tested and constructed the cabinet, take it to pieces again and clean up all parts thoroughly with glasspaper. Take care, however, not to round edges which should be left square, but get a nice rounded surface on any turned beaded edge. Drill screw-holes before putting the parts finally together. The pieces can now be coloured down all one shade by the use of a spirit stain. If water stain is used, it is apt to make the wood swell, and, anyhow, to raise the grain so that the work will need glasspapering down again. The depth of colour is varied by the addition of further coats or more crystals into the liquid. When the stain is fixed, the polish can be applied in the ordinary way with a bob. Remember that the edges will take considerably more than the rest of the work, and see that it is not dragged over to leave a long smeary ribbon. A more simple plan is to mix some varnish with the polish, and apply it carefully and quickly over the parts with a varnish brush. This, of course, will provide quite a bright polished surface, but, to the critical eye, the body of the varnish will always be apparent. This, too, makes it more likely to become scratched and show any such marks. Polish, to be applied properly, must be put on with a bob. Leave the completed cabinet until the polish has thoroughly set before bringing it into use, and then put the set in position. If it is likely to be withdrawn, it can simply be slid into position, but, if preferred,

it can be fitted in by putting ornamental beading or moulding round the edge of the front of the panel to form a frame for the tuning dials, etc.

CABLE.—Any large rope of wire of plural strands.

CAGE AERIAL.—Any aerial consisting of several wires arranged on spreaders in the form of a cage.

CALIBRATING A RECEIVER.—Those who are able to receive foreign stations are often mystified by receiving a station, and, being unable to understand the announcements, cannot get any idea whether it is a low-powered station at a great distance, or a high-powered station nearby. It is convenient to be able to make a note of the various countries heard on a set, and at the same time be able to know where to set the tuning dials to pick up any station when one sees from the newspapers or some other periodical that a certain item is being broadcast which one would like to hear. It is not very difficult to draw up a chart which will make it possible to do all this, and it need only cost a few pence. It will be found a most interesting job drawing the chart, and if it is afterwards fixed inside the lid of the wireless set it will always be handy for reference.

Marking out the Paper. A sheet of squared paper will be required, generally known as graph paper. This is usually obtainable from most good stationers or artists' supply stores. It does not matter whether the squares are in tenths of an inch or millimetres, the actual size chosen depending on the room the chart is to occupy when finished. Rule along one of the lines near the bottom of the sheet, and mark along this the numbers corresponding to those on the tuning dial. This may be 0 to 100 or 0 to 180, it does not

CALIBRATING A RECEIVER — CAPACITY

make any difference which it is. Now at the left-hand side of the sheet rule a vertical line running from the line marked with the 0. Along this line clearly indicate the metres (or frequencies in kilocycles, whichever is wanted) corresponding to the tuning range covered by the condenser. If the tuning condenser is of the type known as a "log" scale, then it is preferable to mark the tuning range in kilocycles. For the other types of condenser use the metre scale. If it is preferred the constructor may mark this in both the frequency and the wavelength. Having done this, one may settle down to the more interesting job of calibrating the set.

First of all tune in to the local station. If possible, avoid the use of reaction when carrying out this calibration. Having tuned in to the exact spot, make a careful note of the reading on the dial. Now find this spot on the bottom line of the chart, and run the pencil up the vertical line above this spot until it arrives at the place where the horizontal line corresponding to the wavelength of the station crosses it. Make a small dot at this spot. Now tune in another loud station, and carry out the same process. When one has, say, three or four dots on the chart, carefully join them up with a light pencil line. Now find the wavelength of a station which has not yet been marked, but which can be received, and run along this line until the pencil line is reached. Drop down the vertical line and see the dial reading this gives. If now the dial is set to this spot the station should be heard, but if any slight retuning is necessary, carry this out, and make the necessary alteration to the pencil line. During the course of two or three days one should have this line dead accurate for at least half a dozen

stations, and it may then be inked in.

Identifying a Station. To use the chart in identifying a station which may be received, note the dial reading, and, as explained above, find its wavelength. If now one takes the list of stations given in the press, one should have no difficulty in ascertaining what the station is. It is just as simple to find a station by the reverse method.

If the set consists of a detector valve followed by L.F. stages, one will have to use reaction during the compilation of the chart, and to avoid variations due to the varying amounts of applied reaction, use this at its maximum. For receivers using H.F. stages, it is preferable to calibrate the condenser which tunes either the H.F. transformer, tuned anode, or detector circuit.

CALORIE.—Same as *Calory*.

CALORY.—The degree of heat required to raise a gramme of water 1° Centigrade (C.G.S. system).

CANAL RAYS.—Diacathode Rays (which see).

CAPACITANCE.—Capacity reactance.

CAPACITY.—The property of storing electricity under electrical pressure (see also *Condenser*). The property which some metallic bodies possess of storing electricity is known as the "self-capacity," and this must not be confused with the capacity between one metallic body and another. The term "self-capacity" is also often applied to the capacity existing between adjacent turns of an inductance. If two metal plates are joined to the terminals of a battery, and the plates are separated by air, a certain capacity will exist between those plates. If the distance between the plates is kept constant, but in place of the air a sheet of glass is placed between the plates, the

capacity will alter. Similarly, the difference between different insulators, or as they are correctly called "dielectrics," will vary the capacity, even though the distance separating the plates is kept constant.

CAPACITY EARTH.—A counter-poise earth; or an earth consisting of some large body of metal. Sometimes referred to as a balancing capacity.

CAPACITY REACTANCE.—The portion of the aggregate impedance due to capacity.

CARBORUNDUM.—A crystal rectifier used in conjunction with steel.

CARBOY.—A large glass jar used to store acids.

CASCADE.—The same as Series.

CATHODE.—The positive pole of a cell or piece of electrical apparatus. The terminal by which the current leaves the cell or piece of apparatus.

CATHODE RAY OSCILLOGRAPH.—A device for giving a visual indication of the magnitude, shape, etc., of an oscillating current. It may also be employed, by suitably connecting it in circuit, to provide actual images of valve characteristics and other wireless data. It consists of a large glass tube which is conical in shape. The large end, or the base of the cone, is coated on the inside with some fluorescent material. At the point of the cone, or the narrow end of the tube, is sealed a cathode. A short distance from this cathode is fixed an anode. The arrangement so far, then, is a replica of an ordinary wireless valve, and it works on practically the same principle. If a negative potential is applied to the cathode and a positive potential applied to the anode, a stream of electrons will be shot off from the cathode, and will be driven with great force on to the anode.

In the oscillograph a small pinhole is made in the anode, and the force of the electron bombardment

drives some of the electrons through this pinhole. The tube is not completely vacuated, but contains a residuum of gas, and the gas tends to conduct the electrons which pass through the hole, so that a stream of electrons passes from the anode down towards the fluorescent screen or plate. Immediately beyond the anode are two pairs of plates, one pair disposed horizontally and the other vertically. These are suitably connected to a circuit so as to form magnetic fields, or fields of stress between the plates, and these fields divert the stream of electrons. The fluorescent plate glows where the stream strikes it, and the size of the hole and all other internal details of the oscillograph have to be so designed that the spot of light on the plate is only a mere point. Various improvements on the above simple arrangement have been carried out, such as providing a metal tube instead of a glass one; a removable screen so that a photographic plate may be interposed; heating arrangements to improve the electron stream, etc. (See also *Braun Tube*.)

C.C.—Cubic centimetres.

CELLS PARALLEL.—All positive poles joined together and all negative poles joined together. An arrangement for obtaining a greater current from a number of small cells. When connected in parallel the voltage remains unchanged, but the current is equivalent to the total current of the individual cells.

CELLS SERIES.—Positive pole of one cell joined to negative of the next cell. An arrangement for obtaining a greater voltage from a number of small cells. In this arrangement the capacity will remain unchanged. A good example is a high-tension battery, where individual cells of 1.5 volts are joined together to obtain a voltage of 100 volts or more.

CENTI — CHARACTERISTIC CURVES

CENTI.—One-hundredth.

CENTIGRADE.—The system of measuring temperatures, in which boil-

Volts." Sometime these three sets of figures are referred to by the technical references V_g for grid volts, V_a for anode volts, and I_a for anode current. The grid volts line is usually divided into two parts, a zero line being placed near the right-hand edge, and the volts to the left of this being marked "negative," and those to the right "positive." Now, this set of curves will give us all the details which are known as the valve's characteristics, and they may be ascertained in the following manner.

How to ascertain a Valve's Characteristics. Connect up a valve holder, grid-bias battery, H.T. battery, and L.T. battery, as shown in the diagram Fig. 82. A milliammeter should be inserted in the anode lead between plate and H.T. positive. Now prepare a piece of squared paper with a zero grid-potential line, as shown in Fig. 80, and mark the right-hand line with a series of numbers from 0 to 30, and insert a valve in the valve holder. With no grid bias and 60 volts H.T., note the current indicated by the milliammeter.

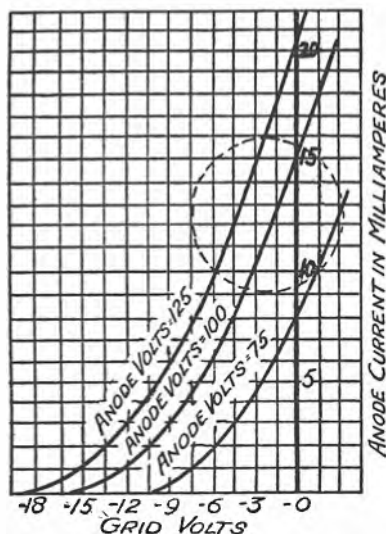


FIG. 80.—The ordinary grid-volts anode current curves.

ing-point is 100° and freezing-point 0° .

CENTRE TAP.—See *Tapping*.

C.G.S.—The centimetre-gramme-second system of units. (See also *Absolute Units*.)

CHARACTERISTIC CURVES, MAKING.—When you buy a valve of well-known make you will find in the box a small pamphlet—the actual arrangement differing with different makes of valves, but all of them give certain data relative to the valve, and these details are known as the valve's "characteristics." In addition to the tabulated details, there is a chart similar to that shown in Fig. 80. The right- or left-hand edge of the squared section bears a number of figures marked "Anode Current," and the thick lines running across the squares are labelled with figures termed "Anode

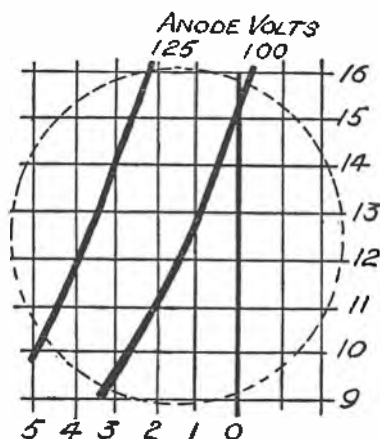


FIG. 81.—An enlarged view of the section shown in Fig. 80.

CHARACTERISTIC CURVES, MAKING

On the squared paper on the zero line make a dot where the line corresponding to the anode current intersects. Now plug the grid-bias plug

in grid volts. (The sign μ , which is the Greek letter mu, is used for this particular characteristic.) When preparing the curves as explained

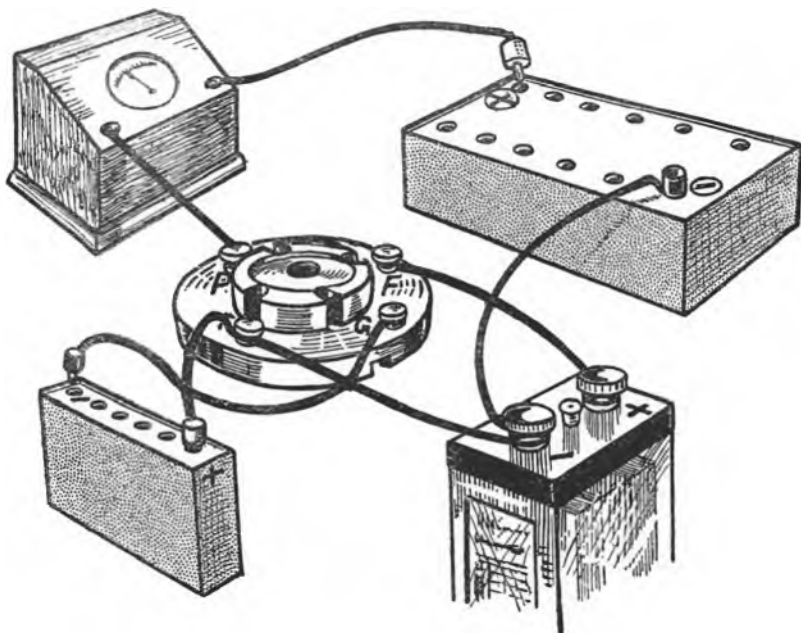


FIG. 82.—How to arrange the necessary parts in order to read a valve and prepare your own curves, or check your valves.

into the 1.5-volt socket, and note the anode current, making a dot on the chart above the 1.5-volt line at the point of intersection with the new anode current. Proceed in this way with various H.T. and G.B. values, joining up all the dots for each H.T. value. The result of this will be a set of curves exactly the same as those supplied by the valve makers, and the various figures, such as amplification ratio, slope, etc., may now be found.

Amplification Ratio. This figure (which is wrongly termed "Amplification Factor") is the ratio of change in anode voltage to change

above, it was noticed that as the grid bias was increased and the H.T. volts left unaltered, the anode current decreased. In our example, you will see that with 100 volts H.T. and no volts on the grid, the anode current is, roughly, 15 milliamps. When the grid bias is increased by 3 volts the anode current will drop to just under 10 milliamps., a drop of approximately 6 milliamps. Therefore, to obtain the same anode current without altering the bias it will be necessary to increase the H.T., and in the example you will see that about 24 volts are required to get the same anode cur-

CHARACTERISTIC CURVES, MAKING

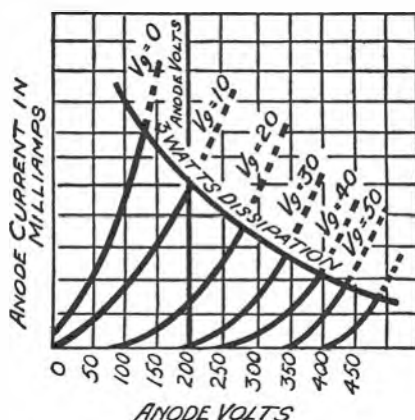


FIG. 83.—The Dynamic Valve Curves—which are the most important curves to have.

rent. We have therefore to add 24 volts H.T. for every 3 volts G.B. added, and this ratio, 24 over 3, is the amplification ratio, which in this case is 8 (see Fig. 80).

A reference to the diagram will make this clear.

Slope. This term is the same as "Mutual Conductance." It is the change in anode current divided by change in grid volts, or, put in another way, the anode-current change per volt grid-potential change. For this factor, the anode potential, or H.T., must be left untouched, and the grid bias only altered. As the bias is increased, we have just seen that the anode current will decrease. Therefore we can obtain a set of figures from which we can see, as in our example, that the anode current decreases 2 milliamps. for every volt that the grid

bias is increased, and therefore the slope is 2 milliamps. per volt, or, as it is expressed on the valve chart, 2.0 mA/v.

Impedance. This is one of the most important figures to know, as upon it depends the value of resistance, etc., which is to be used in coupling the valve to a subsequent stage. No further working has to be done to obtain this figure, as the two previous items, slope and amplification ratio, are used to ascertain the impedance. Simply divide the amplification ratio by the slope, and multiply the answer by 1,000, which in the example we are using will be 8 divided by 2 multiplied by 1,000, or 4,000, and this figure is quoted in ohms.

Unfortunately, the above details—those which are given to you by the valve manufacturers—are what are known as "static characteristics," that is, they are only applicable to a valve which receives constant voltages, and as everyone knows by now, when the valve is being used to receive signals the grid and anode voltages are constantly changing. It is therefore impossible to ascertain from the curves we have so far studied such details as the "maximum undistorted output," correct "anode load," percentage of "second harmonic distortion," etc., and we

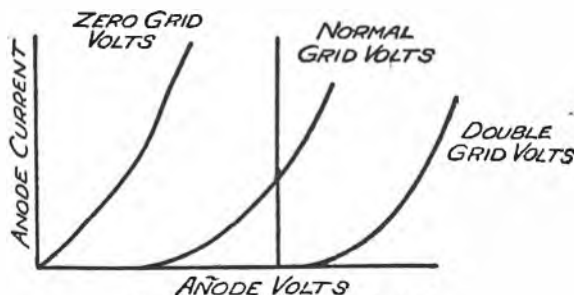


FIG. 84.—The Dynamic Curves simplified.

CHARACTERISTIC CURVES, MAKING

have therefore to prepare a set of curves known as "dynamic" curves. These curves, unfortunately, are rather difficult for the amateur to prepare, and what is still more unfortunate, the valve manufacturers for some reason or other hesitate to publish them for us. As a matter of fact, during the last few months there has been a suggestion that the manufacturers are alive to the position, as dynamic curves are now issued with some types of power valve. But if with one type of valve, why not with them all? However, to get back to our study of these curves. Fig. 83 shows the way these are drawn, and it will be observed that the values of both grid bias and H.T. are carried to a value higher than is normally used. Actually, in order to make use of these curves we must show the current at the correct working point, that is, correct anode volts and correct grid volts, and in addition at half and double these values. It is taken for granted that the reader appreciates the fact that during the operation of the valve (we are, of course, dealing with the valve as an L.F. amplifier) the grid potential varies, when the valve is operating on the proper part of its characteristic, from half the applied bias to double that bias. If it does not do this, then distortion is taking place. The effect of the variation in bias is, as our other curves have shown us, equivalent to a change in anode volts, and, therefore, the dynamic curves will show the anode current at various grid and anode volts.

Undistorted Output. The curves shown in Fig. 83 may be expressed in a much simpler way for the purpose of explaining the manner of ascertaining the undistorted output of the valve and the percentage of

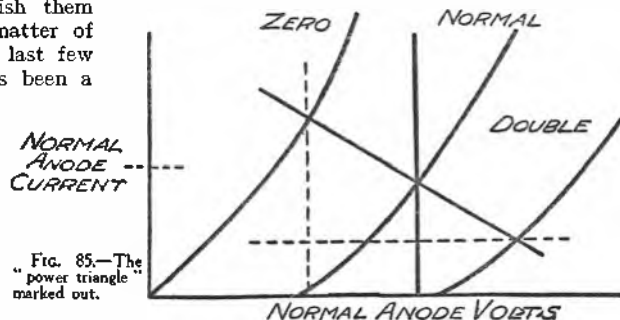


Fig. 85.—The power triangle marked out.

second harmonic distortion, etc. We therefore draw Fig. 84, which is the anode-current curve at normal grid bias, double and half-grid bias, all the other lines in Fig. 83 being omitted. The diagonal line running across the curves is what is known as the "load line," and this gives the value of the resistance, which must be included in the anode lead to obtain the maximum output from the valve, or in other words, the correct matching resistance. The line is drawn by placing a ruler on the curves with its edge at the point where the normal grid-bias line, normal anode-current line, and normal anode-voltage line all intersect. The ruler is then swung about this point until an equal distance separates the zero grid-volts line and the line corresponding to double the normal grid bias. (Actually the distances should not be equal, but one side should be slightly larger than the other, in order to obtain what is known as a 5 per cent. distortion scale—but this need not confuse us at the moment.) Having drawn this line, we drop a

CHASSIS

vertical line at the point of intersection of zero grid volts, and draw a horizontal line at the point of intersection of the load line and the line corresponding to double the grid bias. This gives us a triangle as shown in Fig. 85. Now, the formula for finding the undistorted output is:

$$\frac{(I_{\max} - I_{\min}) \times (E_{\max} - E_{\min})}{8}$$

In other words, it is the anode *current* difference multiplied by the anode *voltage* difference, divided by 8. This figure is the most important in the list of valve details, as it gives a true indication of the power which the valve will deliver. For instance, if we know that Cossard's P.5 valve will give an undistorted output of 500 milliwatts (or .5 watts), and that Mullor's D.7 gives an undistorted output of 900 milliwatts, we know that the latter valve is nearly twice as loud as the former.

There are several other factors which can be ascertained from these dynamic curves, but these are dealt

with elsewhere in this volume under their separate headings.

CHASSIS.—The supporting base (usually of aluminium or foil-covered wood, but sometimes of wood or bakelite) on which are placed the components of a receiver or transmitter.

In its simplest form a chassis is that which is built of wood and covered with metal foil, and is seen in Fig. 86, and while these are all very well in their way, an all-metal chassis makes a wireless set into a real engineering job.

An all-metal chassis can be built up in a variety of ways, and aluminium has the advantage of being easily workable. Fig. 87 shows one method of constructing a chassis. It will be noticed in this arrangement that no sheet-metal bending is required. The metal panel is attached to the platform with a convenient length of angle aluminium, and the same material is used for the returned portion or terminal panel. Thus the chassis comprises three flat pieces of sheet aluminium and a

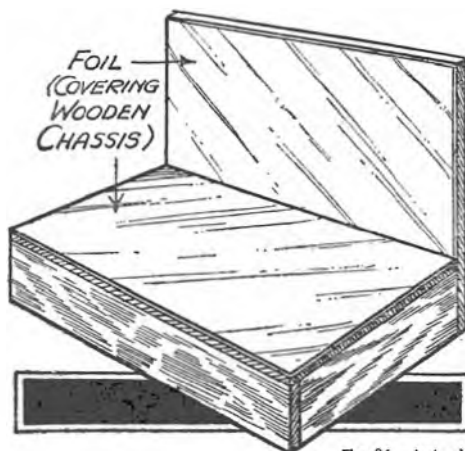


FIG. 86.—A simple way of making a "metal" Chassis. A wooden framework covered with metal foil.

couple of lengths of angle. This material, by the way, is obtainable in various gauges and with equal and unequal width of sides. For the present purpose, however, $\frac{1}{8}$ in. to $\frac{3}{4}$ in. width by 16 to 18 S.W.G. thickness is most suitable. The sheet aluminium and angles are joined together by drilling holes

CHASSIS CONSTRUCTION

through both pieces and fixing with small brass screws and nuts. In another adaptation of this arrangement an ebonite terminal strip may easily be incorporated as shown in Fig. 88. One further advantage to be obtained from the adoption of this or a similar form of construction is that, after marking out the positions of holes required to accommodate fixing

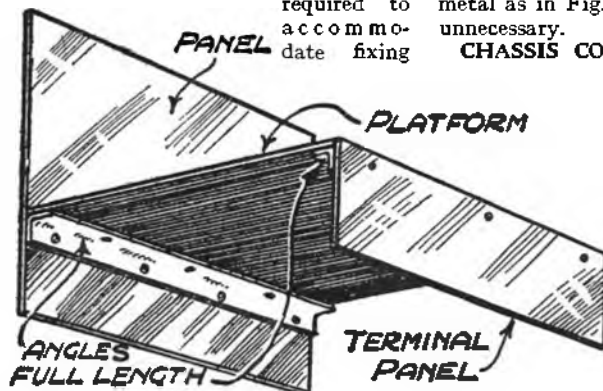


FIG. 87.—A metal Chassis using angle-irons instead of bending the aluminium.

bolts for the components or for the passage of wires, the chassis members may be taken apart, thus leaving the essential portions in the flat, thereby greatly facilitating drilling, and more especially will this convenience be appreciated where an irregular-shaped hole or two has to be pierced with a fret-saw.

The more usual form of chassis now employed is made by bending sheet metal into a fairly wide channel section formation, the panel being either riveted or bolted on to one of the flanges or narrow edges.

Fig. 89 shows such a chassis. Another form of bending is illustrated in Fig. 90. In this the panel platform and terminal panel are in one piece, and the remaining portion of the front panel below the platform is completed by the addition of an angle piece running the whole length. The fitting of side pieces in wood or metal as in Fig. 91 would make this unnecessary.

CHASSIS CONSTRUCTION SIMPLIFIED.

—Angle aluminium, as already stated, is obtainable in various gauges and with equal and unequal width of sides.

For a typical chassis, however, $\frac{1}{2}$ in. to $\frac{3}{4}$ in. width by 16 to 18 S.W.G. thickness is most suitable. The sheet aluminium and angles are joined together by drilling holes through

both pieces and fixing with small brass screws and nuts.

In another adaptation of this arrangement an ebonite terminal strip may easily be incorporated as shown in Fig. 88. One further advantage to be obtained from the adoption of this or a similar form of construction is that, after marking out the

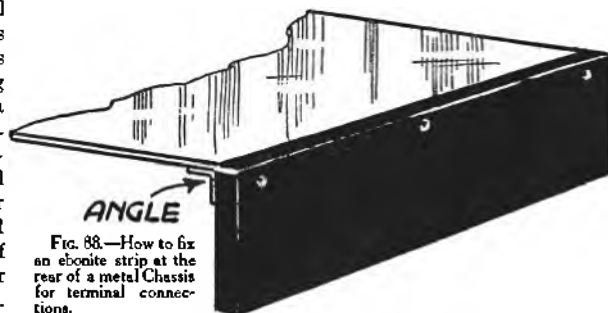


FIG. 88.—How to fix an ebonite strip at the rear of a metal Chassis for terminal connections.

CHASSIS CONSTRUCTION

positions of holes required to accommodate fixing bolts for the components or for the passage of wires, the chassis members may be taken apart, thus leaving the essential portions in the flat, thereby greatly facilitating drilling, and more especially will this convenience be appreciated where an irregular-shaped hole or two has to be pierced with a fret-saw.

Various Formations. The more usual form of chassis now employed is made by bending sheet metal into

right-angled or modified forms of bends are not easy to make with the means at the disposal of home constructors generally, and while beating the metal over an object with a square edge with a hammer or mallet might produce a very nice antique effect, the resulting chassis would not please the discriminating wireless enthusiast.

Method of Bending. The only reliable way of making bends of this description is to employ some mechanical means, and the following is a short description of a simple appliance for this purpose. Reference to the illustrations, Fig. 90a, in which the bender is seen in operation, shows it to be a contrivance which anyone with a very elementary knowledge of woodwork could quickly make. The

essential parts are a baseboard with clamping bar fitted to it with a bolt and wing nut at each end. The bending flap is hinged to the baseboard, and is provided with a short handle for extra leverage. Just a

word of warning: do not use timber that is too light for the job, it should be 1 in. to 1½ in. thick, the latter for preference; use a good pair of steel hinges, either back flap or butt pattern will do, secured with good stout screws. Arrange the position of the hinges so that the unsupported part of the bending flap is divided into three equal parts. The bending face of this flap, when lying flat, should coincide with the top face of the baseboard, so arrange the hinges accordingly. See that the front edge of the clamping bar lies parallel with the flap when it is in a vertical position. The two clamping screws are ¾-in. Whit. countersunk-headed ones;

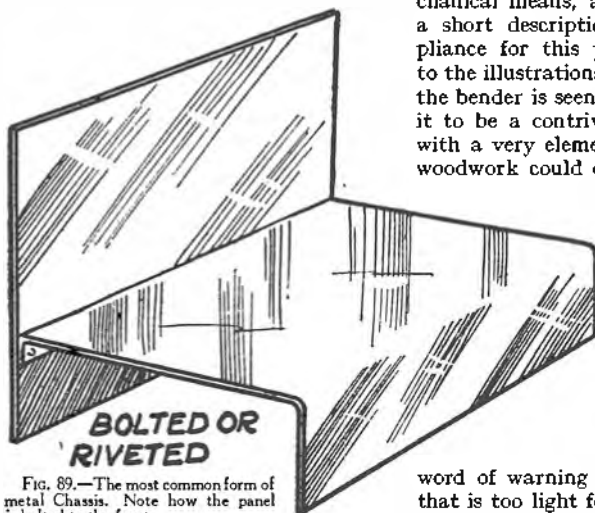


Fig. 89.—The most common form of metal Chassis. Note how the panel is bolted to the front.

a fairly wide channel section formation, the panel being either riveted or bolted on to one of the flanges or narrow edges. Fig. 87 shows such a chassis. Another form of bending is illustrated in Fig. 90. In this the panel platform and terminal panel are in one piece, and the remaining portion of the front panel below the platform is completed by the addition of an angle piece running the whole length. The fitting of side pieces in wood or metal as in Fig. 91 would make this unnecessary.

Now, unfortunately these long

CHASSIS CONSTRUCTION

tight-fitting holes, afterwards countersunk on the underside, are drilled in the baseboard to receive them, and the matching holes in the bar are drilled to give a slight clearance. Provide two large diameter washers for the wing nuts to butt against.

In order that the work to be bent should come out square, it will be necessary to pull the flap through an angle of a little more than 90° , so make an allowance for this by planing the front edge of the clamping bar 1° or 2° out of square, at the same time making sure that there will be room for a thickness of metal of the gauge to be used between the bending faces. A small radius should be worked along the bottom front edge of the clamping bar; this will leave a similar radius in the corner of the work being bent.

Marking Out and Cutting. Having decided on the sort of chassis to be

made, the construction should be proceeded with as follows. If possible, buy the aluminium already cut to required sizes with the edges, of course, clean cut and square with one another. Make allowance in the length for bends, but provided that the radius in the corners is not too small, it will be sufficiently accurate to make the length before bending the total of the lengths of the sides. Should the material require cutting to size, it will presumably have at least one clean-cut edge; if so, this is the one to work from. Make a mark at each end on the opposite side of the metal,

and with a steel rule placed against these marks, strike a well-defined line with a sharp-pointed scriber as shown in the illustration. The remaining edges are scribed off square with the ready-finished edge. To make a good job of the chassis the metal must be kept free from buckles, and great care must be taken to maintain the flat surface during cutting operations. So for this reason work

outside the wanted portion, bending the scrap part as it is cut to provide an easy path for the snips. Any roughness or irregularity caused by a slight deviation from the line in any

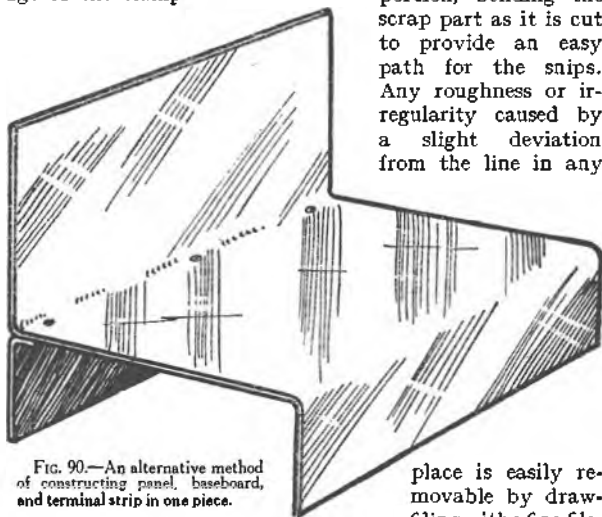


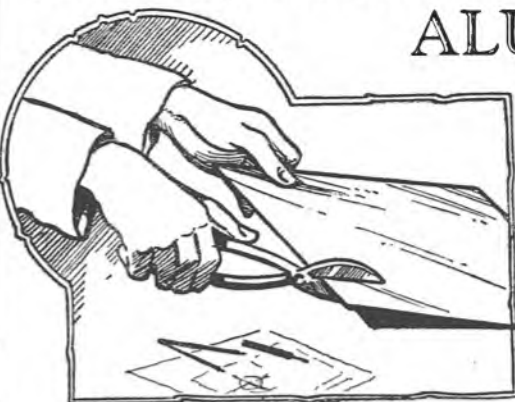
FIG. 90.—An alternative method of constructing panel, baseboard, and terminal strip in one piece.

place is easily removable by drawing with a fine file.

The bending may now be commenced. Make a pencil line where each bend is required, keeping these lines, of course, parallel with the respective edges. Undo the wing nuts and slide the metal under the clamping bar until bending line coincides absolutely with the front edge of the bar, afterwards tightening the nuts well down. Raise the lever until it is in a vertical position, when bend may be examined for squareness. Owing to the slight spring-back on the metal a little extra bending may be necessary. Having attained the desired result, the remaining bend or

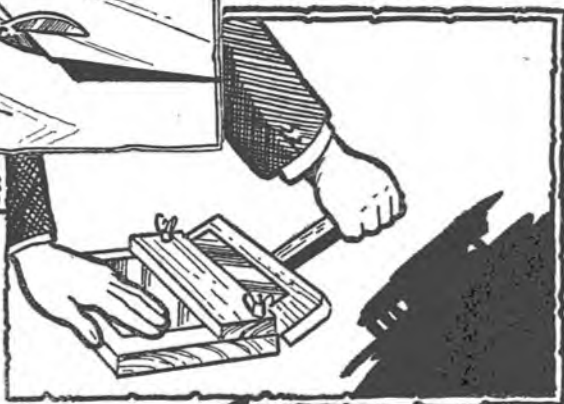
CUTTING, MARKING-OUT *and* BENDING ALUMINIUM

A sheet of aluminium should be cut in the manner shown here, with a pair of tinman's shears.



(Above) Marking out the position of components with dividers, which may also be used to cut the hole clear.

(Right) Using a scriber against the edge of a rule.



A simple bending and forming jig.



FIG 90A.

CHATTERTON'S COMPOUND

bends may be completed in like manner.

The remaining work consists of drilling and needs no comment, but the illustrations show a method of cutting large circular holes such as are required in screens. A small hole is drilled in the centre of the required hole and the metal is cut through from either side with a pair of dividers. These dividers must be of

the type provided with a quadrant and positive locking device, the end of one leg being sharpened to a keen point. Hold the aluminium on a hard surface to prevent the leg in the centre hole from pushing through and enlarging it.

CHATTERTON'S COMPOUND.—

A mixture of 1 part of Stockholm tar, 3 parts gutta-percha, and 1 part resin. This forms a black insulating

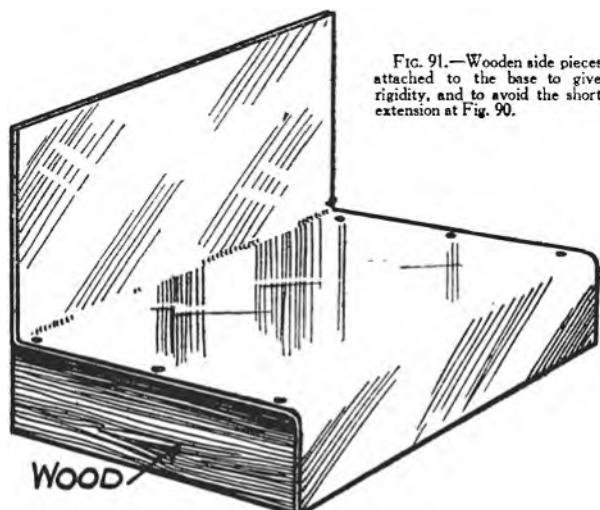


FIG. 91.—Wooden side pieces attached to the base to give rigidity, and to avoid the short extension at Fig. 90.

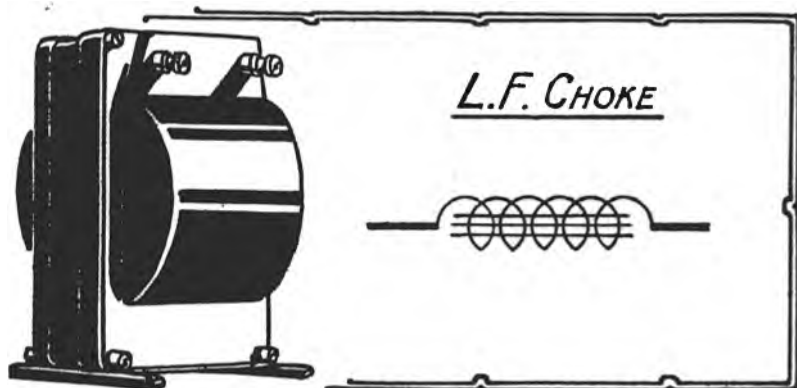


FIG. 92.—Conventional and actual diagram of a L.F. Choke.

CHOKE — CIRCUIT

substance of a plastic character.

CHOKE.—A coil possessing high self-induction, used to impede or check the amount of current flowing in a circuit. It provides *impedance*.

CHOKE, MAKING A.—For the home-made choke a former and a quantity of wire are required. Two terminals may be used for connections, although these are not essential. If one is lucky enough to own, or have the use of, a lathe, obtain a length of ebonite rod 1 in. in diameter, and

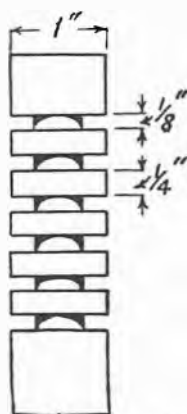


FIG. 93.—A home-made Former.

turn out slots about $\frac{1}{4}$ in. deep by just over $\frac{1}{4}$ in. wide. Six such slots will be needed, and there is no need for great accuracy in the spacing. In order to make the choke easy to handle and mount, it is best to leave an inch or so at each end to carry the ends of the actual winding. If one is not fortunate enough to be able to use a lathe, obtain a piece of $\frac{1}{2}$ -in. diameter ebonite rod and a similar length of ebonite tube having $\frac{1}{4}$ -in. walls and an internal diameter of $\frac{1}{4}$ in. From this tube cut five rings $\frac{1}{4}$ in. wide and two rings 1 in.

wide. These should be slid over the rod and stuck in position with Chat-terton's Compound. Fig. 93 shows the appearance of the former, no matter by which of the above two ways it is constructed.

The most suitable gauge of wire is No. 36, and to enable the required number of turns to be accommodated in the slots it should be preferably of the enamelled variety. Anchor one end through the two holes, leaving sufficient for connections, and in the first slot wind 500 turns. At the five-hundredth turn allow the wire to run across the separating flange, and continue the windings in the second slot. Be careful that the wire continues in exactly the same direction. Wind another 500, and carry on in this way until you have 500 turns in each slot, that is, 3,000 turns in all (2 oz. of wire will be sufficient for this). Anchor the end of the wire, and the H.F. choke is complete. If desired, a piece of celluloid or cellophane may be wrapped round it to keep out moisture and to give it a finished appearance.

CHOKE CAPACITY COUPLING.

—A form of low-frequency coupling, in which a low-frequency (iron-cored) choke is included in the anode circuit of a valve, and the grid of the following valve is coupled to the preceding anode by the customary condenser. A grid-leak resistance is joined to the grid, and the valve receives negative bias through this leak. It therefore only differs from resistance capacity coupling by the use of a choke in place of a resistance in the anode circuit. (See also *Low Frequency Couplings*.)

CHOKE COUPLING.—See *Coupling*.

CIRCUIT.—The path through which a current flows from positive

CIRCUIT

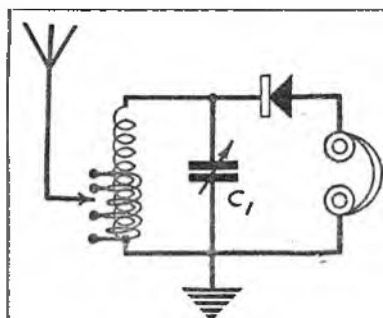


FIG. 94.—Crystal Circuit using tapped coil.

List of Components for Fig. 94

·0005 mfd. variable condenser (C_1).

1 crystal detector.

Plug-in coil holder.

Plug-in coils.

Terminals, connecting wire, and screws.

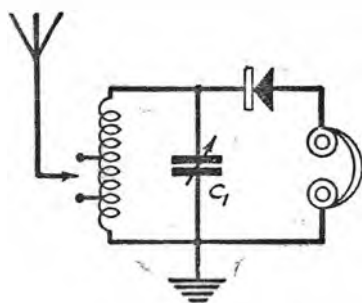


FIG. 95.—The very simplest Crystal Circuit.

List of Components for Fig. 95

·0005 mfd. variable condenser (C_1).

1 crystal detector.

Terminals, connecting wire, and screws.

to negative poles. (See also under *Hartley, Reinartz, Armstrong, etc.*)

coil; L_2 —a No. 60 coil; and L_3 —a No. 50 coil. The H.T. should

TYPICAL CIRCUITS

Two simple crystal circuits are shown in Figs. 94 and 95.

Circuit No. 1. The simplest form of single-valve receiver is shown in Fig. 96. The tuning arrangements consist of three baseboard mounting coil holders screwed on to a baseboard side by side, with just sufficient space between them to allow the largest size of coil to be comfortably inserted. Care should be taken with the connections to the coil holders, the earth lead being taken to the pin of the aerial and grid coil holders, and the anode lead being taken to the pin of the reaction coil holder.

A set of plug-in coils will enable you to listen on any wavelength. For the normal broadcast band the coils should be as follows: L_1 —a No. 35

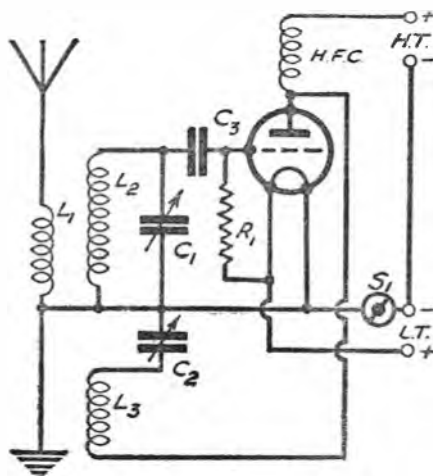


FIG. 96.—Circuit No. 1: The simplest One-valve Circuit.

have a value of 60 volts, and the valve should be of the general purpose type.

CIRCUIT

List of Components for Circuit No. 1

- 0005 mfd. variable condenser (C₁).
- 0003 mfd. variable condenser (C₂).
- 0002 mfd. fixed condenser (C₃).
- 1 2-megohm grid leak and holder (R₁).
- 1 valve holder.
- 3 baseboard mounting coil holders.
- 1 on-and-off switch (S₁).
- Set of plug-in coils.
- 1 H.F. choke.

Terminals, connecting wire, and screws.

on all wavelengths you will require a complete set of coils, and these should consist, for the broadcast bands, of the following: Nos. 35, 50, 60, 75, 100, 150, 250. Instead of a No. 75, another 60 may be used in some cases. For the long-wave stations the centre coil is a No. 250, and the left-hand and right-hand coils are respectively 100 and 150. For the short waves you will require a set of short-wave coils. These are wound with very thick bare wire and have only a few turns. They are generally num-

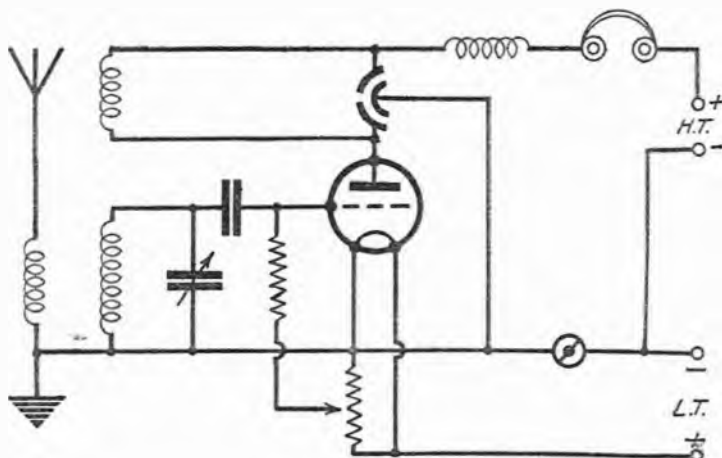


FIG. 97.—Circuit No. 2: A similar circuit to Fig. 96, employing a different system of reaction control.

Circuit No. 2. This (Fig. 97) is a similar arrangement to the previous set, except that differential reaction control is fitted, no terminals are used, and other little refinements are incorporated.

This receiver is a simple one-valve set, which is so designed that it may be used for reception on all wavelengths from 20 metres up to 2,000. The actual construction calls for no skill, and it forms an ideal set for the new-comer to wireless.

In order that you may use the set

bered according to the number of turns, and Nos. 2, 4, 6, 8, and 10 will cover the band from about 20 to 100 metres, whilst Nos. 15 and 20, in conjunction with the smaller sizes of the broadcast range, will enable you to cover the gap from 100 metres up to the broadcast band. The largest of the coils should always be in the centre socket, and the other two sizes should be so chosen that the right degree of selectivity and smooth control of reaction will be obtained.

CIRCUIT

List of Components for Circuit No. 2

- 1 panel, 12 × 7 in.
- 1 baseboard, 13 × 9 in.
- 1 cabinet to fit.
- 1 .0005 mfd. variable condenser with dials.
- 1 .0002 differential reaction condenser.
- 1 .0003 fixed condenser.
- 1 2-megohm grid leak.
- 1 holder for same.
- 1 on-and-off switch.
- 1 valve holder.
- 3 coil holders.
- 1 400-ohm potentiometer.
- 1 H.F. choke.
- 4 terminals.
- 1 4-way battery cord.

Circuit No. 3. Fig. 98 shows a simple one-valve employing home-made coils.

List of Components for Circuit No. 3

- .0005 mfd. variable condenser (C_1).
- .0003 mfd. variable condenser (C_2).

.0002 mfd. fixed condenser (C_3).

1 H.F. choke.

1 2-megohm grid leak and holder (R_1).

Valve holder.

On-and-off switch (S_1).

Terminals, connecting wire, and screws.

Circuit No. 4. Although included amongst the one-valvers, the set shown in Fig. 99 consists of two stages, but only employs one valve. It is a H.F. and detector set, employing a crystal detector.

The receiver is intended for use with headphones, but unlike most one-valve sets, it does not consist of a single detector valve. It is actually a two-stage receiver, a valve of the screen-grid type being employed as a high-frequency amplifier, and this is followed by a crystal detector. In this way one is enabled to reach out in a much easier manner than with

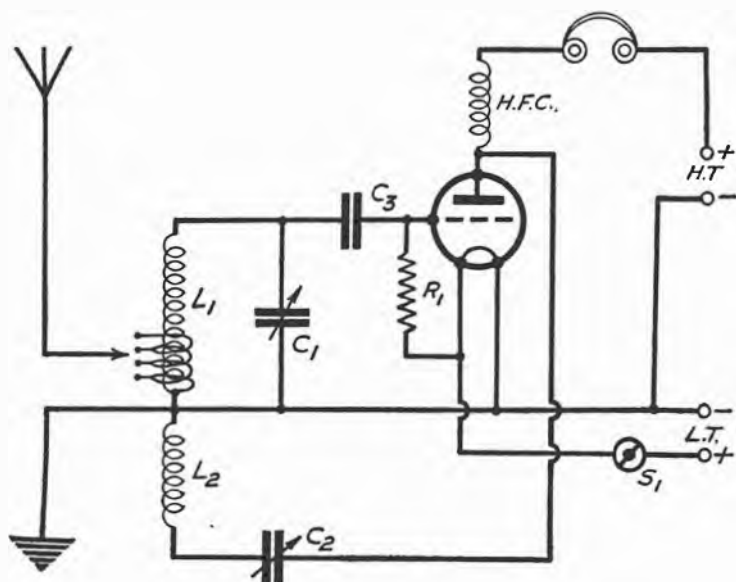


FIG. 98.—Circuit No. 3: Another simple One-valve Set.

CIRCUIT

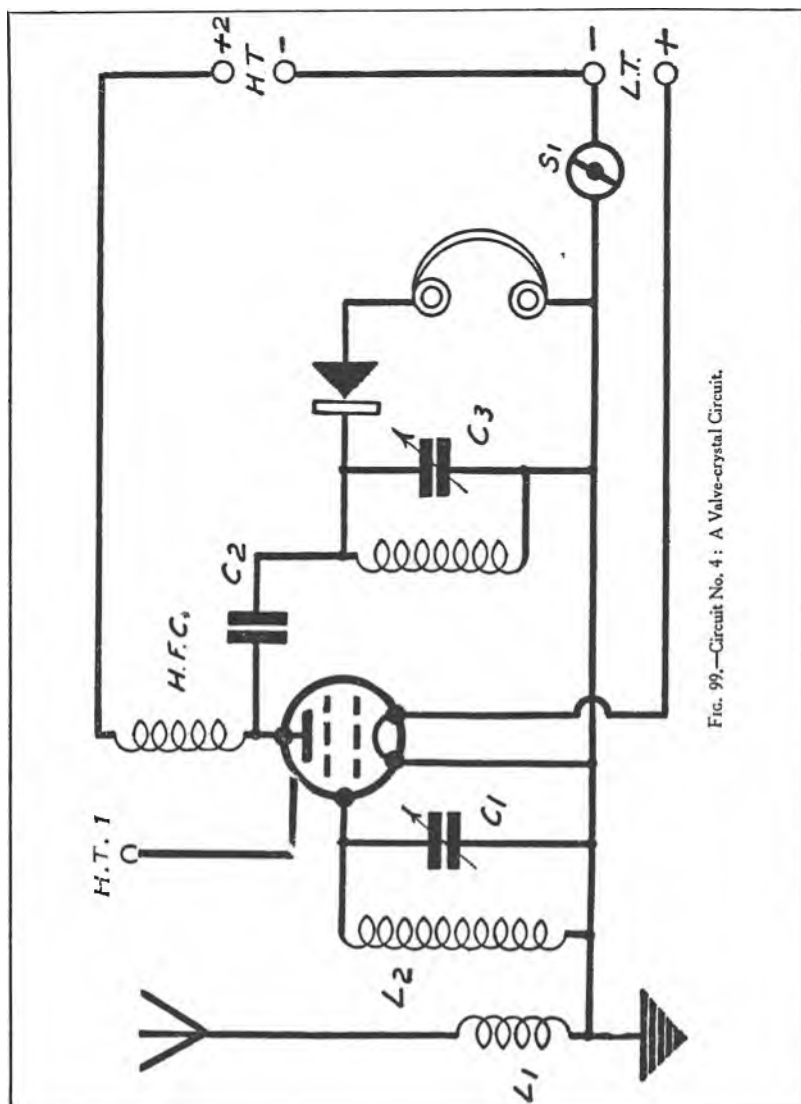


FIG. 99.—Circuit No. 4: A Valve-crystal Circuit.

a reacting detector valve, and those readers who are situated a long way from a broadcasting station, or who desire to hear the numerous foreigners

without a large expenditure, will find this a very powerful little set. The construction should not cause any trouble to the veriest novice, and

CIRCUIT

there is very little chance of anything going wrong.

List of Components for Circuit No. 4

- 1 ebonite panel, 12 x 7 in.
- 1 baseboard, 12 x 9 in.
- 2 variable condensers, .0005 mfd.
- 1 permanent crystal detector.
- 3 baseboard mounting coil holders.
- 1 fixed condenser, .001.
- 1 H.F. choke—screened-grid type.
- 1 aluminium screen.
- 1 valve holder.
- 0 terminals.

Quantity of Glazite connecting wire.

Circuit No. 5. This is a very simple two-valver (Fig. 100) employing a commercial type of dual-range coil possessing many novel features, not the least of which is its extreme selectivity and also absence of break through, and, as will be seen from the diagrams accompanying this section, it is fitted with a push-pull wave-change switch, which has a standard one-hole fixing arrangement enabling the coil to be mounted

change from one to the other being carried out by the operation of the simple push-pull switch.

List of Components for Circuit No. 5

- 1 ebonite panel, 14 x 7 in.
- 1 baseboard, 14 x 9 in.
- 1 terminal strip, 14 x 2 in.
- 1 Type A multi-coil.
- 1 .0005 variable condenser.
- 1 .0002 variable condenser.
- 2 slow-motion dials.
- 1 .0002 fixed condenser.
- 1 compression-type condenser, .0003 max.
- 1 2-megohm grid leak with holder.
- 1 fuse and holder.
- 1 H.F. choke.
- 1 L.F. transformer.
- 1 on-and-off switch.
- 9 terminals.
- 2 valve holders.
- 2 angle brackets.

Quantity of Glazite, screws, wander
plugs, etc.

Circuit No. 6. Fig. 101 shows a two-valve set, designed for purity of

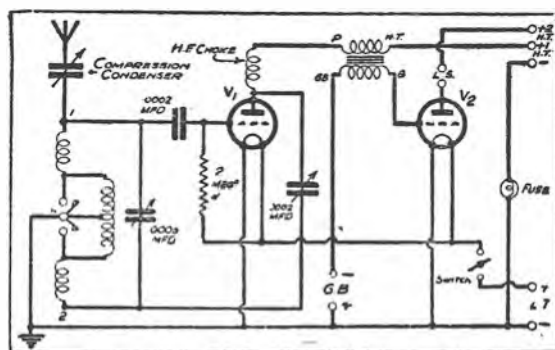


FIG. 100.—Circuit No. 5: A very simple Two-valve Circuit.

direct on to the panel. There are only three connections to the coil, and this enables a set to be designed of the very simplest kind, but which at the same time will cover both the normal and the long-wave bands, the

reproduction. Plug-in coils are used. Remarks in Circuit No. 1 relative to this part of the circuit will also apply. The resistance R_2 , the condenser C_4 , and the resistance R_3 are all incorporated in the commer-

CIRCUIT

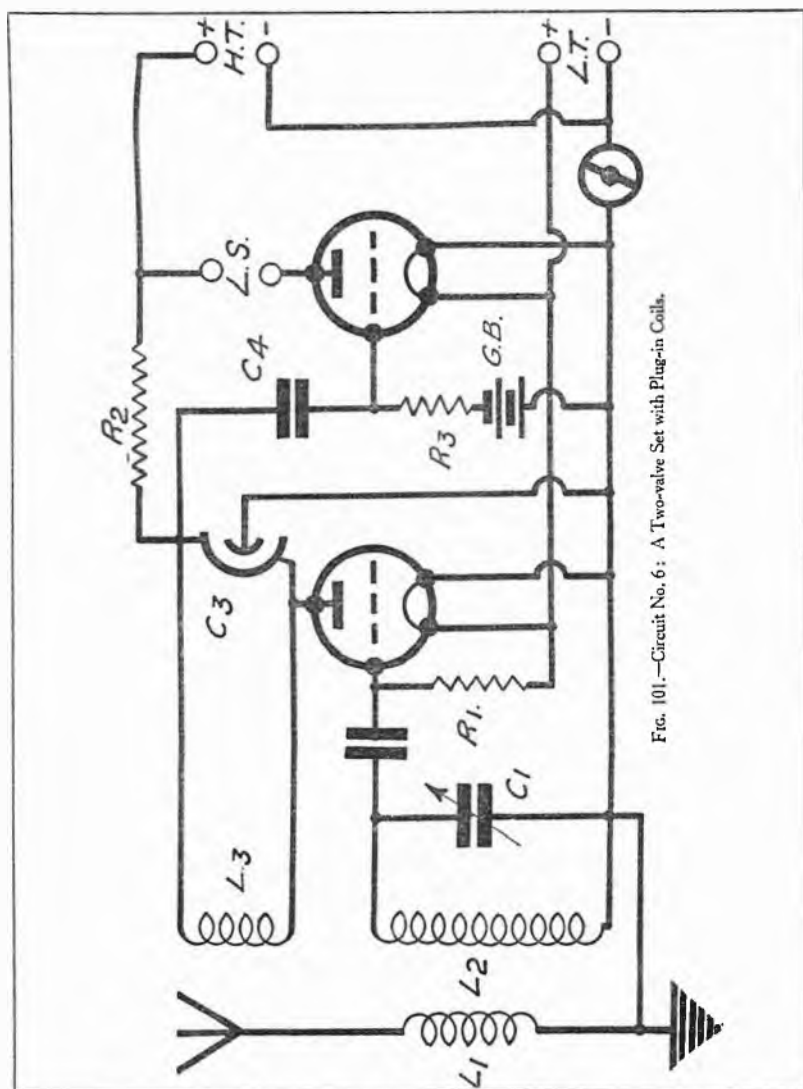


FIG. 101.—Circuit No. 6: A Two-valve Set with Plug-in Coils.

cial type of resistance-coupling unit, and this may be used instead of the separate components if desired. The second valve should be of the

L.F. type, and the H.T. should have a value of 120 volts, with the grid bias adjusted according to the particular instructions of the valve maker.

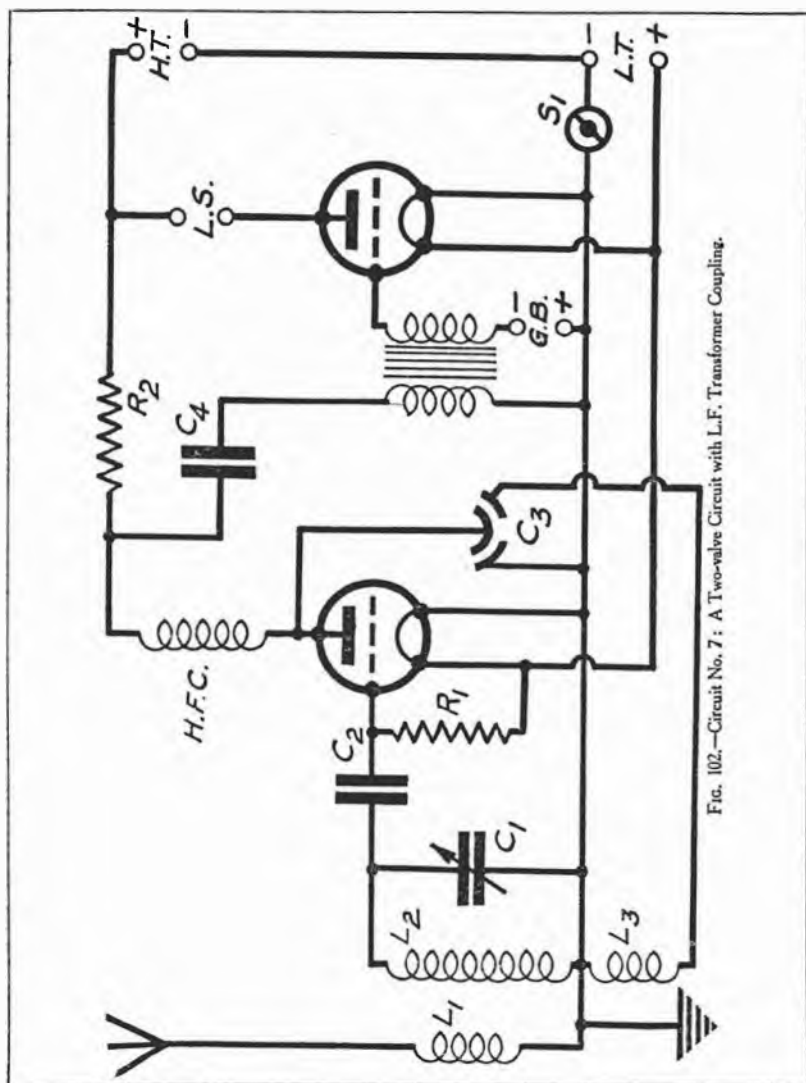


Fig. 102.—Circuit No. 7: A Two-valve Circuit with L.F. Transformer Coupling.

List of Components for Circuit No. 6

- | List of Components for Circuit No. 6 | |
|--|---|
| •0005 mfd. variable condenser (C1). | •01 mfd. fixed condenser (C4). |
| •0002 mfd. differential reaction condenser (C3). | 1 2-megohm grid leak and clips (R1). |
| •0002 mfd. fixed condenser (C2). | 1 100,000-ohm resistance and holder (R2). |
| | 1 25,000-ohm resistance and holder (R3). |

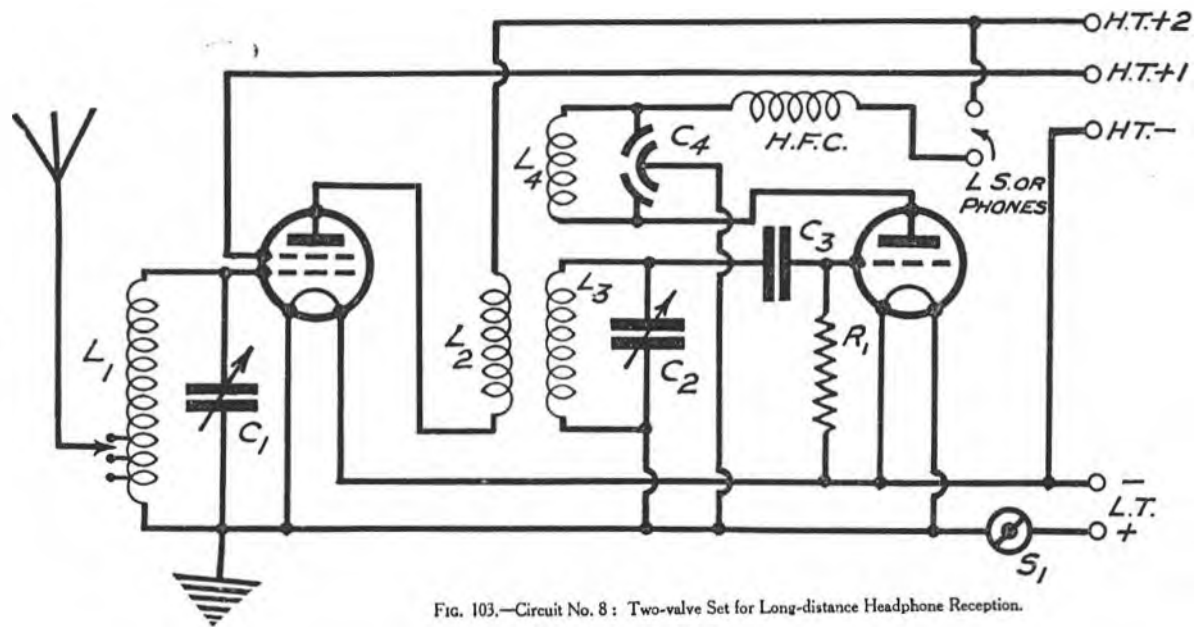


FIG. 103.—Circuit No. 8 : Two-valve Set for Long-distance Headphone Reception.

CIRCUIT

- 2 valve holders.
- 1 on-and-off switch (S1).
- 3 coil holders.
- Set of coils.
- Terminals, connecting wire, and screws.

Circuit No. 7. Fig. 102 is a similar set to the preceding one, but this time an ordinary L.F. transformer is employed. In order to keep the quality of reproduction on a high standard, this transformer is parallel fed, that is, the primary is not placed direct in the anode circuit of the detector valve, and therefore no current passes through its primary. This keeps its inductance high and preserves the bass notes. Further, the values of the grid condenser and leak have been modified to give what is known as power grid detection. Consequently, provided plenty of H.T. is employed, this receiver will give absolutely tiptop quality.

List of Components for Circuit No. 7

- 0005 mfd. variable condenser (C1).
- 0001 mfd. fixed condenser (C2).
- 0002 mfd. differential condenser (C3).
- 1 1-mfd. fixed condenser (C4).
- 1 25,000-ohm resistance and holder (R1).
- 1 30,000-ohm resistance and holder (R2).
- 1 L.F. transformer.
- 3 coil holders.
- Set of coils.
- 2 valve holders.
- On-and-off switch (S1).
- Terminals, connecting wire, and screws.

Circuit No. 8. The two-valver shown in Fig. 103 is designed primarily for long-distance headphone work, and consists of a screen-grid H.F. stage followed by a simple detector valve. The aerial circuit consists of a No. 60X coil, and the coils

L2, L3, and L4 are included in a commercial six-pin coil unit. Several firms make this H.F. transformer, as it is called, and therefore any particular make may be chosen by the constructor. Care should be taken that the transformer for use with S.G. valves is obtained, as there is a different type of transformer for the triodes, or ordinary three-electrode valve. Differential reaction control is employed for stability, and the detector valve may be of the H.F. or general purpose type. As there are two tuned circuits in this receiver, care will have to be exercised in tuning in, as, unless both circuits are tuned to the wavelength of the desired station, nothing will be heard, unless, of course, the station is very close.

List of Components for Circuit No. 8

- 2 ·0005 variable condensers (C1 and C2).
- 1 ·0002 fixed condenser (C3).
- 1 2-megohm grid leak and holder (R1).
- 1 differential reaction condenser (C4).
- 1 H.F. choke.
- 1 6-pin H.F. transformer and base.
- 1 plug-in 2-pin coil holder.
- 1 60X coil.
- 2 valve holders.
- 1 on-and-off switch (S1).
- Terminals, connecting wire, and screws.

Circuit No. 9. This unit (Fig. 104) has been designed for attachment to existing sets. Those possessing ordinary receivers, which have been built for the broadcast band, often wish they were able to tune down to the short waves and pick-up stations situated as far away as America or on the other side of the globe, Kenya, etc. These short waves seem to come in remarkably well, and the short-wave unit here described may be connected to any

CIRCUIT

ordinary receiver (provided it is not a mains-driven set), and which will enable reception to be carried out on the very shortest of wavelengths at present in use. The unit is quite cheap, and the total expenditure need not exceed £1. No extra valve is needed, as will be explained on the following page, the detector valve from the set being used.

The list of components should be studied, and practically any make of standard design may be used. The only point which requires careful attention is the method of connection used in the variable condensers. These must be fitted with "pig-tail" connections if rustling noises are to be avoided when tuning in on the short waves. Most of the better makes of variable condenser now employ this method of connection.

Having obtained the various parts, proceed to mark out the panel, using as your guide the measurements given on the "wiring diagram." The exact size of the holes will depend, of course, on the particular make of component chosen. Mount up the condensers and then proceed to fix the remaining components to the baseboard. Pay particular attention to the coil holders, allowing sufficient space between them to permit the largest of the coils to be safely in-

serted without touching its neighbour. The only two terminals required in this unit may be mounted on a spare piece of ebonite, or one

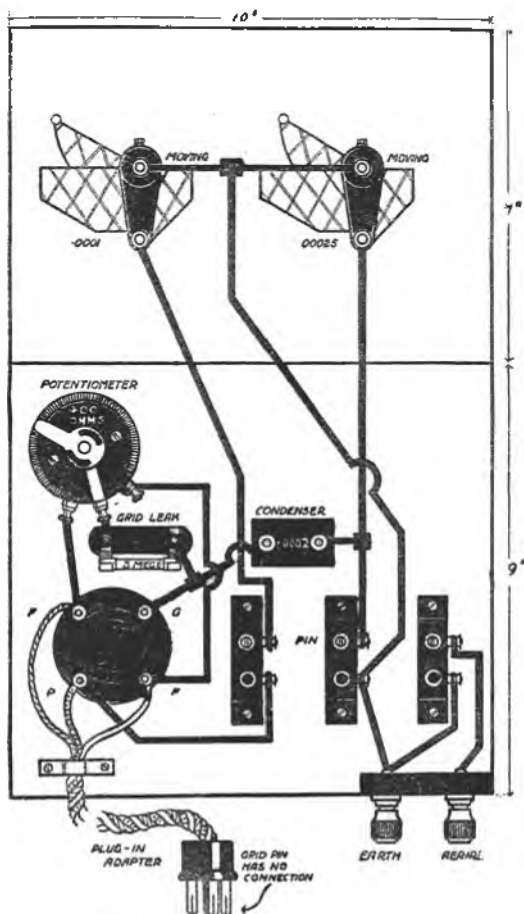


FIG. 104.—Circuit No. 9: Wiring Diagram for Short-wave Adapter Unit.

of the special terminal blocks may be purchased.

When everything is in its place you may proceed to wire up. This should be carried out with heavy-gauge wire, say 16 or 18 bare copper,

CIRCUIT

well spaced, and by the most direct method. Do not try to make this part of the work look neat by taking the leads a long way round with nice right-angle bends. Where short waves are concerned the leads must be as short and direct as possible. Do not let any wire run within $\frac{1}{2}$ in. of another unless it crosses at a dead right-angle. Attention to this part of the work will be well repaid in efficient working. Note also that the moving vanes of both condensers are connected together and to earth.

When the unit is wired you will have to make the actual connecting link with your present receiver, and this will have to be made of such a length that it will comfortably reach your present detector socket. Three single lengths of flex are required, and to avoid mistakes these should preferably be of different colours. Alternatively, you may cut three lengths of ordinary flex and bind the ends of each separate strand with a different-coloured thread. These three strands are connected up in the following way. One strand to each of the filament terminals of the valve holder in the unit, and to each filament pin of the valve adapter; the remaining strand from the plate terminal of the valve holder to the plate pin of the adapter. No connection whatever is made to the grid pin of this adapter.

Having finished this part of the work, carefully check over all connections, and when you are quite sure no mistakes have been made, you may proceed to connect it to your present receiver. This is quite a simple job. Take out the detector valve of the set, and plug it into the valve holder of the short-wave unit. The valve adapter is then plugged into the now empty valve holder of your existing set. The aerial and earth leads should then be disconnected from your receiver,

and taken to the two terminals on the unit. If now the receiver is switched on, the short-wave unit becomes a very efficient one-valve short-wave set, and the low-frequency stages of your present receiver serve to amplify the received signals. If there are two such stages, quite good loudspeaker signals will be obtained.

The following refinements may be mentioned to ensure maximum results in short-wave work. If oscillation seems rather erratic, carefully adjust the position of the arm of the potentiometer. If this does not seem to help matters, look at the H.F. choke in your existing receiver. This may not be good enough for short-wave work, and you should therefore obtain one which is efficient on all waves. Tuning on the short waves is very critical, and you will have to adjust the tuning dial with much more care than you are accustomed to employ on the ordinary broadcast band. If you buy a complete set of short-wave coils, try the effect of different sizes of coil in the left-hand, or aperiodic aerial, coil holder. Generally speaking, this coil should be two sizes smaller than that used in the centre holder, and the right-hand, or reaction coil, should be of a size between these two.

For those who wish to make their own short-wave coils, it is best to make up a set having 2, 4, 6, 8, 10, 12, 14, and 16 turns of No. 16 gauge tinned copper wire, wound round a 3-in. diameter former and then allowed to spring off. The four smaller sizes should be allowed to space themselves out with about $\frac{1}{2}$ in. between the turns, and the four larger ones should have a space between turns equal to the thickness of the wire. The ends of the coils may be made fast to ordinary plug-in coil holders, and provided care is taken

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in handling them, they will be found to keep themselves quite rigid.

List of Components for Circuit No. 9

Panel, 10 x 7 in.

Baseboard, 10 x 8 in. or 9 in.

1 .00025-mfd. variable condenser, with slow-motion dial.

1 .0001-mfd. variable condenser, with slow-motion dial.

3 baseboard mounting coil holders.

1 .0002 fixed condenser.

1 3-megohm grid leak and holder.

1 400-ohm potentiometer for baseboard mounting.

The wavelength range covered by the set, with the coils recommended, whether commercial or home-made, is roughly 15 metres to 120 metres. Within this range there are something like 120 high-powered broadcasting stations, all of which are well within the range of the set. Unfortunately, some of them do not operate regularly, and others are only received in this country at times when the average British listener is unable to listen-in.

Dozens of other stations may be logged, as one would expect, includ-

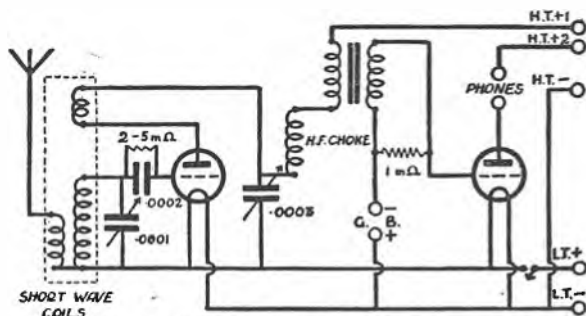


FIG. 105.—Circuit No. 10: Circuit for a Short-wave Two-valve Set.

1 anti-microphonic valve holder.

1 set of short-wave coils.

1 plug-in valve adapter.

Flex, wire, screws, etc.

2 terminals.

Circuit No. 10. This is a set (see Fig. 105) designed for those who are tired of receiving the local stations only, and yet do not feel like tackling a complicated multivalver for receiving the more distant stations. The short-wave receiver is an ideal set for everyone—as you receive programmes from seemingly impossible distances, with the minimum of trouble and the minimum of expense.

ing amateur transmissions from sixty-four different countries, and many of the broadcasting stations transmit for many hours both during the daytime and also at night.

The most conspicuous of all the "landmarks" is Rome on 25.4 metres. It is receivable at a tremendous strength throughout the whole evening. Immediately below this, and audible by 10.30 p.m. or just after, is W8XK, the short-wave edition of the famous KDKA station.

The best American station, however, is W2XAD, on 19.56 metres. This starts at about 9 p.m., at which time it is not always very strong, but by 10 or 11 p.m. it is quite

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uncomfortable in the headphones, unless it is an abnormally bad night.

It will be noticed that the broadcasting stations are arranged in

other simply by his placing in the "group."

W2XAD, on 19.56 metres, however, is isolated and therefore all the more conspicuous.

Spread over the entire short-wave spectrum are the Transatlantic telephony stations. Most of them have some distorting system to prevent eavesdropping, but, nevertheless, they provide a useful test both of the receiver and of radio conditions.

The amateur wave bands in greatest use in most countries are just above 20 and 40 metres. On the 20-metre band, almost any evening, the Americans can be heard in scores. Most of them work in Morse, but there are about a dozen particularly good telephony signals. W1CCZ at Cape Cod is always among the best. Others heard regularly are W3ZX and W8DLD, respectively, at Collingwood, N.J., and Cleveland, Ohio. Such is the "skip distance" of this wave that the Americans will probably be stronger than the numerous British stations that work with them. Although in this country there are about two thousand licensed and *active* amateur transmitters, you will not hear much of them unless you move to a point 1,000 miles or more away.

On 40 metres, particularly on a Sunday morning, scores of Britishers may be heard on "phone" as well as Morse.

Circuit No. 11. This receiver (Fig. 106) is best operated from the electric-light mains, and will give the most power for a two-valver, in view of the fact that a pentode valve is used for the output stage. The detector part of the re-

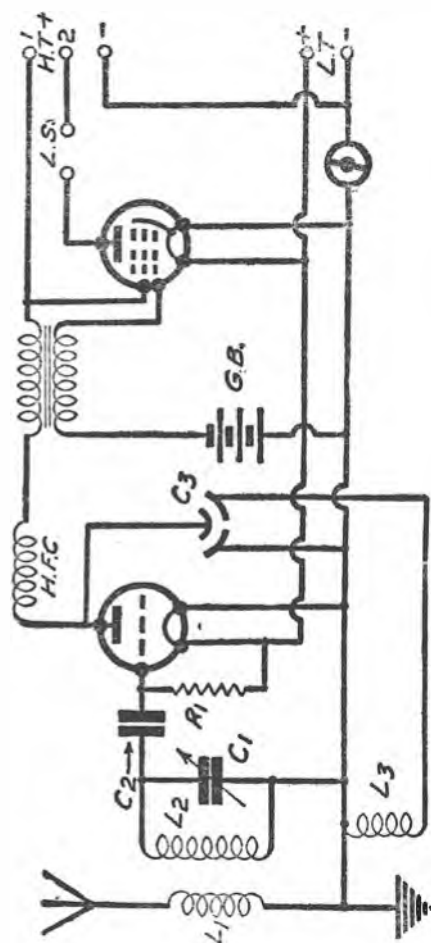


FIG. 106.—Circuit No. 11: Two-valve set suitable for working with a battery eliminator.

groups on the short waves. One "band" is in the region of 25 metres, another round about 32, and a third in the neighbourhood of 48-50 metres. This makes it fairly easy to distinguish one station from an-

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ceiver is similar to Circuit No. 10, and the L.F. transformer should have a ratio of 3:1. H.T.2 should be as high as the valve will take, and H.T.1 should be adjusted to give best results, so far as quality and signal strength are concerned. Use a general-purpose valve for the detector, and make quite sure that the pentode valve has sufficient grid bias. The valvemakers' instructions should be very carefully adhered to in this respect.

List of Components for Circuit No. 11

- 1 .0005-mfd. variable condenser (C₁).
- 1 .0001-mfd. fixed condenser (C₂).
- 1 .0002 differential condenser (C₃).
- 1 25,000-ohm grid leak and holder (R₁).
- 1 low-ratio L.F. transformer.

3 coil holders.
2 valve holders.

Set of plug-in coils.

- 1 on-and-off switch (S₁).
- 1 H.F. choke.

Terminals, connecting wire, and screws.

Any reputable make of component may be used for the circuits herein described.

Circuit No. 12. Fig. 107 shows a

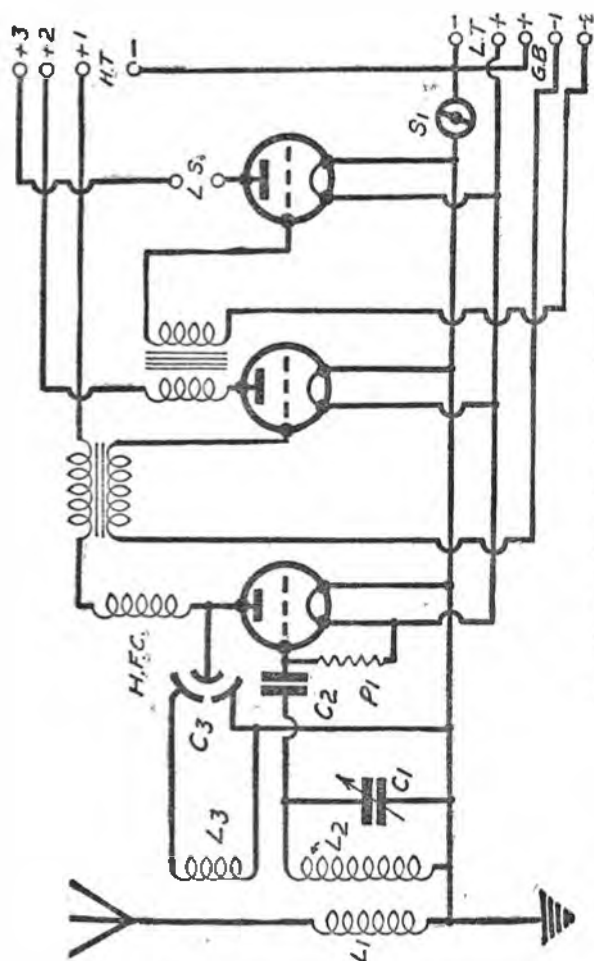


FIG. 107.—Circuit No. 12: A Simple Three-valve Circuit.

very simple three-valve set, consisting of a simple detector followed by two transformer coupled L.F. stages. The first transformer should be of low or medium ratio, say 2:7

CIRCUIT

or 3:1, and the second may be of the 5:1 type. Plug-in coils are employed for tuning. The valves required are detector, L.F., and power, the first valve having about 60 volts H.T., the second 100 volts, and the last, or power, valve having the maximum which the makers recom-

rangement (Fig. 108), as well as a commercial form of tuner.

Circuit No. 14. In this arrangement (Fig. 109) a special type of L.F.

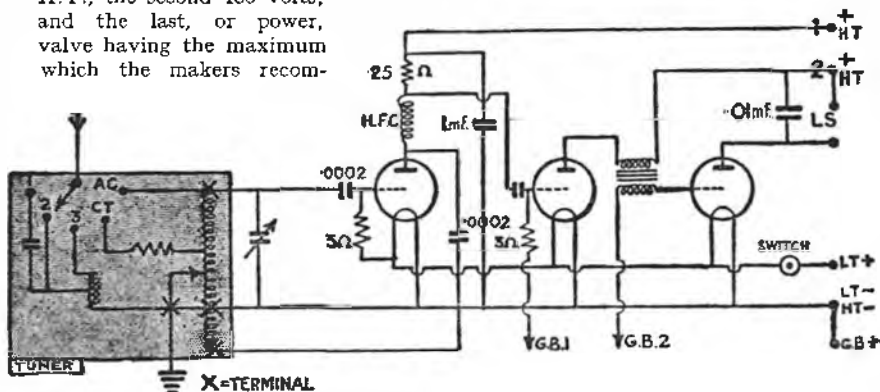


FIG. 108.—Circuit No. 13: A similar Circuit to Fig. 106, except that it employs Resistance Capacity Coupling.

mend. As mentioned in previous circuits, pay particular attention to the adjustment of the grid bias, as you will thereby prolong the life of both H.T. battery and valves.

List of Components for Circuit No. 12

- 1 .0005-mfd. variable condenser (C₁).
- 1 .0002-mfd. fixed condenser (C₂).
- 1 .0002 differential reaction condenser (C₃).
- 1 2-megohm grid leak and holder (R₁).
- 1 H.F. choke.
- 2 L.F. transformers.
- 3 valve holders.
- 3 coil holders.
- 1 on-and-off switch (S₁).

Set of plug-in coils.

Terminals, connecting wire, and screws.

Circuit No. 13. This circuit is similar to No. 12, only here the first transformer has been substituted by a resistance-capacity coupling ar-

coupling has been incorporated. This is known as an auto-transformer, and it gives a large step-up in voltage, besides being very good from the purity point of view. In other respects the receiver is similar to the two preceding sets. To make this receiver selective, a special form of band-pass tuner is employed, and this is made by the same firm that makes the auto-transformer. The set will be eminently suitable for those who live fairly close to a regional station, on account of the selectivity of the special tuner employed, which provides excellent quality as well, and is reasonably simple to operate.

Circuit No. 15. The receiver now described (see Fig. 110) is entirely self-contained, although provision has been made for the attachment of an external aerial and earth, where this is found to be necessary. No great skill is required in the construction of the complete set, al-

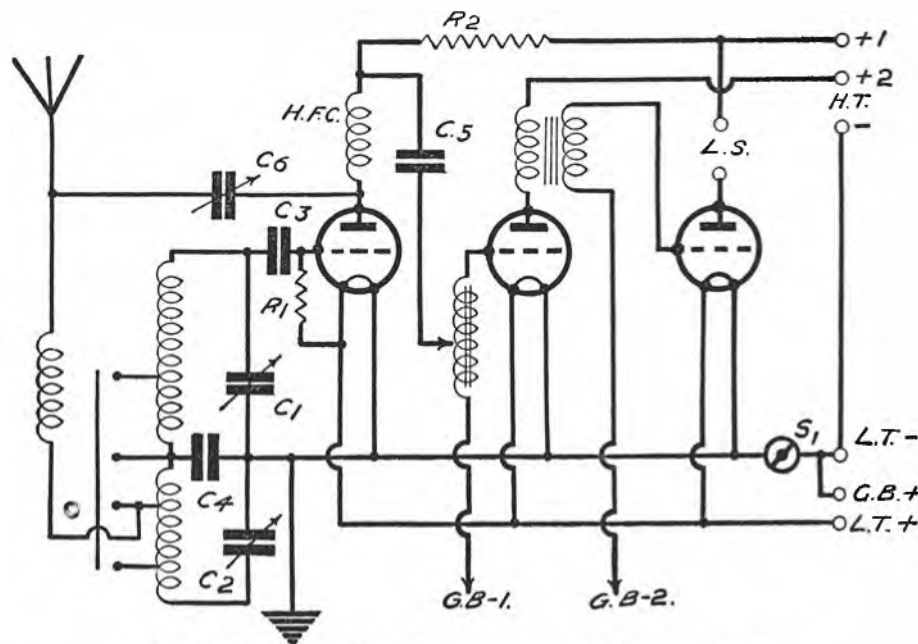


FIG. 109.—Circuit No. 14: Three-valve Circuit employing Auto-Transformer Coupling.

*List of Components
for Circuit No. 14*

- 2 .0005-mfd. variable condensers (C1 and C2).
 - 1 band-pass tuner.
 - 1 .04-mfd. non-inductive condenser (C4).
 - 1 .0002-mfd. fixed condenser (C3).
 - 1 2-megohm grid leak and holder (R1).
 - 1 30,000-ohm resistance and holder (R2).
 - 1 .5-mfd. fixed condenser (C5).
 - 1 auto-transformer.
 - 1 low - ratio L.F. transformer.
 - 3 valve holders.
 - 1 on-and-off switch (S1).
- Terminals, connecting wire, and screws.**
- 1 .0001 reaction condenser (C6).

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though those readers who are handy with wood-working tools will be able to exploit their skill in the construction of the case.

The Frame Aerial. The frame aerial should be the first part to receive attention, and this is made from $\frac{1}{2}$ -in. softwood, the screws holding the joints being countersunk to avoid con-

(leaving a length for connection), and anchor off.

Half an inch away from this last turn make another pair of holes at which to commence the long-wave winding. This commences with 9 turns of wire, each turn touching, after which a hole is made and a loop passed through as before, the

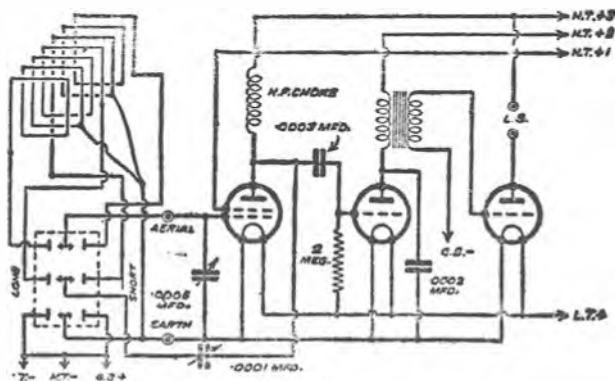


FIG. 110.—Circuit No. 15: Circuit diagram for a Three-valve Portable Set.

tact with the wire of the aerial. Two pieces of $\frac{1}{2}$ -in. square-section strip-wood are screwed on the inside of the frame 7 in. from the top. The actual winding consists of No. 22 D.C.C. wire wound in the following manner. Pierce two small holes near one edge of the frame, and thread the wire round the holes to make a firm anchorage, leaving a few inches of wire for subsequent connection to the switch. Wind on tightly 15 turns of wire, allowing a space of $\frac{1}{16}$ in. between each turn. At the fifteenth turn pierce a hole through the frame and pass a large loop of wire through the hole, afterwards wedging the wire in the hole with a small splinter of wood and a drop of glue. Continue the winding for a further 4 turns, pierce two holes, cut off the wire

winding continuing for another 50 turns. Each section of these windings should be in the same direction. The two loops of wire are bared and joined together, eventually being taken to the centre contacts of the switch nearest the edge of the panel (Fig. 111). The remainder of the connections to the switch are clearly shown in the drawing.

A small type of accumulator, preferably filled with jelly acid, a H.T. battery of 108 or 120 volts, both of the type built for portable receivers, and a 9-volt grid-bias battery will then occupy the bottom of the receiver. A little care should be exercised in the choice of these components in view of the small space available.

The Valves. The valves required

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are a screen-grid, general-purpose, and L.F. type, the screen-grid valve going in the socket on the right (when viewing the receiver from the back), the general-purpose valve in the centre, and the L.F. valve in the remaining socket. Attach the leads to the accumulator, plug H.T. +1 into a tapping round about 80 volts, H.T. +2 about 60 volts, and H.T. +3 into the maximum voltage available. This latter plug will have two wires attached to it, one from the loudspeaker and one from the H.F. choke. This latter component must be of the type specially designed for use with screened valves, the ordinary type not being generally suitable.

No difficulty should be experienced in operating the set, the centre knob being used to tune in the required station, the small knob on the left bringing the volume up to the required strength. The switch when pressed down will bring the long-wave aerial into action; when raised, the short-wave aerial is in use, and in the centre position the valves are switched off. The actual position of the receiver has a great deal to do with the selectivity, the top of the set being pointed in the direction of the station for maximum strength. A turntable will be found very useful for the purpose of searching, although of course it is not essential. When an outside aerial and earth are employed, very much louder signals will be obtained, but the selectivity will fall off.

List of Components for Circuit No. 15

Ebonite panel, $15\frac{1}{2} \times 4$ in.

·0005 variable condenser.

·0001 reaction condenser.

·0002 fixed condenser.

·0003 fixed condenser.

2-megohm grid leak.

3 valve holders.

L.F. transformer.

H.F. choke (S.G. type).

2 flush mounting sockets.

3-pole change-over switch.

Loudspeaker, chassis portable type.

$\frac{1}{2}$ lb. No. 22 D.C.C. wire for frame aerial.

Wood for cabinet, silk gauze for grille.

Screws, Glazite for terminals, wiring up, wander plugs, etc.

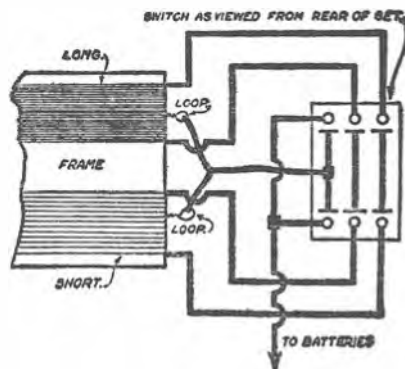


FIG. 111.—The Switch Connections to the Aerial of Circuit No. 15.

Circuit No. 16. The circuit shown (in Fig. 112) is a very good all-purpose arrangement, consisting of screen-grid H.F. stage, detector and output valves, the latter being resistance coupled. This will give very good quality loudspeaker results from quite a number of stations and is really simple to handle. The aerial circuit consists of a simple plug-in coil of the X type, and the H.F. transformer is made up of three plug-in coils. L₃ will be of the same size as the aerial coil, whilst the sizes of the other two coils may be adjusted to give just the desired balance of signal strength and selectivity. The anode resistance R₂ may conveniently be of the spaghetti type, and this will simplify the wiring, as it may be made the actual connection between the anode terminal of the detector valve holder and the H.T.

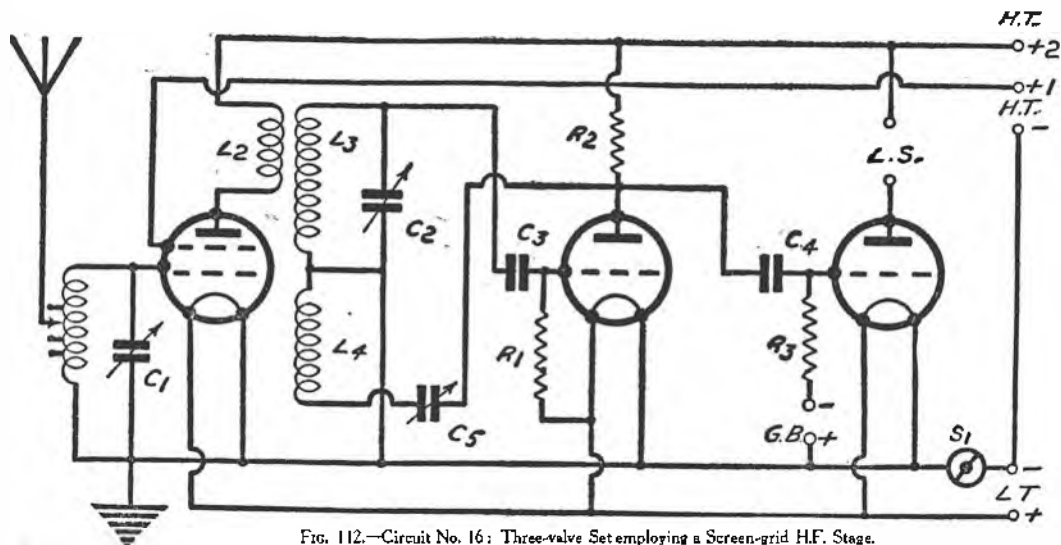


FIG. 112.—Circuit No. 16: Three-valve Set employing a Screen-grid H.F. Stage.

List of Components for Circuit No. 16

- | | | |
|---|---------------------------------------|---|
| 2 .0005-mfd. variable condensers (C1 and C2). | 1 2-megohm grid leak and holder (R1). | 4 baseboard-mounting coil holders. |
| 1 .0002-mfd. fixed condenser (C3). | 1 1-megohm grid leak and holder (R3). | On-and-off switch (S1). |
| 1 .01-mfd. fixed condenser (C4). | 1 midget reaction condenser (C5). | Terminals, connecting wire, and screws. |
| 1 100,000-ohm fixed resistance (R2). | 3 valve holders. | Set of plug-in coils. |

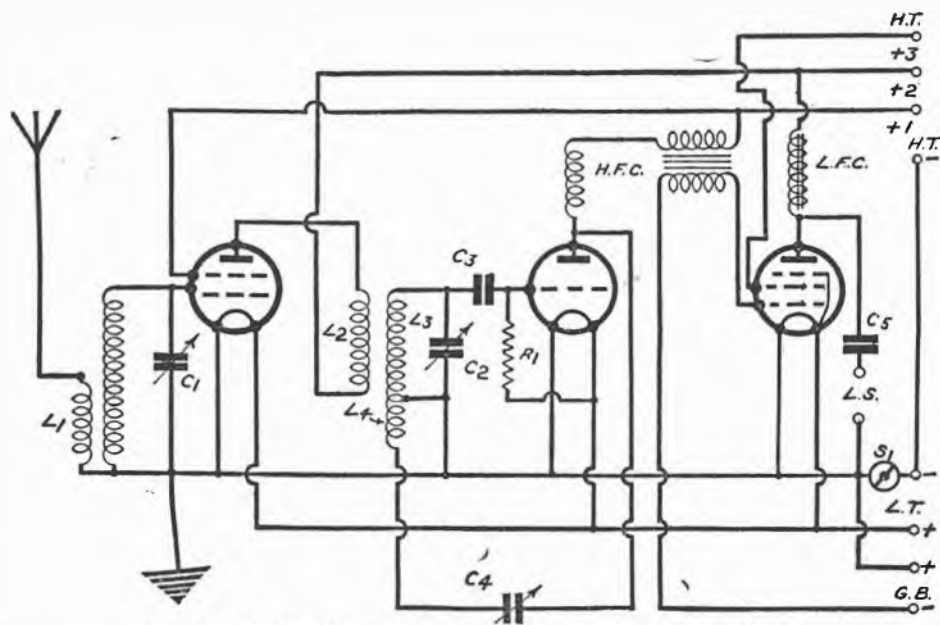


FIG. 113.—Circuit No. 17: Three-valve Circuit employing Pentode and Screen-grid Valves.

*List of Components
for Circuit No. 17*

- 2 .0005-mfd. variable capacitors (C1 and C2).
 - 1 .0002-mfd. variable condenser (C4).
 - 1 .0002-mfd. fixed condenser (C3).
 - 1 2- or 4-mfd. fixed condenser (C5).
 - 1 H.F. choke.
 - 1 L.F. transformer.
 - 1 pentode output choke.
 - 1 aerial transformer and six-pin base.
 - 1 H.F. transformer and six-pin base.
 - 1 2-megohm grid leak and holder (R1).
 - 1 on-and-off switch (S1).
 - 3 valve holders.
- Terminals, connecting wire, and screws.

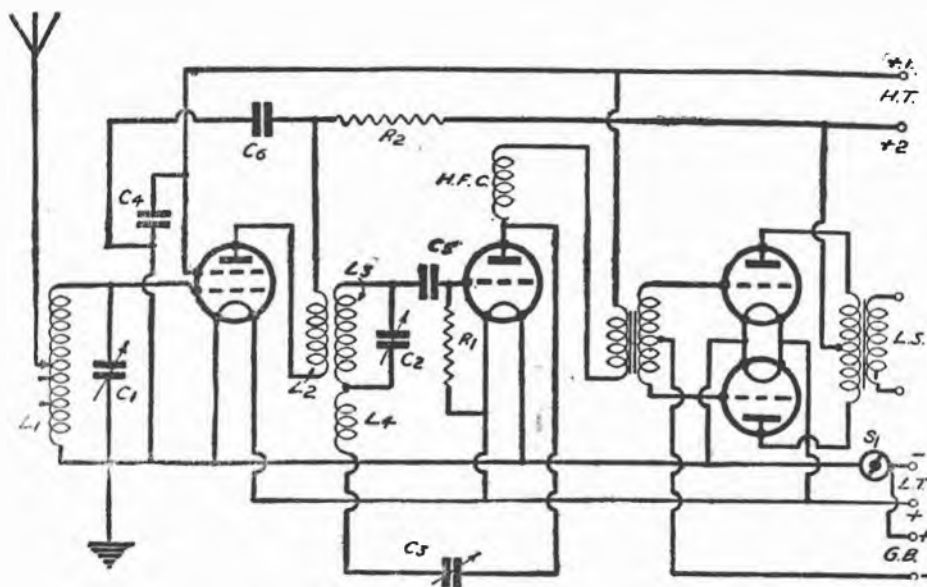


FIG. 114.—Circuit No. 18: Four-valve Circuit with two valves in Push-Pull.

*List of Components
for Circuit No. 18*

- 2 .0005-mfd. variable condensers (C1 and C2).
 - 1 .0002-mfd. variable condenser (C3).
 - 1 .0001-mfd. fixed condenser (C5).
 - 2 2-mfd. fixed condensers (C4 and C6).
 - 1 25,000-ohm resistance and holder (R1).
 - 1 H.F. choke.
 - 1 input push-pull transformer.
 - 1 output push-pull transformer.
 - 1 on-and-off switch (S1).
 - 1 20,000-ohm spaghetti resistance (R2).
 - 4 valve holders.
 - 1 baseboard mounting coil holder.
 - 1 60X coil.
 - 1 H.F. transformer and six-pin base.
- Terminals, connecting wire, and screws.

CIRCUIT

Circuit No. 17. This circuit (Fig. 113) combines two of the latest types of valve—the pentode and the screen-grid. Consequently, the range and volume of the three valves easily equal that of an ordinary type of five-valver. The aerial circuit and H.F. transformer should consist of a commercial type of six-pin coil, preferably wound with Litz wire. All the other components should also be chosen with a view to high efficiency, and therefore only the best will do. The L.F. choke in the anode circuit of the pentode valve must be of the type especially made for the purpose. The ordinary type of L.F. choke will not do. If funds allow, a special pentode matching output unit may be used instead of the choke and condenser C₅. The transformer should be of the medium or low-ratio type, say 3 : 1, although to avoid overloading of the pentode output valve, it may also be necessary slightly to detune when receiving a powerful signal.

Circuit No. 18. Although employing four valves, Fig. 114 is actually a three-stage receiver. In place of the usual output valve, two valves are used in push-pull. The result of this is to give a greater output; in fact, it works out roughly at double. Special transformers have to be used both in front and behind these two valves, and these are made by several well-known firms. The signal which is passed on from the detector valve, which works on the power-grid principle, is sufficient to fully load the two push-pull valves, and therefore sufficient signal strength can be obtained for a small hall, or a large room for dancing. The aerial circuit consists of a plug-in coil of the X type, whilst the H.F. transformer should be a commercial article. When purchasing the valves, you should ask for two matched

valves for the last stage. Most manufacturers will now do this, and better results are of course obtained when the two valves are working together.

Circuit No. 19. Fig. 115 is a simple four-valve arrangement, consisting of a screen-grid valve, detector, and two transformer-coupled low-frequency stages. The H.F. valve is coupled by what is known as the parallel-fed method, a H.F. choke being included in the anode circuit of the screen-grid valve. This choke must be of the special kind designed for use with this type of valve. There will be loss of amplification if the usual type of choke is included here. For the L.F. transformers, a low-ratio one should be used for the first stage, and a high-ratio for the second. The valves required, in their order, are: screen-grid, general-purpose or detector, L.F., and power. This last valve should be of the type which will handle a fairly powerful signal if distortion is to be avoided. Ordinary plug-in coils are used, a No. 60X for the aerial circuit, No. 60 for L₂, and No. 50 for L₃. These are, of course, for the normal broadcast band. For the long waves they will be Nos. 250, 250, and 100 respectively. The H.T. values should be 80 volts for +1, 100 to 120 volts for +2, and the maximum taken by the particular valve purchased for +3. In the case of battery valves this will be 150 volts.

Circuit No. 20. This circuit (Fig. 116) is on the same lines as No. 20, except that the H.F. valve is coupled by the tuned-anode method, which gives greater signal strength, but requires a little more care in construction. A special type of commercial coil will be required, and this should be wound in what is known as the astatic manner. In addition, a vertical screen of copper or aluminium must be affixed to the baseboard,

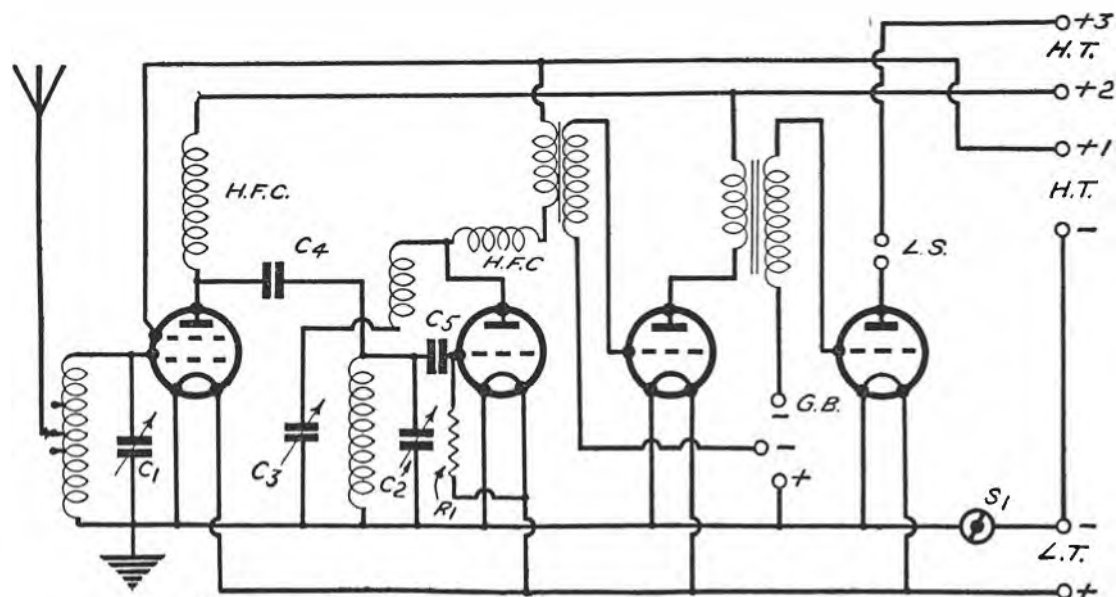


FIG. 115.—Circuit No. 19: Four-valve Circuit with Screen-grid, Detector, and Two L.F. Coupled Valves.

List of Components for Circuit No. 19

- | | | |
|---|---------------------------------------|---|
| 2 .0005-mfd. variable condensers (C1 and C2). | 1 H.F. choke—screen-grid type. | 1 high-ratio L.F. transformer. |
| 1 .0003-mfd. variable condenser (C3). | 1 H.F. choke—ordinary type. | 3 baseboard mounting coil holders. |
| 1 .0002-mfd. fixed condenser (C5). | 1 low-ratio L.F. transformer. | 1 on-and-off switch (S1). |
| 1 .001-mfd. fixed condenser (C4). | 1 2-megohm grid leak and holder (R1). | Terminals, connecting wire, and screws. |

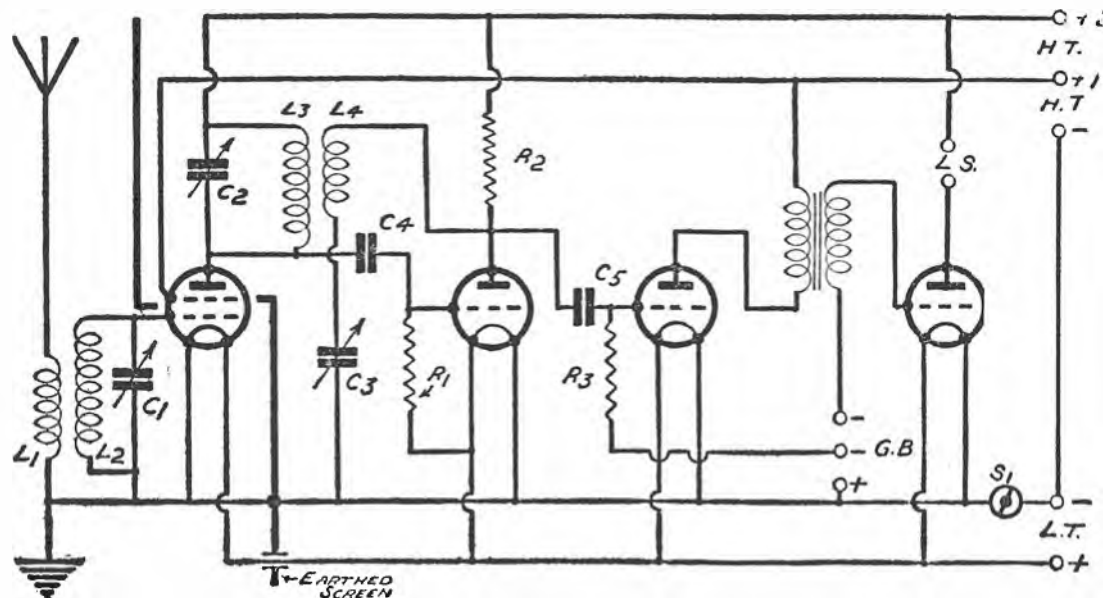


FIG. 116.—Circuit No. 20 : Four-valve Circuit with Tuned Anode Coupling for H.F. Valve.

List of Components for Circuit No. 20

- | | | |
|--|---|---|
| 2 ·0005-mfd. variable condensers (C1 and C2). | 1 100,000-ohm anode resistance and holder (R2). | 4 valve holders (one of the horizontal screen-grid type). |
| 1 ·0003-mfd. variable condenser (C3). | 1 medium-ratio L.F. transformer. | 1 on-and-off switch (S1). |
| 1 ·001-mfd. fixed condenser (C4). | 1 astatic tuned anode unit with reaction. | Aluminium screen with hole for valve. |
| 1 ·0002-mfd. fixed condenser (C5). | 1 aerial transformer or coils and holders. | Terminals, connecting wire, and screws. |
| 2 2-megohm grid leaks and holders (R1 and R3). | | |

List of Components for Circuit No. 21

- | | | |
|--|---------------------------------------|---|
| 2 0.0005-mfd. variable condensers (C1 and C2). | 1 0.002-mfd. fixed condenser (C5). | Set of coils. |
| 1 panel-mounting neutralising condenser (C3). | 1 S.G. H.F. choke. | 4 valve holders. |
| 1 0.001-mfd. fixed condenser (C4). | 1 2-megohm grid leak and holder (R1). | On-and-off switch. |
| | 1 medium-ratio L.F. transformer. | Terminals, connecting wire, and screws. |
| | 3 baseboard mounting coil holders. | |

CIRCUIT

and a hole in the screen should allow the valve to be mounted with the screening grid in the same plane as the screen. On one side of the screen all the grid-circuit components are mounted, whilst on the other the anode components are fixed. The screen is shown in the circuit diagram. The aerial circuit coils L_1 and L_2 may be ordinary plug-in coils or a commercial six-pin aerial transformer. No H.F. choke is required in the anode circuit of the detector valve, as the anode resistance acts as an efficient H.F. stopper.

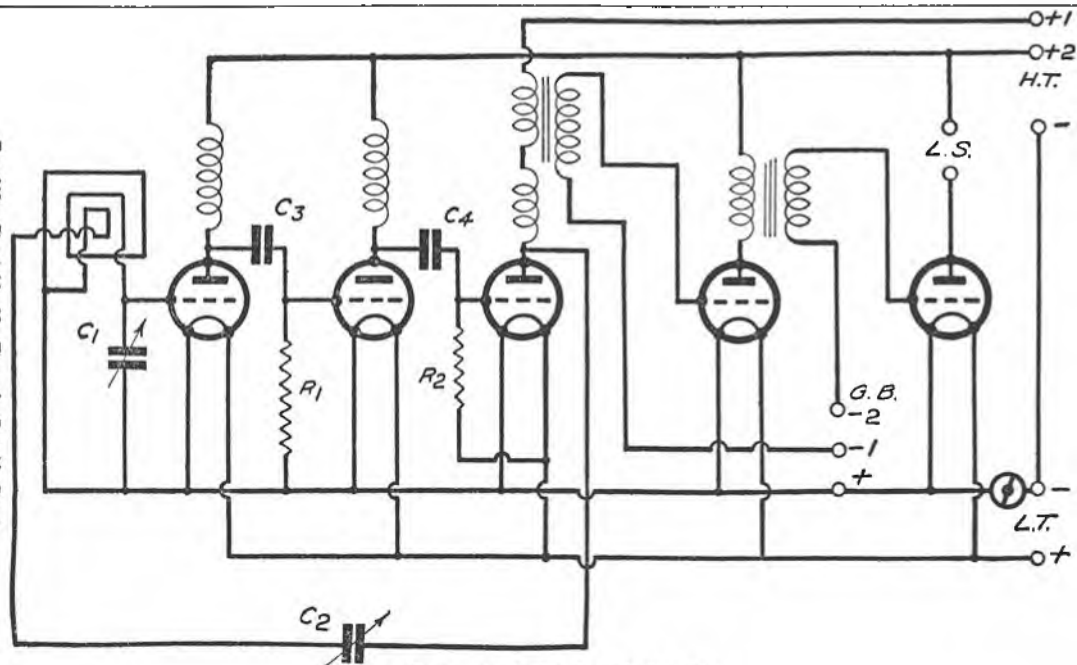
Circuit No. 21. The screen-grid valve, owing to its high amplification factor, is rather unselective, and therefore if employed near a very high-powered station may have to be adjusted so that quite a lot of its amplification is sacrificed in order to get selectivity. The neutralised triode, on the other hand, is very selective, without the high amplification. An ideal arrangement would therefore be to use both of these valves, one to get the selectivity and the other to get signal strength. This circuit is shown in Fig. 117, and is followed by a simple detector and L.F. stage. Ordinary plug-in coils are employed throughout, the aerial coil (L_1) being a No. 35, the grid coil (L_2) a No. 60, and the neutralising tuned anode (L_3) a No. 60 centre-tapped coil. For the long waves these should be No. 75 or 100, No. 250, and No. 250 C.-T., respectively. The H.F. choke must be of the S.G. type, and the neutralising condenser (C_3) should be of the type which can be mounted on the panel in order that it may be used as a reaction control. This is done by over-neutralising very slightly—it must not be overdone, or interference will be caused. The valves required are, in order: H.F., screen-grid, detector, and L.F., and the

transformer should be of the medium-ratio type.

Circuit No. 22. Fig. 118 shows a five-valve circuit specially designed for portable receivers. A small attaché case or suitcase should be chosen to accommodate the set, the five valve holders being mounted on a strip of ebonite, sunk to the bottom of the case, and the condensers and switch mounted on another piece of ebonite secured at the front and high up in the case. The other components may be screwed to a small wooden base accommodated between these two ebonite panels. The frame aerial should be wound round a piece of wood which will fit in the lid, and the loudspeaker could be mounted on a piece of plywood which would allow the cone to fit inside the frame, the whole serving to hold the frame inside the lid of the case. Whatever size of frame is used, take 75 ft. of 24 D.C.C. wire for the aerial section, with an additional 6 or 7 ft. for the reaction section. The two lengths should run in the same direction, the end of the aerial section and the beginning of the reaction section being joined together and taken to the side of the tuning condenser, which is also joined to the filaments. Three valves of the H.F. type are required in the first three sockets, the fourth being of the detector type, and the last of the L.F. type. This will keep the H.T. consumption low, and make for economical running. The L.F. transformers should be of the latest midget type, having a ratio of 3 or 4:1, and the valves should be chosen with a view to keeping the anode current at a low value in order that the smallest size of H.T. battery can be utilised.

Circuit No. 23. This is a multi-stage receiver (Fig. 119) of the very latest type, employing what is known as the super-heterodyne principle.

FIG. 118.—Circuit No. 22: Five-valve Portable Circuit.



List of Components for Circuit No. 22

- | | | |
|---------------------------------------|--|-------------------------------|
| 1 .0005-mfd. variable condenser (C1). | 2 .0003-mfd. fixed condensers (C3 and C4). | 5 valve holders. |
| 1 .0003-mfd. variable condenser (C2). | 2 2-megohm grid leaks and holders (R1 and R2). | On-and-off switch (S1). |
| 3 H.F. chokes. | | Connecting wire, screws, etc. |
| 2 L.F. transformers—midget type. | | |

CIRCUIT

The selectivity of this type of receiver is of the very highest order, and is, in fact, practically the only type of set used in America where broadcasting stations are very numerous and close together. The condenser should be ganged, and therefore one knob only is used for tuning. The coils must be specially chosen for this type of set, and two or three firms now

frame aerial is tapped in the electrical centre, and then connected to the correct end of the oscillator coil. The H.T. battery must be kept in good condition, or instability will be experienced with this type of circuit.

List of Components for Circuit No. 23

2 .0005-mfd. variable condensers (ganged) (C_1 and C_2).

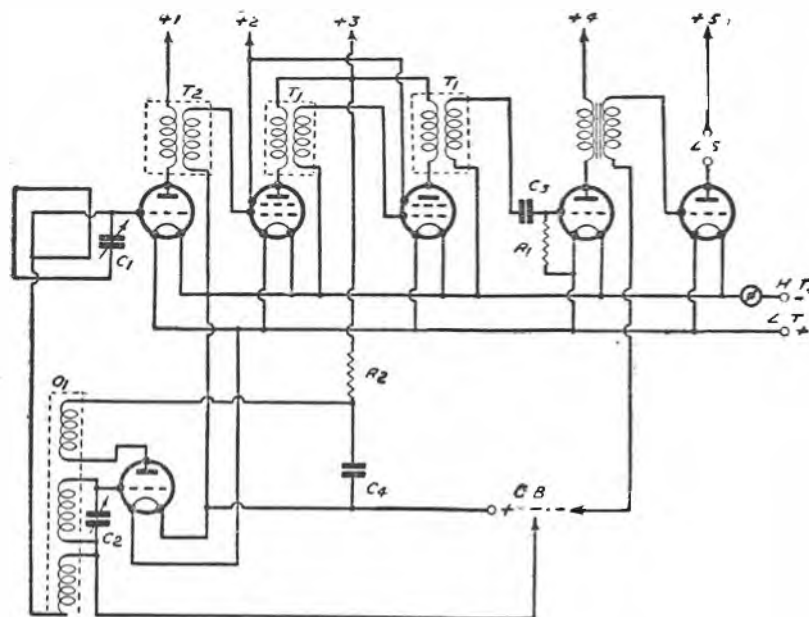


FIG. 119.—Circuit No. 23: "A Six-valve Supersonic Heterodyne Circuit."

turn out these special coils, complete in metal screening cans. They are sold in sets, an oscillator coil (O_1) and the intermediate H.F. transformers T_1 , of which two are required, and T_2 . The first valve is of the ordinary I.F. type, the next two are screen-grid valves, the next a detector valve, and the output valve should be of the small-power type. The oscillator valve should be of the general-purpose type. The

Set of super-heterodyne coils.

6 valve holders.

1 .0003-mfd. fixed condenser (C_3).

1 2-megohm grid leak and holder (R_1).

1 medium-ratio L.F. transformer.

1 spaghetti resistance, 20,000 ohms (R_2).

1 2-mfd. fixed condenser (C_4).

On-and-off switch.

Wire for frame aerial.

Terminals, connecting wire, and screws.

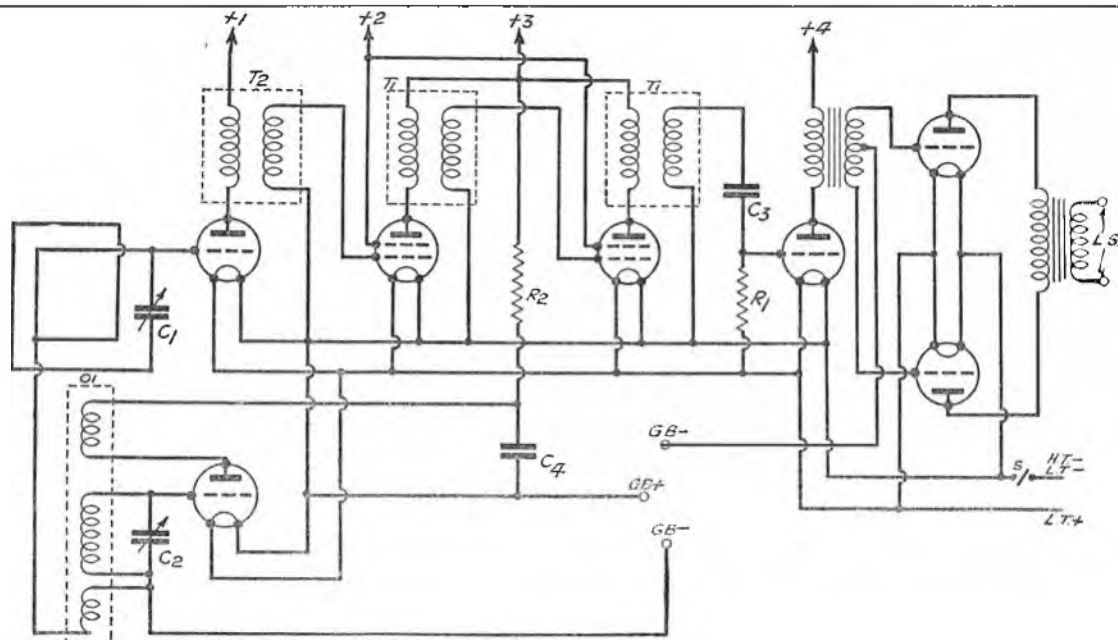


FIG. 120.—Circuit No. 24: Seven-valve Superheterodyne Circuit with Two-valve Output Stage in Push-pull.

List of Components for Circuit No. 24

- | | | |
|--|---|---|
| 2 ganged .0005-mfd. variable condensers (C1 and C2). | 1 spaghetti 20,000-ohm resistance (R2). | 1 output push-pull transformer. |
| 1 .0003-mfd. fixed condenser (C3). | Set of screened super-heterodyne coils. | On-and-off switch. |
| 1 2-mfd. fixed condenser (C4). | 7 valve holders. | Wire for frame aerial. |
| 1 2-megohm grid leak and holder (R1). | 1 input push-pull transformer. | Terminals, connecting wire, and screws. |

CIRCUIT

Circuit No. 24. Fig. 120 indicates an arrangement exactly similar to the preceding circuit, with the exception that the output stage consists of two valves in push-pull. This enables much greater signal strength to be dealt with, and will give sufficient power for dancing in a small hall. As mentioned in the previous push-pull circuits, the valves should be obtained specially matched to avoid distortion. All the previous remarks apply to this receiver, and if possible only H.T. batteries of the treble capacity or super type should be used. This receiver lends itself admirably to mains operation, and the special A.C. valves may be substituted, provided care is taken to adequately screen each valve in a copper or aluminium container. With this type of valve five-pin valve holders will be required, and the leads for the heaters will have to be of ordinary twisted lighting flex in order to minimise the risk of induced hum from the A.C. current carried by the heater leads.

A Universal Amplifier. The amplifier described is called "Universal," as it is so wired that it may be connected to any existing receiver, whether crystal or valve. A glance at the wiring diagram (Fig. 121) will show that no terminal has been provided for the H.T. negative lead, and also that a grid-bias battery is supplied for the amplifier. These two facts are easily explained, however. In any valve receiver the H.T. wire is connected to one or other of the L.T. terminals, and, therefore, when the two L.T. terminals on this amplifier are joined to the corresponding terminals on the receiver with which the amplifier is used, the H.T. lead is automatically joined in circuit. The existing receiver may employ a grid battery, but in this case there is not the slightest objection

to having a separate battery for the amplifier, especially as a valve will be needed in this case taking a higher value of bias, and then two of the 9-volt batteries may be joined in series, and the higher value of bias obtained in this way.

The above remarks apply, of course, only to the use of the amplifier with a valve set. In the case of a crystal receiver being used, the H.T. lead is joined to the L.T. terminal, and in addition a lead is taken from this terminal to earth. So much for the design of the amplifier, and now to deal with its construction, which is of the very simplest, and should cause no trouble, even to the very youngest novice.

The only components are a transformer, valve holder, switch, terminal strip and terminals, wire for wiring-up, grid-bias leads, and wander plugs. The ratio of the transformer will depend on the use to which the amplifier is put. If added to a crystal set, the transformer should have a ratio of 7 : 1. If used after a single detector valve, the ratio may be 5 : 1; whilst if added to a receiver employing two or more valves, then the ratio should not be more than 3 : 1.

The panel of the amplifier may be constructed from 3-ply or any other wood, although if you wish to match your present set you may employ ebonite. This is an unnecessary expense, however. In the centre of the panel mount the on-and-off switch. The transformer and valve holder are screwed down to the baseboard as shown in the wiring diagram, leaving sufficient space at the right-hand side for two grid-bias batteries side by side. The terminal strip with the six terminals fitted is then screwed to the rear of the baseboard. Use glazite or some similar wire for wiring-up, and take care that the two leads to the primary of the

CIRCUIT → COHERER

transformer (that is, those lettered P and H.T.) are connected to the input terminals, so that when these latter are connected to the 'phone terminals of your present set, they will be in the correct direction. For this reason it is preferable to use the type of terminals which have engraved lettering so that no mistake can occur. The rest of the wiring is quite straightforward.

The input terminals are then joined to the 'phone or L.S. terminals of your present receiver, and if this is a valve set, two insulated leads should then be joined from the two L.T. terminals on the amplifier to the corre-

If added to a multi-valve set, the valves should be of the small-power type.

If your present set also has an on-and-off switch, don't forget to operate the switch on the amplifier as well when switching off, or the valve will be left burning.

List of Components for Universal Amplifier

- 1 L.F. transformer.
- 1 valve holder.
- 1 on-and-off switch.
- 6 terminals.
- Ebonite strip.
- Wire for connections, screws, wander plugs, etc.

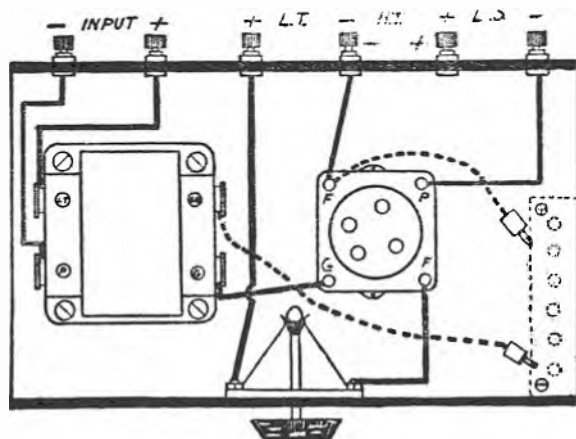


FIG. 121.—A One-valve Amplifier.

sponding terminals on the set. A separate flexible lead is joined to the L.S. + terminal on the amplifier to an appropriate tapping on the H.T. battery. If added to a crystal set, a separate lead should also be joined to the L.T. - terminal, and this lead should be plugged into the H.T. - tapping. Adjust the grid-bias tapping according to the H.T. value and the valve-makers' instructions, and if only one valve or a crystal is employed in front of the amplifier a valve of the L.F. type should be used.

CIRCUIT, REJECTOR.—See *Rejector Circuit*.

CLOSE COUPLING.—The arrangement of two inductances so that the maximum induced currents are obtained.

CODE, MORSE.—See *Morse Code*.

COHERER.—A form of detector in which a non-conducting tube is filled with metallic filings loosely packed. The application of a current to the filings causes them to "pack" or "cohere" and so provide a conducting path.

COIL

COIL.—An aerial tuning inductance, incorporated so that the circuit will respond or tune to various frequencies. (See also *Tuning Coils and Tuning Systems*.)

with the circumference of the block. If you then mark the positions for the nails, just under $\frac{1}{2}$ in. apart, starting from any given point, you will find them practically regular.

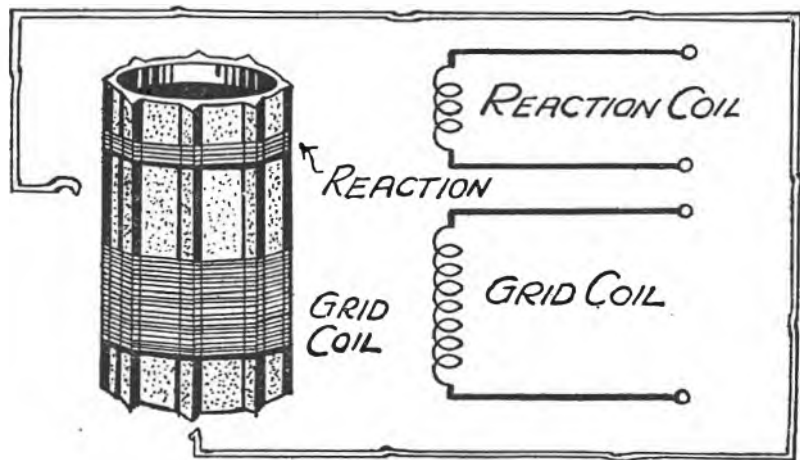


FIG. 122.—Theoretical and actual diagrams of an Aerial Tuning Coil.

Making Tuning Coils. The first type of coil to describe is known as the "basket-weave" variety. It should not be confused with the basket coil, generally wound on cardboard. The "basket-weave" coil is self-supporting, very easy to make, and probably the most efficient of all.

Fig. 123 shows the only "apparatus" necessary. This is a circular wooden block, $2\frac{1}{2}$ in. in diameter (to standardise the turn numbers), round the edge of one flat surface of which are a number of nails. These nails should be driven in $\frac{1}{4}$ in. from the circumference, and should be equally spaced. For the purpose of this description we will take it that there are eleven of them, although you may use any number that is not divisible by two or three.

The best way to space out these nails evenly is to draw a circle of 2 in. diameter, concentric, of course,

If you like to operate with a protractor and draw angles of 33° all round, you will be still more accurate.

Knock the nails in sufficiently hard to prevent them from bending inward under pressure, but not so hard that they cannot be extracted.

Winding the Coil. The actual winding is simple. Take the end of the wire,

twist it round any given nail, and go off round the circle as follows. Take it inside the second

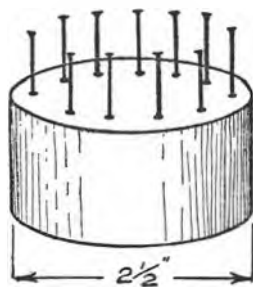


FIG. 123.—The wooden block and nails for making a Basket-weave Coil.

COIL

nail, outside the third, inside the fourth, and so on. When you have got back to the starting point you will find the second turn naturally

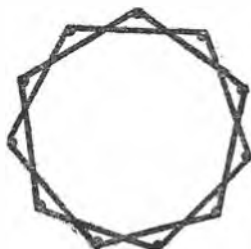


FIG. 124.—The finished Coil.

goes outside the nail that it was previously inside, and, when you have continued for ten turns or so, you will see the coil take shape. On reaching the desired number of turns, simply bind the coil round with cotton in six places (it is best to tie the cotton round the "thin" portions where two sets of turns cross—that is, midway between any two nails), pull the nails out, and the coil is complete. The ends are simply twisted once round the nearest nail.

Reference to Fig. 124 will show the general idea and, roughly, the appearance of the finished coil.

Previously it was said that the number of nails must not be a multiple of three. This is because it is possible to make an even neater coil, as a "de luxe" job, by taking your wire inside two nails, outside the next one, inside two again, outside one once more, and so on. You may experiment with various methods of winding, since these slight alterations will not seriously affect the turn numbers given in the table farther on.

These "basket-weave" coils are particularly suitable for short-wave work, since no two adjacent turns are really concentric. Any turn is only touching its next-door neighbours at the points that were halfway between the nails when the winding was being carried out. In the case of the first type, concentric

turns are spaced from each other by one other turn, and, with the second type, there are three different kinds of turns before a return to the first one is made.

The "Sub-100-Metre" Coil. Now for more detailed particulars. For wavelengths above 100 metres, the coils will be rigid enough with No. 22 D.C.C. wire. Naturally D.S.C. may be used, but it hardly warrants the extra expense. For the "sub-100-metre" coils No. 18 should be used, since they have few turns and are not too rigid otherwise. Further, the use of thick wire has the desirable effect of increasing the spacing between turns.

The following table gives a rough indication of the turn numbers required for various ranges. It is made out for a .0005 condenser above 100 metres, and a .0001 below:

Turns	Wavelength Range Metres
2	8-14
5	13-27
9	25-42
12	30-60
18	55-125
25	100-180
50	160-400
75	220-560
100	360-740

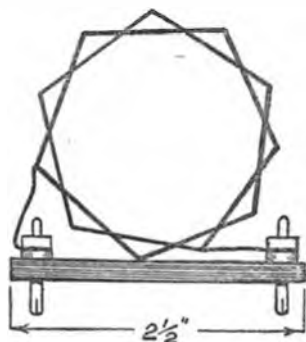


FIG. 125.—The Coil mounted on a strip of ebonite.

VARIOUS COMMERCIAL COILS

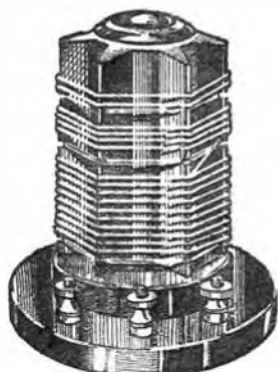


FIG. 126.—A well-known commercial Triple-range Coil.

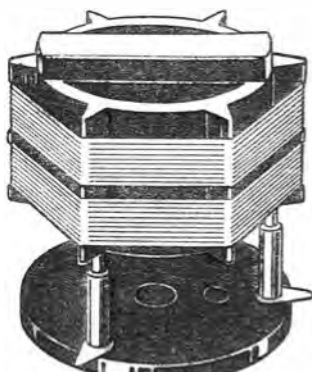


FIG. 127.—A "low-loss" air-spaced Coil.

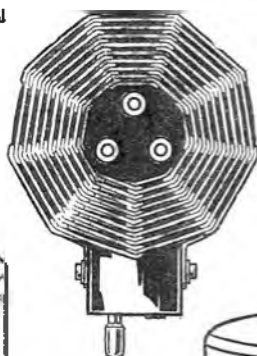


FIG. 128.—A simple air-spaced plug-in Coil.

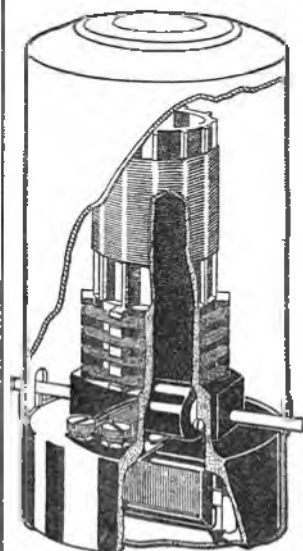


FIG. 129.—A canned Coil of the dual-range type, with enclosed switching.

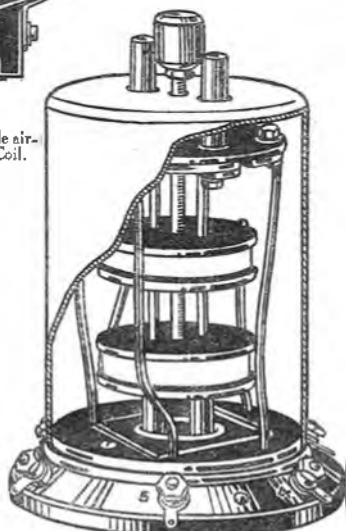


FIG. 130.—A screened type of intermediate frequency amplifier Coil for super-heta.

although a cardboard former may be used instead. In this case a hole is drilled in the centre of the cardboard, and two shaped pieces of ebonite are bolted, one on either side, through this hole, and again at the bottom.

The remarks made previously about

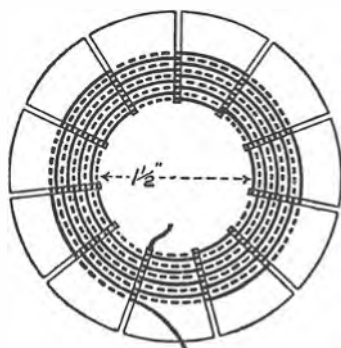


FIG. 131.—The Coil ready for mounting.

the reaction coil still apply—use the next smallest in the scale throughout.

The true "basket" coil was used long before the so-called "basket-weave" coil was first invented. It is probably still the most popular type of home-made coil, for two reasons. First, it is absurdly simple to make. Secondly, it is very rigid, and will stand a greater amount of knocking about than any of the self-supporting types of coil.

The "frame" of the basket coil is a circle of cardboard, with slits cut in it to accommodate the winding. Simply as a precaution against the possibility of its absorbing moisture, it is advisable to "dope" the cardboard, though *not* too liberally, with shellac or varnish. It should be emphasised,

though, that this treatment is not for any reason connected with a more efficient dielectric material! The reverse, unfortunately, may be the case, but at the same time the losses are not high enough to worry about.

Fig. 131 shows the arrangement. This consists of a circular piece of cardboard of any diameter, with slots running towards the centre and stopping on the circumference of a circle with a diameter of $1\frac{1}{2}$ in. This diameter should be kept constant for all sizes of coil, and naturally the number of turns in the coil will decide the outside diameter.

Eleven or nine slots are the usual numbers, but any odd number of slots may be used.

Winding. The winding procedure is similar to that for "basket-weave" coils. Simply bore a hole just inside the unslotted area of the cardboard, twist round sufficient wire to make connection to the mounting scheme, and go off round the circle, winding outside one "prong," inside the next, and so on until the required number of turns has been wound on. Then make the end fast through a hole in the nearest prong, and you have a very serviceable coil.

Two hints that will save unnecessary waste of time are these: (1) make your slots roughly three times the diameter of the wire to be used; and (2) pull the wire tight as you go along. The second may seem too obvious to need mentioning, but there is a fascination about winding

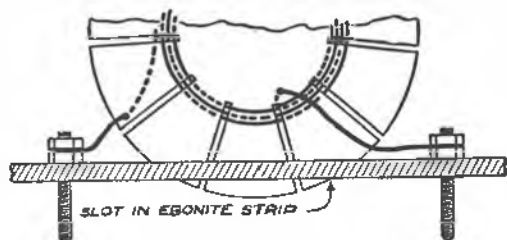


FIG. B2.—How the Coil is mounted.

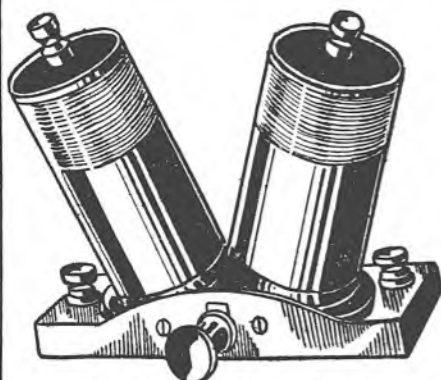


FIG. 133.—An Astatic Band-pass Tuner.

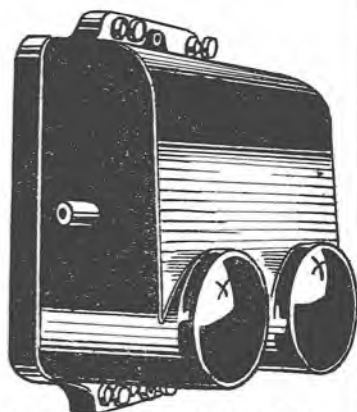


FIG. 134.—A Band-pass unit of original design.

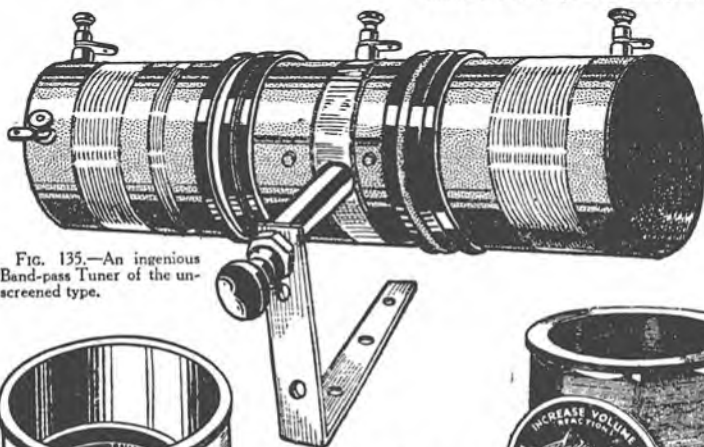


FIG. 135.—An ingenious Band-pass Tuner of the un-screened type.

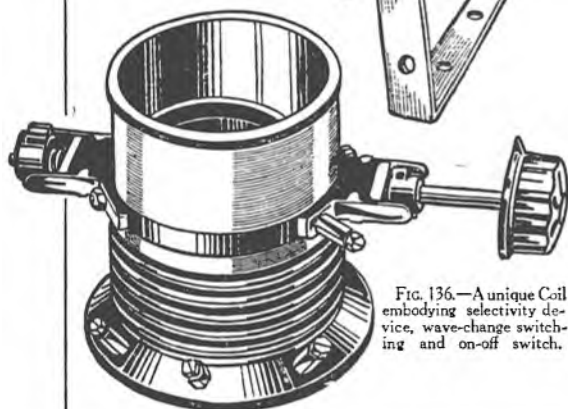


FIG. 136.—A unique Coil embodying selectivity device, wave-change switching and on-off switch.

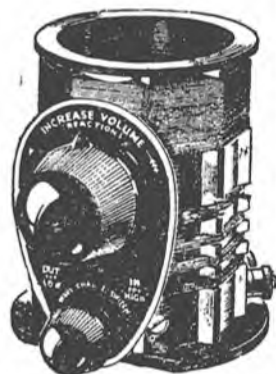


FIG. 137.—An all-range Tuner having many useful adjustments.

COIL

these coils that tends to make the novice run blithely on, only to find a contraption like a wire entanglement in his hands at the finish!

Below are given the turn numbers for wavelengths of 100 metres upwards, and carrying on higher up the scale than in the table given on an earlier page.

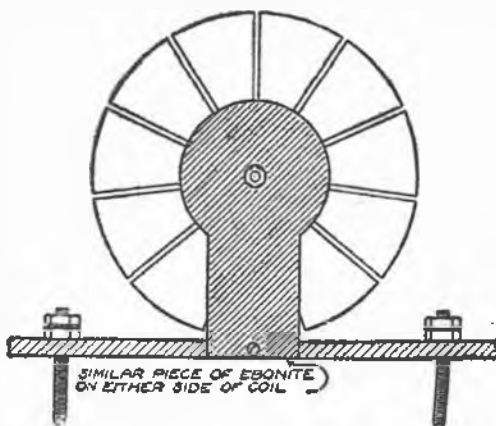


FIG. 138.—The finished Coil.

The Wavelength Ranges. These are approximately correct with a .0005 condenser, and for wire of No. 24 gauge up to 500 metres, above which No. 30 is used.

Wave Range Metres	No. of Turns	Gauge
100— 220	24	No. 24
150— 340	35	No. 24
250— 560	55	No. 24
500— 1,000	95	No. 30
900— 2,000	190	No. 30
1,800— 3,800	300	No. 30
3,500— 7,000	550	No. 30
6,000—19,000	1,000	No. 36

Some of the turn numbers may seem peculiar in relation to the ranges covered, but you must remember that the diameter is steadily increasing. The very largest are apt

to become a little unwieldy, and really substantial cardboard should be used.

An ideal set of coils for all wavelengths could well be made up by using the "basket-weave" type up to 200 metres or so, and carrying on with cardboard-supported basket coils after that. Remember, incidentally, to standardise your direction of winding for *all* the coils.

On the subject of "doping," it cannot be emphasised too strongly that the self-supporting type should never be doped at all. The others should likewise never be smeared all over with shellac, as is sometimes done, after they have been finished. The former is the only part that needs it, and you can be very sparing with that!

Mounting the Coil. As regards the mounting of basket coils, probably the best scheme is to fit one edge of the cardboard former into a slot cut in the piece of ebonite that is to take the terminals or plugs. Fig. 132 shows a suggestion for doing this neatly.

The figures given are for use when the coil is a closed circuit, without an aerial tapped on to it.

A Reaction Receiver. Where the coils are to be used in a reaction receiver, it is well to make the whole set once only, and it will usually be found that for a given coil in the grid circuit, the next smaller coil will serve for reaction.

As regards the mounting of the coils, tie them down to a strip of ebonite with a plug at each end, as shown in Fig. 138. This makes quite a rigid job for experimental purposes, and the wide spacing between the plugs makes for greater efficiency

COIL

than one generally associated with two-pin coil mounting.

If it is not desired to use a series of plug-in coils, naturally one large "basket-weave" coil may be wound, and **tappings** brought out at the necessary places. For this purpose it is best to give the wire an outward twist where it takes a turn round one of the nails. The loop formed may be bared afterwards, and connection made by a crocodile clip in the usual way.

Making a Dual Coil. The coil

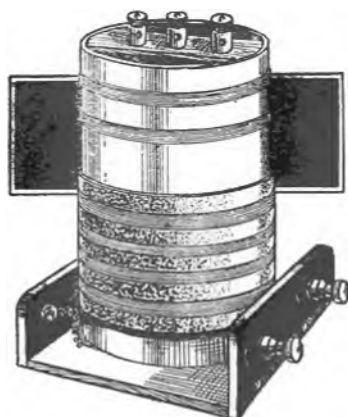


FIG. 139.—The completed Coil.

shown in Fig. 139 has been specially designed for easy construction.

The results are also an improvement in that the coil is a "General Purpose" one, and can be used in circuits ranging from a crystal set to screened grid.

The materials required are few, and the only item which need be bought is the wire, which is usually sold at 10d. or 1s. per 4-oz. reel (although

actually only 2 oz. of wire is needed).

The coil is "pile wound," which makes for easier winding, and saves the tedious method of layer winding

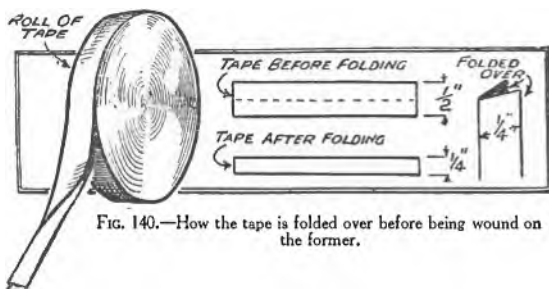


FIG. 140.—How the tape is folded over before being wound on the former.

—which is the bugbear of amateurs.

In "pile winding" the wire is simply wound on anyhow (the turns on top of each other), in the slots or spaces on the coil, and the *whole* winding can be done in a *quarter of an hour* by this method.

The reaction winding has been placed *between* the short- and long-wave windings, and this gives far more even results in *both* wave bands. The reaction is also provided with a *tapping* (a most useful feature not found on manufactured coils), which

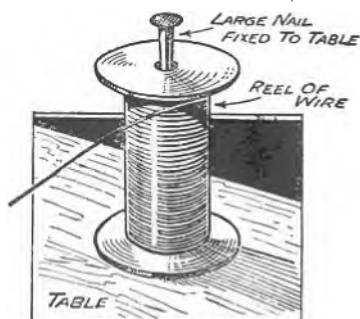


FIG. 141.—A nail driven in the bench to hold the reel while the wire is wound on the coil.

is a proved success, and provides a simple method of adjustment.

To start the Former. This is wound with five windings of insulat-

COIL

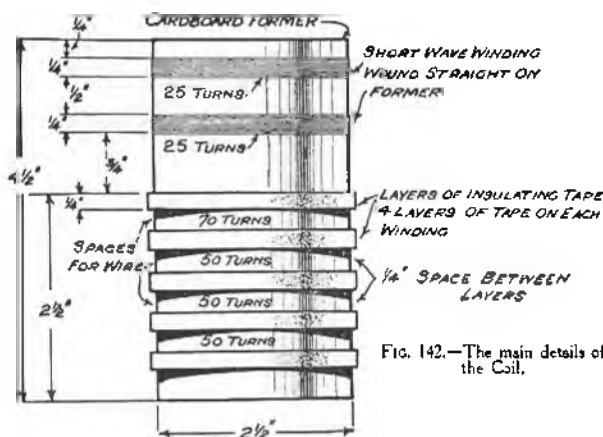


FIG. 142.—The main details of the Coil.

is commenced. Bore two small holes in the first slot (bottom slot), thread the wire through several times to secure it, and leave about 6 in. of wire inside of the former for connecting up. Wind fifty turns in the first slot, then cross over and continue winding in second slot, cross over again from

ing or electricians' tape (as it is called). These "windings" are $\frac{1}{2}$ in. apart; about four layers of tape to each "winding" will suffice to form the "slots" or spaces for the wire to be wound in.

The insulating tape should be doubled as it is wound on, as shown in Fig. 140. This operation, although sounding tedious, actually only takes a few minutes. The reel of wire is then taken and slipped over a long nail (Fig. 141), which is clamped in a vice or nailed on the table top, and the winding

second slot to the third slot, thus winding fifty turns in each slot, making a total of 150 turns on the long-wave winding (Fig. 142). Bore

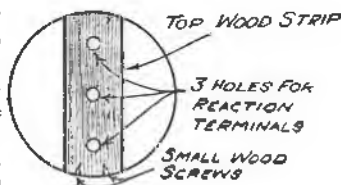


FIG. 143.—The top wooden Strip.

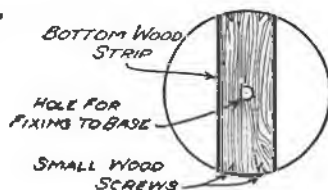


FIG. 144.—The bottom wooden Strip.

two more holes and secure coil end as before. The easiest way is to count ten turns and then jot it down with a pencil, then wind ten more,

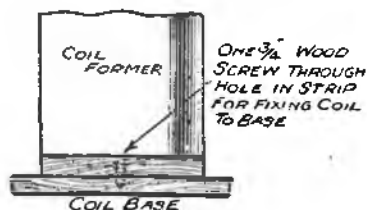


FIG. 145.—The Coil fixed to the base.

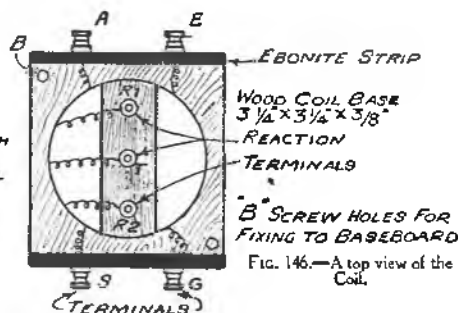


FIG. 146.—A top view of the Coil.

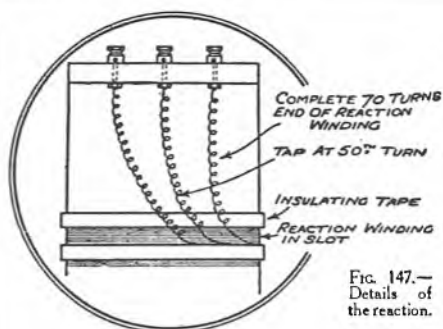


FIG. 147.—
Details of
the reaction.

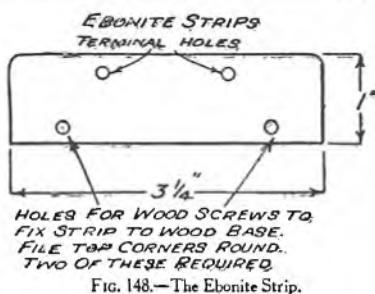
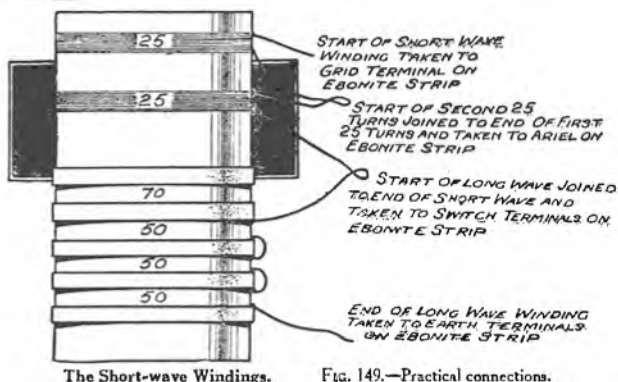


FIG. 148.—The Ebonite Strip.



The Short-wave Windings.

FIG. 149.—Practical connections.

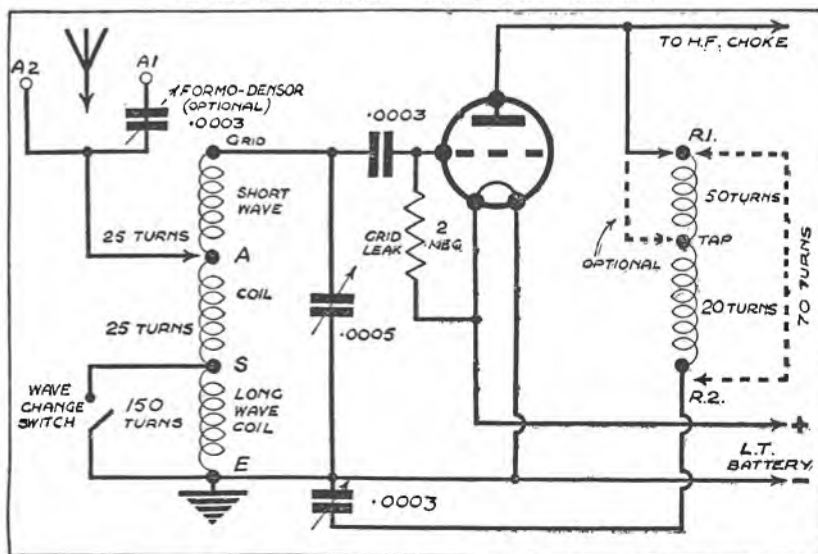


FIG. 150.—A circuit diagram showing the Coil fitted in the set.

COIL **COIL-WINDING TABLE** (LONG-WAVE COILS.)

Dia- meter of Former.	Inductance 1,600 Microhenrys.			Inductance 2,100 Microhenrys.			Inductance 3,000 Microhenrys.		
	No. of Slots.	Wire.	Turns per Slot.	No. of Slots.	Wire.	Turns per Slot.	No. of Slots.	Wire.	Turns per Slot.
1 in.	4 5	36 enam. 36 D.S.C.	80 69	4 5	36 enam. 36 enam.	92 80	5 6	38 D.S.C. 36 enam.	95 85
1½ in.	3 4 5	36 D.S.C. 36 D.S.C. 34 D.S.C.	71 57 53	3 4 5	36 enam. 36 D.S.C. 34 enam.	81 65 60	3 4 5	36 enam. 36 enam. 36 D.S.C.	97 78 72
2 in.	3 4 5	34 enam. or 36 D.S.C. 34 D.S.C. 34 D.S.C.	56 45 38	3 4 5	36 D.S.C. 34 D.S.C. 34 D.S.C.	65 51 44	3 4 5	36 enam. 36 D.S.C. 34 enam. or 36 D.S.C.	77 61 53

(MEDIUM-WAVE COILS.)

Dia- meter of Former.	Inductance 175 Microhenrys.			Inductance 200 Microhenrys.			Inductance 230 Microhenrys.		
	Wire.	Turns.	Length in inches.	Wire.	Turns.	Length in inches.	Wire.	Turns.	Length in inches.
1½ in.	32 enam. 30 D.S.C.	84 93	1·01 1·38	32 enam. 30 D.S.C.	93 102	1·11 1·52	30 D.S.C. 32 enam.	115 102	1·71 1·22
1¾ in.	30 D.S.C. 28 D.C.C.	74 94	1·10 2·24	30 D.S.C.	82	1·22	30 D.S.C.	90	1·34
2 in.	30 D.S.C. 28 D.S.C.	63 67	0·94 1·16	30 D.S.C. 28 D.S.C.	68 73	1·01 1·26	30 D.S.C. 28 D.S.C.	76 80	1·13 1·38
2½ in.	30 D.S.C. 28 D.S.C.	54 58	0·805 1·01	30 D.S.C. 28 D.S.C.	59 64	0·88 1·13	30 D.S.C. 28 D.S.C.	65 70	0·97 1·24
3 in.	26 D.C.C. 28 D.S.C. 24 D.C.C.	70 52 65	1·96 0·925 2·08	26 D.C.C. 28 D.S.C. 24 D.C.C.	78 57 72	2·18 1·01 2·30	26 D.C.C. 28 D.S.C. 24 D.C.C.	86 62 80	2·40 1·10 2·56
3½ in.	28 D.S.C. 24 D.C.C.	47 58	0·835 1·85	28 D.S.C. 24 D.C.C.	51 64	0·91 2·04	28 D.S.C. 24 D.C.C.	56 70	1·0 2·24
4 in.	26 D.S.C. 22 D.C.C.	41 50	0·86 1·90	26 D.S.C. 22 D.C.C.	45 55	0·95 2·09	26 D.S.C. 22 D.C.C.	49 61	1·03 2·32

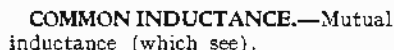
leads to reaction condenser) severely alone.

Materials Required. One cardboard former, 4½ × 2½ in., 2 oz. No. 30 enamelled wire.

Seven terminals (any type, bell or telephone). One small roll insulating

tape. One piece of wood 3½ × 3½ in. by about ½ in. thick. Two strips of wood 2½ × 1 in. by about ½ in. thick. Two strips of ebonite 3½ × 1 in. up to ½ in. thick. One doz. small brass wood screws (about ¾ in. long). One ¾-in. wood screw (for screwing coil to base).

FIG. 152.—The Coil fitted to a simple two-valve set.



separating the plates of a condenser is known as the Dielectric, and the formula for ascertaining the capacity of a fixed condenser is:

where A = overlap area of each plate.
 n = number of dielectrics.

K = dielectric constant of the insulator.

t = thickness of dielectric (in inches).

The formulæ for complicated shapes such as spheres, etc., are much more intricate. For two spheres, one inside the other, separated by air, the formula is:

R and r are the radii of the spheres in inches.

CONDENSER

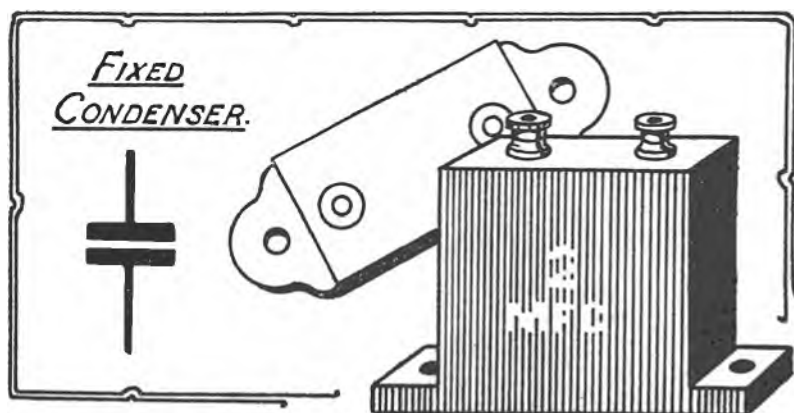


FIG. 153.—Fixed Condenser shown theoretically and pictorially.

Making Fixed Condensers. Fig. 154 shows the construction. Notice that alternate plates are connected together and brought to one terminal, likewise the remaining alternate plates are joined together and fixed to the other terminal. The capacity of the

curable for a very small outlay.

The capacity is dependent upon the area and number of plates used, and also the thickness of the insulating material; therefore, before being able to make the condenser, it is essential that something be

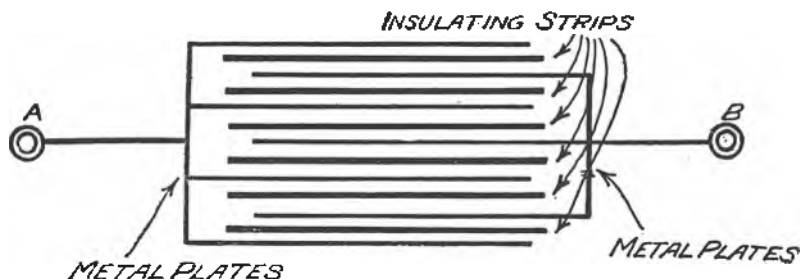


FIG. 154.—The plates in a condenser, shown on an enlarged scale.

condenser then exists between the terminals A and B.

To make up a selection of condensers, then, the requirements are: copper or tinfoil sheet between 0.001 and 0.002 in. thick, mica about 0.002 in. thick for the insulating material, scrap ebonite to make up the body of the component, and a few small brass nuts, bolts, washers, and terminals. These items are readily pro-

known of the method of calculating one from the other. This is not a difficult matter, as will be seen from the details furnished below.

When making ruler measurements some people prefer to use the metric system, in which case centimetres are the units; others prefer the English standard of inches. Two formulæ are given, one with centimetre units, the other inch units. However,

CONDENSER

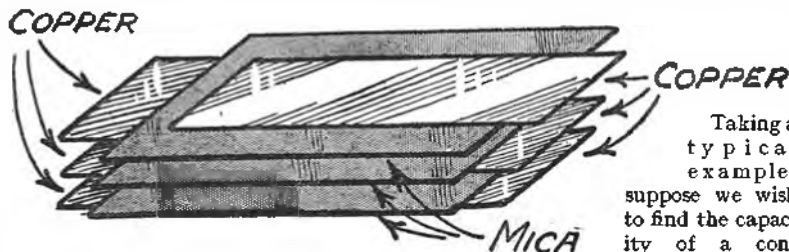


FIG. 155.—Pictorial diagram of the Copper and Mica Layers.

should the measurements be in inches, and one desires to use the other formula, it is only necessary to multiply inches by 2.54, and they are then reduced to centimetres.

The first formula is:

$$C = \frac{0.0885 \times a \times K \times N}{1,000,000 D}$$

where C=capacity in micro-farads.

D=thickness of the insulating material in centimetres.

a=area of one metal plate in square centimetres.

K=the dielectric constant.

This is known as the specific inductive capacity (or S.I.C., as it is generally called) of the insulating material. This value is found from the tables contained in this book. For example, the table shows an average value of 6 for mica.

N=the number of insulating strips used. This is calculated simply by subtracting one from the total number of copper or tinfoil plates. In Fig. 154 there are 7 plates, hence the value of $N=7-1=6$. Verify this by counting the number of insulating strips, when it is found there are 6, which is correct.

each 4 square centimetres in area, the plates being separated by mica insulating strips $\frac{1}{4}$ millimetre thick.

Substituting the values for the symbols:

$$\begin{aligned} C &= \frac{0.0885 \times a \times K \times N}{1,000,000 D} \\ &= \frac{0.0885 \times 4 \times 6 \times (7-1)}{1,000,000 \times 0.05} \\ &= 0.000424 \text{ micro-farad.} \end{aligned}$$

For practical purposes this can be called 0.004 micro-farad.

The second formula, where the measurements are in inches, is:

$$C = \frac{0.225 \times a \times K \times N}{1,000,000 D}$$

Therefore, to find the capacity of a condenser consisting of, say, 6 copper foil plates each $1 \times \frac{1}{2}$ in., with mica insulators each 0.002 in. thick, proceed as before:

$$\begin{aligned} C &= \frac{0.225 \times 1 \times 0.5 \times 6 \times 5}{1,000,000 \times 0.002} \\ &= \frac{0.675}{200} \\ &= 0.0033 \text{ micro-farad.} \end{aligned}$$

Having worked these simple examples, and determined the capacity of a condenser from given values, let it now be assumed that it is necessary to know the number of plates to be used in making a condenser of 0.001 micro-farad, having plates $\frac{1}{2} \times \frac{1}{2}$ in. and mica insulators each 0.002 in.

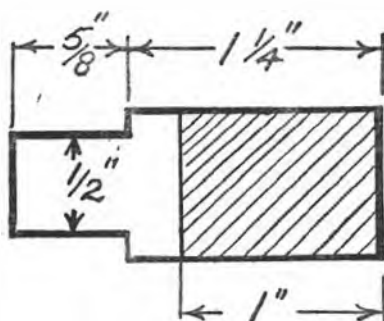


FIG. 156.—Size and shape of the copper foils. The additional area on the left enables the plates to be joined together.

FIG. 158.—Extreme right. Section of Fixed Condenser, showing how it is built up.

FIG. 159.—How the Condenser is clamped together.

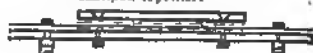


FIG. 160.—Diagram of the complete assembly.

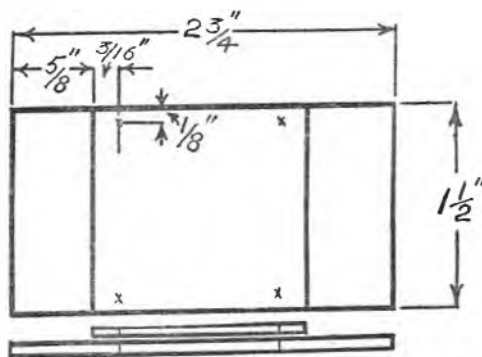
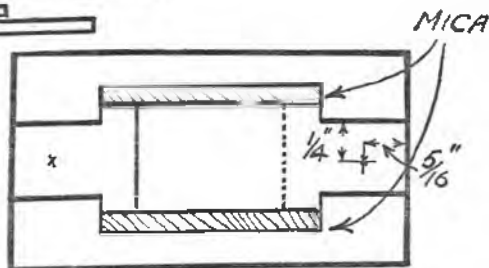


FIG. 157.—Dimensions of the Ebonite Plates for making fixed condensers.

FIG. 160A.—Plan view of the Fixed Condenser, showing how the alternate laminæ of mica and foil overlap.



CONDENSER

thick. Do the same as before, and substitute the values known, except that the formula is now rearranged for the purpose:

$$N = \frac{C \times D \times 1,000,000}{0.225 \times A \times K}$$

$$N = \frac{0.001 \times 0.002 \times 1,000,000}{0.225 \times 0.75 \times 0.5 \times 6}$$

$$= \frac{2}{0.506} = 4 \text{ approx.}$$

Now, the values of N in the previous examples were found by subtracting 1 from the total number of plates, hence 1 must be added to the value of N just determined, i.e. $4 + 1 = 5$. This is the number of plates required.

For the benefit of those readers who do not wish to spend time working out values from the above formulae, a short list is appended, which will enable them to see at a glance the requisites for a condenser of a given value.

Copper Foil. Mica 0.002 in. thick.

<i>C in Micro-farad.</i>	<i>Dimension of Plate in In.</i>	<i>No. of Plates.</i>
0.001	$\frac{1}{2} \times \frac{1}{2}$	5
0.002	$1 \times \frac{1}{2}$	7
0.003	$1 \times \frac{3}{4}$	7
0.0015	$\frac{1}{2} \times \frac{3}{4}$	3
0.0005	$\frac{1}{2} \times \frac{1}{2}$	4
0.0006	1×1	2
0.0008	$\frac{1}{2} \times \frac{1}{2}$	6

This simple part completed, all that remains to be done is the construction. To make, for example, a 0.003-micro-farad condenser, cut seven pieces of copper foil to the shape and size shown in Fig. 156. The additional area on the left enables the plates to be joined together in the manner mentioned earlier. The shaded portion is actually the operative area. Next cut eight mica strips each $1\frac{1}{2} \times 1$ in. It will be noticed that the number of insulators is two

in excess of those required to satisfy the value of N for this particular capacity. They are merely placed between the first and last metal plates and the ebonite base and cover respectively as additional insulation only. Notice also that these are of larger dimensions than those of the copper plates; this is necessary to prevent the metal plates from bending over and touching each other.

Cut a piece of ebonite $2\frac{1}{2} \times 1\frac{1}{2}$ in. (see Fig. 157) to form the baseplate, and at the same time cut another piece $1\frac{1}{2} \times 1\frac{1}{2}$ in. for the cover. Before commencing assembly place the smaller piece of ebonite on top of the larger, and drill four 8 B.A. holes (number 42 drill) at the X positions indicated in Fig. 157, countersinking these if desired. With the ebonite base on a flat surface, place a strip of mica in a central position on the face, the longer side being parallel to the $2\frac{1}{2}$ -in. side of the ebonite. Next, lay the first copper plate over the mica, the lug being flush with the $1\frac{1}{2}$ -in. side, cover with another strip of insulating material, and place the second metal plate over this, so that the lug is on the opposite side to the first plate. A glance at Fig. 158 shows how this should be done. Continue the process, feeding on alternate strips of mica and copper, using the additional insulator to cover the last plate. The ebonite cover is then pressed over the whole, in the same position as when the drilling was done. Fig. 159 illustrates the assembly as it should now be.

Clamp the whole, and bolt together with four 8 B.A. brass bolts as tightly as is practicable. It is absolutely essential that no air space exists between the copper and mica strips, otherwise the capacity will be affected. It will be understood that this is so by referring to the formula, where it was seen that the insulating material possessed a certain

definite value, denoted by K. If air, therefore, is present, the constant is altered to a value dependent upon the combination of mica and air.

The remaining operation is to fix the terminals. With a 6 B.A. drill (No. 24), drill two holes through the plates and base, using Fig. 160 as a guide to their position. Reverse the condenser, and from the base side insert two 6 B.A. terminals, firmly bolting together with washers and nuts.

The finished condenser should now resemble that shown in Fig. 159.

To construct a condenser of any other capacity adopt the same procedure as used in the given example, cutting the ebonite base and cover smaller or larger in proportion to the area of the copper plates employed. (See also *Variable Condenser*.)

CONDENSERS IN PARALLEL.

—Condensers connected as in Fig. 5 to increase the total capacity. The total capacity of the series is obtained by adding the capacities together.

CONDENSERS IN SERIES.—Condensers connected as in Fig. 4 to reduce the total capacity. The capacity of a number of condensers so connected would be the reciprocal of

$$\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots$$

CONDENSER VALUES. — Series

Aerial Condensers, .0001–.0003 mfd.

Aerial Tuning Condenser, .0005 mfd.

Anode Tuning Condenser, .0003 or .0005 mfd.

Anode Coupling Condenser, .0001–.0003 mfd.

Grid Condenser, .0001–.0003 mfd.

Detector Anode Bypass Condenser, .0001–.0005 mfd.

R.C.C. Condenser, .01–1 mfd.

Decoupling Condenser (H.F.), .1–1 mfd.

Decoupling Condenser (L.F.), 2–4 mfd.

Smoothing Condenser (Mains Unit), 2–8 mfd.

CONDUCTANCE.—The property a body possesses for conducting electricity. The mho (ohm reversed) is the unit of conductance.

CONDUCTIVELY COUPLED.—Direct coupled (which see).

CONDUCTIVITY.—Ability to conduct heat or electricity.

CONDUCTOR. — Any material through which a current may be passed. All metals are conductors.

CONTINUOUS CURRENT.—Direct current.

CONTINUOUS WAVES.—A train of waves whose amplitude is never varying. Produced usually by an arc discharge, or by an oscillating valve, or frequency multiplying transformers.

CONTROL, REMOTE.—See *Remote Control*.

CONVENTIONAL SIGNS.—A wireless circuit diagram consists of some of the signs shown in Fig. 1, linked together in a certain way. These conventional signs are shown in Fig. 1. It will be seen from this that various wireless components have a standard form, and a wireless circuit is a combination of some of those signs. A circuit, it should be remembered, is a theoretical diagram; a wiring diagram shows the actual components with the wires attached. In some of the sets dealt with in this book wiring diagrams are given; in others the circuits only are included.

COPPER PYRITES.—Copper ore crystal containing also iron. Used as a rectifier. Correct name Chalcopyrites.

CORROSION.—The eating away of metals or metallic bodies by acid or acid fumes. To prevent corrosion in a new accumulator, simply wipe all susceptible parts with a rag, wet with ammonia, and then coat with pure vaseline. Once corrosion has started, it must be removed from all metal

CORROSION — COUPLING CONDENSER VALUES

COPPER WIRE DATA

Stand- ard Wire Gauge.	Dia- meter in Inches.	Resistance in Ohms per Yard.	Resistance in Ohms per Lb.	Lb. per Ohm.	Weight in Lb. per 1,000 Yds.	Yards per Lb.	Turns per Inch.				
							Enamel Covered.	Single Silk Covered.	Double Silk Covered.	Single Cotton Covered.	Double Cotton Covered.
10	.128	.001868	.0130	83.3	148.8	6.67		7.64	7.55	7.55	7.04
11	.116	.002275	.0200	50.0	122.2	8.16		8.41	8.30	8.06	7.69
12	.104	.002831	.0280	35.7	98.22	10.23		9.35	9.22	8.93	8.48
13	.092	.003617	.0550	18.1	76.86	13.00		10.5	10.4	10.0	9.43
14	.080	.004784	.0820	12.2	58.12	17.16		12.1	11.8	11.4	10.6
15	.072	.005904	.1400	7.14	47.08	21.23	↓	13.3	13.1	12.5	11.6
16	.064	.007478	.2021	4.95	37.20	26.86	15.0	14.9	14.6	14.1	13.2
17	.056	.009762	.3423	2.38	28.48	35.00	17.1	16.9	16.5	15.9	14.7
18	.048	.01328	.6351	1.56	20.92	47.66	19.8	20.0	19.4	18.5	17.4
19	.040	.01913	1.315	.757	14.53	68.66	23.7	23.8	23.0	21.7	20.0
20	.036	.02362	2.012	.497	11.77	85.00	26.1	26.3	25.3	23.8	21.7
21	.032	.02990	3.221	.309	9.299	107.6	29.4	29.4	28.2	26.3	23.8
22	.028	.03905	5.498	.181	7.120	140.6	33.3	33.3	31.8	29.4	26.3
23	.024	.05313	10.14	.098	5.231	191.6	38.8	38.5	36.4	33.3	29.4
24	.022	.06324	14.38	.069	4.395	228.3	42.1	42.1	40.0	35.7	31.3
25	.020	.07653	21.08	.0471	3.632	275.3	46.0	46.0	43.5	38.5	33.3
26	.018	.09148	32.21	.0309	2.942	340.0	50.6	50.6	47.6	41.7	35.7
27	.0164	.11138	46.55	.0215	2.442	410.0	55.9	55.1	51.6	44.6	37.9
28	.0148	.1398	70.12	.0141	1.989	503.0	61.4	60.4	56.2	48.1	40.2
29	.0136	.1655	98.65	.0101	1.680	596.6	66.2	65.2	60.2	51.0	42.4
30	.0124	.1991	142.75	.0069	1.396	716.6	73.3	72.0	67.1	54.4	44.7
31	.0116	.2275	185.80	.0054	1.222	820.0	77.8	76.3	70.9	56.8	46.3
32	.0108	.2625	248.20	.0040	1.059	943.3	83.0	81.3	75.2	63.3	50.5
33	.0100	.3061	337.50	.0029	.9081	1100	88.9	87.0	80.0	66.7	52.6
34	.0092	.3617	471.00	.0023	.7686	1300	98.0	93.4	85.5	70.4	54.9
35	.0084	.4338	676.50	.0014	.6408	1556	106	101	91.8	80.6	61.0
36	.0076	.5300	1009	.00098	.5254	1903	116	110	102	86.2	64.1
37	.0068	.6620	1574	.00064	.4199	2380	128	120	110	92.6	67.6
38	.0060	.8503	2598	.000385	.3269	3056	143	133	121	100	71.4
39	.0052	1.132	4645	.000217	.2456	4066	168	149	134	109	75.8
40	.0048	1.328	6360	.000156	.2092	4766	180	159	142	114	78.1
41	.0044	1.581	9020	.000112	.1758	5700	194	169	150	↑	↑
42	.0040	1.913	13150	.000076	.1453	6866	211	191	167	↑	↑
43	.0036	2.362	20120	.000050	.1177	7500	230	206	179	↑	↑
44	.0032	2.989	32210	.000030	.0929	10766	253	225	192	↑	↑
45	.0028	3.904	54980	.000015	.0712	14066	282	247	208	↑	↑

surfaces by scraping, filing, or with a wire brush. Ammonia and vaseline should then be applied as before. Pay particular attention to keeping the top of the affected accumulator clean and dry. Vaseline is specified as a preventive of corrosion because ordinary grease contains animal or vegetable fats which increase rather than prevent the evil. (See also *Accumulator*.)

COULOMB.—The electrical unit of quantity, named after Coulomb, the French physicist. It is the quantity which flows in 1 second through a conductor carrying 1 ampere. One ampere-hour equals 3,600 coulombs. The coulomb is equal to one-tenth

of an electro-magnetic unit.

COUNTER E.M.F.—Back E.M.F. **COUNTERPOISE.**—An "earth" system consisting of a wire suspended above the ground and parallel to the aerial.

COUPLING CONDENSER VALUES.—The value of the coupling condenser depends upon the stage of the receiver in which it is employed, and the correct value of the condenser is best found by experiment. In the case of a detector valve, the value depends to some extent upon the constants of the valve and upon operating conditions. In a power grid detector, for example, where the coupling condenser usually is

COUPLING

smaller than the conventional .0003 mfd., say .0001 mfd., and the valve is operated at a high anode voltage and current, a much smaller grid leak, generally of the order of a quarter megohm, is necessary. A fairly wide range of choice is usually given for the value of the coupling condenser in low-frequency resistance capacity coupled amplifiers. A capacity value between .005 mfd. and .05 mfd. will be perfectly satisfactory, but the actual choice depends very much upon the band of frequencies it is desired to pass. If the set builder wishes for full round tone with plenty of bass, then the value of .05 mfd. or even greater should be chosen, while a lower value, by cutting off some of the bass response, will give a higher pitched and perhaps more brilliant tone.

COUPLING. — Broadly speaking, the essence of a set is a string of valves with some means of selecting the required station and some means of connecting each valve to the one following it. A few years ago, when valve efficiency was comparatively low, almost any reasonable number of valves could be coupled together without any special precautions being taken, but in these days of super valves and mains eliminators, almost as much care has to be taken to avoid coupling where it is not wanted as to provide efficient coupling where it is wanted.

The average modern set that has been designed to work on batteries does not function well when driven by an eliminator unless, of course, provision has been made to overcome this trouble either in the set itself or elsewhere.

Similarly, far more attention has been paid to coupling in recent years, largely because the efficiency of the latest loudspeakers has been greatly

increased, with the result that it will reproduce as much bass as it is given, and, therefore, low notes must not be lost in the interval coupling.

It is a great mistake to assume that bass is more important than treble, as very low notes indeed sometimes rely upon very high harmonics for their actual timbre or, if the expression can be used, the personality of the instrument. Generally speaking, the treble is lost in the tuning circuit if these are unduly sharp or, alternatively, by the use of excessive values of condensers connected across, say, the transformer primary, whereas bass is usually lost after the detector valve.

The question of tuning circuits is dealt with later on, but reference is

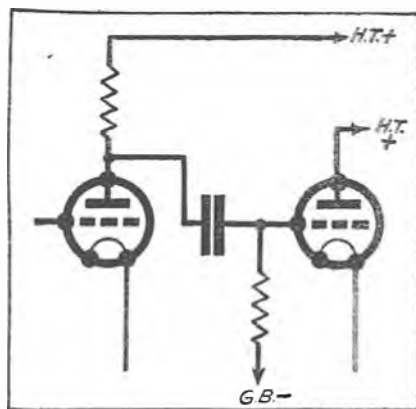


FIG. 161.—R.C. Coupling.

made below to the question of decoupling these stages. The reader's attention is therefore drawn to the coupling circuits following the detector valve.

Taking the low-frequency side in the logical sequence, the anode circuit of the detector valve will first receive attention. This generally consists of a small fixed condenser (connected between anode and earth

COUPLING

to bypass unwanted H.F. energy), a H.F. choke, and a transformer primary, anode resistance, or L.F. choke.

When using the resistance-capacity

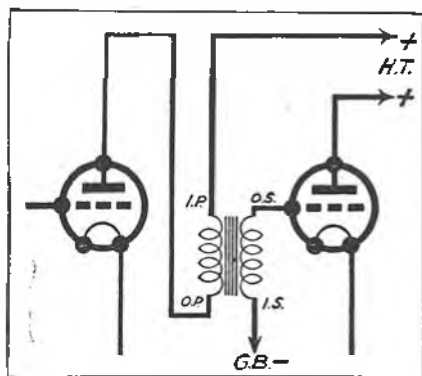


Fig. 162.—Transformer primary directly in anode circuit.

method of coupling, as shown in Fig. 161, considerable care must be exercised in choosing the right value. Within certain limits, the higher the value of anode resistance, the greater the amplification, but quality is impaired, as, although few people realise it, the valve is actually in parallel with its own anode resistance.

In general, the anode resistance should be three times the valve impedance, but when the most perfect quality is required at some expense of volume, this value may be lowered to twice the impedance or even less. The grid leak may have a value of four or five times that of the anode resistance; remember that 1 megohm is a million ohms, so that if the anode resistance happens to be 20,000 ohms, the grid leak might well be 100,000 ohms, or to quote it in megohms—1. This rule holds good except in certain circumstances, unless a really big valve is following im-

mediately after it, when the maximum value should be 50,000 ohms in the interests of safety.

The third component of the resistance capacity coupling unit is the condenser, which should always be a reliable type, as a serious leak would result in the high tension getting on to the grid of the following valve. As there is no simple way of working out the best value for this condenser, a table, No. 1, is given (see *Decoupling*) to indicate the best value of grid leak and condenser for various values of anode resistance.

At the present time transformers can be divided broadly into two classes: those containing generously proportioned iron cores and those containing comparatively small cores of a special mixture of nickel and iron. There are, in addition, certain badly designed, cheap transformers, containing very little ordinary iron, but these will not be considered.

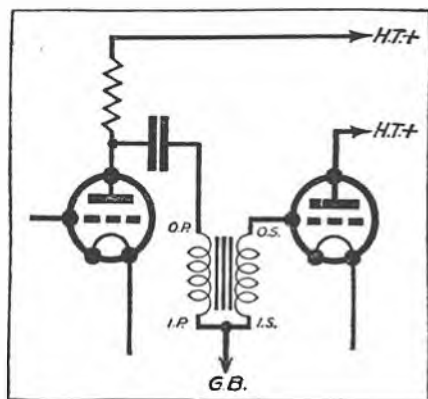


Fig. 163.—Parallel-fed Transformer. With this arrangement no current passes through the primary.

These two main classes of transformers call for entirely different treatment: the heavy ones, with the big cores, can be connected straight

COUPLING

in the anode circuit as shown in Fig. 162, but the small nickel-iron transformers should be parallel fed as shown in Fig. 163. The reason for this is that the latter type have relatively poor efficiency when the high-tension current is passing through a primary winding, as the inductance of the latter gets smaller and smaller as larger and larger currents are put through it, and a decrease of impedance means a decrease of bass.

Some care has to be taken when selecting resistance in the anode circuit, but three times the valve impedance is generally suitable, provided that there is a reasonable high-tension voltage, say 120 volts, available. Care

should be taken, however, not to use the value of condensers shown in Table No. 1 (see *Decoupling*), as a very much larger value is desirable, depending upon the transformer used. However, 1 mfd. is a good general value, but if with the transformer used this results in one or two of the bass notes being reproduced out of proportion, condensers having a value of .5 or 2 mfd. may be tried. A L.F. choke is sometimes used instead of a resistance, but as considerable trouble may be caused by an unfortunate selection of values, it is not recommended.

Fig. 164 indicates the method of using low-frequency choke coupling. Here, again, a certain amount of

difficulty presents itself regarding the choice of grid leak and condenser, but as a rough guide the grid leak may be eight to ten times the value of the valve impedance, and the appropriate condenser selected from Table No. 2 (see *Decoupling*).

There is the possibility of an additional low-frequency stage in addition to the output valve, but this is rapidly dying out with modern high-efficiency valves, although still re-

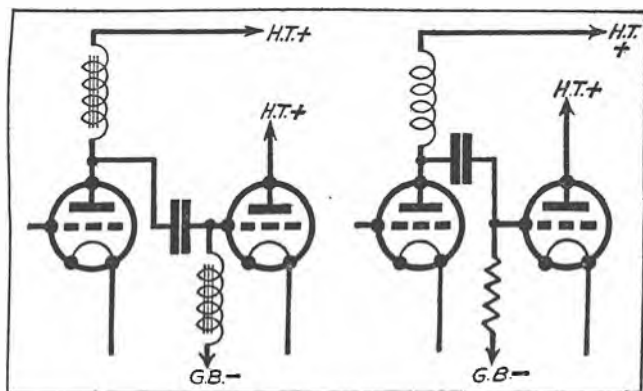


FIG. 164.—Two forms of Choke Coupling.

tained when the detector is not preceded by a high-frequency valve. The great mistake when using two valves following the detector is to arrange for too much amplification, with the result that the output valve is horribly overloaded, and gives terribly distorted reproduction, punctuated by an assortment of resonance points.

Suppose, for example, that the detector valve gives a 2-volt swing in its anode, which is not unreasonable on a high-powered station, and that a $3\frac{1}{2}$ to 1 transformer is used, we shall get almost 7 volts on the grid of the next valve. Assuming that this is a L.F. type, it might well have a working amplification factor of 12, which will give 84 volts in the anode.

CRYSTAL DETECTOR — CRYSTALS

Assume a 3 to 1 transformer: this would give almost 252 volts to the power valve, which, with an amplification factor of 7, would give 1,700 volts odd. This is, of course, ridiculous, but it indicates what would happen if either the second or third valve overloaded. As, however, an ordinary power valve would not develop without distortion more than about 30 volts in its anode, the discrepancy between this and 1,700 indicates in a very definite manner the overloading that will take place, and it is obvious that under such conditions one resistance and one transformer, or two resistance stages, would be more useful.

CRYSTAL DETECTOR.—A detector based upon the fact that some of the metallic crystals allow a current to flow in one direction only, or more readily in one direction only. It thus acts as a rectifier, converting oscillations as received by the aerial into intermittent D.C.

TABLE OF CRYSTALS

Bornite	Hematite
Carborundum	Hertzite
Cassiterite (Tin-stone)	Iron Pyrites
Copper Pyrites	Malachite
Galena	Molybdenite
Ghanc	Silicon
Graphite	Tellurium
Hessite	Zincite

CRYSTALS.—Minerals and mineral ores used for the purpose of detecting, or rectifying, wireless signals. The exact manner in which these crystals function is not yet definitely ascertained, some holding that a form of thermo action takes place, others that the effect is purely electrical. A small piece of the mineral is joined to one side of a tuned circuit, and the remaining side of the circuit is provided with a contact for the mineral. In some cases this contact consists

of another piece of similar, or different, crystal and in other cases a metallic contact is used. In the former class there is the combination known as "Perikon," which consists of copper pyrites in conjunction with zincite. This is the most popular and reliable crystal combination. A very common ore of lead goes by the name of galena, and this requires a contact of copper or brass, although sometimes silver gives better results. In the earlier days of broadcasting, when crystal receivers were more popular, the market was flooded with "synthetic," or artificially treated, galena, and the various types were marketed under different trade names, practically all of which ended in "-ite." (For Crystal Circuits, see *Circuit*.)

Extreme care is necessary in mounting crystals where they are soldered into a cup. The best form of crystal cup is that in which three screws are used to lock the crystal and provide contact. Wherever it is thought better to fix the crystal by means of solder, a particular grade known as Woods metal should be used. This has an extremely low fusing point, and consists of 2 parts of lead, 1 part of tin, 4 parts of bismuth, and 1 part of cadmium. In using crystals it is desirable that they be handled with a pair of tweezers, for the slightest trace of greasiness upsets their sensitivity. Another point is that after a crystal has been in use for some time reception sometimes gets weaker, due to slight oxidation of the surface of the crystal itself. In such a case the crystal can be revived by cracking it in half, and using the newly exposed surfaces for "searching."

For crystal contacts (the cat's whisker) it is desirable to use the correct wire according to the crystal in use. The crystal whisker to be used in connection with galena has

already been described, but for molybdenite a flat silver strip is used, for silicon a gold or steel whisker, and for an iron pyrites a gold point should be used. The carborundum and steel crystal detector is undoubtedly the best, but this necessitates the use of an applied potential in the form of a 4½-volt dry cell connected across the crystal and contact. This, of course, must be used in conjunction with a potentiometer. With a crystal set, the best results are usually secured by wiring 'phones on the earth side; the crystal detector itself should be kept as near the aerial terminal as possible.

CURRENT.—The flow of electricity in a circuit.

CURRENT DENSITY.—The relationship or *ratio* between the cross-sectional area of the conductor and the current flowing through it.

C.W.—Continuous Waves.

CYCLE.—Any sequence of events occurring in a regular *time* order. An A.C. cycle is the two alternations in opposite directions.

CYOMETER.—Another name for the Fleming wavemeter, in which the capacity and inductance are varied by one control.

D

DAMPING.—The gradual reduction in amplitude of a train of waves or oscillations.

DANIELL CELL.—A Daniell cell consists simply of an outer glass jar containing a porous pot. Surrounding the porous pot there is a cylinder of sheet copper in a solution of copper sulphate. The porous pot contains a diluted solution of sulphuric acid in which stands a rod of zinc. The details will be quite clear from the diagram (Fig. 165). The copper may be sheet stuff about $\frac{1}{64}$ in. thick, bent round into the form of a cylinder, with a lug soldered on

for connection purposes. The outer vessel is charged with a saturated solution of copper sulphate in water, and the porous pot with a solution of 15 parts of distilled water, or rain-water, and 1 part of sulphuric acid. In mixing the latter the acid should always be added to the water and not *vice versa*, otherwise violent action will take place.

The copper plate provides the positive terminal and the zinc rod the negative. Such cells may be employed in some cases for charging accumulators. There are two free terminals, copper and zinc; the former, being positive, is connected to the positive of the accumulator and the latter to the negative.

Such a battery can be connected to an accumulator and allowed to remain charging continuously, day and night, without attention beyond seeing that a surplus of the copper-sulphate crystal remains in the outer jar in order that the solution may be fully saturated.

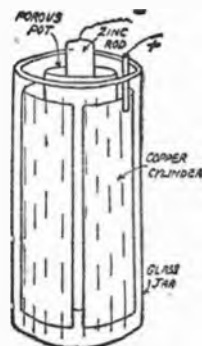


FIG. 165.—Constructional details of Daniell Cell.

D.C.—Direct Current (which see).

D.C. MAINS UNIT.—A unit for supplying H.T. (and sometimes also L.T.) from the mains. (See also *Eliminators*.)

DEAD BEAT.—A term applied to meters where the pointer travels up to the reading and remains perfectly stationary. In cheap meters the needle usually passes beyond the maximum reading required and then oscillates backwards and forwards

DECIBEL — DECOUPLING

for some seconds before coming to rest. This results in an unnecessary drain on the battery being measured and takes time. The dead-beat instrument avoids this. In cheap meters of the dead-beat type, this is obtained by placing a flat metal plate on the end of the pointer to act as an air brake.

DECIBEL.—The comparative unit of sound strength. The value chosen for 1 decibel is the sound which can just be discerned by the trained ear. A sound is 1 decibel louder if its ratio to the first is about 1.26, 2 decibels louder if the ratio is 1.6, and 10 decibels if the ratio is 10. The numbers do not increase in any common arithmetical ratio in consonance with the limitations of our hearing, but in logarithmic order.

DECIMAL EQUIVALENTS.—The following table gives the decimal equivalents of all fractions of an inch, progressing in sixty-fourths of an inch.

TABLE OF DECIMAL EQUIVALENTS
of Eighths, Sixteenths, Thirty-seconds,
and Sixty-fourths of an inch

$\frac{1}{8}$	. . .	.015625	$\frac{1}{32}$	. . .	.390625
$\frac{1}{16}$	. . .	.03125	$\frac{1}{16}$	. . .	.40625
$\frac{1}{32}$	. . .	.046875	$\frac{1}{8}$	. . .	.421875
$\frac{1}{64}$	. . .	.0625	$\frac{1}{4}$	. . .	.4375
$\frac{1}{128}$	. . .	.078125	$\frac{1}{16}$	. . .	.453125
$\frac{1}{256}$	. . .	.09375	$\frac{1}{8}$	. . .	.46875
$\frac{1}{512}$	. . .	.109375	$\frac{1}{4}$	. . .	.484375
$\frac{1}{1024}$	. . .	.1250	$\frac{1}{2}$	. . .	.5000
$\frac{1}{2048}$	. . .	.140625	$\frac{1}{16}$	. . .	.515625
$\frac{1}{4096}$	. . .	.15625	$\frac{1}{8}$	. . .	.53125
$\frac{1}{8192}$	. . .	.171875	$\frac{1}{4}$	. . .	.546875
$\frac{1}{16384}$	. . .	.1875	$\frac{1}{2}$	. . .	.5625
$\frac{1}{32768}$	. . .	.203125	$\frac{1}{16}$	. . .	.578125
$\frac{1}{65536}$	. . .	.21875	$\frac{1}{8}$	. . .	.59375
$\frac{1}{131072}$	. . .	.234375	$\frac{1}{4}$	. . .	.609375
$\frac{1}{262144}$	. . .	.2500	$\frac{1}{2}$	. . .	.6250
$\frac{1}{524288}$	. . .	.265625	$\frac{1}{16}$	. . .	.640625
$\frac{1}{1048576}$	. . .	.28125	$\frac{1}{8}$	. . .	.65625
$\frac{1}{2097152}$	. . .	.296875	$\frac{1}{4}$	. . .	.671875
$\frac{1}{4194304}$	. . .	.3125	$\frac{1}{2}$	. . .	.6875
$\frac{1}{8388608}$	. . .	.328125	$\frac{1}{16}$	. . .	.703125
$\frac{1}{16777216}$	. . .	.34375	$\frac{1}{8}$	. . .	.71875
$\frac{1}{33554432}$	. . .	.359375	$\frac{1}{4}$	. . .	.734375
$\frac{1}{67108864}$	. . .	.3750	$\frac{1}{2}$	. . .	.7500

$\frac{1}{8}$	. . .	.765625	$\frac{1}{32}$	. . .	.890625
$\frac{1}{16}$	. . .	.78125	$\frac{1}{16}$	. . .	.90625
$\frac{1}{32}$	. . .	.796875	$\frac{1}{8}$	. . .	.921875
$\frac{1}{64}$	. . .	.8125	$\frac{1}{4}$	. . .	.9375
$\frac{1}{128}$	. . .	.828125	$\frac{1}{16}$	. . .	.953125
$\frac{1}{256}$	. . .	.84375	$\frac{1}{8}$	. . .	.96875
$\frac{1}{512}$	. . .	.859375	$\frac{1}{4}$	. . .	.984375
$\frac{1}{1024}$	. . .	.8750	$\frac{1}{2}$	. . .	1.0000

Note.—Although the above equivalents have been calculated in millionths of an inch, it is seldom necessary to go beyond $\frac{1}{16}$ in. Any decimal of .0005 in. or over should be added as an extra .001.

DECOUPLING.—In the ordinary straightforward three-valve set, the H.T. side of each of the components in the anode circuit are joined together either directly or through the few intervening cells of the H.T. battery, with the result that the major portion of the battery is between the anode leads and earth. This portion of the high-tension battery may have a considerable high-frequency resistance which, being common to all three valves, redistributes such stray currents as are flowing in each anode circuit to the other anode circuit, thus causing instability, motor-boating, or violent oscillation. This effect is considerably more marked if an eliminator is used, as usually the resistance between the positive tappings and H.T.— is greater than that of a battery.

In order to stop this trouble, it is necessary to give other than battery current a direct path to H.T.—, and to separate the anodes from each other by a resistance, or choke, and a condenser. In general practice the choke is very seldom used, as it only becomes useful when a very heavy high-tension current is passing. It is, however, generally used in the output stage to choke-feed the loudspeaker and direct the speech current through the loudspeaker winding to earth. Fig. 166 shows the anode and screen circuits of a screen grid with decoupling added. The screen resistance may be 600 to 1,000 ohms,

while a reasonable value for the anode circuit is 5,000 ohms. As the screen is provided with a condenser in any case, an additional one is not necessary, but in the anode circuit the condenser marked A has to be inserted. This might be a 1-mfd., non-inductive type. When using a mains screen-grid valve the screen is usually fed by a fixed or variable potentiometer as shown in Fig. 167. The top part of this, marked B, acts automatically as a decoupling resistance, so no further precautions are necessary.

The decoupling of the detector is probably the most important. Here it is necessary to make certain that the values are adequate. Unfortunately, however, if too high a resistance is used, the H.T. value will be lowered, which is undesirable below a certain point. In order to ensure that decoupling

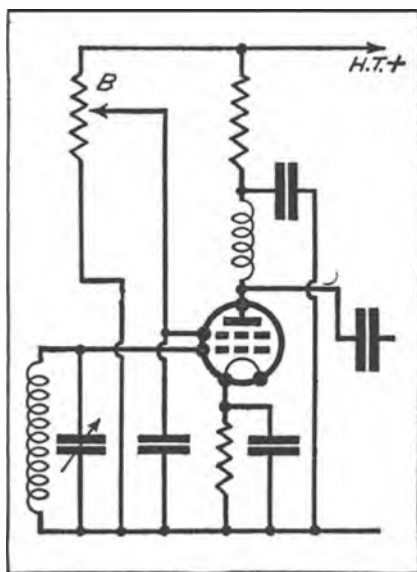


FIG. 167.—With the usual arrangement of a mains set the potentiometer acts as a decoupler.

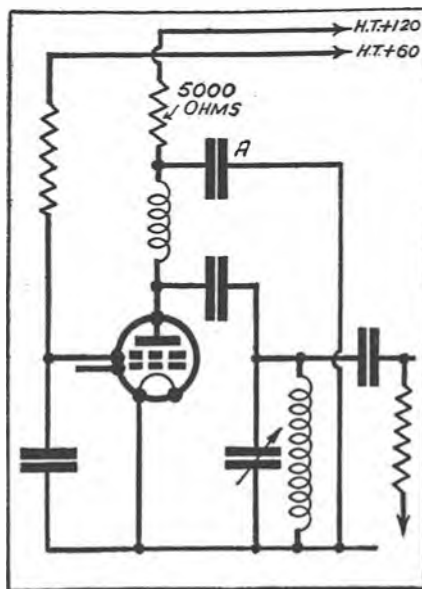


FIG. 166.—S.G. stage decoupled.

is efficient, the resistance in ohms when multiplied by the capacity of the condenser in micro-farads should not be less than 40,000. For example, 30,000 ohms associated with 2 mfd. will be 60,000, which is in order, as would be 20,000 and 2 mfd.; but 15,000 and 2 mfd., or 30,000 and 1 mfd., would both fall below 40,000 and would be inadequate. It does not follow that in every case figures arrived at by this method would be high enough, but such cases are rare, and are not likely to be met with by the constructor. In big amplifiers, however, it is not unusual to have to use double these couplings, as shown in Fig. 168.

Returning to the question of actual values, it has been indicated what the two decoupling components should total, and it would appear at first sight that the cheapest method

DECOUPLING

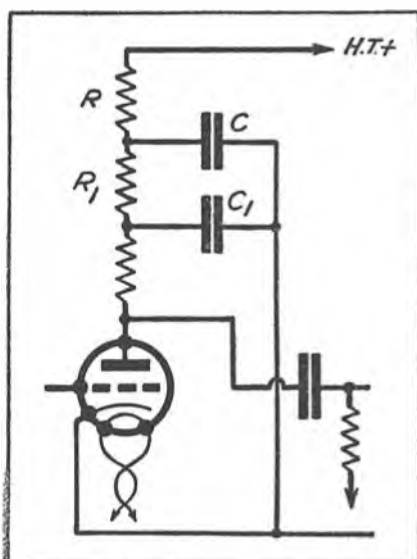


FIG. 168.—R.C.C. stage with double decoupling by resistance R and R_1 , C and C_1 .

would be to use 40,000 ohms with 1 mfd., but unfortunately such a value of resistance will often throw away too much of the high-tension voltage. The amount of voltage lost over the resistance is extremely simple to arrive at, it merely being necessary to multiply the resistance by the number of milliamps.

passing and knock off three noughts. For example, if the anode resistance were only 30,000 ohms, and the current 3 milliamps., multiply these two together and the result is 90,000; knock off three noughts and it will be seen that the loss of voltage would be 90. Thus the matter has to be approached in the following manner. Decide first of all what voltage it is desired to apply to the detector stage and subtract this from the H.T.-battery voltage, which will leave the amount that may be sacrificed in the interests of decoupling. Say 80 volts is required on the detector, and the battery voltage is 120, then 40 volts can be spared. Now, reference to the valve curve or the use of a milliammeter will show what current the valve is taking. Suppose it is taking 3 milliamps.; it is now desired to find what resistance will drop 40 volts when 3 milliamps. is flowing. This is arrived at by dividing the milliamps. into the voltage, when the answer will be the number of thousands of ohms required. Continuing with our example, if we divide the 3 milliamps. into the 40 volts, this goes approximately 13 times, and as the answer is in thousands of ohms, the resistance

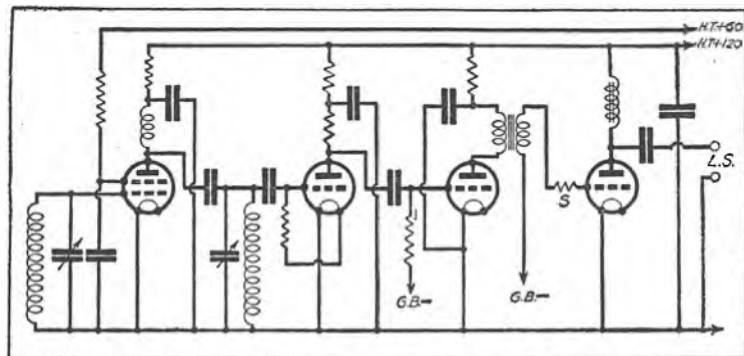


FIG. 169.—A typical four-valve circuit showing the method of inserting the decoupling resistances.

DECOUPLING — DIELECTRIC

TABLE No. 1

Anode Resistance.	Grid Leak.	Condenser.
Ohms.	Meg.	Mfd.
250,000	1	.006
200,000	1	.006
100,000	.5	.01
75,000	.5	.01
50,000	.25	.02
30,000	.2	.03
25,000	.1	.05
20,000	.1	.05
15,000	.05	.1
10,000	.05	.1

Values correct to nearest values listed by makers.

resistance for a detector valve that is resistance-coupled to the next valve, the decoupling resistance can usually be half the value of the anode resistance associated with the necessary condenser to give a combined value of 60,000, as already explained in the preceding pages.

D.F.—The abbreviation for Direction Finding or Direction Finder.

DEPOLARISER.—The substance used to prevent local action (polarising) in a primary cell.

TABLE No. 2

Anode Current. mA.	Volts Drop.									
	20		40		60		100		200	
	Res.	Cond.	Res.	Cond.	Res.	Cond.	Res.	Cond.	Res.	Cond.
1	20,000	2	40,000	1	60,000	1	100,000	1	200,000	1
2	10,000	4	20,000	2	30,000	2	50,000	1	100,000	2
3			15,000	3	20,000	2	30,000	2	70,000	2
4			10,000	4	15,000	3	25,000	2	50,000	2
5					12,000	3	20,000	2	40,000	2
6					10,000	4	15,000	3	35,000	2
8							12,000	3	25,000	2
10							10,000	4	20,000	2

Correct to nearest values obtainable. The resistance used must be capable of standing the current flowing. Condenser must be capable of standing the voltage.

will be 13,000 ohms. The nearest value obtainable will be 15,000 ohms, which will have to be associated with a 4-mfd. condenser in order to reach the 40,000 which we have indicated as being a general figure for safety.

This is a little complicated to work out, but Table No. 2 indicates a number of values from which it will be simple to arrive at any intermediate figure.

When decoupling a first L.F. stage, the result of multiplying the resistance and condenser can usually be lowered to 30,000, which is fortunate, as otherwise the relatively large anode current, which results in small values of resistance, would result in the use of large and expensive condensers.

When working out the decoupling

DETECTOR.—See *Valve*.

DIAKATHODE RAYS.—Ions, positively charged, which travel at a reduced velocity as compared with kathode (cathode) rays. Sometimes referred to as Canal Rays.

DIELECTRIC.—The insulating material in a condenser. A condenser consists of two or more plates separated by some insulating material. The nature of this insulator will vary the capacity, although the distance separating the plates of the condenser be kept constant. All insulators have a value given to them according to their efficiency, compared with air, as a dielectric, and this is known as the dielectric constant (another term for this is specific inductive capacity). Air is rated as 1, and therefore the dielectric

DIELECTRIC CAPACITY — DIELECTRIC STRENGTH

constant is rated as a comparative figure to the air dielectric. For instance, the dielectric constant (or S.I.C.) of ebonite is $2\frac{1}{2}$, which means that for a given size of plate, and a given separation between them, a

DIELECTRIC COEFFICIENT.—Dielectric constant.

DIELECTRIC CONSTANTS.—The following table gives the specific inductive capacities of various materials. These figures represent the dielectric constants.

Material.	S.I.C.
Air	1
Paper	1.5
Paraffin Wax	2.5
Ebonite	2.75
Shellac	3
Presspahn	3
Flint Glass	4 to 6
Plate Glass	4.5
Mica	5 to 8

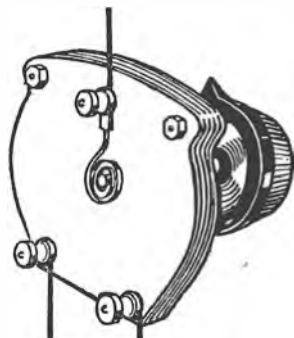


FIG. 170.—A Differential Condenser of the solid Dielectric type.

condenser with ebonite as a dielectric would have a capacity $2\frac{1}{2}$ times as

DIELECTRIC HYSTERESIS.—

The dielectric of a condenser does not rid itself from "strain" after first discharge. A second and smaller discharge may be obtained after a short lapse of time. Residual charge. Electric absorption.

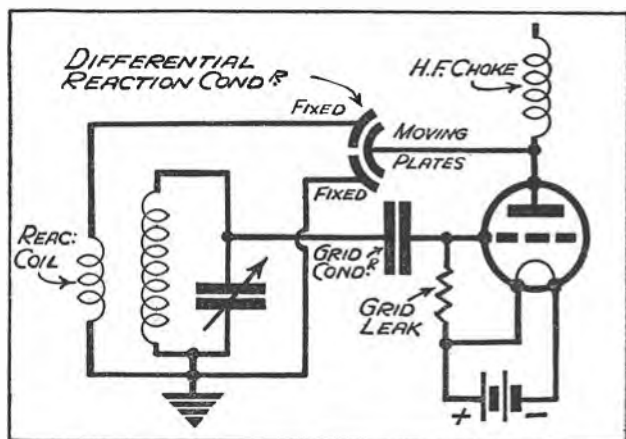


FIG. 171.—Connections for Differential Condenser.

great as one with air as the dielectric. (See also *Dielectric Constants*.)

DIELECTRIC CAPACITY.—The inductive capacity.

DIELECTRIC STRENGTH.—The degree of strain, without breaking down, of a dielectric. Refer to the following table:

DIFFERENTIAL CONDENSER — DIRECTIONAL RECEPTION

Material.	Dielectric Strength per Mm.
Glass . . .	8,000
Shellac . . .	10,000
Presspahn . . .	6,000 to 15,000
Porcelain . . .	16,300
Rubber . . .	18,000
Mica . . .	17,000 to 28,000
Ebonite . . .	30,000
Micanite . . .	40,000

DIFFERENTIAL CONDENSER.

—A condenser having one rotor but two stators. In the most common form the stators are disposed at opposite sides of a plate, and the rotor arranged so that as the plates are rotated they mesh with one stator as they unmesh with the other stator. The result of this arrangement is that the total capacity always remains the same, no matter what position the rotor is in, but the capacity is distributed between the two stators. The principal use for this component is in reaction circuits, where one stator is "earthed" and the other stator is joined to the reaction coil. The anode is joined to the rotor, and therefore the capacity from anode to earth remains constant, providing greater stability

and smoother reaction control. The condenser may also be used as an aerial volume control by joining the rotor to the aerial, and the stators to each end of the aerial coil.

DIODE.—The two-electrode valve.

DIPLEX.—The transmission and reception of two messages at the same time. Duplex.

DIRECT CURRENT.—Continuous current flowing in one direction.

DIRECTION FINDER.—A special

type of frame aerial arranged so that it is possible to ascertain exactly in what direction a transmitting station is situated. It consists of two frame aerials arranged one inside the other at right angles. The signals in one aerial cancel out those in the other when in a certain position relative to the transmitting station, and it is therefore possible to correctly ascertain the direction. (See also *Bellini Tosi*.)

DIRECTIONAL RECEPTION.—

Now that transportable sets have become so extremely popular, many enthusiasts are confronted with the question as to the functioning of the frame aerial usually incorporated inside these receivers, and why the set is rotated—or in other words—why it has directional properties. It would be as well first of all to explain one or two of the peculiarities of the electro-magnetic wave. If it is borne in mind how a violin or piano string when struck

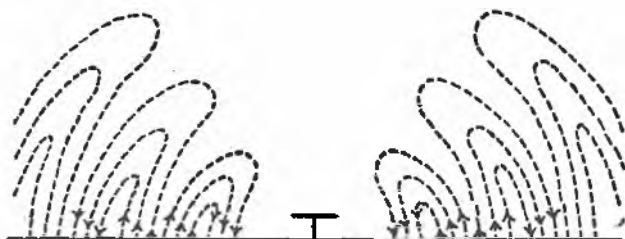


FIG. 172.—How the Lines of Stress radiate.

sets up mechanical oscillation, putting the surrounding medium in a state of alternate bands of compression and rarefaction in all directions, which are termed sound waves, it should help considerably in grasping how an electrical wave motion of a much higher frequency—called wireless waves—can be transmitted under suitable conditions.

The Electro-magnetic Wave. Assume that a station is broadcasting

DIRECTIONAL RECEPTION

a speech, its transmitting aerial being charged alternately positive and negative, emitting a high-frequency-carrier wave, modulated at audible frequency. To simplify what takes

tration (Fig. 172) will perhaps serve to make more clear how these lines of electric stress combine to travel outwards with extending height, but of constant width, at the tremendous

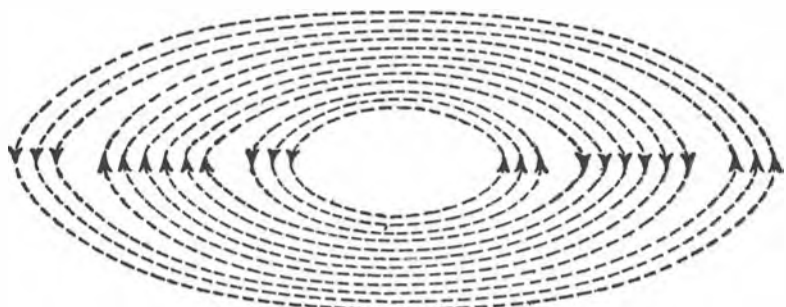


FIG. 173.—A diagram of the Lines which accompany the Radiation illustrated in Fig. 172.

place, imagine, by way of example, the first complete cycle of electro-motive-force (E.M.F.) which charges the aerial. When the latter has reached its maximum voltage, and the current is at zero value, we can imagine lines of electric strain existing between

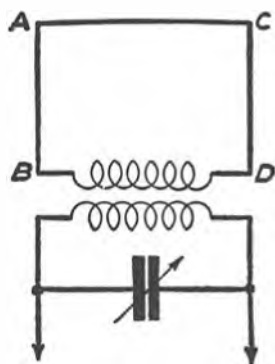


FIG. 174.—The Frame Aerial with its small coil coupled to the main tuning circuit.

charge and radiates outwards in the form of annular loops. The current then flowing in the reverse direction produces a reverse effect. The illus-

tration of electric strain existing between aerial and earth. Directly the voltage falls and current flows down the aerial, this electric field, with its imparted energy, separates itself from the aerial

velocity of 186,000 miles per second. This alternating moving system of electric force, varying in intensity, has associated with it a magnetic property, which always attends electrons in motion, and is at right angles to these lines of electric strain in the form of horizontal bands as in Fig. 173.

The strength of the magnetic flux density will, of course, vary as the strength of the electric field after the first quarter cycle has passed, when they come into step and rise and fall in phase, gradually dissipating energy as various conductors are encountered. Maybe it is realised that one needs an unlimited stretch of imagination, since this wave happens to be invisible, intangible, and inaudible! However, let us perceive what effect these two forces will have upon a frame aerial when they are flashed into space. Perhaps we had better deal with these two components separately, although their effect on the aerial is somewhat similar.

Action of Electric Component. By glancing at the accompanying sketch (Fig. 174) it will be seen that the

DIRECTIONAL RECEPTION

frame aerial is inductively coupled to the high frequency or detecting stage of the receiver by the mutual coupling coil, while Fig. 175 is a plan form of the aerial, with rings indicating the approaching wave from broadcasting stations at different points. First, we will consider the electric component of waves F and J as either pass the aerial, which is at right angles to the direction of the waves as shown in Fig. 175. We find that this force has induced simultaneously an electro-motive force (potential difference, or difference in electrical pressure as it may be called) in the order of milli- or microvolts in our vertical conductors—so that A is at a higher voltage with respect to B—as is also C to D—but the induced E.M.F.s, which are exactly the same in value, are acting in opposition to each other; and as the resultant current round the aerial circuit depends upon the difference between these two opposing forces (which in this case is zero) by neutralising each other, no current results, consequently the coupling coil is not influenced. Reasoning in the same way, the waves from L or H do not strike both sides of the aerial simultaneously as before—one conductor being reached in advance of the other—so that the total effective E.M.F. driving the current round the circuit will be the difference between the induced E.M.F. in both conductors.

The Magnetic Effect. A similar state of affairs takes place by magnetic induction. According to Lenz' Law, an alternating magnetic field will induce an E.M.F. in any vertical conductor when it is cut *across* by the flux. Referring to the oncoming waves in the same sequence as before, we have a potential difference set up in both sides of the frame aerial, the magnitude of which will depend upon the linkage of the magnetic

lines of force with the aerial. From whichever part of the compass we desire to receive signals, one has to rotate the set, thereby placing either side of its aerial in the direction of the incoming wave in order to receive maximum current through the aerial circuit, assuming, of course, that this circuit is already in resonance with the desired wave frequency.

It is, therefore, obvious that if two high-powered stations are situated in the same direction, it will not be possible to obtain any advantage from the aerial's directional property as a selectivity aid. In this case, all that can be done is to rotate the frame to a position slightly out of the correct line, and use the reaction control to make up for the loss of signal strength caused by this "offsetting." By a judicious use of the

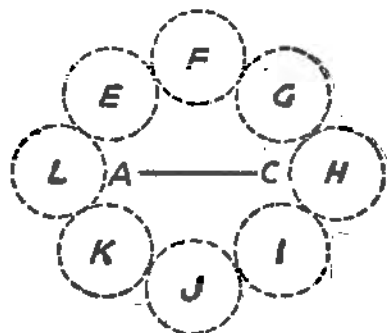


FIG. 175.—The Wave-forms of different stations approaching the frame aerial A—C.

reaction and this method of using the frame, it is possible to eliminate an interfering station. In constructing a frame aerial to cover both short and long waves, it is preferable to arrange the two sections at right angles to one another. This avoids losses due to the unused section.

It is hardly necessary to state that the presence of any metallic body, especially of large dimensions, will affect

DISTILLED WATER — DISTORTION

the directional property of the frame. Therefore this fact should be borne in mind.

DISTILLED WATER.—See *Accumulator*.

DISTORTION.—For perfect reproduction, the sound issuing from the loudspeaker should be an aural replica of what is taking place at the broad-

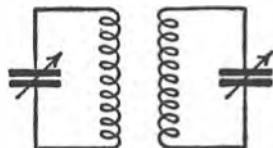


FIG. 175A.—Inductively coupled coils.

casting studio of the station tuned in. When this fails to happen, as judged by a critical ear or by the movements of tell-tale meter needles inserted at correct positions in the power feeds, distortion is said to be taking place. (Later sections deal with the use of meters.)

The H.F. Side. First of all it may come as a surprise to many to know that, contrary to popular belief, the high-frequency section of a wireless receiver is often the cause of more distortion than the low-frequency side. The introduction of so many high-powered broadcasting stations has made the question of selectivity rather an acute one. When a station is sending out speech or music it broadcasts, in addition to the carrier wave, other frequencies which are known as sidebands. These are spaced equally on either side of the carrier frequency, and may extend as far as 7,000 to 8,000 cycles either side.

A receiver of the ordinary type boasting of razor-edge selectivity cuts off a large section of these sidebands, or at least reduces their amplification to such an extent that they compare very unfavourably with the amount of amplification accorded to the lower frequencies. Anyone musically in-

clined will realise that the higher frequencies bring about the brilliance or timbre, and if they are not present then quality must to a certain extent be reduced.

Band-pass Tuning. If the constructor of a wireless receiver finds himself in a cleft stick, owing to his desire for adequate selectivity without cutting sidebands, he can adopt what has come to be known as band-pass tuning (which see).

In the modern arrangement we have three main types, and these are shown simply in Figs. 175A to 175C. In every case it will be noticed that there are two tuned circuits, and energy is transferred from one circuit to the other by a mutual magnetic interaction (Fig. 175A), a coil common to both tuned circuits (Fig. 175B), or a carefully controlled capacity-coupling (Fig. 175C).

The frequency response of each circuit is thus combined, and it is possible to make the complete circuit accept frequencies over quite a wide range and almost wholly reject the others. In other words, brilliance and reproduction are maintained together with selectivity.

Faulty Components. Another very marked cause of distortion is the use of "shoddy" components of doubtful origin. Too often is a set blamed

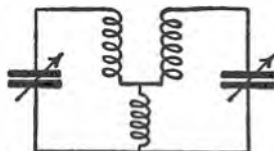


FIG. 175B.—Coil common to both tuned circuits.

for distortion when the fault is located in the fact that it is being starved of its H.T.

Valve Couplings. Returning now to the question of frequency distortion, the items chiefly responsible for this are the methods of coupling

DISTORTION

between the valves and the loud-speaker itself. Taking the first named, it must be remembered that if L.F. transformers are employed, the primary or input winding must have an adequate primary inductance. This does not necessarily mean that the transformer with the largest size is going to give the best results. Modern development has produced transformer cores which are quite small compared to the early types. It is also necessary to maintain the inductance high even when quite large anode currents from the valve pass through the primary winding, so in this case it is necessary to learn whether a manufacturer guarantees the inductance in henries to be a certain value up to a given current and then take steps not to exceed that current.

With inadequate primary inductance in transformers, there will be a loss of the bass frequencies, so that even if you have the most perfect sound reproducer coupled to the set, if the bass frequencies are lost in the set, they will not be heard from the loudspeaker.

Resistance Capacity. Next consider the resistance-capacity coupling method. The secret of success here lies primarily in the selection of suitable valves and components. For most purposes the value of the anode resistance should not exceed about four to five times the valve impedance. The grid leak, on the other hand, may be about five times the value of the anode resistance, while the capacity value of the coupling condenser depends primarily on the value of the lowest frequency to be amplified, the ohmic value of the grid leak, and the fraction of maximum amplification desired at the lowest frequency. The greater this last-named fraction the greater will be the capacity of the condenser.

For example, if the grid leak is

$\frac{1}{2}$ megohm, the lowest frequency 50, and the fraction just mentioned $\frac{1}{10}$, then the capacity is calculated to be about .015 mfd.; so be careful not to make your condenser of low value if you want to pass through the low frequencies.

Passing now from frequency distortion which, as has been pointed out, arises from the exaggeration or, alternatively, the suppression of particular notes, frequencies, or bands of frequencies, we come to what is known as amplitude distortion. This produces a mutilation of the wave form of the original sound, and the incorrect use of valves is one of the principal causes.

A Question of Bias. It may be that the valve is over biased or over loaded, or even under biased. To

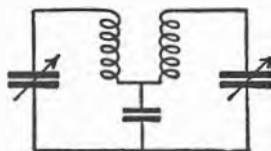


FIG. 175c.—Capacity-coupled Circuit.

secure a faithful replica of the signals handed on to the grid of the valve, the incoming grid swing must take place over the straight portion of the valve's characteristic.

If by chance the valve is over biased, the incoming signals will operate over the lower curved part of the characteristic, and distortion will occur. If a valve is overloaded, that is to say, has a grid swing applied to it greater than it can handle on the linear portion of its characteristic, then distortion is most marked—one gets frequently what is known as blasting.

As the signal is amplified stage by stage, the grid swing increases in magnitude, and each valve following a particular stage must be capable of accepting what is passed on. A good

indication of the strength of signal which a valve can handle without distortion is afforded by the value of grid bias recommended by the maker. For example, a valve of the H.L. class requiring a grid bias of about 3 volts might be used for the first stage, while a valve requiring 7 or 8 volts grid bias might follow it.

Now, although these published figures are a good guide of acceptance or handling powers, in order to be on the safe side and avoid distortion it is preferable to apply a smaller signal voltage than that which the valve is apparently capable of handling. In this way you will have a margin to spare, and no attempt will be made to run the receiver all out.

Reaction. Mention must be made of reaction. Keep this control adjusted so that it is as far off oscillation point as possible, and bear in mind that reaction badly designed or badly handled is a notorious agent for detracting from good reproduction.

Then, again, carefully consider the detector valve. If working as a "leaky grid," care must be taken that the impressed signal does not overlap the bottom bend of the valve characteristic. There is a risk of this when strong signals are handled at this stage, and if this does occur a secondary, or what is known as anode bend, rectification will occur and introduce serious distortion. For strong signals one should resort to normal anode-bend rectification or, alternatively, use what has recently come to be known as "power-grid" detection (which see).

DOUBLE ANODE VALVE.—The valve employed for full-wave rectification in a mains battery eliminator. This type of valve has a filament and two anodes, and the two ends of the secondary winding of the mains transformer are joined to the two

anodes. The two ends of a filament winding on the transformer are joined to the filament of the valve, and the result of this combination is to rectify the A.C. currents induced in the secondary windings. The centre taps of the two windings are used respectively for negative and positive high-tension supplies (D.C.). (See also *Eliminator*.)

DOWN-LEAD.—The wire leading from an aerial down to the receiver. Also termed the lead-in, although strictly speaking this latter is the section which passes through the wall or window to the receiver.

D.P.—Double Pole. Difference of Potential.

DRILLS AND DRILLING.—The best known type of drill is that of the twist or spiral flute type, but there are several other types, notably the straight flute type, such as are included and contained in the hollow handle of some of the better makes of hand drills, and the flat or harpoon drills. For general purposes the twist drill is the best, as it permits being reground until worn out, has a constant cutting rake during its life, maintains its size, and is self clearing. Straight flute drills are handy, particularly for drilling brass and aluminium. Flat drills are useful for drilling small holes in fairly thin material, but for hand work are very liable to run when drilling deep holes.

Standard twist drills are commercially obtainable in fractional sizes ranging from $\frac{1}{16}$ in. diameter to 1 in. diameter by increments of $\frac{1}{16}$ in. In wire sizes from No. 80 (.0135 in. diameter) to No. 1 (.2280 in. diameter)—80 different sizes in all, and in letter sizes from Letter A (.2340 in. diameter) to Letter Z (.4130 in. diameter).

These drills may be purchased separately, or are to be had made up in sets and mounted in wood or aluminium stands provided with

DRILLS AND DRILLING

holes to suit the drill shanks. Each hole is distinctly marked with its respective drill size, so the task of selecting a correct drill is made easy.

For wireless work, however, most requirements are covered in the tables given on a later page.

These drills, and a $\frac{1}{16}$ -in. and $\frac{1}{8}$ -in. diameter and possibly a few extra fractional sizes below $\frac{1}{2}$ in., should complete the range required. To keep them together and instantly found, a drill stand might be made as shown in Fig. 176 A.

When resharpening becomes necessary this should be done by grinding. Drills that do not get a lot of use may be sharpened with an oilstone to restore a keen edge. When re-grinding, follow the original ground faces as closely as possible, grinding from the back and finishing at the cutting edge of each face. After grinding examine the drill for the following points:

- (1) That the point is central.
- (2) That the angles are equal.
- (3) That the backing off is equal (see Fig. 176 B and C).

Where any appreciable thickness of metal has to be drilled it is a good practice to thin the point of the drill, that is, where the same is unduly thick. This will make the drill cut faster, and also less pressure will be required on the drill. Fig. 176 D and E shows how to do this.

It is very noticeable, when drilling brass, aluminium, or ebonite, how the drill is inclined to "bite" into the material. A remedy for this is to grind the face at the cutting edges slightly to reduce the cutting rake (Fig. 176 F).

When using an ordinary twist drill for countersinking, to prevent chattering occurring during cutting, the cutting clearance on the drill lips should be reduced to a minimum, so that the drill is almost rubbing. This

TWIST DRILL GAUGE SIZES

No. Drill.	Decimal Sizes.	No. Drill.	Decimal Sizes.
1	.2280	31	.1200
2	.2210	32	.1160
3	.2130	33	.1130
4	.2090	34	.1110
5	.2055	35	.1100
6	.2040	36	.1065
7	.2010	37	.1040
8	.1990	38	.1015
9	.1960	39	.0995
10	.1935	40	.0980
11	.1910	41	.0960
12	.1890	42	.0935
13	.1850	43	.0890
14	.1820	44	.0860
15	.1800	45	.0820
16	.1770	46	.0810
17	.1730	47	.0785
18	.1695	48	.0760
19	.1660	49	.0730
20	.1610	50	.0700
21	.1590	51	.0670
22	.1570	52	.0635
23	.1540	53	.0595
24	.1520	54	.0550
25	.1495	55	.0520
26	.1470	56	.0465
27	.1440	57	.0430
28	.1405	58	.0420
29	.1360	59	.0410
30	.1285	60	.0400

LETTER SIZES OF DRILLS

A .234	H .266	O .316	U .368
B .238	I .272	P .323	V .377
C .242	J .277	Q .332	W .386
D .246	K .281	R .339	X .397
E .250	L .290	S .348	Y .404
F .257	M .295	T .358	Z .413
G .261	N .302		

will produce a clean-cut countersink in any material.

To produce flat-bottomed holes, such as are required to accommodate the heads of cheese-headed screws, the hole or holes are first drilled to take the shanks of the screws and opened out with another drill to take the head. This drill is then ground off flat and backed off, as seen in Fig. 176 G, and the drilling continued with it to the correct depth.

When a drill is incorrectly ground it will cut a hole larger than the diameter intended. As soon as the point of the drill has entered the material

DRILLS AND DRILLING

WHITWORTH THREADS

Diameter	$\frac{1}{8}$ in.	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.
Tapping size	$\frac{5}{16}$ in.	No. 31	$\frac{7}{16}$ in.	$\frac{1}{2}$ in.	Letter D
Clearing size	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{9}{16}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.

B.S.F. THREADS

Diameter	$\frac{1}{8}$ in.	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.
Tapping size	No. 5	Letter B	Letter G	Letter O	
Clearing size	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	

B.A. THREADS

Diameter	$\frac{1}{8}$ in.	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.
Tapping size	No. 10	No. 17	No. 24	No. 29	No. 32	No. 37	No. 43	No. 46	No. 50
Clearing size	Letter B	No. 3	$\frac{1}{8}$ in.	No. 19	No. 27	No. 30	No. 33	No. 39	No. 43

WOOD SCREWS

Size No.	$\frac{1}{16}$ in.	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.
Clearing size	No. 52	No. 51	No. 50	No. 44	No. 40	No. 31	No. 24	No. 18	No. 11

and the lips have started cutting, both lands (the narrow spiral portions against each flute) should be in contact with the edge of the hole (Fig. 176 II); if as shown in Fig. 176 II (right), it indicates that either the point is out of centre or that the angles are unequal.

Holes requiring to be drilled at an angle with a square face or through the edge of a piece of round material as shown in Fig. 176 I should be started by commencing to drill square with the work until a hole about $\frac{1}{16}$ in. deep (full diameter) has been drilled, and then gradually bring the drill over to the desired angle, keeping the drill cutting slightly whilst so doing. Holes that have started slightly out of position may be pulled over in this manner.

Rose cutters, such as that illustrated in Fig. 176 J, are used for countersinking; resharpening when necessary is done with a small oilstone.

Two types of counterbores for larger holes are shown in Fig. 176 K. These are used by first drilling a small hole for the pilot to work in,

and afterwards using as an ordinary drill until the desired depth is obtained. Large holes may be drilled out in this manner, but when dealing with ebonite, to prevent any raggedness when breaking through, the material is best drilled from either side.

Large holes in sheet metal or circles from ebonite for formers can be cut out with the fly cutter shown in Fig. 176 L. A centre hole is also necessary in this case to accommodate the pilot, and the cutter is adjustable to suit different diameters.

To deal with a hole of a special size, when the right-sized drill is not available, a flat drill may be made to overcome the difficulty. A piece of silver steel smaller in diameter than the hole required (if the hole is $\frac{1}{4}$ -in. diameter $\frac{3}{16}$ -in. dia. silver steel will be about right) is heated at the end in the gas to a dull red and flattened out with a hammer. After allowing it to cool slowly the steel is carefully filed up to the shape shown in Fig. 176 M, the width of the point being made equal to the diameter of the

DRILLS & DRILLING

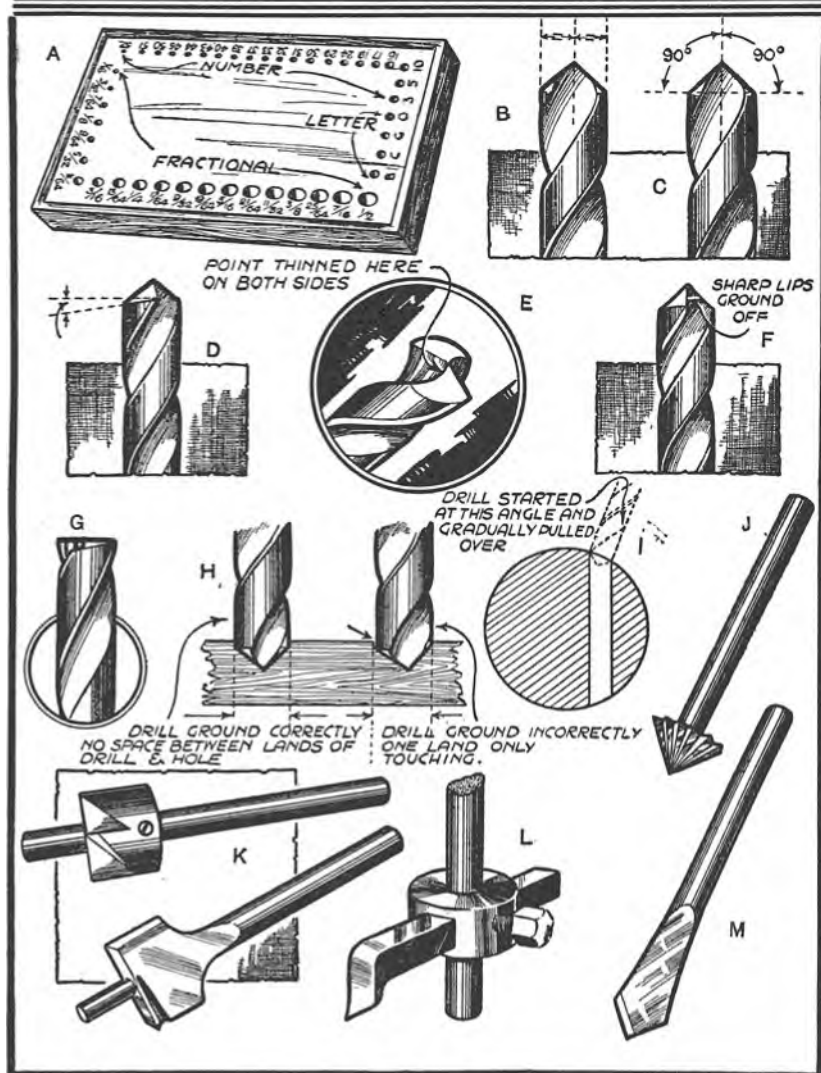


FIG. 176.—Various Hints about Drills and Drilling.

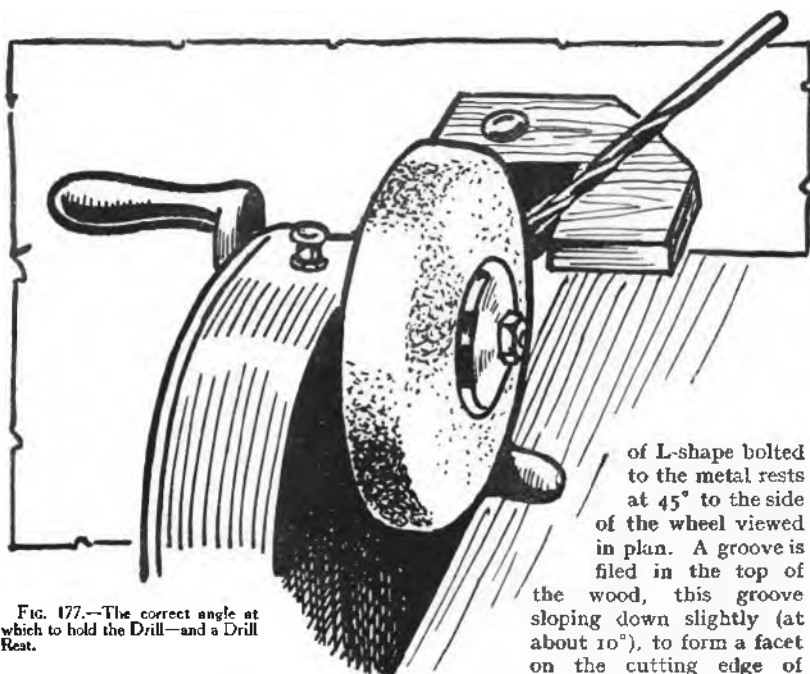


FIG. 177.—The correct angle at which to hold the Drill—and a Drill Rest.

of L-shape bolted to the metal rests at 45° to the side of the wheel viewed in plan. A groove is filed in the top of the wood, this groove sloping down slightly (at about 10°), to form a facet on the cutting edge of

required hole. The end of the drill is reheated to a dull red and cooled quickly in water. After polishing with emery cloth it is tempered in the gas until the polished portion assumes a yellowish brown tint; very little heating is required to accomplish this.

DRILLS, SHARPENING. — The only tool recommended is a rotating emery wheel, and while the hand machine is all that is necessary and often the only appliance possible in an amateur's workshop, it is somewhat awkward to use single-handed when it comes to sharpening twist and straight-fluted drills.

It is essential that the angle of point shall be approximately 45° to the axis of the drill and both sides exactly alike. A simple guide, like that shown in Fig. 177, will ensure this. It consists of a piece of hardwood

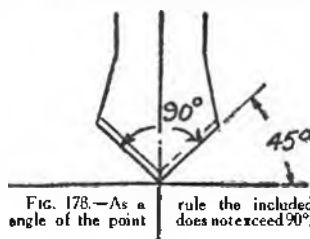


FIG. 178.—As a rule the included angle does not exceed 90° .



FIG. 179.—Grinding groove edge of twist to prevent the drill digging in on brasswork.

drill equivalent to the back rake of the cutting tool.

The flat or "diamond-point" drill is the simplest form of drill, and until the advent of the twist drill

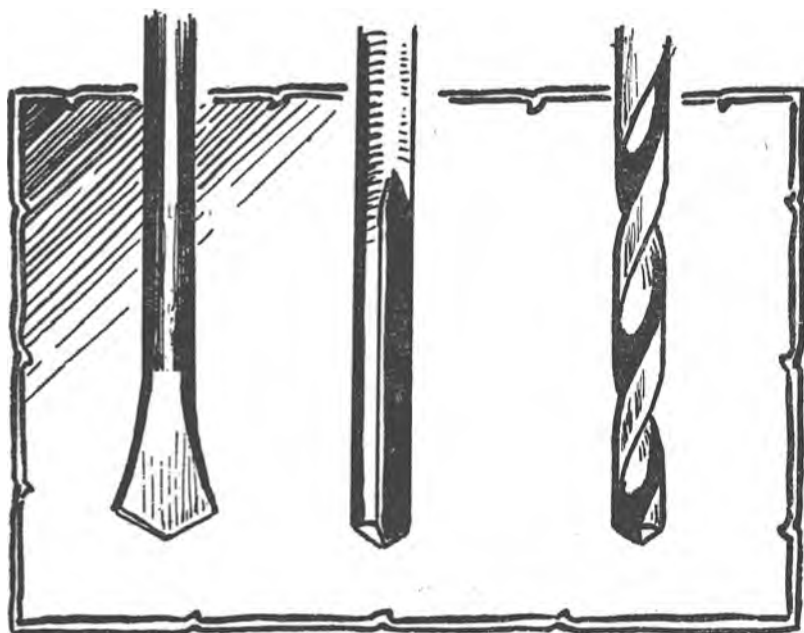


FIG. 180.—Three types of Drill—the Diamond, Straight Flute and Twist.

was the only one used in all phases of engineering. It is made by hammering down the softened tool steel to a flat point to about one-fifth the thickness of the rod material employed. On it two facets are formed at the usual point angle (90° included angle approximately) as shown in the illustration (Fig. 178). The diamond drill is now only used for rough blacksmith work and by jewelers for small jobs; in both cases because of the ease with which the drills can be made from bar material. Except for brass the cutting edge is not ideal.

The twist drill (Fig. 180) has two merits as a cutting tool. In the first place, the groove clears the chips out of deep holes, and secondly, it forms an angle equal to the front rake desirable for a tool cutting iron or steel. This front rake is not really

necessary for brass, and some mechanics, to prevent twist drills "grabbing" and "tearing" brass work, often grind off the points of their twist drills in the flute, as indicated in the sketch (Fig. 179) to remove this front (or top) rake to the cutting edge.

Therefore, for brass drilling the straight flute drill (see Fig. 180), which accomplishes the same result, is preferred. These drills are readily obtainable in all the smaller sizes. They are sharpened in exactly the same way as a twist drill.

DRY CELL.—A combination of chemicals giving forth electrical energy. Active elements consists of a piece of carbon and a piece of zinc. They are known as the electrodes. Separating these is a chemical composition known as a depolariser. It is in this composition that the vari-

DRY CELL — D.X. UNIT

ous types of dry cell differ. The voltage of a dry cell (one cell consists of one carbon electrode—the positive, and one zinc—the negative electrode with the appropriate depolariser) is 1.5 volts. The capacity, or the amount of current which it will deliver, depends upon the size of the cell. These cells are used principally for H.T. batteries, as the current from them is so small. Where valves having a very small filament current are used, dry cells of large size may be employed for lighting the filaments, but it is preferable for this purpose to employ "wet cells," or in other words, accumulators. (See also *Leclanché Cell*.)

D.S.C.—Double Silk Covered (wire).

DUAL COIL.—A tuning coil which covers the medium- and the long-wave bands. (See also *Coil*.)

DUMB AERIAL.—An artificial aerial (which see).

DUPLEX.—Duplex. Two-way telegraphy and telephony. (See also *Duplex*.)

D.X.—An abbreviation for the word "distance." This is a relic from the early days of amateur transmission.

"D.X. UNIT."—Those listeners who do not employ a receiver having a H.F. stage will no doubt have found that the strength of the foreign transmissions falls off during the summer season. In some cases it will be found impossible even to hear a

station which previously could perhaps be heard on the loudspeaker. Of course, atmospherics will render the long-distance signals rather uncomfortable, but there will be occasions when it is desired to hear a distant station, and without a good stage of high frequency the signal will be too weak to work the loudspeaker. The unit described under this heading

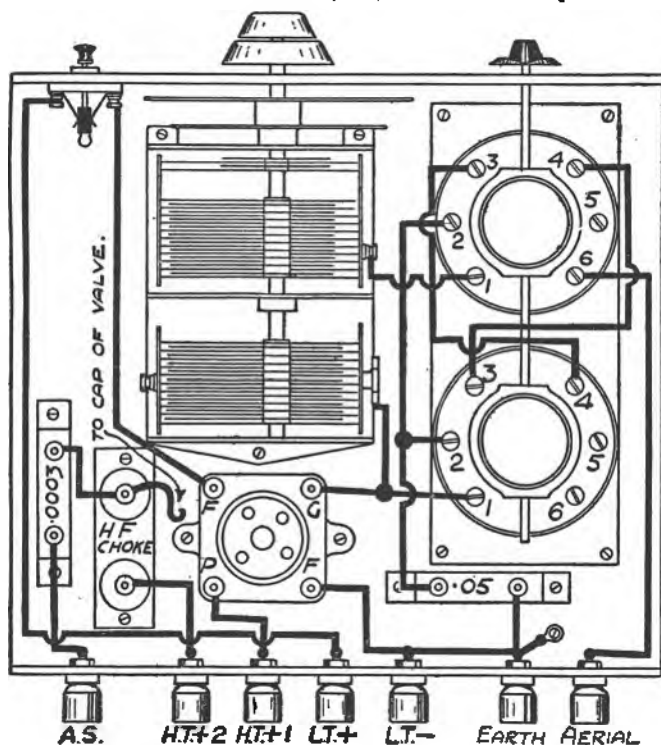


FIG. 181.—The wiring diagram of the D.X. Unit.

D.X. UNIT

is a stage of screen grid H.F., employing screened coils and a screened and ganged condenser. The coils are of the band-pass type, and therefore this unit can be added to an ordinary detector circuit and will give all that can be desired in the way of selectivity.

Screening. In order to avoid difficult metal work, and yet at the same time obtain the advantages of screening, an ordinary wooden baseboard covered with metal foil has been used. The metal foil can be obtained from any good-class ironmongers, or alternatively a very thin sheet of copper or aluminium may be used. There is also on the market a material consisting of paper coated on one side with aluminium foil. This can be obtained quite cheaply and could be used for the set. Whatever material is eventually decided upon, it must be cut to the size of the baseboard (9 × 8 in.), and fixed at the four corners by small round-headed screws. The ganged condenser should then be placed in its position, and the three screws passed through the requisite holes to hold this firmly down.

A little care will have to be taken when attaching this condenser, as it must be on a perfectly straight plane in order to allow the ivory dial to rotate evenly behind the escutcheon window. Follow the details given by the manufacturers of the condenser, and take extreme care to see that the panel is vertical, and also that the condenser

spindle is concentric with its hole. Next attach the coil assembly at the side of the condenser, first of all pulling out the rod which operates the switches. This rod is a sliding fit, and is not held by any screws, so that it will slide out from the front quite easily. To make quite certain that it is in the correct position, the panel (already drilled) may be held in the front of the baseboard in the position it is eventually to occupy, and the switch rod pushed home from the panel front.

When this has been done, attach the remaining baseboard components, making quite certain that you do not get the fixed condensers in the wrong places. The .05 condenser (which must be of the special type specified—and must not be an inductive condenser) goes at the back of the tuning coils. You will notice a soldering tag has been attached to the baseboard near the earth terminal, and a wire joined to this. If copper foil is used to cover the baseboard, there will be no need for this screw and tag, as the necessary lead

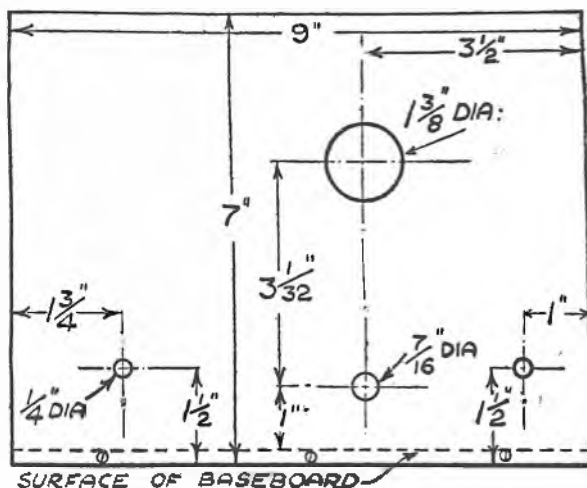


FIG. 182.—The Panel Layout for the D.X. Unit.

may be soldered direct to the copper. As, however, it is difficult to solder to aluminium, this screw and tag device has been employed to make the screen at earth potential, and, incidentally, to earth the moving plates and framework of the tuning condenser.

Remove the cans from the coils, and join terminal 3 on one coil to terminal 4 on the other one. Do this with both coils, crossing the wire between the coils, and only baring just sufficient of the insulated wire to enable a loop to be formed to go under the screw head. If too much wire is bared there will be a danger of a short circuit through the shielding can. If desired, the thin insulated sleeving sold for the purpose may be slipped over the leads going to the coils to avoid this risk of short circuiting. Join the terminals marked 2 on the two coils together, and take the junction of the two wires to one side of the .05 condenser. Terminal 1 on the coil farthest from the panel is then joined to the grid terminal of the valve holder, and to the fixed plates of the section of the tuning condenser fitted with the trimmer. Terminal 1 on the remaining coil is then joined to the fixed section of the condenser nearest the panel. A wire from the .0003 fixed condenser to the H.F. choke will complete the wiring of the baseboard so far, and the panel and terminal strips may then be fitted. Complete the wiring as shown in the wiring diagram, making quite certain of the connections of the leads to the filament terminals of the valve holder. As a metallised valve is to be used, it is essential that the L.T.- leg is the one shown, as the metallic covering of the valve is joined to this leg by the valve makers, and the screening will not be complete if this covering is not "earthed."

Before the unit can be joined to

the receiver, there is one important point to observe. Examine the circuit of your present set, and see if L.T.- and H.T.- are joined together, and to the earth terminal of the set. If they are, then everything is straightforward. If not, then you will have to make a slight alteration to your circuit, to bring it into line with this arrangement. The grid leak of the detector valve should be joined between the grid terminal of the detector valve holder and the positive filament leg of the same valve holder. Now disconnect the aerial and earth leads from the set, and place the unit at the aerial side of the set. Attach the aerial and earth leads to the respective terminals on the unit, and join the terminal marked A to the aerial terminal on the set.

Next join up the L.T. terminals on the unit to the same terminals on the set, and connect a lead from H.T.2 to a tapping on the H.T. battery between 100 and 120 volts. H.T.1 should be about 60 to 80 volts. On switching on *both* the unit and the set one should soon find the local station by adjusting the tuning dial of the two sets. (Of course, make certain that the wave-range switch of the unit agrees with the wave range covered by the present set.) When you have tuned to the loudest point, carefully adjust the trimmer at the side of the condenser section farthest from the panel, adjusting the tuning knob at the same time. It will be found that there is a position for this, where a turn either forwards or backwards results in reduced signal strength. The condenser will then be balanced or trimmed for this particular station. When tuning to any other part of the scale it will only be necessary to make use of the trimming knob at the front of the panel to compensate for any slight difference in gangings.

D.X. UNIT — ELECTROLYTIC CONDENSER

If the receiver at present in use makes use of a tuning arrangement which only covers the lower wave band, or if it is desired to replace the tuning arrangement with a coil of the same type as is used in the unit, a canned coil to match up with the aerial coils will be required, and this may be placed in the set; it is provided with a wave-change switch similar to that in the unit. The characteristics of the coils are identical.

List of Components

One pair band-pass coils.
One variable condenser.
One panel, 9 × 7 in.
One valve holder.
One H.F. choke.
One .05 fixed condenser (non-inductive).
One .0003 fixed condenser.
One on-and-off switch.
Seven terminals.
One terminal strip, 2 × 9 in.
One baseboard, 9 × 8 in.
One sheet copper or aluminium foil.
One *metallised* screen-grid valve.
Coil of wire, screws, etc.

DYNATRON.—A vacuum-tube device having two electrodes, a cathode, and an anode. The electrons from the cathode strike the anode with great force and set up a secondary emission, and the current received in the anode circuit is the difference between the re-emitted electrons and the original electron stream.

DYNE.—The C.G.S. unit of force. The force which gives a velocity of 1 centimetre per second when acting on a mass of 1 gramme for 1 second; 13,835 dynes = 1 poundal.

E

EARTH PLATE.—The metal used for completing the earth connection. It may consist of a sheet of copper gauze, copper plate, etc. On aeroplanes the earth plate consists usually of the metal engine bearers, and on

board ship the metal hull of the ship is generally employed.

EARTH RETURN.—The single-wire system of wiring, the "earth" (metallic) being used as the common lead for the other (usually the negative.) (See also *Aerials and Earths*.)

EBONITE.—An insulating material produced by vulcanising rubber with approximately 25 per cent. sulphur. Vulcanite.

EBONITE SHEET

Table of Weights and Areas

Thickness.	Area of 1 oz.	Area of 1 lb.	Weight of 1 sq. ft.
<i>in.</i>	<i>sq. in.</i>	<i>sq. in.</i>	<i>oz.</i>
$\frac{1}{16}$	24	44	52
$\frac{1}{8}$	36	56	39
$\frac{3}{16}$	54	88	26
$\frac{1}{4}$	72	117.5	20
$\frac{5}{16}$	90	147	13

EDDY CURRENTS.—The small currents which are generated in a piece of metal when it is placed in a magnetic field. The higher the frequency of the field the larger will be the eddy currents. If the eddy currents reach sufficient magnitude the metal will become hot. The energy dissipated in this manner is known as "Eddy Current Loss."

EDISON ACCUMULATOR.—See *Accumulator*.

ELASTANCE.—Unity divided by capacity. The reciprocal of capacity.

ELECTRODE.—Either of the two poles of a battery, dynamo, etc. An *anode* or *cathode*.

ELECTROLYSIS.—See *Accumulator*.

ELECTROLYTE.—See *Accumulator*.

ELECTROLYTIC CELL.—A cell in which electrolysis takes place in its own electrolyte.

ELECTROLYTIC CONDENSER.—A condenser consisting of two plates of different metals in a chemical liquid solution. It is not a condenser until a potential is applied, where-

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giving only H.T. from the mains, as the H.T. battery is the really expensive part of the broadcast receiver, so far as upkeep is concerned. The unit is quite cheap to make up, and there are no replacements to add to the initial cost, as a metal rectifier is employed in place of the usual valve.

Having obtained all the parts as specified in the list of components, the constructor should obtain a piece of stout board on which they may be mounted. In most cases it will no

therefore to arrange the terminal strip and choke so that they are not too far apart for the resistance in use.

Carry out the wiring with thick-covered wire, of, say, 18 gauge. If condensers are obtained having only soldering tags, care must be taken in making the connections to them. The iron must be really hot, and must not be left too long in contact with the lug, or the condenser may be damaged or come adrift from the inside of the case. Note carefully that the correct connection is made

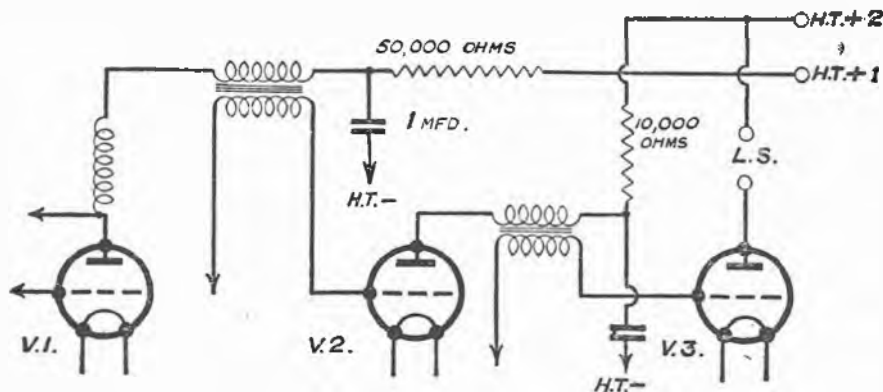


FIG. 184.—The Battery Connections of a simple three-valve.

doubt be preferable to make this unit of approximately the same dimensions as the present H.T. battery, in order that it may be accommodated in its place in a cupboard, or in part of the actual wireless cabinet. No dimensions are therefore given for this board.

Mounting the Components.—Mount the various components on the board in a position as near that shown in the wiring diagram as possible. In arranging these parts, take care to fix the fuse holder in such a position that it is easy to replace the fuse in the event of this blowing. The spaghetti resistance is the link between the terminal H.T.1 and one terminal on the choke. Take care

to the transformer. The flex lead for connection to the mains socket must be of sufficient length to reach the socket you intend to use, and this may, of course, be a power or lighting one. Running off the lighting socket will in most cases be more expensive, but, even with lighting at 6d. per unit, the cost will not be nearly so high as the dry H.T. battery. When the correct length of flex has been obtained, tie a knot a few inches from the end which is to be connected to the transformer, and with a piece of wood or ebonite, fix the flex to the baseboard. This will ensure that the ends are not inadvertently pulled off the transformer terminals with

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the possibility of blowing the mains fuse. One lead of this flex is connected to the lower terminal on the transformer, and the other lead is taken to the terminal marked with the voltage of the particular mains.

An Iron Case for Safety.—For the sake of safety, and to satisfy the insurance company, it is preferable to enclose the complete unit in an iron case to which a terminal is fixed, without insulation. This terminal should be connected direct to earth. Of course, if a box is made to fit over the baseboard, make quite sure that no bare wires or terminals are likely to come into contact with the box.

Connect the unit to the receiver in exactly the same way as the H.T. battery, plug into the mains, and switch the set on. Probably signals will be much more powerful than when the battery was in use, as the unit delivers about 150 volts, and therefore the grid bias will need adjusting to avoid distortion. Examine the curves of your valves, and set the correct value of bias for the above amount of H.T. In the event of the unit being connected to a receiver having one H.T. positive terminal serving two or more valves, it is quite possible that trouble will be experienced from what is known as "motor boating." This, as its name implies, is a "popping" noise similar to the exhaust of a motor bike or motor boat, and very often makes it impossible to listen in.

A Simple Remedy.—Each H.T. lead must be decoupled, as has previously been explained (see *Decoupling*). The detector valve should be connected to the H.T. +1 on the unit, and the last valve of the set to the other H.T. + terminal. Any other valves in the receiver must then have their H.T. leads joined to this latter terminal via a resistance of 10,000 ohms, the end of the resistance farthest

from the battery lead being connected to one terminal of a fixed condenser of 2 mfd., the other terminal of which is connected to H.T. —.

Fig. 184 shows, by way of an example, the battery connections of a simple three-valver consisting of a detector and two transformer-coupled L.F. stages.

List of Components for the A.C. Unit

One mains transformer.
One power choke.
One Westinghouse metal rectifier.
Three 4-mfd. fixed condensers (500-volt test type).
One 1-mfd. fixed condenser.
One fuse holder and fuse.
One spaghetti resistance, 50,000 ohms.
Three insulated terminals.
Small ebonite strip.
Wire, screws, mains plug, and flex.

A D.C. Mains Unit. Quite a number of houses are still connected to mains using direct current, and although this type of mains is gradually being superseded by the alternating-current mains, there is a demand for an eliminator to drive the wireless set from this type of mains. To meet the needs of readers so situated instructions are now given for the building of a simple D.C. battery eliminator, suitable for the simpler types of broadcast receiver employing up to three valves, and not taking more current than about 20 to 30 milliamps. The total cost should not exceed 30s., so that it is cheaper in the end than dry batteries.

The only components needed are shown in the list of parts, and here a word of warning is necessary. The condensers must be of the type tested at 250 volts or more. The remaining components may be of any desired make, and it is only necessary to ensure that the choke carries 30 milliamps. with an inductance of 20 henries, and that the mains voltage

ELIMINATOR

dropping resistance is robust enough to stand up to its job.

Marking Out the Baseboard.—Having obtained the complete list of parts, commence by marking out the baseboard in accordance with the wiring plan (Fig. 185). This is quite simple, and no trouble should be experienced in getting the various parts screwed down without touching, so that wiring can be easily carried out. Drill the ebonite terminal strip and affix the terminals, which should be of the insulated variety, to avoid shocks and short circuits. The flex for connection to the mains plug should be anchored to the baseboard with a small block of ebonite to avoid the risk of it being pulled away and shorting

the mains. Do not use a brass clip to fix this flex down, as it may cut through the covering of the wire and so produce a short circuit.

Wire up, using glazite or similar covered wire, and take care with the connections of the spaghetti resistance, as these are of different values and must be connected in the correct places.

Voltage Dropping Resistance.—So far no value has been given for the voltage dropping resistance given in the list of components, and to ascertain this a little sum has to be worked out. First of all, ascertain the voltage of your mains supply. Next, find out from the makers' in-

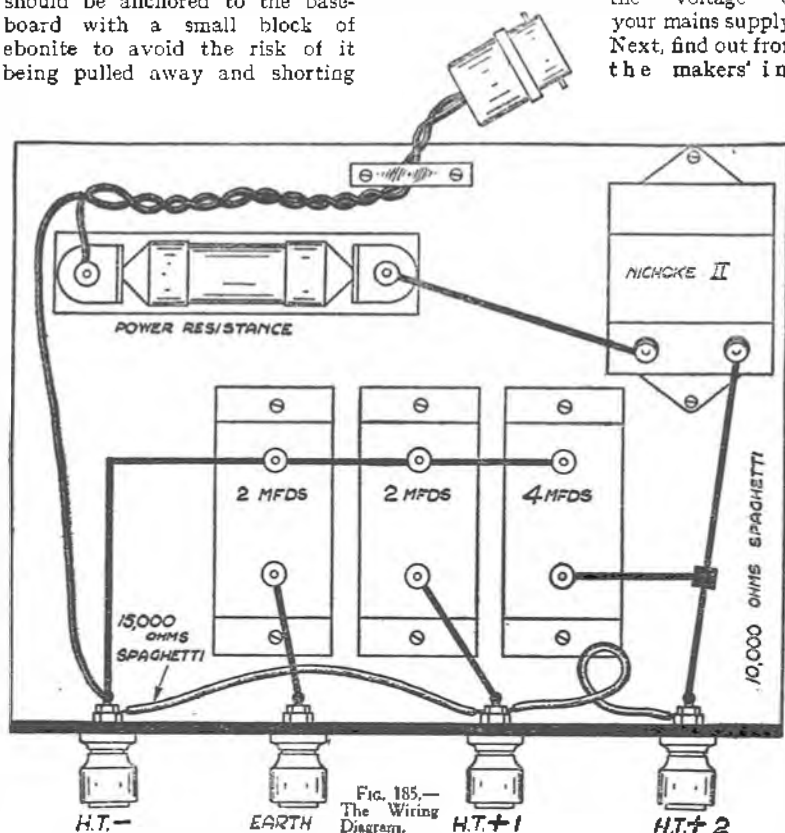


FIG. 185.—
The Wiring
Diagram.

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structions what is the maximum voltage your last (or output) valve will take. Subtract this latter value from the former. For instance, suppose your mains are of 200 volts, and your last valve will take 150 volts: 200 minus 150 will give 50 volts. This latter figure must then be multiplied by 1,000 and divided by the total current taken by the set. This, of course, is simply the total of the current of each valve, to which must be added a further 5 milliamps, which is dropped through the smoothing and voltage dropping resistances R 1 and R 2. In the case of a simple three - valver using 2-volt valves, this figure should be in the neighbourhood of 20 milliamps. The answer to this little sum will give the value of the resistance in ohms, and, if no resistance is made of the exact value, you should obtain the next nearest value.

Mounting the Unit.—The completed unit should be mounted where it cannot be tampered with, or preferably enclosed in a metal box, and before it can be attached to the receiver the following points must be watched. First of all, disconnect the aerial and earth from the set. Next, mount a small fixed condenser (of .001 mfd. or more) on the cabinet near the aerial terminal, and join one side of this condenser to the aerial terminal. The aerial lead-in is then taken to the free side of this fixed condenser instead of to the aerial terminal. The earth lead must be taken to the terminal on the D.C. unit marked "E," and *not* connected to the earth terminal on the wireless set.

Testing Out.—Plug the mains plug

into the nearest socket, and switch on. If no signals are heard, reverse the plug, and when the correct way round has been found, mark the plug to avoid it being plugged in the wrong way round.

Below is given an example of the working for the value of the resistance R 3 in case the above particulars are not understood.

Example

Mains voltage, 250 volts.

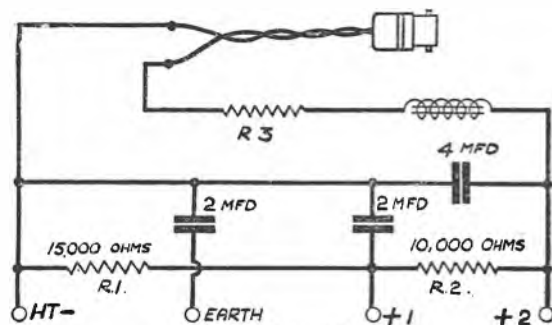


FIG. 186.—The Circuit Diagram.

Last valve rated at 150 volts 8 milliamps.

Detector valve takes 2 milliamps.

First L.F. valve takes 6 milliamps.

Therefore, total current = 16 + 5 = 21 milliamps.

Volts to be dropped = 250 - 150 = 100 volts.

$$\frac{100 \times 1,000}{21} = 4,762 \text{ ohms.}$$

The nearest value to this is 5,000 ohms.

List of Parts

One L.F. smoothing choke.

One spaghetti resistance 10,000 ohms.

One spaghetti resistance 15,000 ohms.

One power resistance (for values see notes).

One 4-mfd. fixed condenser.

Two 2-mfd. fixed condensers.

E.M.F. — EUROPEAN BROADCASTING STATIONS

Four insulated terminals.

Wire, mains plug, flex, baseboard, and screws.

E.M.F.—Electromotive Force (unit is the volt).

EMISSION.—The flow of electrons from a heated filament in a valve. The emission consists of negative electrons, and is secured by manufacturing the filament from a metal or combination of metals which have a good electronic emission, or by coating the filament with a chemical substance for the same purpose.

ENDODYNE.—A method of reception differing from heterodyne reception, in that the oscillation generator is an actual part of the receiver.

ERG.—The unit of work (C.G.S. system); is equal to the work done by 1 dyne moving, by 1 centimetre, its point of application. One foot-poundal = 421,390 ergs.

ETHER.—The supposed medium filling all space through which the vibrations of light, heat, and electricity are propagated.

EUROPEAN BROADCASTING STATIONS

In order of Wavelengths. (See also *British Broadcasting Stations.*)

K/cs.	M.	M.P.	Station.	Country.	Notes.
155	1,935	7	Kaunas	Lithuania	
160	1,875	8.5	Huizen	Holland	
167	1,796	40	Lahli	Finland	Relays Helsinki
174	1,725	75	Radio Paris	France	
183.5	1,635	60	Konigs Wusterhausen (Zeeseen)	Germany	Relays Berlin
193	1,554.4	30	Daventry National	Great Britain	
195	1,538	7	Ankara	Turkey	
202.6	1,481	100	Moscow (Old Komintern)	Russia	
207.5	1,445.7	13	Eiffel Tower (Paris)	France	
212.5	1,421	120	Warsaw No. 1	Poland	
222	1,350	0.5	Kasbah	Tunis	
222.5	1,348	30	Motala	Sweden	Relays Stockholm
230.7	1,304	100	Moscow (Trades Union)	Russia	
238.1	1,260	—	Novosibirsk	Russia	
242.5	1,237	—	Vienna (Experimental)	Austria	
244	1,229.5	0.6	Boden	Sweden	
250	1,200	5	Istanbul	Turkey	
250	1,200	21	Reykjavik	Iceland	
256	1,171.5	—	Taschkent	Russia	
260	1,153	7.5	Kalundborg	Denmark	Relays Copenhagen
268.5	1,116	40	Moscow, Popoff	Russia	
277	1,083	60	Oslo	Norway	
280	1,071	10	Tiflis	Russia	
290	1,034	36	Kiev	Russia	
300	1,000	100	Leningrad	Russia	
320	937.5	20	Khar'kov	Russia	
353.5	848.7	4	Rostov-Don	Russia	
385	779	2	Petrozavodsk	Russia	
389	770	0.6	Ostersund	Sweden	Relays Sundsvall
394	761.4	1.8	Nijni-Novgorod	Russia	
385	760	1.5	Geneva	Switzerland	
416.7	720	20	Moscow (Experimental)	Russia	
428.6	700	4	Minsk	Russia	
434.7	600	1.2	Oulu, Uleaborg	Finland	
442	680	0.6	Lausanne	Switzerland	
522	574.7	2.5	Ljubljana	Yugo-Slavia	
527	570	0.25	Freiburg-im-Breisgau	Germany	Relays Stuttgart
530	566	2	Grenoble (PTT)	France	
531	565	0.25	Hanover	Germany	Relays Hamburg
533	563	2	Smolensk	Russia	
		16	Wilno	Poland	
		0.25	Augsburg	Germany	Relays Munich
536	560	1.5	Kaiserlaughtern	Germany	Relays Munich
		0.7	Hamar	Norway	Relays Oslo
		1	Tampere	Finland	Relays Helsinki
545	550	18.5	Budapest No. 1	Hungary	

EUROPEAN BROADCASTING STATIONS

<i>K/es.</i>	<i>M.</i>	<i>kW.</i>	<i>Station.</i>	<i>Country.</i>	<i>Notes.</i>
554	542	3	Palermo	Italy	
563	533	10	Sundsvall	Sweden	
572	533	60	Munich	Germany	
581	525	15	Riga	Latvia	
590	517	15	Vienna (Rosenhugel)	Austria	
599	509	15	Brussels No. 1	Belgium	
603.6	500.8	20	Florence	Italy	
608	497	1.8	Nijni Novgorod	Russia	
614	493.4	1.2	Moscow	Russia	
625	488.6	1.2	Trondheim	Norway	
630.2	480	120	Prague	Czechoslovakia	
635	476	50	North Regional (Manchester)	Great Britain	
644	473	1.2	Sebastopol	Russia	
653	465.8	60	Langenberg	Germany	
		1.5	Lyons (La Doua)	France	
		0.5	Tartu	Estonia	
		60	Schweizerischer Landessender (Beromünster)	Switzerland	
	459	0.5	Dodo	Norway	
		0.5	Danzig	Free City	
		0.5	Klagenfurt	Austria	
		0.7	Possgrund	Norway	
		1	Salamanca	Spain	
		0.6	San Sebastian EAJ8	Spain	
662	453.2				
		0.1	Tromsø	Norway	
		0.15	Upsala	Sweden	
666.5	450.1	4	Odessa	Russia	
		0.35	Aalesund	Norway	
671	447.1	0.08	Notodden	Norway	
		0.7	Paris (PTT) (École Supérieure)	France	
		0.15	Rjukan	Norway	
680	441	50	Rome	Italy	
689	436	0.25	Malmberget	Sweden	
696	431	55	Stockholm	Sweden	
697	430.4	1.5	Paredé	Portugal	
		2.8	Belgrade	Yugo-Slavia	
		2	Madrid (Union Radio) (EAJ7)	Spain	
707	424.3				
		100	Madrid (Radio Español)		
715	419.3	1.5	Moscow-Stalin	Russia	
721.1	416	6	Berlin (Willeben)	Germany	
725	413	1.2	Rabat	Morocco	
734	408	16	Dublin	Ireland	
743	403	25	Katowice	Poland	
752	398.9	25	Radio Suisse Romande (Sottens)	Switzerland	
761	394	25	Midland Regional	Great Britain	
		12	Bucharest	Romania	
770	390	10	Archangel	Russia	
779	385	150	Leipzig	Germany	
788	381	9	Toulouse (Radio)	France	
792.5	378.6	16	Lwow	Poland	
797	376.4	—	Moscow	Russia	
806	372	50	Scottish Regional (nr. Falkirk)	Great Britain	
810	370.4	1.5	Hamburg	Germany	
		1.2	Radio LL (Paris)	France	
		1	Bolzano	Italy	
815	368.1	10	Helsinki	Finland	
		1.5	Seville (Union Radio) EAJ5	Spain	
816	367.6	0.7	Fredrikstad	Norway	
824	364	1	Bergen	Norway	
825.3	361.3	13	Algiers	North Africa	
834	360.5	60	Stuttgart (Muglacker)	Germany	
842	356.3	50	Tiraspol	Russia	
843	356	1	London Regional	Great Britain	
852	352.1	1.2	Graz	Austria	
855.5	351	8	Leningrad	Russia	
860	349	11.5	Radio Barcelona (EAJ1)	Spain	
869	345	35	Strasbourg (Brunath)	France	
878	342	15	Brno	Czechoslovakia	
887	338.2		Brussels No. 2	Belgium	

Relays PTT

Relays Königsberg
Relays Vienna
Relays Oslo
EAJ2

Mon., Wed., Fri., 7.30-9 p.m.; other days, 10 p.m. to midnight.

Relays Stockholm

Relays Oslo

Relays Bodan

7.30 p.m. and (except Monday) 10 p.m. to midnight.
Spain 5-7 p.m. (Mon. 5 p.m. to midnight).

Relays Oslo

Usually relays Vienna

Flemish Programme

EUROPEAN BROADCASTING STATIONS

<i>K/cs.</i>	<i>M.</i>	<i>kW.</i>	<i>Station.</i>	<i>Country.</i>	<i>Notes.</i>
896	335	5.5	Cadiz	Spain	
		1.9	Poznan	Poland	
905	331.5	60	Milan	Italy	
914	325.2	60	Poste Parisien (Paris)	France	
923	325	60	Breslau	Germany	
932	322	10	Göteborg	Sweden	Relays Stockholm
		0.25	Dresden	Germany	Relays Leinizg
941	319	1.5	Naples	Italy	
		1	Sofia (Rodno Radio)	Bulgaria	
950	315	2.6	Marseilles (PTT)	France	
		1.5	Cracow	Poland	
959	312.8	10	Genoa	Italy	
			Radio Vitus (Paris)	France	
968	309.9	1	Cardiff	Great Britain	
		0.25	Pietarsaari (Jacobstad)	Finland	Relays Helsinki
977	307	0.5	Falun	Sweden	
		0.75	Zagreb	Yugo-Slavia	
986	304	13	Bordeaux-Lafayette (PTT)	France	
995	301.5	50	North National (Manchester)	Great Britain	
1,004	298.8	11	Tallinn	Estonia	
1,013	296.1	20	Hilversum	Holland	
1,022	293	2.5	Kosice	Czechoslovakia	
1,031	291	0.7	Limoges (PTT)	France	
		13.2	Viiipuri (Viborg)	Finland	Relays Helsinki
		1	Bournemouth	Great Britain	
1,040	288.5	0.12	Plymouth	Great Britain	
		50	Scottish National (nr. Falkirk)	Great Britain	
		0.12	Swansea	Great Britain	
1,043	287.6	0.7	Radio Lyons	France	
1,049	286	0.8	Montpellier	France	
		0.5	Berlin Relay	Germany	
1,058	283	0.5	Magdeburg	Germany	Relays Berlin
		0.5	Stettin	Germany	Relays Vienna
		0.5	Innsbruck	Austria	
1,063	282.2	2	Lisbon	Portugal	
1,067	281	0.75	Copenhagen	Denmark	
1,071	280	—	Radio Liege	Belgium	
1,076	279	14	Bratislava	Czechoslovakia	Relays Königsberg
1,085	276.5	60	Heilsburg	Germany	
1,096	275.7	7	Turin	Italy	
1,103	272	1.3	Rennes	France	
1,112	270	0.25	Bremen	Germany	Relays Hamburg
		20	Bari	Italy	
1,121	267.6	0.7	Oviedo	Spain	
		1.5	Radio Valencia	Spain	
1,130	265.4	1.3	Lille (PTT)	France	
1,137	263.8	11	Moravska-Ostrava	Czechoslovakia	
1,147	261.6	50	London National	Great Britain	
1,157	259	17	Frankfurt-am-Main	Germany	
1,166	257	10	Hörby	Sweden	Relays Stockholm
1,175	255	0.7	Toulouse (PTT)	France	
1,184	253	5	Gleiwitz	Germany	Relays Breslau
		1	Almeria	Spain	
1,193	252	1	Barcelona (E.A.J.15)	Association Nat.	
		0.25	Trollhättan	Sweden	
1,202	248.6	0.3	Varberg	Sweden	
1,205	249	0.8	Juan-les-Pins (Nice)	France	
		0.2	Kolmar	Sweden	Relays Stockholm
		10	Trieste	Italy	
		0.5	Berne	Switzerland	
		0.4	Cartagena	Spain	
1,211	247.7	0.25	Cassel	Germany	Relays Frankfurt
		0.2	Eskilstuna	Sweden	Relays Stockholm
		0.25	Kiruna	Sweden	Relays Boden
		0.5	Linz	Austria	Relays Vienna
		0.4	Saffte	Sweden	Relays Stockholm
		0.6	Turka (Abo)	Finland	Relays Helsinki
1,229	244.7	0.5	Basle	Switzerland	
1,236	242.7	—	Liège Experimenta	Belgium	
1,238	242.3	1	Belfast	N. Ireland	
1,247	240.6	0.5	Stavanger	Norway	
1,250	240	1.5	Radio Beziars	France	
1,256	239	2	Nurnberg	Germany	Relays Munich

EUROPEAN BROADCASTING STATIONS — FAULTS

<i>Kcs.</i>	<i>M.</i>	<i>W.</i>	<i>Station.</i>	<i>Country.</i>	<i>Notes.</i>
1,265	237.2	3	Bordeaux-Sud-Ouest	France	Relays Stockholm
		1	Radio Nîmes	France	
		0.2	Orebro	Sweden	
1,274	235.5	0.5	Christiansand	Norway	Experimental
1,283	235	2	Lodz	Poland	
1,292	232.2	0.15	Kiel	Germany	Relays Hamburg
		0.25	Norrköping	Sweden	
		0.25	Hälsingborg	Sweden	
1,301	231	0.2	Malmö	Sweden	Relays Stockholm
		1.25	Umeå	Sweden	
		0.2	Uddevalla	Sweden	
1,310	229	0.05	Flensburg	Germany	Relays Hamburg
1,319	227.4	0.5	Hudiksvall	Sweden	
1,328	226	0.15	Cork	Ireland	
1,337	224.4	1	Fecamp (Radio Normandy)	France	Relays Helsinki
1,345	223	0.5	Pori (Björneborg)	Finland	
1,355	221.4	0.5	Salzburg	Austria	
1,373	218	0.5	Karlstad	Sweden	Relays Vienna
1,382	217	0.25	Königsberg	Germany	
		0.5	Halmstad	Sweden	
		0.2	Radio Chatelineau	Belgium	
1,391	216	3	Aberdeen	Great Britain	Relays Stockholm
1,400	214.3	1	Newcastle	Great Britain	
1,420	211.3	1	Csepel	Hungary	
1,428	210	3	Borås	Sweden	Relays Stockholm
1,450	207	0.15	Ornsköldevik	Sweden	
1,460	206	0.2	Gävle	Sweden	
1,470	204	0.2	Kristinehamn	Sweden	Relays Stockholm
1,480	203	0.25	Jönköping	Sweden	
1,490	201.3	0.25	Karlskrona	Sweden	
1,530	196	0.2	St. Quentin	France	Relays Stockholm
1,714	175	—			

F

FADING.—A phenomenon which is experienced by all listeners, whatever kind of receiver they use, is that of fading, which occurs principally when listening to distant stations. Fading is inevitable and incurable, but it is nevertheless interesting to speculate how it is caused. When wireless waves are sent out from a transmitting aerial they divide into two portions, and each one travels in a different way. One part, called the "ground wave," follows the curvature of the earth and in time is all absorbed by metallic objects. The other part travels upwards at an angle to the ground until it encounters the Heaviside Layer. This layer, which is estimated to be about forty miles above the earth, consists of ionised atmosphere and acts as a reflector to the waves. The upward waves are therefore reflected back again just as light waves are reflected by a mirror. But as the Heaviside Layer presents an uneven surface and

is in constant motion, the reflection is uneven. Thus the reflection is at one time "favourable" to any particular aerial, and at another "unfavourable"; hence the fading. The same general theory explains why reception of distant stations is always better after dark than in daylight.

FARAD.—The unit of capacity. A conductor is said to have a capacity of 1 farad when its potential difference is raised by 1 volt by a charge of 1 coulomb. Name is derived from Michael Faraday.

1 farad = 1,000,000 micro-farads.

FAULTS AND THEIR REMEDY.—There are four distinct classes into which most of the more likely faults are divided; these are: (1) a complete cessation of signals, (2) a falling off in signal strength, (3) intermittent reception, and (4) reception accompanied by crackling sounds, and the remedy varies slightly in each case.

When Reception fails entirely. It is generally fairly easy to find what is wrong when reception fails entirely. First, suspect the aerial and earth

FAULTS AND THEIR REMEDY

wires if these are fairly old; ascertain that the down-lead is not broken, and that it makes good contact with the lead-in tube. Trace the wire from the lead-in tube to the aerial terminal and make sure there is no break. If any doubt exists, therefore, it is well to remove the wire and test it for continuity with a flash-lamp battery and bulb (see Fig. 187). Failure of the bulb to light, or an intermittent light, indicates a broken wire. A bad earth connection is hardly likely to stop reception entirely, but it can do so in some cases. With a "buried-plate" type of earth, the wire usually comes adrift just where it is soldered to the plate. Should the aerial and earth wires prove to be in order, test, in a similar manner, the loudspeaker and battery leads, replacing any doubtful ones. The state of the batteries can generally be judged by the time from which they were last charged or replaced, but they occasionally come to an untimely end by being short circuited, so it is as well to test them before looking at the set itself. A voltmeter or flash-lamp bulb is most useful for this purpose, but the tests must be applied whilst the set is switched on, or in other words, whilst the batteries are "under load," because run-down batteries will often give a fairly good voltage reading when disconnected from the set. Connect the voltmeter or bulb across the accumulator terminals first; there should be a steady reading of 2 volts per cell or a constant light in the bulb. The most satisfactory way to test a high-tension battery is to measure the voltage between each 6-volt tapping, since one faulty cell can spoil the performance of the whole battery. If the voltmeter is a low-resistance one, do not keep it in contact for more than a second or so; the same thing applies when testing the cells with a 6-volt bulb. Any faulty sec-

tion of the battery may be short-circuited with a piece of flex and two wander plugs. If an eliminator is employed for H.T., the voltage at its terminals can be measured with a *high-resistance* voltmeter. When the batteries have been checked, test the loudspeaker with a 2-volt accumulator. Connect one lead to an accumulator terminal and touch the other lead against the second terminal; there should be a distinct "plop" both as the connection is "made" and "broken." Next, look to the set and make sure that there are no loose connections, and that the valves are firmly in their holders. Try changing over two of the valves as a further check on their contacts. To make sure that high-tension current is passing through the output valve take out the H.T. wander plug and replace it; two distinct clicks should be heard in the speaker. If the clicks are not heard there is a break in the anode circuit or else the valve is faulty. To decide whether or not the valve is wrong connect a high-resistance voltmeter between the negative filament ter-

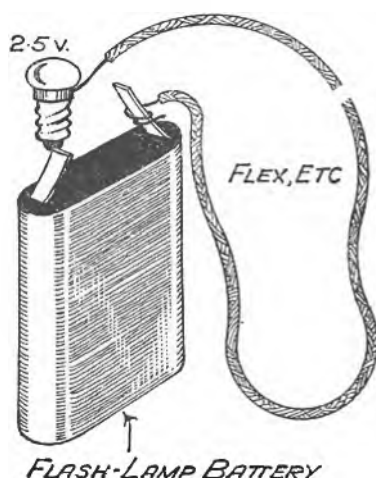


FIG. 187.—The simplest form of Tester.

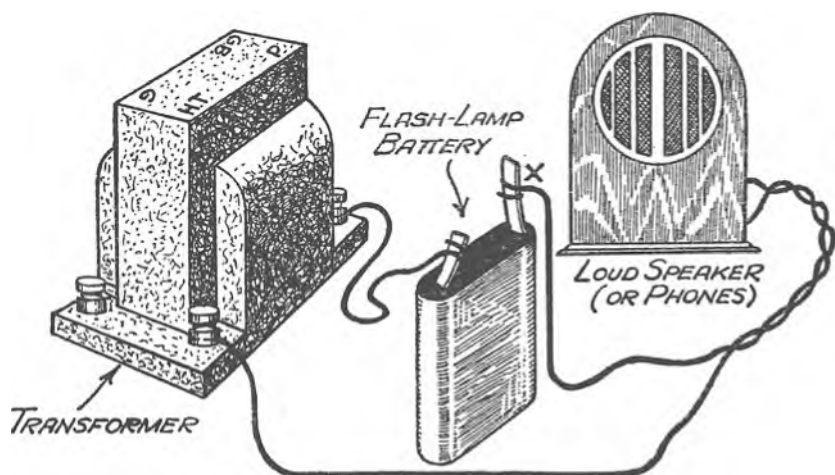


FIG. 188.—The way to test a Transformer Winding.

minimal and the anode terminal of the valve holder. If the voltage is normal the valve must be wrong, or else it is not receiving the proper L.T. current. Test for the latter possibility by connecting a voltmeter or flash-lamp bulb across the filament terminals. If the current is not reaching these points there must be a break in the wiring or the filament switch is not making proper contact.

If no reading, or even a low one, is obtained between the anode and H.T.—the fault is more likely to be elsewhere. In sets employing a choke or transformer in the anode circuit one of these components is probably "burnt out." To test, connect a loudspeaker (or phones) and a battery across each winding in turn as shown in Fig. 188. When connection X is made and broken a distinct plop should be heard in the speaker. Do not mistake a feeble single "click" for the double "plop," because the former will probably be heard even if there is a break in the windings. Having made sure that the last valve

is functioning correctly, pass on to the preceding one and apply similar tests. If decoupling resistances are connected in the anode circuit they will, of course, reduce the anode voltage, so a lower reading must be expected. Low-frequency transformers, chokes, and resistances can be tested in exactly the same manner as the output transformer, but in the case of resistances the sound from the speaker will be less in proportion to the resistance value. Proceed with these tests until the detector valve is arrived at. The high-frequency amplifying valves can be tested in a similar manner, but it will be found quicker first of all to put them out of circuit by removing the aerial lead from its normal terminal and connecting it to the anode terminal of the valve immediately preceding the detector.

Where screened-grid valves are employed the lead normally going to the anode terminal on the glass bulb must be left in place. The detector and L.F. stages should then work by themselves, giving good reception of

FAULTS AND THEIR REMEDY

the nearer stations. Once it is established that the fault is in the H.F. amplifying portion move the aerial lead to the anode terminal of the first valve (when two H.F. stages are included). This will show whether the first or second valve is not functioning, so after deciding this point the anode circuit tests can be carried out on the valve not working as explained for the L.F. valves. A further test is necessary in the case of S.G.

terminals for a few seconds, disconnect battery, and allow the condenser to stand for some time. Then touch its terminals with a pair of loud-speaker leads; a distinct click should be heard in the speaker, showing that the condenser has held its charge. In carrying out such tests the condenser terminals must not be touched with the hands, or the charge will leak away. The battery voltage should vary from about 100 volts for capaci-

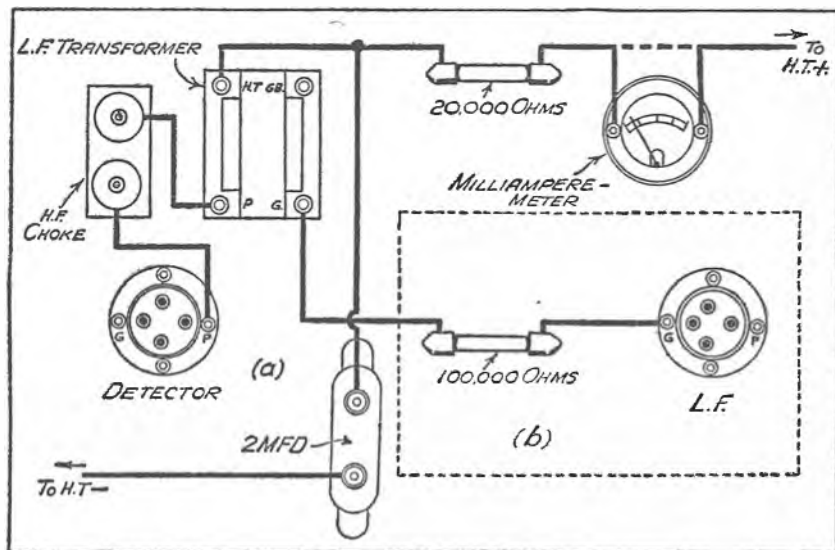


FIG. 189.—A decoupling resistance in the anode lead, and a resistance in the grid lead to cure instability.

valves; the voltage on the screening grid (connected to the "anode" pin) must be checked. This can only be measured with a *high-resistance* voltmeter. If there is no voltage reading disconnect the by-pass condenser wired between the screening grid and earth, and repeat the voltage test. If the voltage is normal in the latter case the condenser must be short circuiting the H.T. supply. The correct way to test any condenser is as follows: connect a battery to its two

ties of .0001 mfd., to 4 volts for 4 mfd.

Should it be found that the anode circuits are right, the tuning coils and condensers should receive attention. Coils can be tested in the same way as transformers, resistances, etc. (Fig. 188). The same apparatus is required for testing variable condensers, but in this case there should *not* be a click; rotate the vanes to make sure that they do not short circuit at any point. Before leaving

FAULTS AND THEIR REMEDY

the tuning system see that the contacts of the wave-change switches are properly opening and closing. This is especially important when using ganged coils with self-contained switches, because it is often found that a switch blade in one of the coils has become jammed or strained, with a result that it does not move with the others. When testing any component it should be disconnected entirely from all others and preferably be removed from the set. All the above tests have referred only to battery receivers, but most of them

this purpose, and one showing a full scale deflection on 10 milliamps. is most convenient. Measure the anode current to each valve by breaking the connection between H.T. + and the anode component (resistance, transformer primary, choke, etc.), as shown in Fig. 271. The current passing can then be compared with that given on the maker's instruction sheet for the particular H.T. voltage in use. Remember that it is the voltage between the *anode of the valve and*

H.T. — which counts and not the total battery voltage. Too low a current indicates (1) too much grid bias, (2) run-down accumulator, (3) defective valve. In the case of all-mains receivers it might also indicate that the rectifier valve is losing its emission, but the H.T. voltage would

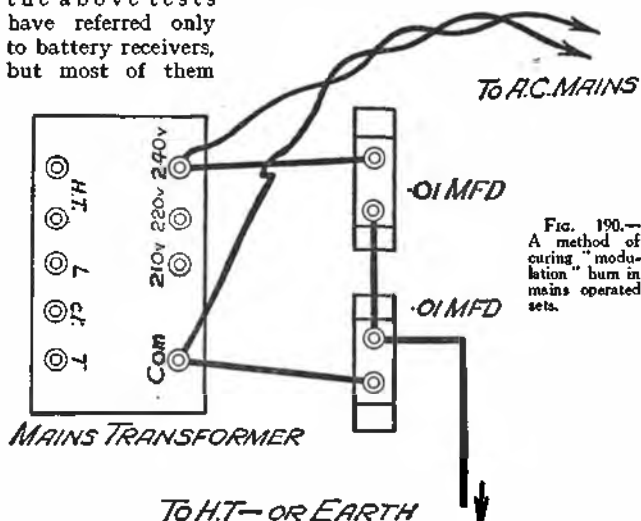


FIG. 190.—
A method of
curing "modu-
lation" burn in
mains operated
sets.

apply equally well to mains sets. In testing the filament or heater supply in sets of the latter type a flash-lamp bulb is most convenient, but if a voltmeter is preferred it must be of a pattern suitable for alternating current.

Weak Reception. Generally speaking, the cause of weak reception can be traced in the manner just outlined, but there are a few additional tests which are sometimes necessary. The most important of these is to measure the anode current of each valve in turn. A milliammeter is required for

then be low. An unduly high anode current indicates (1) insufficient grid bias (probably a burnt-out resistance, if an all-mains set), (2) a break in the grid circuit, (3) valve oscillating, or (4) if a S.G. or pentode, screen voltage too high. To check for (3) touch anode terminal with damp finger; the current will change if valve is oscillating. If the anode current fluctuates when signals are not being received there must be a bad contact in either anode or grid circuit. To check, first short circuit the anode components in turn to find

which, if any, is wrong. Then do the same with grid circuit components. When the anode current to every valve is normal and yet reception is impossible it is fairly safe to assume that a component in either the grid or anode circuit is short-circuited.

Intermittent Reception and Crackling. These two forms of trouble are often confused one with the other, so it might be well to explain the difference. Intermittent reception, that is when signals come and go without there being any noises, are generally caused by a fault in the aerial or tuning circuits, whilst crackling is more often due to a bad contact in an anode circuit. The method of testing anode circuit components has been dealt with previously and the tests described apply in this case. If the crackling can be provoked by lightly tapping the panel it is quite clear that a connection must be loose, but if it is unaffected by this treatment a transformer or similar component is probably defective. In the former case make sure that all the valves fit tightly in their holders and that the pins are clean. Also take the same precautions in respect to the high-tension wander plugs. Crackling noises are very frequently caused by a run-down high-tension battery or by a faulty cell. A new battery would, of course, put things right, but a temporary remedy might be effected by connecting a 2-mfd. or 4-mfd. condenser between H.T. negative and one of the positive tapings. Intermittent reception is often caused in a very sharply-tuned set by the aerial lead-in blowing to and fro and so changing its capacity to earth. The same effect would be noticed if some wires or components were free to move inside the set. Although this particular form of trouble is most common in short-wave receivers, it does sometimes occur in broadcast instruments.

Other Common Faults. Another cause of much exasperation is low-frequency reaction. This sometimes manifests itself as a constant whistle which accompanies all reception, and sometimes as a peculiar spluttering noise commonly referred to as "motor-boating." It is more common in older sets, and becomes particularly troublesome when the high-tension battery begins to run down. The fault can often be cured by the well-known method of fitting a decoupling resistance in the detector anode lead and by-passing this with a 2-mfd. condenser. Fig. 166 illustrates this point.

When two transformer-coupled L.F. valves are employed, the trouble can often be remedied by reversing the leads to the secondary terminals of the second transformer. Sometimes the howling is caused when the speaker is near to the set, by inter-coupling between the loudspeaker leads and the first valve. In that case the remedy is to connect a 0.002-mfd. fixed condenser across the loudspeaker terminals or to employ metal-shielded wire for the speaker leads. In the latter case the metal screening should be connected to earth or high-tension negative. Yet another way of preventing the howling is to connect the first L.F. transformer to the grid of the L.F. valve through a non-inductive resistance of any value about 100,000 ohms. A similar kind of trouble to that just dealt with is frequently caused by a "microphonic" detector valve. The detector valve is sensitive to vibration, and when it receives a slight jar, a "ring" or "hum" is heard in the speaker. If the speaker is near the valve the vibration set up by the diaphragm causes the valve to vibrate still more. This process goes on indefinitely, the sound increasing meanwhile. The cure in this case is to use an anti-microphonic valve holder

and to wrap the valve in thick felt. Instead of felt, a good result is often obtained by sticking a lump of plasticine on top of the glass bulb.

Mains Hum. The most frequent

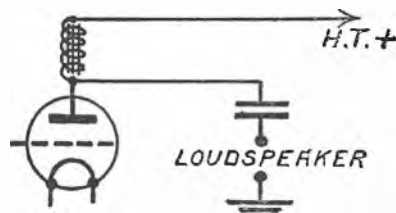


FIG. 191.—The Filter Circuit. (See also Fig. 354.)

source of trouble with the older types of mains receivers is hum. There are numerous other causes, but most of them can be cured by fairly simple means. Fig. 190 shows a method which is generally beneficial. Two .01-mfd. fixed condensers are put in series across the primary of the mains transformer and the junction is connected to H.T. — or earth. Hum caused by an electric gramophone motor housed in the same cabinet as the set can often be cured by a simi-

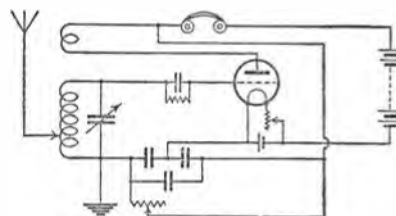


FIG. 192.—The Flewellyn Circuit.

lar connection of condensers across its terminals. An insufficient earth lead can be the cause of the most troublesome mains hum, so this point should receive special attention when using an all-mains set. Instability of the kind dealt with as low-frequency reaction often appears as a troublesome hum in mains sets, and the tests are the same as those explained

above. Just one word of warning. Unless you are thoroughly conversant with electrical engineering, do not tamper with any all-mains set without first disconnecting it from the power supply. (See also *Noises, Testing, and Break Through.*)

FAURE PLATES.—See *Accumulator.*

FILAMENT.—The fine wire (of a valve) which, when heated (by the low-tension current), emits electrons.

FILAMENT RESISTANCE.—A variable resistance used to control the flow of current to the filament.

FILTER CIRCUIT.—A circuit arranged to permit of the passage of low frequencies only. By "low" is meant all the audible frequencies, as distinct from high-frequency oscillations. The output filter circuit is perhaps the best-known form of filter. This consists of a large inductance iron-core choke arranged in the anode circuit of the output valve. Connected to the anode is a large-value fixed condenser. The free side of this condenser is joined to one side of the loudspeaker, the other side of which is joined to earth. In this manner the speech frequencies pass through the easy path provided by the condenser and speaker, instead of going through the choke (see Fig. 191).

FLEWELLYN CIRCUIT.—A circuit in which modifications were made to the filament circuit to produce large reaction effects. Like the Armstrong, and most of the old unorthodox circuit arrangements, modern valves are not suitable for this circuit (see Fig. 192).

FLUX.—A substance employed in soldering to prevent oxidation of the metal being soldered. The application of heat to a metal usually produces an oxide, and this prevents the solder adhering to the metal. The most simple flux is resin. This is always used on soft alloys and tinware. It is non-corrosive.

FLUX — FRAME AERIAL

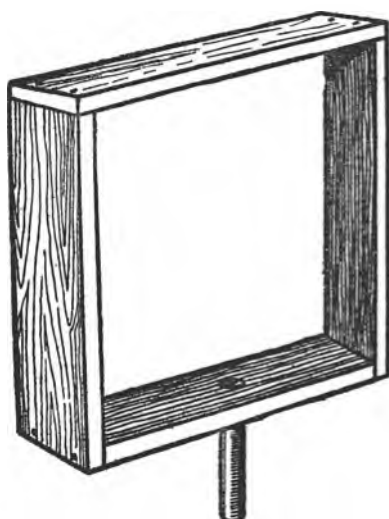


FIG. 193.—A Square Frame Aerial.

Ammonium chloride is used for soldering copper and iron.

Ammonium phosphate is used for tin, zinc, copper, and brass. It is non-corrosive and non-poisonous.

Hydrochloric acid for zinc and zinc-coated articles.

Lactic acid for copper and copper alloys. This acid tarnishes the metal round the soldered part.

Venice turpentine for pewter or Britannia metal.

Russian tallow for heavy lead work.

Palm oil for light lead work.

For wireless purposes the best flux is resin, and it is essential that non-acid fluxes are employed for this work. There are a number of commercial brands of flux on the market, and the majority of these have resin as the base. (See also *Soldering*.)

FLUX DENSITY.—The strength of the magnetic field surrounding an electromagnet. It depends upon the

type of iron employed for the magnet, the number of ampere turns wound round the magnet, and the potential applied to the magnet.

FOREIGN BROADCASTING STATIONS.—See *European Broadcasting Stations* and *Short-wave Stations*.

FOUR-ELECTRODE VALVE.—A valve having two grids between plate and filament.

F.P.S.—Foot-Pound-Second. The British system of units.

FRAME AERIAL.—The frame aerial is usually associated with super-het. receivers or portable sets, and it is not generally realised that

it may be used with the ordinary type of broadcast receiver, very often giving better results than are obtainable with a crude outdoor aerial. Of course, the actual amount of energy picked up is small, but for the flat dweller, or those who for any reason are unable to erect a good outdoor aerial, it will be

found much more useful than the usual "picture-rail aerial." For those who are beginners in wireless, perhaps it should be explained that the frame aerial is, as its name suggests, an aerial wound on a frame. Perhaps the simplest forms, both from the point of view of actual construction and winding, are the square, diamond, and circle. These are illustrated in Figs. 193, 194, and 195. The wire which is wound around these frames is in one piece, and it will be observed

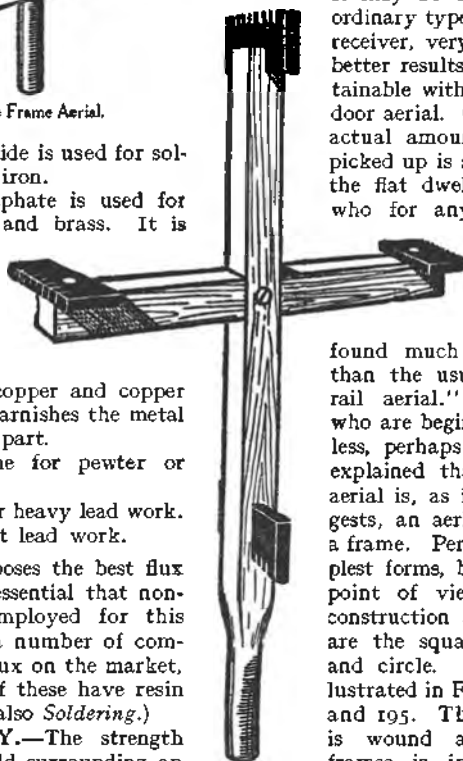


FIG. 194.—A Diamond Aerial.

FRAME AERIAL

that actually this is a very large tuning coil.

Directional Property. The principal feature of this type of aerial is

when the frame is at right angles, no signals will be heard. This valuable property has made possible the direction finder employed on ships at sea, and by the post office officials for tracking out unlicensed transmitting stations and those listeners who spoil the reception of the programmes by oscillating. Listeners who live near a high-powered station will often be able to carry out satisfactory reception of distant stations by means of the frame, provided, of course, that the desired station is situated in a direction at right angles, or nearly so, to the nearby station.

The Frame. In Fig. 193 will be seen the simplest of frames. Here, four pieces of

$\frac{1}{2}$ -in. wood, 4 in. wide by 2 ft. long, are nailed or screwed together at the ends to form

its directional property, and it is this which makes it so valuable. In use, the frame acts as two vertical aerals, the top and bottom being ignored for the sake of this non-technical explanation. If, now, you imagine a signal from a station passing through the air, and the frame aerial being turned in the plane of the oncoming waves, it is obvious that the waves will strike one side of the aerial before they arrive at the other side. Forces are therefore generated which are "out of phase," and a current flows. If, however, the waves hit the aerial broadside on, both vertical aerals receive the impulses at the same moment, and, therefore, no signal current will flow. It therefore follows from this that maximum signals are heard when the frame is in the plane of the received signals, and the signal strength will diminish as the aerial is rotated until,

a square. At one side something must be attached to enable the frame to be rotated to make use of the property above-mentioned. This may be a

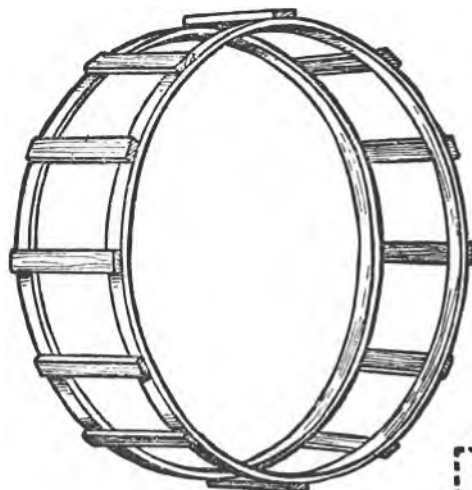


FIG. 195.—A Circular Aerial.

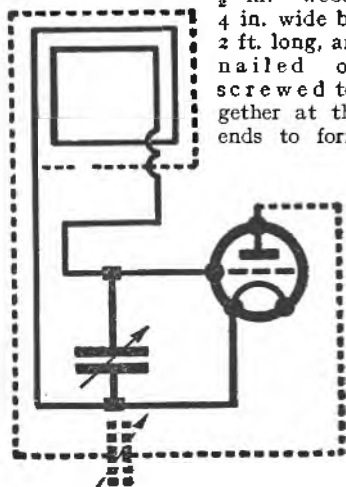


FIG. 196.—The Connections for a Frame Aerial: the dotted lines show the additional connections for capacity-controlled reaction.

FRAME AERIAL

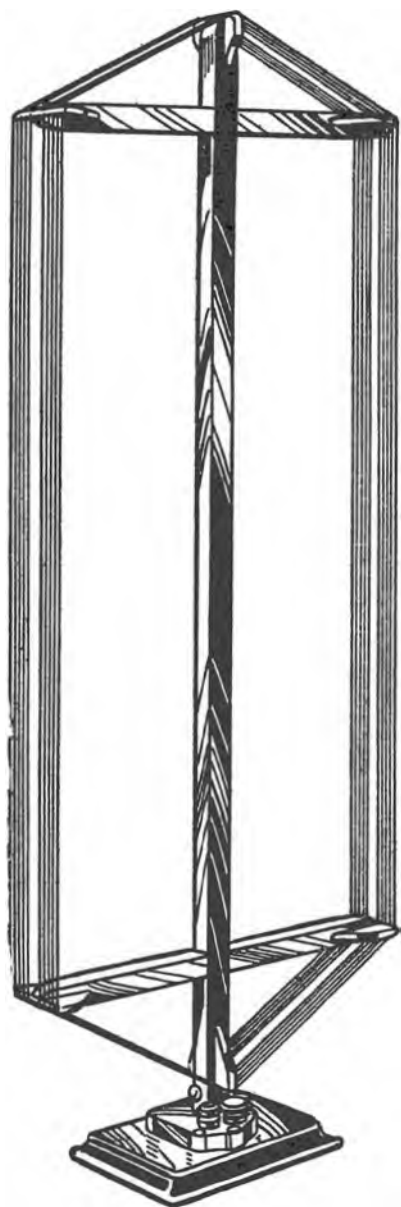
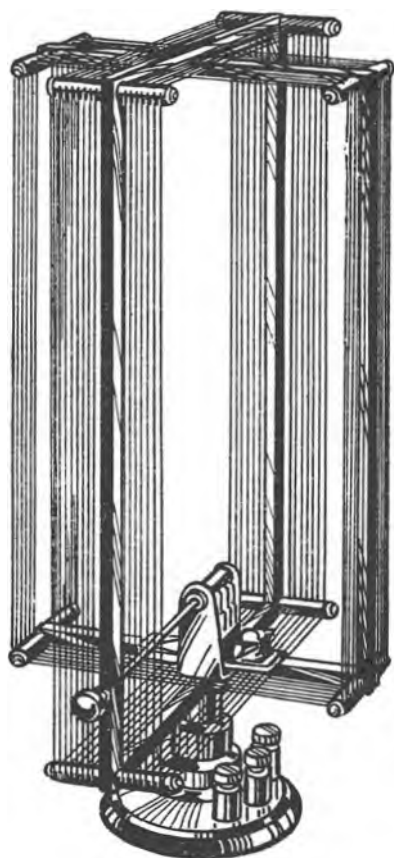


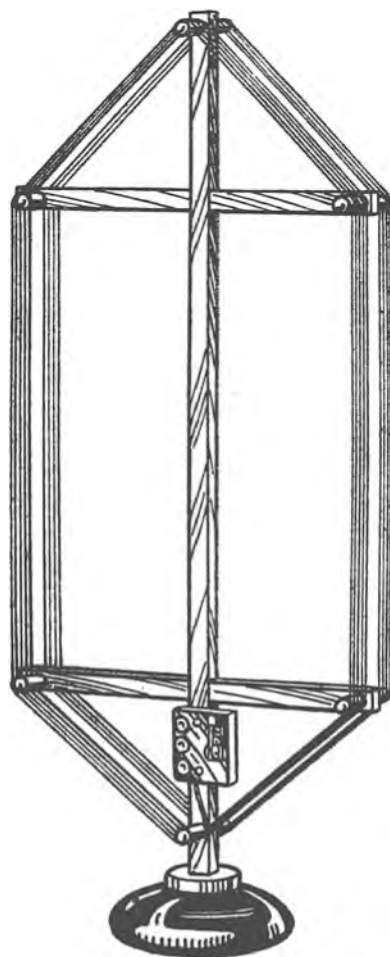
FIG. 197.—Two types of Commercial Frame Aerial.



section of round dowelling, broom handle, etc., fitting into a socket mounted on a base of sufficient size and weight to prevent the frame from falling over. Holes bored near the pivot serve as anchorages for the ends of the wire.

In Fig. 194 a more ambitious arrangement is shown. Two lengths of quartering $1\frac{1}{2}$ in. square are halved together, and at the ends strips of ebonite are fixed. Slots cut in the ebonite hold the wires securely, and the lower end is rounded off for a bearing. Fig. 195 shows an arrange-

FRAME AERIAL



ment which may be made to look very effective if varnished. Two ordinary hoops of the kind used by children, and about 24 in. in diameter, are held about 4 in. apart by strips of ebonite fixed round the periphery. Shallow grooves or saw-

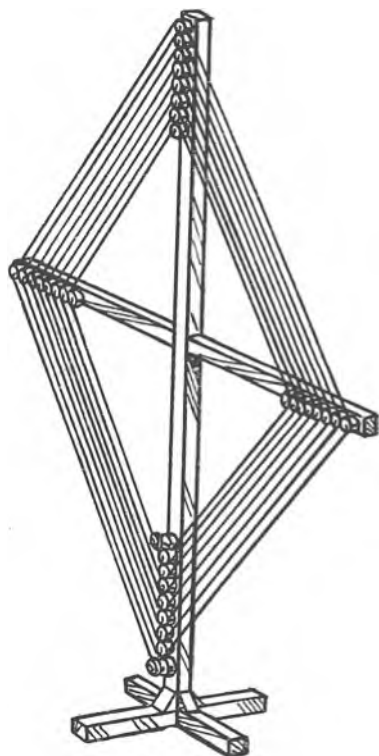


FIG. 198.—Two further types of Frame Aerial.

FRAME AERIAL DATA

<i>Length of Side of Square Frame.</i>	<i>No. of Turns.</i>	<i>Space between Wires.</i>	<i>Inductance. (Micro-henries.)</i>	<i>Self-capacity. (Micro-farads.)</i>	<i>Natural Wave-length in Metres.</i>
8 ft.	3	$\frac{1}{4}$ in.	96	75	160
6 "	4	$\frac{1}{2}$ "	124	66	170
4 "	6	$\frac{3}{4}$ "	154	55	175
3 "	8	1 "	193	49	185

cuts should be made in these ebonite spaces to hold the wire. Again, some form of rotatable bearing must be fitted.

The Wire for the Aerial. The wire for these aerials consists of thin flex, usually 14/36, that is, fourteen strands of No. 36 gauge wire, covered with art. silk in various colours, and costs about 2s. 6d. a 100-ft. coil. For the normal broadcast band 75 ft. should be sufficient, although the exact length will depend upon the shape of the aerial, the size of the condenser used for tuning, and the spacing between the turns. As a rule, the wire should be wound on with a space of about $\frac{1}{16}$ in. between each turn. The ends should be long enough to be rotated, and those who have the necessary tools should construct a "collector" made from two strips of brass mounted on a piece of ebonite, and connected to the aerial and earth terminals of the receiver, the ends of the frame aerial being connected to two plungers taken from a standard lamp holder, mounted on a strip of ebonite so that they bear on the brass strips. Of course, no tuning coil is necessary with this type of aerial, and if the set is fitted with one it should be removed. In the case of a simple detector circuit employing a reaction coil, four or five extra turns should be wound on the frame, the junction of these extra turns and the end of the frame proper being connected to the earth terminal. The free end of the extra turns should then be connected to the reaction condenser.

FREQUENCY.—The periodicity or number of cycles per second; the frequency of waves or oscillations.

FREQUENCY CHANGER.—The part of a super-heterodyne circuit which changes the frequency of a received signal in order that it may be amplified by the intermediate frequency amplifiers. It consists of an oscillating valve and a detector,

which may be two separate valves or one valve doing the combined work, and which yields a beat note having the frequency of the difference between the received signal and the frequency of the oscillator.

FULL-WAVE RECTIFICATION.

—See *Accumulator and Eliminator*.

FULTOGRAPH.—Apparatus for transmitting and receiving photo-



FIG. 199.—Fuse and Connections.

graphs by wireless. The picture is recorded by a stylus on a rotating drum.

FUNDAMENTAL.—The true frequency. This term may be applied to musical frequencies or the frequencies of wireless signals. In music the fundamental note is the true number of vibrations per second, and in wireless it is the actual wavelength. The fundamental is always accompanied by components having a frequency which is an integral multiple of the fundamental. For instance, a wavelength of 300 metres is accompanied by frequencies which are double, quadruple, and so on. The harmonic which is double the frequency of the fundamental is known as the "second harmonic."

FUNDAMENTAL WAVE-LENGTH.—The natural wavelength (of a 100-ft. aerial is approximately 120 metres).

FUSE.—A piece of wire of low

FUSE — GALVANOMETER

melting-point inserted in a circuit so that only a predetermined amount of current can flow. Beyond that limit the fuse melts. Small fuses for wireless sets should be inserted in the H.T.-lead.

Actually it could be fitted in either the positive or negative high-tension lead, but it is generally inserted between H.T.- and L.T.-.

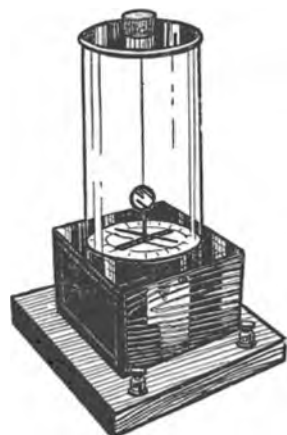


FIG. 200.—The finished Galvanometer.

The simplest way to fit a fuse to a set not so equipped is to employ one of those combined with a battery wander plug. It is then only necessary to replace the negative H.T. wander plug by the combined plug and fuse. This type of fuse has the further advantage of being readily accessible.

G

GALENA.—A crystal consisting of sulphide of lead.

GALVANIC CELL.—A cell of the voltaic type (which see), named after Galvani.

GALVANOMETER.—An instrument for detecting the existence and direction of current in a circuit.

Making a Galvanometer. Many wireless experiments involve the detecting of very small currents, impossible without a sensitive galvanometer (see Fig. 200). These are expensive instruments, but with a

little care one can be made to give very good results. Fig. 201 shows a sectional view of the completed instrument, fixed to a heavy base in a little cabinet, $2 \times 2\frac{1}{2} \times 1\frac{1}{2}$ in., composed of two sides, a top, and a back, with a small drawer, which can be pushed in and out, at the front. On the drawer is wound a coil. On top of the cabinet a glass lamp chimney is fixed, covered at the top with a cardboard lid. From the centre of this lid hangs a hair, supporting a little system of two magnetic needles. The lower needle hangs in the centre of the coil, while the upper one hangs above it, both eyeing across the coil. When a current passes through the coil, the needles are deflected. Just above the needles a tiny mirror of polished tin is fixed, which reflects a spot of light on to a wall, the movement of which spot shows the slightest deflection of the needles.

The Base. This should be at least 1 in. thick, and as heavy as possible. A sheet of lead on the bottom is useful. The sides of the cabinet should be about $\frac{1}{2}$ in. thick, but the top and back can be of fretwood. Use glue and brass screws or pins to fix together. No iron must on any account be used. The front should be made of two pieces of fretwood, one large enough to cover the entire front of the cabinet; the other a little smaller, so that it just fits between the two sides, the top, and the base. Glue

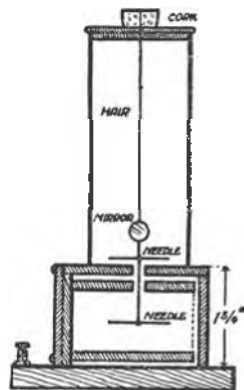


FIG. 201.—A sectional view of the completed instrument.

GALVANOMETER

these together. To the back of this glue four pieces of wood, as shown in Fig. 203, to make the former for winding the coil. The lower needle swings inside the former. The former is wound with a dozen yards of No. 26 double silk-covered wire. Wind this on closely and evenly, being careful to leave the slot in the top clear. Through this slot the needle is passed when assembling the instrument.

Assembling the Parts. When wound it is advisable to give it a coat of shellac varnish. Push this little drawer into place and fasten by two brass screws. Bring out the ends of the coil to the two terminals fixed on the base.

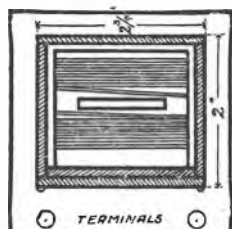


FIG. 202.—A plan view of the Cabinet with the top removed.

of sewing needle. Fasten them firmly with secotone to a vertical wire, so that the north pole of one is over the south pole of the other (see Fig. 204). Secotone the upper end of the vertical wire to a hair, the other end of which is fastened to the cover of the lamp chimney.

Secotone the chimney firmly to the top of the cabinet. Lower the needles into place, the bottom one passing through slits in the cabinet top and former.

The mirror is a tiny disc of polished tinplate about $\frac{1}{16}$ -in. diameter, secotined to the top of the vertical wire just above the upper needle. It should be made slightly concave to give a sharper spot of light. A nar-

row beam of light from a shaded lamp should be thrown upon the mirror, and the galvanometer placed about 3 ft. from the wall. For less delicate readings a graduated circle can be fixed to the top of the cabinet, inside the chimney, readings being indicated by the upper needle.

A galvanometer, of course, is an instrument for detecting small currents—it does not measure them.

These devices can be made also from a small $1\frac{1}{2}$ -in. diameter compass. This should be mounted upon a board, and beneath should be attached an electromagnet. This latter may be made from two or three punchings or stampings, from an old wireless transformer. Cut them $\frac{1}{2}$ in. wide and of a length equal to the diameter of the compass, that is, $1\frac{1}{2}$ in. Put them together, and wind 2 turns of paper round them. Then wind this core with about 80 turns of fairly fine wire, say 30 D.C.C., and wind it in an anti-clockwise direction. Mount the magnet so that the magnetic needle of the compass when pointing to north is at right angles to it, and bring the two leads from the electromagnet to two terminals.

To test an instrument made in this way, connect the left-hand terminal of the galvanometer to the shorter strip of an ordinary pocket-lamp battery, and adjust it so that the needle of the

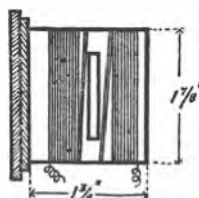


FIG. 203.—The Former for winding the Coil.

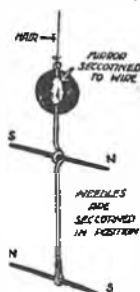


FIG. 204.—Details of the Hair, Magnetic Needles, and Mirror.

GALVANOMETER — GRAMOPHONE AMPLIFIER

compass points due north to the earth's magnetism. Then connect the longer strip of the battery to the other terminal, and the needle should immediately take up another position between north and east, and the new position will depend on the current flowing through the instrument: the stronger the current, the nearer will the compass needle point to east.

A very weak current will only cause the needle to move

and coils are the chief components ganged.

GEISSLER TUBE.—A vacuum tube in which the electrodes are disposed in bulbs attached at each end.

GETTER.—See *Valve*.

GONIOMETER.—A special instrument for measuring angles. (See also *Radio Goniometer*.)

GRAMOPHONE AMPLIFIER.—

A device consisting of one or more valves suitably coupled, to amplify the "signals" picked up from a gramophone record.

The Pick-up. Electrical reproduction is carried out with the help of the gramophone pick-up. In such a pick-up the needle is attached to a small armature which is capable of vibrating between pole pieces of a permanent magnet.

Around the armature or the magnet there is a small coil in which electrical impulses are induced owing to the change in the magnetic field caused by the vibrating armature. In this manner each sideways vibration results in an electrical impulse, so that

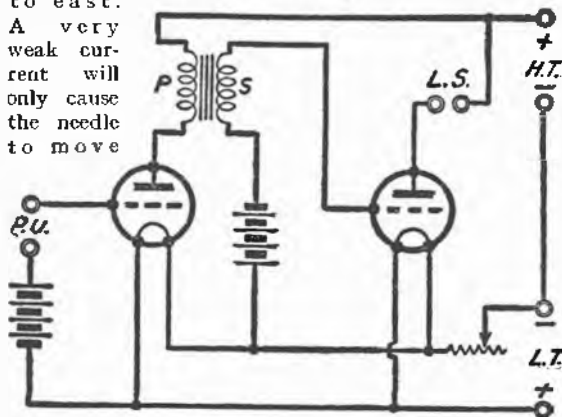


FIG. 205.—Circuit Diagram for a Two-Valve Gramophone Amplifier.

very slightly. To use for polarity testing, the needle will move in the direction towards the positive terminal.

GANG.—Any series of similar components joined together and operated by a common control. Condensers

are used to couple the various stages of the amplifier together. The output of the amplifier is connected to a loud speaker.

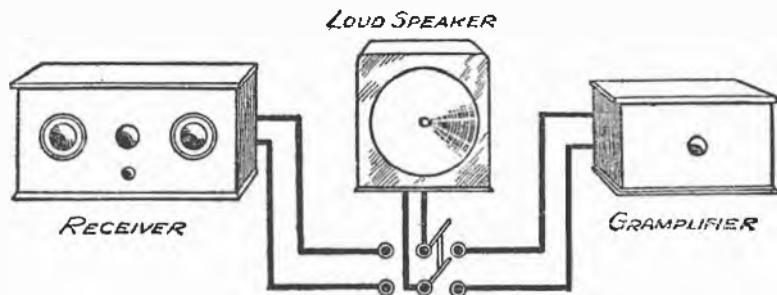


FIG. 206.—How the Gramophone Amplifying Apparatus is connected.

GRAMOPHONE AMPLIFIER

there is a group of such impulses corresponding to each sound. It will be realised that the electrical currents generated in the pick-up coil are of a very minute character and have to be amplified. This is done with the help of a low-frequency amplifier, such as is described elsewhere. The recommended amplifier has two valves, as will be seen from the theoretical diagram shown in Fig. 205. The two wires from

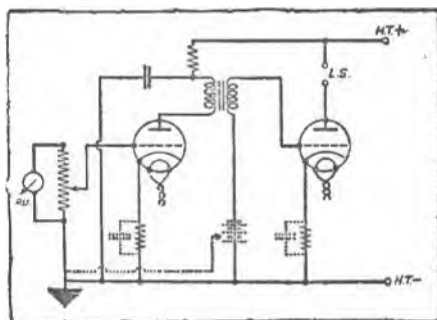


FIG. 208.—Mains version of Circuit shown in Fig. 207.

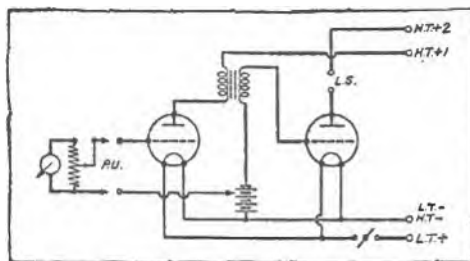


FIG. 207.—Theoretical Circuit of Two-Valve Gramophone Amplifier.

the pick-up terminals (the latter are connected to the pick-up coil) are connected across the grid and the filament of the first valve. Notice that a grid bias is applied to the grid through the pick-up.

The Connections. The filaments of the two valves are connected in parallel across the L.T. supply, a common filament regulator controlling the voltage across the filaments. The anode of the first valve is connected to one side of the primary of a L.F. transformer, the other side of the primary going to the positive side of the H.T. battery. The secondary of the transformer is connected to the grid of the second valve on one side, while

its other side is given a grid bias in the usual way. The anode of the second valve is connected to the positive side of the H.T. battery through the loudspeaker. It will be found that a detector valve in the first stage and a power

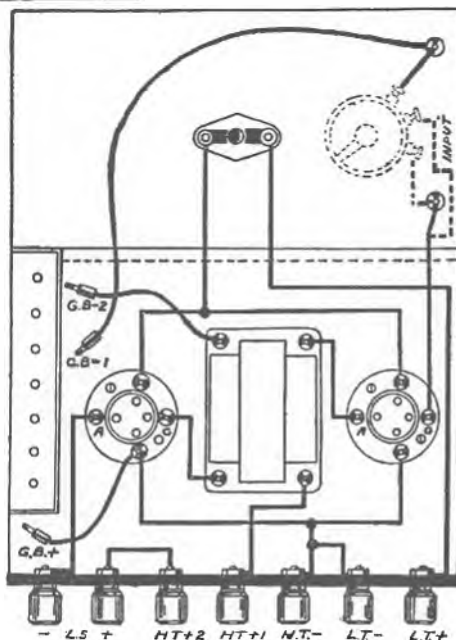
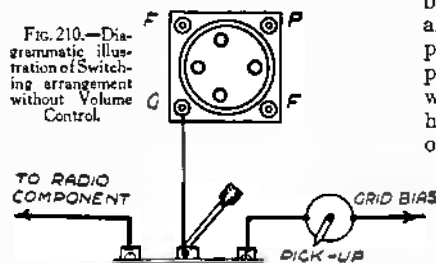


FIG. 209.—Wiring diagram of Gramophone Amplifier shown in Fig. 207.

GRAMOPHONE AMPLIFIER — GRAMOPHONE PICK-UP

valve in the second stage will suit best. Make sure that a good quality transformer is used. A cheap transformer will cause a good deal of distortion. As will be seen from the circuit diagram (Fig. 207), it is ex-



ceedingly simple, and can be built up in a couple of hours, including the panel drilling and the assembling. Fig. 206 shows how to connect the gramophone amplifier to the set. The following components are required:

List of Components

- 1 detector valve.
- 1 L.F. or power valve.
- 2 9-volt dry grid-bias batteries.
- 1 4-volt accumulator.
- 1 150-volt H.T. battery.
- 1 ebonite panel, $9\frac{1}{2}$ in. wide, 4 in. high, and $\frac{1}{8}$ in. thick.
- 1 wooden baseboard, $9 \times 8\frac{1}{2}$ in.
- 1 ebonite terminal strip, $9\frac{1}{2} \times 1 \times \frac{1}{8}$ in.
- 7 terminals, screws, wood-screws, and wire.
- 2 metal brackets.
- 1 gramophone pick-up. (See that it fits the tone arm of the gramophone before purchasing it.)
- 2 valve holders.
- 1 L.F. transformer.

GRAMOPHONE PICK-UP.—A device similar in form to a gramophone sound box and tone arm, used in

place of the latter on a gramophone record. Two leads from the pick-up are connected to the wireless set; the valves amplify the impulses, and they are then passed through the speaker.

The pick-up has to be connected between the grid of the input valve and the grid-bias tapping, and a simple way of carrying this out is to purchase one of the pick-up adapters, which takes the form of a valve holder or valve base, with pins on one side, sockets on the opposite side,

and two or more terminals arranged at some other part of it. The valve to which the pick-up is to be added is removed from its holder, the special

adapter plugged in its place, the valve replaced in the adapter, and the pick-up leads and grid-bias lead attached to their respective terminals. This, however, takes time to carry out, and is not so convenient as a switching arrangement. Switches are now obtainable which have small indicators fitted showing the words "Radio" and "Gram." Any form of switch may be used, provided it is of the single-pole change-over type. Mount this on the panel, as near as possible

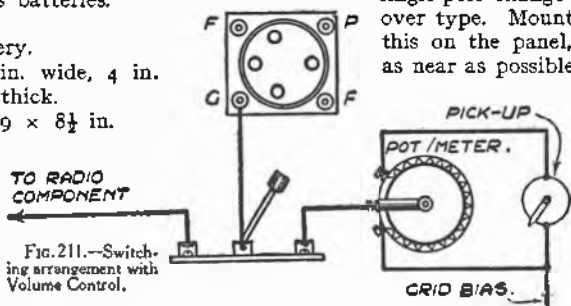


FIG. 211.—Switching arrangement with Volume Control.

to the grid terminal of the valve holder to which you wish to connect the pick-up. Now disconnect the wire which goes to this grid terminal, and connect it to one side of the switch. Connect a wire from the grid terminal of the valve holder to the arm of the switch, and from the remaining

GRAMOPHONE PICK-UP — GRID LEAK

contact of the switch a wire must go to one side of the pick-up.

Connecting the Pick-up. It will generally be found most convenient to fit two extra terminals on the terminal strip so that the pick-up may be connected and disconnected as required. The remaining lead from the pick-up must be plugged into a grid-bias battery at a tapping which will apply the correct voltage to the grid of the valve. Of course, in a good many cases the detector valve will be used to connect the pick-up to, and when used in this way it is acting as a L.F. valve, so care must be taken in getting the correct grid-bias voltage (see Figs. 210 and 211).

THE GREEK ALPHABET.—The Greek alphabet is as follows:

A α (alpha), B β (bēta), Γ γ (gamma), Δ δ (delta), Ε ε (epsilon), Ζ ζ (zēta), Η η (ēta), Θ θ (thēta), Ι ι (iōta), Κ κ (kappa), Λ λ (lambda), Μ μ (mu), Ν ν (nu), Ξ ξ (xi), Ο ο (ōmicron), Π π (pi), Ρ ρ (rho), Σ σ (sigma), Τ τ (tau), Υ υ (ūpsilon), Φ φ (phi), Χ χ (kai), Ψ ψ (psi), Ω ω (ōmēga).

(See also *Symbols and Conventional Signs.*)

GRID.—See *Valve.*

GRID BIAS.—A potential applied to a valve to bring its working characteristic up to a certain point. For instance, in low-frequency amplification it is essential that the grid shall be at a potential of such a value that the applied signals will vary an equal amount on the anode curve. If you examine Fig. 52 you will see a standard grid volts-anode current curve, and at 100 volts H.T. the centre point of the sloping line is directly above the grid-bias volt line. Therefore, if a valve with characteristics shown by these curves is employed as a L.F. valve, then a certain bias must be applied in order to bring the working point to the centre

of the line. If too much bias is applied, so that the working point is brought to the bottom bend of the curve, the valve will rectify, and this method is known as anode-bend detection (which see).

Valves which are employed for H.F. operation sometimes require a positive bias, whilst all L.F. valves require a negative bias. The bias is applied by inserting a small battery between the grid-return lead and the negative L.T. lead. In some forms of mains receivers the bias is applied

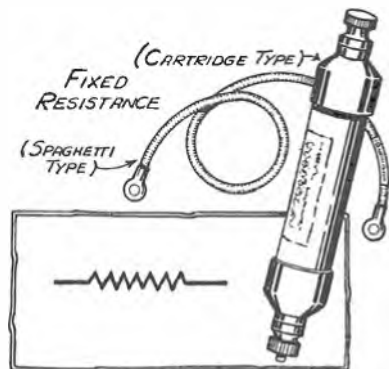


FIG. 212.—Theoretical and actual diagrams of Grid Leak and Fixed Resistances.

automatically by the insertion of resistances in the cathode or grid return leads. (See also *Automatic Grid Bias.*)

GRID CONDENSER.—A condenser (usual values .0003 mfd. and .0001 mfd.) used to control the grid potential of the detector valve. Usually has a grid leak of from 2 Ω to 5 Ω connected in parallel with it.

GRID LEAK.—A fixed resistance of the non-inductive type (usually 2 Ω value) connected in parallel with the grid condenser.

GRID LEAK AND CONDENSER VALUES.—Take the values of condenser and grid leak employed in a leaky grid or power-grid detector circuit, or in a resistance capacity-

GRID LEAK — HARMONIC

coupled amplifying stage. For the average leaky grid detector a condenser of .0003 mfd. capacity and a grid leak of about 2 megohms resistance usually are recommended, while for the low-frequency R.C. stage the condenser may be as great as .05 mfd. or even more, and the grid leak of the order of 250,000 ohms. What are the rules governing the choice of these values, and to what extent, if any, can the recommended values be departed from? Without going too deeply into theory, it can be stated that the function of the coupling condenser is principally to convey the alternating signal to the grid of the valve, while the grid leak acts as a discharge resistance. Now the reactance, or opposition offered by a condenser to the passage of an alternating current, is high at low frequencies and lower at high frequencies. At the enormous frequencies used for broadcasting, which are of the order of a million cycles per second, a small condenser, of about .0003 mfd., is quite satisfactory over the whole radio frequency range. But in a low-frequency amplifier the ratio between the lowest frequency it is required to pass (perhaps 12 cycles) and the highest (say 12,000 cycles), is in the neighbourhood of 1,000 to 1. If, therefore, the coupling condenser is very small, its reactance at the lower audio frequencies will be so high that the lower notes will be weakened or "attenuated" and serious amplitude distortion will occur.

The grid leak is called upon, in a detector circuit, to discharge the electrons accumulated on the grid during alternate half-cycles, while in the resistance capacity-coupled stage it has to complete the grid circuit of the valve and discharge it continuously and rapidly so that the voltage at the grid at any instant accurately follows the signal voltage fluctuations. Its value, therefore, must be

such that the "time constant" of the grid circuit is small compared with the frequency of the incoming signals, so that at all times the grid is "cleared" ready for the next signal wave. The value of the grid leak in conjunction with other constants of the circuit plays an important part in the time factor, and although the value is not very critical it should be understood that too high a value will result in a "choking" of the grid, causing serious distortion, while too low a value will result in a loss of signal strength and distortion in addition.

H

HALF-WAVE RECTIFICATION.

—See *Accumulator* and *Eliminator*.

HALYARD.—The rope used to support an aerial.

HAND CAPACITY.—The name applied to the interference caused by approaching the body or hand to a receiver and the transference of high frequencies through the body to earth. This is most noticeable in short-wave work, when the presence of the hand near the tuning condenser causes all signals to pass to earth. The cure for this form of interaction is to insert a large metallic plate (which is itself joined to earth) between the tuning controls and the operating knob, or in other words, between the operating knob and the component to which that knob is fitted. On normal broadcast wavelengths the connection of the moving plates of variable condensers to earth helps to avoid the trouble.

HARD VALVE.—A valve which has been completely exhausted. This results in a longer life, and better qualities, owing to the fact that full use may be made of the filament electron stream. (See also *Soft Valve*.)

HARMONIC.—A component pos-

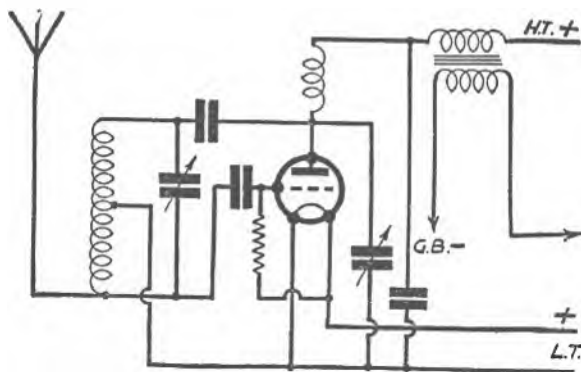


FIG. 213.—The Hartley Circuit.

sessing a frequency which is an integral multiple of the fundamental. If, for instance, we have a frequency of 100, the second harmonic would have a frequency of 200, the following harmonics having frequencies of 400, 800, 1,600, 3,200, etc.

HARTLEY CIRCUIT.—A circuit arrangement in which a centre tap is provided on the grid coil. One half of the coil serves for the reaction circuit and this is completed by a condenser between anode and coil.

HEAVISIDE LAYER.—A layer of the atmosphere about forty miles above the surface of the earth, and presumably ionised.

HENRY.—The unit of inductance. When a pressure of 1 volt is induced through a coil and changes at the rate of 1 ampere per second, it is said to have an inductance of 1 henry. Named after Joseph Henry.

Other units are the *millihenry* (one-thousandth of a henry), and the *microhenry* (one - millionth of a henry).

HERTZIAN WAVES. — Ether waves (discovered by Hertz).

HETERODYNE.—See *Beat Reception* and *Super-heterodyne*.

H.F.—High Frequency (which see).

H.F.C.—High-frequency Current, or High-frequency Choke.

HIGH FREQUENCY.—Any frequency over 20,000 cycles per second.

HIGH - FREQUENCY AMPLIFIER.—An amplifier in which amplification of the received impulses takes place before detection.

HIGH - FREQUENCY CHOKE. A coil of wire having a very low

self capacity, but fairly high inductance, which offers a barrier to high-frequency oscillations. Its principal use is to divert the H.F. oscillations of a detector valve for reaction purposes, although it is also used for coupling purposes in H.F. amplifying stages. For this latter purpose a very good component is essential, and a higher degree of efficiency is demanded than for reaction purposes. The ideal choke has the winding wound in sections, a device which reduces the capacity. (See also *Choke*.)

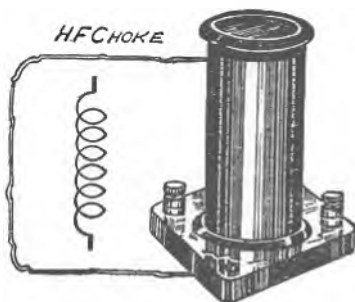


FIG. 214.—Theoretical and pictorial diagram of a H.F. Choke.

HIGH-FREQUENCY TRANSFORMER.—A component used for coupling H.F. valves. It consists of two coils coupled together. These

HIGH-FREQUENCY TRANSFORMER — HIGH TENSION

two coils are designed so that a step-up in ratio is obtained, and the coupling between the coils is arranged so that tuning one of the windings has the effect of tuning the other. The secondary winding, which is always included in the grid circuit of the following valve, is the one most commonly tuned. If the two windings are arranged so that the coupling between them may be varied, the selectivity of the amplifier may be adjusted.

HIGH TENSION AND LOW TENSION.—High tension usually refers to voltages above 6 volts, and low tension to 6 volts and under,

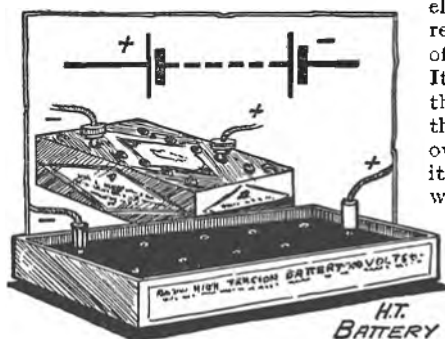


FIG. 215.—Theoretical and actual diagrams of a High-Tension Battery.

although these are somewhat loosely applied terms, and there can be no exact definition. A high-tension battery need not necessarily be dry cells.

HIGH-TENSION BATTERY.—A number of dry (sometimes wet) cells connected in series, used for supplying plate current.

There are several grades and prices of H.T. batteries on the market, and it behoves the listener to consider well before buying any but those manufactured by firms of repute. It should be understood that the useful life of the battery is governed by several important points. A battery of 120 volts is made up of 80 cells of 1½

volts each. These cells are connected in series: that is to say, the positive of the first is the positive or + of the battery, the negative of this cell being joined to the positive of the second cell, the negative of which goes to positive of the third, and so on until the requisite number of cells are connected up, the sum of which makes up the voltage required, ending, of course, with the negative or -. It can be seen now how simple it is for the manufacturers to make provision at different points on the top surface of the battery, enabling it to be tapped for intermediate voltages. The larger the elements in the cell the lower is its resistance, which enables the current of the cell to have a greater output. It must stand to reason, then, that the larger these cells are made—and this must consequently increase the over-all dimensions of the battery in its cardboard or tin case—the better will the aggregate number of cells stand up to the consumption of the valves. That is the reason why a "triple" capacity battery of the same voltage is bigger than one of the "standard" capacity.

There are three different ratings made, "standard," "double," and "triple" capacities. The following is a list of capacities most economical for the number of valves in a set:

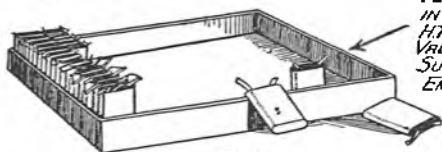
"Standard" capacity for 3-valve sets taking up to 6-7 milliamperes.

"Double" capacity for 4 to 5-valve sets taking up to 10-16 milliamperes.

"Triple" capacity for multi-valve sets taking anything up to 30 milliamperes.

The battery having a "double" capacity does not cost twice as much as the "standard," although, if used on the same set will give twice its life. Another good feature of the larger capacity is that its voltage

Hints on High Tension Batteries!



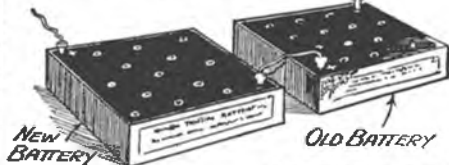
FLASH LAMP CELLS CONNECTED IN SERIES MAKE A USEFUL H.T. BATTERY FOR A SIMPLE VALVE SET, BUT ARE NOT SUITABLE FOR RECEIVERS EMPLOYING LARGE POWER VALVES



TEST YOUR H.T. BATTERY IMMEDIATELY AFTER IT HAS BEEN IN USE FOR SOME HOURS

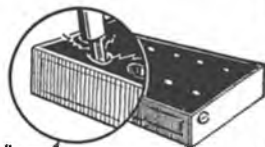
HIGH RESISTANCE VOLT METER

NEVER JOIN A PARTLY EXHAUSTED H.T. BATTERY TO A NEW ONE

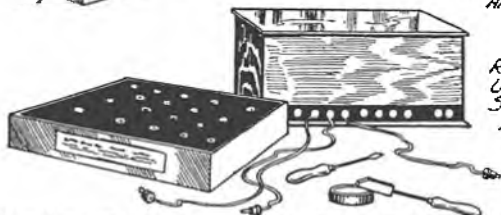


NEW BATTERY

OLD BATTERY



"SCRATCHING" SOUNDS WILL BE HEARD IN THE LOUD SPEAKER IF THE PLUGS ARE NOT TIGHT FITTING.



REMOVE H.T. PLUGS BEFORE USING A SOLDERING IRON, SCREWDRIVER, OR ANY METAL TOOL INSIDE THE RECEIVER.

FIG. 216.
185

drops more slowly; this means a more uniform output and a better performance of the set. A big H.T. battery, the initial cost of which is very little more than a smaller size, if taken over a long period, is much more economical to run.

The active parts of the cell are made up of a carbon rod, positive element, the electrolyte (which is in paste form), and the zinc container or negative element.

The action of the paste—and this is a mixture of sal-ammoniac and certain other ingredients—supplies the electrical current. This action in time tends to eat away the zinc and is one of the things which govern the life of the battery, for the corrosion of the container cannot be removed without dismantling the whole battery. The paste electrolyte is very important, for if this dries up the whole chemical action of the battery ceases, and it becomes dead. The grid-bias battery consists of a number of cells of exactly the same nature as the H.T. battery, i.e. of the dry Leclanché type.

HOT-WIRE AMMETER.—An instrument for measuring, in amperes, the current flowing in a circuit. It consists of a fine wire which heats up and expands in proportion to the current passing through it.

H.T.—High Tension (which see).

HUM.—See *Noises*.

HYDROMETER.—An instrument for measuring the density (the specific gravity) of the electrolyte of an accumulator. See *Accumulator* and *Areometer* for instructions on using.

HYSTERESIS.—Tendency to resist change of condition. Lagging.

I

I.C.—Intermediate Circuit or Condenser.

IMPEDANCE.—The resistance to flow of current offered by a circuit.

INDUCED CURRENT.—When a

current is passed through a wire which is in close proximity to another wire, currents will be induced in that other wire. The induced current will be in the opposite direction. A good example is a transformer, where currents passed through the primary winding induce currents in the secondary winding.

INDUCTANCE.—The electrical unit of inertia. The tendency of a circuit to resist current flow and also change of rate of flow. Unit of inductance is the henry.

INDUCTANCE AND CAPACITY.—A familiar example of the way in which one radio quantity depends upon the product of two quantities is the question of tuning. The wavelength to which a circuit is tuned depends upon the product of the inductance and capacity of the circuit. Actually, it is equal to the number 1,884 multiplied by the square root of the product of the inductance and the capacity, the former being expressed in microhenries, and the latter in microfarads. Why is it, then, that a tuning condenser of .0005 mfd. is invariably specified for a broadcast receiver? The answer is that considerations of size and overall efficiency more or less settle beforehand the inductance of tuning coils, values of approximately 200 microhenries for the medium waves, and about 2,000 microhenries for the long-wave band, having become standard. In conjunction with an aerial possessing average capacity to earth, a variable condenser of .0005 mfd. will comfortably tune either coil over the normal range of wavelengths. If a condenser of, say, .0003 mfd. were substituted, the receiver could not be tuned to the higher wavelengths in each band. On the other hand, a larger capacity of tuning condenser would not decrease the wave range of the set—would, in fact, increase it beyond the useful range, and the

actual broadcast band would be crowded into a small section of the dial, making accurate tuning difficult, and giving a spurious "sharpness" to the tuning.

INDUCTANCE COIL.—A coil possessing a high degree of inductance. A choke. Inductances in parallel reduce total inductance, and *vice versa*.

INDUCTION.—The transfer of magnetism from one body to another not in contact with it.

INDUCTION COIL.—A coil in which voltage is increased by reduction of amperage.

INDUCTION MOTOR.—A motor consisting of a powerful magnetic field with a disc suspended in the field. The action of the eddy currents in the disc causes rotation of the disc, and by so designing the magnetic poles, the spacing of the poles, the metal of the disc, and the method of suspension, quite a powerful torque is obtainable. This type of motor works from alternating current only, and no brushes are required, consequently there is no interference with radio. This has resulted in the motor being used chiefly for gramophone work.

INDUCTIVE CAPACITY.—See *Dielectric Constants*.

INKER.—A device used in telegraphy for making permanent record of the Morse signals. It consists of a sounder, with a device which is supplied with ink. A roll of paper tape is fixed on this device, and the paper tape is drawn through a gap over which is suspended the inking point. As the armature of the sounder is vibrated in sympathy with the received signals, the inked point makes contact with the tape and so creates a permanent record of the signals.

INTERACTION.—If one compares the average home-constructed receiver with a commercial product of similar size, both for appearance and per-

formance, one will find many differences. On the grounds of appearance, the usual contrast between the two sets is that while the home product looks scrappy the commercial receiver is usually a model of neatness and compact design. Under these conditions the performance is very often equal. When the home-made set is compressed a little, however, and made to look neat, it very seldom works as well. The one word "interaction" goes a long way to explain this phenomenon. While almost anyone with a little knowledge of radio principles can make an untidy set work well, it takes a qualified expert to design the same set in such a way that it still works when it is "tidied up." It has been accepted almost as a proverb among constructors that the efficiency of a home-made set varies in inverse proportion to the tidiness thereof. The fact of the matter is that one cannot take liberties with the placing of the separate components of a set until one understands first principles. Certain components *must* be close up to others; certain components, on the other hand, must be deliberately separated from others.

Conventional Layouts. From this reasoning, to make things easier for the home constructor, have sprung certain accepted conventional "layouts," with which one cannot go far wrong. Consider the layout of the universal "detector and two-note-mags" type of set, with the signals entering via the aerial terminal, on the extreme left, passing through the tuned circuit to the detector, out to the note magnifiers, and "exit right" at the loudspeaker terminals. While this standardisation process undoubtedly makes the lot of the amateur a happy one, it rather tends to prevent him from finding out things for himself in the very useful school of experience.

A few suggestions about layouts

INTERACTION

and avoiding interaction will prove helpful to those listeners who are possessed of an inquiring turn of mind. The main thing to be avoided is interaction between *two tuned circuits*. When a set uses a stage of H.F. amplification the grid circuit of the H.F. valve and the grid circuit of the de-

of metal, moreover, is not sufficient. A screen of sensible size is well worth any trouble involved in the construction of the set.

Since a tuned circuit consists of a coil and a condenser, it is obviously no great gain to screen the coils from one another while the conden-

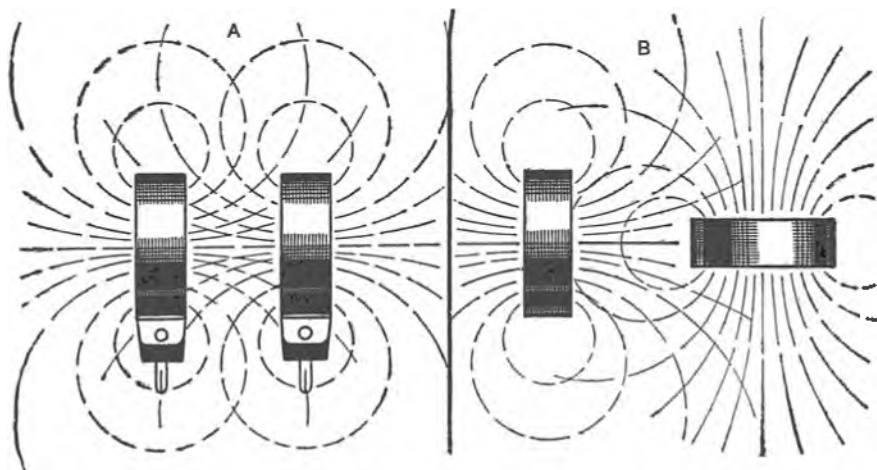


FIG. 217.—Showing the shape of the electro-magnetic field of coils of the usual plug-in type.

detector (or the anode circuit of the H.F. valve—really the same thing) will be tuned to the same wavelength.

Any possibility of interaction between these two circuits must be carefully guarded against. Fig. 217 shows roughly the shape of the electro-magnetic field of coils of the usual plug-in type, and it will be readily seen that the "A" arrangement is unsatisfactory while the "B" is considerably better.

Screening. Screened coils and screening boxes for complete H.F. stages make things fairly satisfactory nowadays, but if a set is built with plug-in or home-made coils, it is important that the two circuits should be arranged at right-angles, as in Fig. 218, and that a screen should be arranged between them. A small piece

sers lie side by side on the front panel. This is one good reason for using a screen of the same depth as the baseboard, and "partitioning off" the H.F. stage altogether (Fig. 218). A metal or metal-backed panel, and a baseboard covered on the underside with copper foil, also help things considerably.

The screened-grid valve was invented to do away with the anomaly that, while it was possible to screen the grid and anode *circuits* of a valve from each other, the grid and anode were still fairly closely coupled together inside the valve. A meshed screen was therefore introduced between them, and the anode lead brought out at the opposite end of the valve from the others.

If one is to make the most of the

INTERACTION

possibilities of a screened-grid valve, one must "back up the designers," and see that the grid and anode really are still screened from one another. The easiest way of doing this is to use a layout similar to that in Fig. 218, mounting the valve horizontally through the vertical screen,

end of the receiver. Interaction between two L.F. transformers can produce unsatisfactory effects. If it does not result in audible oscillation, to the accompaniment of anything between a "fog-horn" note and a high-pitched whistle, it may easily produce a parasitic oscillation

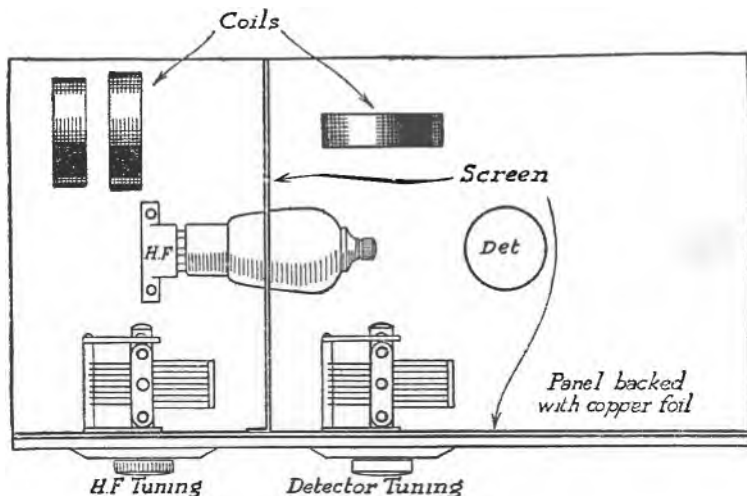


FIG. 218.—A Screen the same depth as the Baseboard is used for "partitioning off" the H.F. stage.

so that its anode goes through into the detector compartment, the rest of it being left behind where it belongs, with the input side of the H.F. stage. One can see the screening grid in most modern valves of this type, and the valve should be arranged through the hole in the screen in such a way that the screen is level with the "continuation" of the screening grid (Fig. 219). As a matter of fact, it is almost useless to attempt to use a valve of this type nowadays without screening it in this way, thanks to the high efficiency of modern valves and components, which have made interaction a much greater problem than it used to be.

Interaction between Transformers. The same rules apply to the L.F.

above the audible range of frequencies, which will only betray its presence by spoiling the quality of reproduction completely.

Fortunately, most modern L.F. transformers are efficiently screened, but even then it is folly to mount two of them too closely together. The cores should be placed at right angles, and the distance should be as great as can conveniently be arranged. Incidentally, aluminium or copper screening is not of very great use for L.F. work. Heavy iron is necessary to do the job at all well. The average home constructor, however, will not be concerned with amplifiers of such dimensions that screening is necessary. This does not dispose of interaction defects, by any

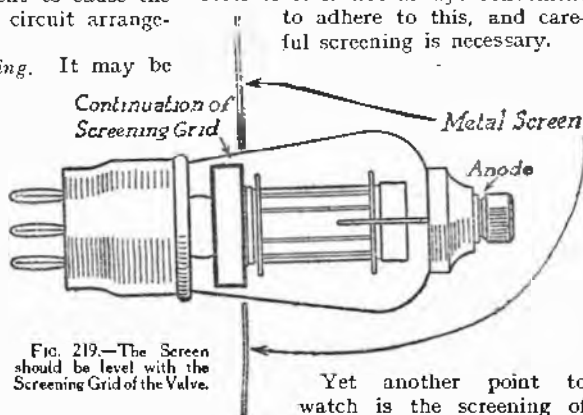
INTERACTION

means, by merely dealing with the effects already discussed. Bad wiring alone is often sufficient to cause the ruination of a good circuit arrangement.

Points about Wiring. It may be taken as a general rule, for instance, that any wires leading from the grid and anode of the same valve should not be taken nearer to each other than necessary. Even more important is it that the grid wiring of an early valve in the set should not go near the anode wiring of a later valve. It needs only a very small capacity to start a "vicious circle," resulting in instability and generally bad performance.

The standard layout already mentioned undoubtedly goes a long way

towards the prevention of mistakes of this kind; but in a more compact receiver it is not always convenient to adhere to this, and careful screening is necessary.



Yet another point to watch is the screening of the H.F. side of a set from the L.F. side. If, to make the size of the set convenient, the "doubling-back" type of layout is used (Fig. 220), it will be seen that the input and output ends of the receiver come close together. Screen-

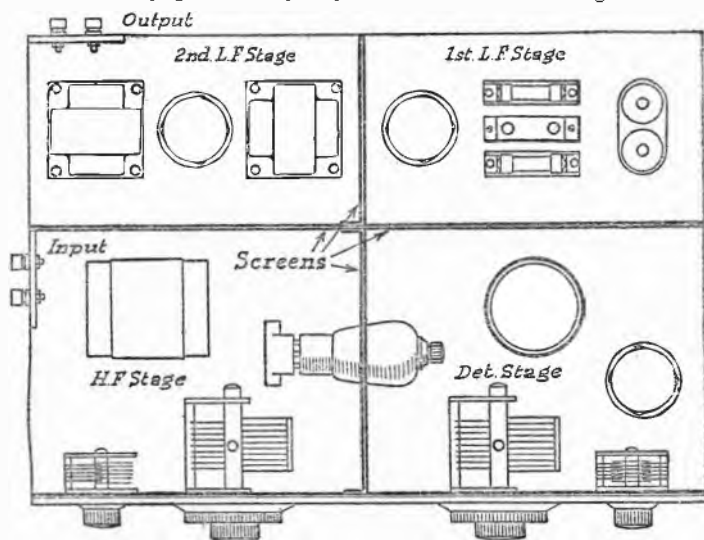


FIG. 220.—When the Input and Output ends of the receiver come close together the set should be screened as shown.

INTERFERENCE — ISOCRONISM

ing, as indicated, is therefore necessary.

Much more could be written on this subject, but probably the foregoing remarks, aided by the use of layouts adopted by skilled designers, will be sufficient to put the home constructor on the right path.

INTERFERENCE.—Two stations "jamming," due to wavelengths being too close. Also caused by Morse transmission. A rejector should be incorporated between aerial and set to reduce this to a minimum. Also due to mains hum. (See also *Noises*.)

INTERMEDIATE FREQUENCY.—In a super-heterodyne, the frequency produced by the intermediate amplifiers after "detection" by the preceding valves.

INTERMEDIATE FREQUENCY AMPLIFIER.—In super-heterodynes, two closed oscillatory circuits. Great selectivity of the detector circuit is obtained.

INTERNATIONAL AMPERE.—The current which, when passed through a solution of nitrate of silver in water, deposits silver at the rate of 0.0011800 gramme per second.

INTERNATIONAL OHM.—The resistance offered to a current by a certain column of mercury at the temperature of melting ice.

INTERNATIONAL VOLT.—The electrical pressure which causes 1 international ampere of current to flow when applied to a conductor having a resistance of 1 international ohm.

INTERNATIONAL WATT.—The energy used in 1 second by an international ampere when flowing under a pressure of 1 international volt.

INTERRUPTER.—Mechanism used to break up direct current into a series of impulses, hence producing intermittent current. It is chiefly used in connection with an induction coil.

INTERVALVE TRANSFORMER.

—A component placed between the valve stages which amplifies the signal voltages before passing them on to the next valve. (See also *Low-frequency Couplings*.)

INVERTED INDUCTION COIL.—An induction coil which is used for stepping-down purposes.

ION.—Any atom of matter which carries an excess of electrons or which is short of its normal number of electrons is termed an "ion." Subsidiary terms are: the triad-ion (one carrying three unit charges), the dyad-ion or divalent (carries two unit charges), and the monad-ion (carries one unit charge). A negative ion is an atom plus an electron, and a positive ion is an atom minus an electron.

IONIC VALVE.—The thermionic valve. (See also *Valve*.)

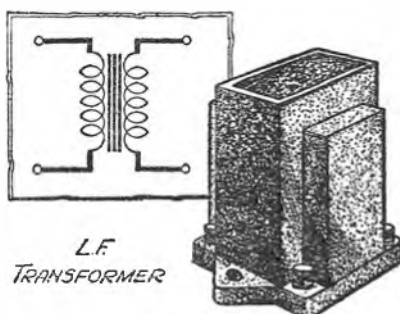


FIG. 221.—Theoretical and pictorial diagrams of a L.F. Transformer.

IONISATION.—The separation of molecules into ions. When air is ionised it becomes a conductor.

IRON PYRITES.—Iron sulphide.

IRON SULPHIDE.—A crystal used as a rectifier in connection with a gold or bronze cat whisker.

ISOCRONISM.—Equality of time; the quality of being done in equal times. Two circuits are isochronous when they have the same frequency.

JAMMING — LAYING OUT COMPONENTS

J

JAMMING.—The simultaneous reception of two or more stations.

JAR.—A unit of capacity. 1 jar = 1,000 cms.; 900,000 = 1 mfd.; therefore 1 jar = .01 mfd. (obsolete term).

JELLY ELECTROLYTE.—Prepare jelly electrolyte by adding sodium silicate to the acid (never add acid to silicate) in the proportion of 1 to 3, and immediately pour the mixture into the cell until the usual acid level is reached. Take care not to overfill the cell, as this is difficult to rectify once jellification has taken place. If some slight shrinking of the electrolyte occurs, thus exposing the tops of the plates, it should be made good by preparing and adding a little more of the mixture.

After filling, the cell should be inverted for six to eight hours to allow any free acid to drain off. It is advisable to give the cell a freshening charge before putting it into service. Pour off any free acid that is driven to the surface by this charge. Jelly acid always shows a tendency to dry out during service, and this should be prevented by adding 3 or 4 spoonful of distilled water before every recharge. Any excessive liquid should be drained off at the end of each charge.

The disadvantages of jelly electrolyte (it is unsuitable for cells fitted with wood separators, and the state of charge cannot be tested by hydrometer readings) are easily outweighed by the fact that it makes any accumulator unspillable and thus reduces the chances of accidents to a minimum.

JIGGER.—Slang for transformer.

THE JOULE.—This is the unit of energy, and is equal to 1 watt per second. Ten million joules equal 1 erg. The Board of Trade Unit equals 3,600,000 joules, and is known

as the kilowatt hour. Named after Joule, the English physicist.

K

KATHODE.—See *Cathode*.

KEEPER.—Term used to denote the bar of iron placed across the poles of a horseshoe magnet to preserve its magnetism.

KEY.—A transmitting key—a form of switch for breaking the primary circuit of a transformer.

KILOCYCLE.—A frequency of 1,000 cycles per second. One kilocycle (abbreviated kc.) corresponds to a wavelength in metres of 300. Therefore to convert kilocycles to metres divide 300,000 by the number of kilocycles; and to convert wavelengths in metres to kilocycles, divide 300,000 by the number of metres.

KNIFE SWITCH.—A type of switch having a pivoted arm which wedges between parallel phosphor-bronze spring clips, obtainable in single- and double-pole types. (See also *Switches*.)

L

LAG.—A term used to denote the time lapse between the application of maximum electromotive force and maximum current.

LAMINATED.—Having a number of thin plates (laminæ) superposed.

LAP WOUND.—That style of winding in which the winding is done in loops in such a manner that the connections "lap" towards the commencing back connection.

LAYING OUT COMPONENTS.—There are a number of receivers that are a disappointment to their constructors because, for some mysterious reason, they fall far short of the ex-

LAYING OUT COMPONENTS

pected performance; they are built strictly in accordance with a sound, well-trying circuit, and in many cases the best possible components have been used regardless of cost. In addition, the construction has been carried out neatly and surely, and possibly the majority have been rebuilt more than once. A receiver that falls short of the efficiency that it may reasonably be expected to give is almost invariably ruined by bad component arrangement—so many constructors overlook, or are unaware of, the third golden rule of set building, *i.e.* study the layout. The first two rules are: use a tried circuit, and use good components. The disposition of components can have a tremendous effect on the performance of the finished receiver, selectivity can be ruined by interaction between two tuned circuits, which permits signals in the aerial coil to jump the arrangements for trapping them, and in certain circumstances to reach the actual detector grid. In a similar manner quality can be ruined by high-frequency currents reaching the low-frequency section, or by the field of one transformer mixing with the field of another; the former only occurs with sets that employ one or more stages of screen-grid amplification, otherwise the currents

are not sufficiently powerful to be harmful.

Range is a matter of paramount importance to many listeners, who may be surprised to hear that the actual arrangement of components is the most vital factor that determines the number of stations that will be received, assuming, of course, that the receiver is reasonably sound in other directions: this applies equally to any receiver, from a single valve to a multi-stage radio gramophone. An argument that is often used against the importance of proper spacing is that many commercial receivers are packed into a small space. This is true, but it is equally true to say that the performance would be even better if it were not so cramped; and in any case, it is not a fair comparison, because manufacturers have components specially made so that they fit in together nicely, and in

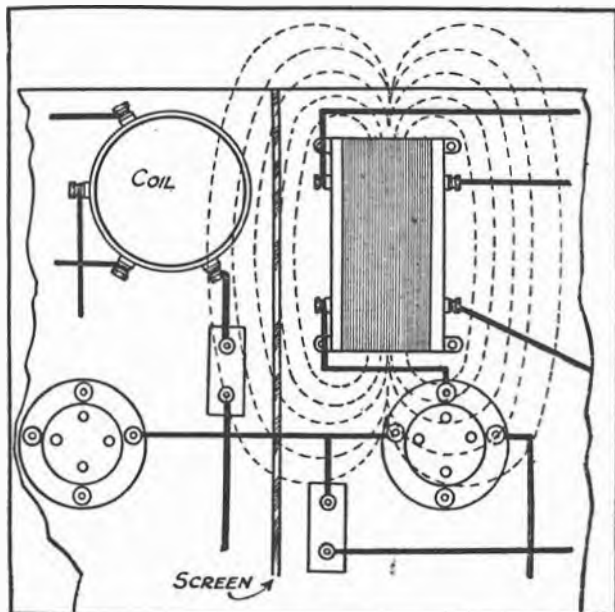


FIG. 222.—The placing of a Transformer near a Coil (even if there is a Screen) is bad.

LAYING OUT COMPONENTS

addition months of work are devoted to arranging and rearranging to prevent one component from militating against another. Several years ago the home constructor was always instructed to follow the ideal (impos-

the actual shape of the baseboard is a controlling factor of great importance; for example, the square type of layout is to be avoided; it is very unsatisfactory to all but the most experienced, as the proximity of the stages

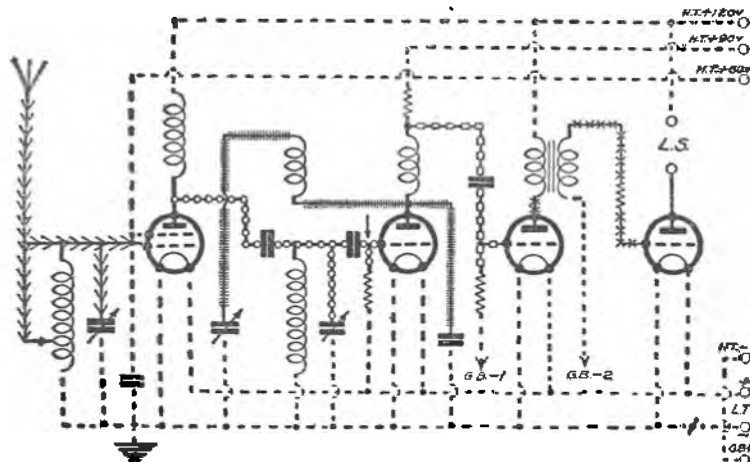


Fig. 223.—A Circuit with the various Circuits separated by different types of lines.

sible in actual practice) when designing his own sets; that is, to keep components *wide* apart and all wires *very short*. It is impossible to lay down any hard-and-fast rules, as every circuit or set of components requires different treatment; it is therefore only possible to indicate the general lines, but the reader will find them of inestimable value in aiming at 100 per cent. efficiency from the receiver.

Bad planning causes trouble that can be divided into two distinct classes: interaction between two stages of a receiver, such as the two coils of the screen-grid set, and accidental coupling between two wires or components in the same stage, such as the grid and anode leads of the detector valve.

Dealing first with interaction between stages, it is quite obvious that

makes fatal stray couplings very hard to avoid. Sets of this type use screened coils, which are often extremely troublesome, as the constructor is misled by assuming that coils in metal "cans" have no field, whereas they have diminished and somewhat localised fields. Screened components are very useful, but they must be treated with respect. It is a great mistake to use a metal baseboard and earth everything to the nearest piece of exposed metal; all high-frequency circuits should, when they are connected to earth, go direct to the earth terminal by means of a wire.

The author recollects building a set of this type which turned out to be extremely unstable until the earth end of the tuned anode coil was disconnected from its "can" and taken straight to the earth terminal. The

LAYING OUT COMPONENTS

best form of layout is, without doubt, a long baseboard with each stage following the preceding one in the logical manner; for some unknown reason sets of this type are invariably arranged with the aerial stage on the left; there is nothing against building the set with the aerial tuning on the right-hand side if it is convenient, and sometimes it actually makes the wiring more direct. When a single metal plate is used between two stages as a screen be careful to avoid a component showing round the edge; also keep the coils at a reasonable distance from the screen, as undue proximity will lower the wavelength range. In addition, the fields will not be prevented from reaching the opposing coil. Before leaving the subject of screening, it should be borne in mind that aluminium will not screen low-frequency currents, hence the placing of a transformer near a coil (even if there is a screen in between) is bad (see Fig. 222). The only practical way to keep the transformer field from the coil is to leave a generous air space between them.

The second type of interaction, *i.e.* coupling between two parts of the same valve, is not so easy to avoid, but is most important. The most common mistake is that of keeping separate the grid and anode circuits and components of two valves that are connected together; in other words, the anode of the first valve is connected by a fixed condenser and wires, making it quite unnecessary to keep them apart. What should be separated is the grid and anode circuits of valve Number One and the similar circuits of the following stages. Taking an example of a typical screen-grid three, the most important point is to separate the aerial and anode coils and associated components, such as tuning condensers one stage from the other, and

it is a minor point if the anode coil and anode lead get tangled up with the grid circuit of the *second* (detector) valve. Fig. 223 shows a circuit with the various circuits separated by different types of lines; all wires drawn in the same manner can be placed close together. Earth wires are shown dotted, and it should be quite understood that these wires are "earth" from the point of high- and low-frequency currents, but may be of any voltage that can be applied from the batteries, which is of no moment from the point of view of wiring. For example, the screen grid of the first valve has a voltage of 60 applied from the high-tension battery, but as it is connected to earth through the 1-mfd. condenser, it is at earth or zero voltage as far as high-frequency is concerned. Reference to Fig. 223 will show that there are five circuits to be kept free from each other and all free from earth. In addition, there is the loud-speaker circuit, but as the danger here is the actual lead, it does not come into the question of the design of the actual receiver; and it will not be out of place to mention that coupling between speaker leads and the aerial end of the set can be prevented by using flex and keeping the whole apparatus away from the high-frequency side of the receiver.

Different-coloured Wires. The most reliable way of avoiding trouble is by the discriminate use of different-coloured wires for the connections: if black is used for the earth and distinct colours for the other circuits, such as red, blue, and yellow, the proximity of two opposed circuits will show up by the obvious clashing of the colours. At the beginning of this section it was pointed out that the best form of set was one using a long, narrow baseboard, partly because it stops interaction between stages and partly because wiring is less compli-

LAYING OUT COMPONENTS — LENZ LAW

cated, as it is impossible to cramp together wires that are "several steps away." In Fig. 223 one wire, the detector grid lead, is indicated by an arrow, as it is the most troublesome lead in the receiver, and its length should be reduced to the absolute minimum. It is preferable to clamp the condenser tag under the valve-holder terminal when possible.

Wiring can be often simplified and shortened by the study of the terminals on components; this is particularly true of low-frequency transformers, as if put at right angles, so that each terminal is as near as

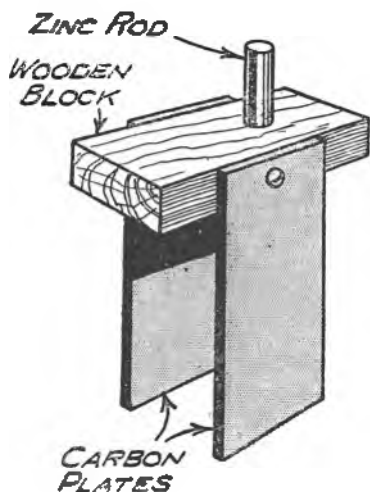


FIG. 224.—The Carbon Plates for a Leclanché Cell.

possible to the point of connection, wiring is as short as practicable.

In the same manner the correct positioning of a valve holder will often completely separate two wires which otherwise would cross each other. The importance of good wiring cannot be over-emphasised, and it is true to say that a well-planned three-valve set will easily excel a four-valve set of poor arrangement from the point of selectivity, range, and quality.

LEAD.—Any current-carrying wire.

LEAD-IN.—The connection from aerial to receiver. (See also *Aerials*.)

LEAKY GRID DETECTION.—A process of rectification in which a condenser is joined between the tuned circuit and the grid. From the grid a high resistance (the grid leak) has to be joined to earth to allow the accumulated electrons to leak away. Hence the term, leaky grid.

LECLANCHE CELL.—A cell of the single-fluid type. In this case, however, the plates are zinc and carbon and the exciting liquid sal-ammoniac (ammonium chloride). By using several carbon plates instead of one, it is possible to increase greatly the strength of the cell. Fig. 224 shows one simple arrangement that should prove quite satisfactory.

The necessary carbon plates are best obtained from old dry cells. These plates, by the way, are very brittle and should be handled with care, particularly when drilling, etc. Old jamjars make excellent cell containers, and the zinc rods can be purchased from most ironmongers.

Polarisation is again a great drawback with this type of cell, and many attempts have been made to overcome the difficulty. In the shop-made cell, the carbon plate is placed in a porous pot and surrounded by manganese dioxide. This acts as an oxidising agent, and unites with the free hydrogen to prevent it collecting on the carbon plate.

A simpler method than this is for the experimenter to place a depolariser in the actual solution. Common depolarisers are the bichromates of sodium or potassium, and one of these mixed with the acid in a zinc-acid cell will give it a far longer and more efficient life. A good battery solution may be made by mixing 2 oz. of bichromate, 2 oz. sulphuric acid, and 10 oz. of water.

LENZ LAW.—Any reduced current

has a tendency to nullify the current producing it.

LETTER DRILLS.—See *Drills*.

LEYDEN JAR.—A type of condenser consisting of a glass jar, the lower part of which is coated inside and out with tinfoil.

L.F.—Low Frequency; audio frequency.

L.F. AMPLIFIER.—Beginners in radio are often surprised to find identical valves being used to serve so many different purposes. It certainly is a little puzzling to the novice to distinguish clearly between a detector and an L.F. amplifier. Strictly speaking, the L.F. amplifier has little or nothing to do with radio, since all radio frequencies have disappeared by the time this part of the set is reached. It is really a matter of pure "land-line" technique. But so indispensable a part of a receiver has it become that it is most conveniently taken in with other radio matters.

Now consider the working of the three-electrode radio valve for a moment. Put briefly, its action is as follows: a varying voltage applied to its grid will cause similar variations in the *current* flowing through its plate circuit.

When the valve is a detector, the necessary variations in its grid voltage may be supplied by the incoming signal itself, and the valve is so treated that the resulting variations of plate current are "unsymmetrical." That is the principle of rectification.

It is this rectified signal that forms the input to the L.F. amplifier. It has to be converted from the form of a varying *current* in the plate circuit of the detector valve to that of a varying *voltage* ready to apply to the grid of the L.F. amplifying valve.

This may be done in various ways. Fig. 226 shows the most common—illustrating the use of a L.F. trans-

former. The varying plate current passes through the primary winding of an iron-cored transformer, and causes similar impulses in the secondary winding. As the two windings are arranged to give a "step-up" ratio (by which is meant that the secondary winding comprises many more turns than the primary), the secondary terminals have available a varying voltage which is—if the transformer is well designed—a replica of the varying current.

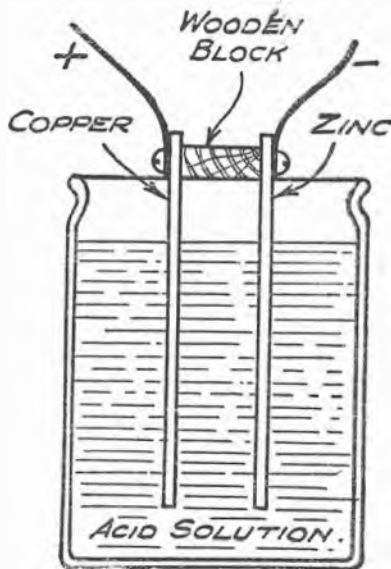


FIG. 225.—A Voltaic Cell.

It will be understood, nevertheless, that the grid of the second valve has a rapidly varying potential which will, again, produce a varying *current* in the plate circuit of that valve, although, this time, the variations will be of much greater magnitude, owing to the amplification that has been obtained through the valve and transformer.

Thus another L.F. amplifier may be added in precisely the same

L.F. AMPLIFIER

manner. Resistance-capacity coupling is an old favourite that is still greatly used for L.F. amplifier couplings. It will be seen from Fig. 227 that, instead of passing the plate current of the detector valve through the primary winding of a transformer, it is simply passed through a high re-

"mag." of 10 and a 4:1 transformer will thus give a "gain" of 40. On the other hand, when resistance coupling is used, it is the "mag." of the valve only that can be made use of. Luckily, a valve with a much higher impedance—and therefore a higher amplification factor—can be used with this form of coupling, and the "gain" in these cases can be anything between 35 and 60 in ordinary simple sets.

It should very seldom be necessary to use more than two L.F. stages, and one is sufficient for most purposes, if it is carefully chosen

and worked out. Next, decide whether it is desired to utilise resistance—or transformer—coupling, bearing in mind these two facts: that a really good transformer will give just as good quality as resistance coupling, and that a cheap transformer should therefore be used when there is one stage only.

Disappointing results almost invariably come from the wiring up of a set with any odd transformer and the plugging in of any odd valve. A good combination may be found, but the chances against it are about 1,000 to 1.

If a L.F. amplifier is added directly to the detector stage, it is best to choose transformer coupling. In this case the transformer ratio may be anything up to 7:1, provided that after a 7:1 transformer a bigger valve is used to take the full input without distortion. Always use a good power valve for the stage after

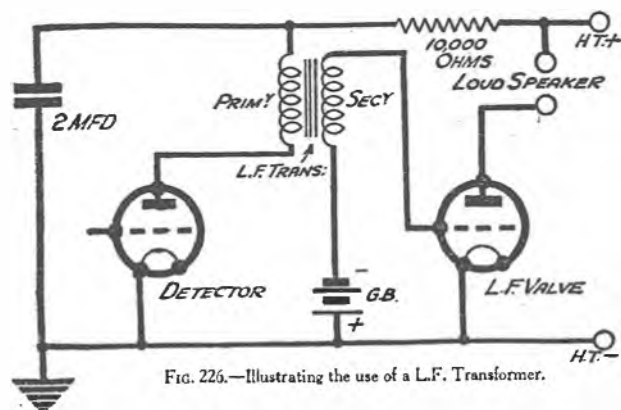


FIG. 226.—Illustrating the use of a L.F. Transformer.

sistance. A value frequently met with is 100,000 ohms, and this is shown in the diagram.

The rapidly varying plate current will undergo a varying voltage drop, which is applied to the grid of the L.F. valve by coupling it to the bottom end of the resistance. This is done by means of a fairly large fixed condenser. The only other point remaining is that the grid of the L.F. valve will now accumulate a charge until it "chokes," unless it is provided with a path for the D.C. to leak away to earth. Therefore a grid leak of a high value is connected from the grid to the grid-bias battery.

The fundamental difference between transformer and resistance coupling is that, when the former is used, the total amplification of the "stage" is expressed by the amplification factor of the valve multiplied by the transformer ratio. The common combination of a valve with a

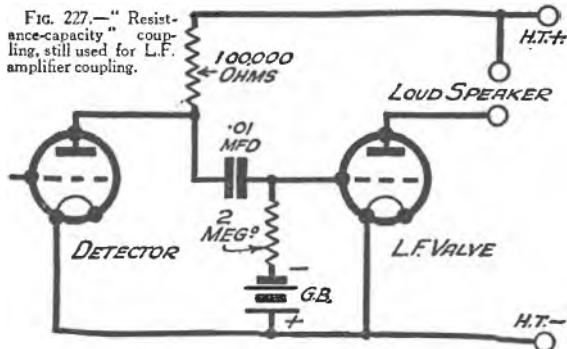
L.F. AMPLIFIER

a high ratio transformer, even if another valve is to follow.

For the more common plan of using a $3\frac{1}{2}:1$ or $4:1$ transformer, a valve

aimed at. True, this particular scheme is more likely to give trouble in the hands of the inexperienced than the previous one, but only because of one or two pitfalls that await the unwary.

Interaction between the two transformers is the most frequent. They should be mounted as far away from each other as is practicable, and their cores should, if possible, be at right angles to each other. Fig. 228 shows a suggested



of the "first L.F." type may be chosen from the valve-makers' list.

If two stages of amplification are added, it is usually a good plan to use resistance coupling for the first. A "first L.F." type valve should still be used to follow the detector. This may then be coupled by means of a transformer, with a ratio up to $4:1$, to a really good output valve. A larger output valve will naturally be needed in this case. It is necessary to pick out individual types of valve. Choose valves to suit the set.

As a final practical point receivers using two transformer-coupled stages are dealt with. There is nothing whatever against this arrangement, providing that the layout is well chosen and that too much amplification is not

layout for the L.F. end of a three-valver, using two transformers.

L.F. instability may take the form of an audible whistle, or, more commonly, of severe distortion of music and speech. In the latter case the whistle is probably there just the same, but it so happens that the whole arrangement is oscillating at a frequency well above the audible range.

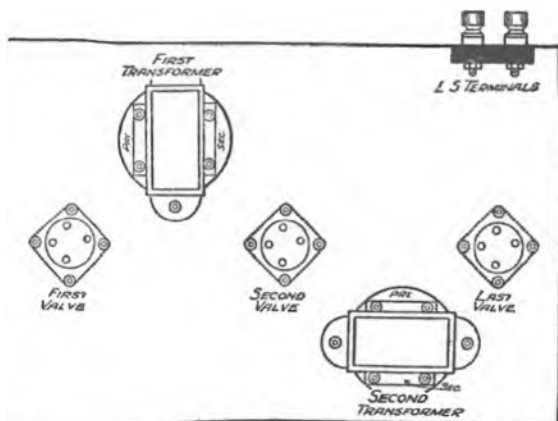


FIG. 228.—The Transformers should be mounted as far away from each other as possible to avoid interaction between them.

Such trouble should be cured, if possible, by changing the layout, unless it is found that reversing the secondary leads on one of the transformers puts matters right.

If any of these devices has any effect, it may generally be cured (at the expense of a slight amount of amplification) by connecting a grid leak of 1 megohm across the secondary winding of one or both transformers. But if the amplifier is so bad that the latter is necessary, it is as well to go back to one *good* stage—it will do as much work as two bad ones.

Finally, it is as well to mention the old pitfall of high-resistance batteries. Nothing is so fatal to a "high-mag." L.F. amplifier as insufficient H.T. voltage and poor batteries. If your set is battery-operated, see that each valve really is getting the voltage recommended by the makers. Also do not omit the "decoupling" unit shown in Fig. 226, particularly in transformer-coupled sets. A resistance of 10,000 ohms and a condenser of 2 mfd., connected as shown, generally make all the difference between success and failure.

L.F.C.—Low-frequency Couplings.

LICENCES.—The Post Office Licence must be obtained by every listener who is in a position to receive the broadcast programmes. If an aerial is erected a licence is necessary, even although no set is connected to it. The authorities take the view that the intention is to receive the programmes, hence the aerial.

The licence also covers the use of a portable receiver, but another licence is required for a receiver which is taken to a further dwelling. If you have two receivers, one permanently connected to the aerial and a portable in addition, only one licence is required.

In addition to the Post Office

Licence, it is also necessary to have a licence from Marconi's Wireless Telegraph Company, Ltd., for the use of their patents (if such patents are employed in the receiver). Most manufacturers hold such a licence, and the receiver should carry a small licence plate stating that the due royalties have been paid.

The home constructor is not immune from this levy. If he constructs a receiver for his own use, and makes use of any of the above company's patents, he should write to them for a licence plate, which will be supplied on payment of the royalty. If in doubt about the employment of patents, he should send them a wiring diagram of the receiver. The Post Office Licence is 10s. per annum; the home constructor's Marconi Licence is 12s. 6d. per valve; and the Manufacturer's Marconi Licence is 5s. per valve.

LIGHT-RAY CONTROL.—An ingenious apparatus, which depends for its action on the fluctuations in resistance of a selenium cell or "bridge," due to variations in intensity of a ray of light projected on to it. The ray may be used to switch a wireless set on or off, set alarms, shut and open doors; in fact, anything that can be operated by means of a switch.

To-day control by light is used to a very great extent in television, which is practically wholly a question of light control. This apparatus is based on what is known as a selenium cell. Selenium is an element with a peculiar property, which was discovered by accident. It was being used as a high resistance in an electrical experiment, when it was found to vary its resistance to an electric current as the light which shone upon it varied in intensity. Thus, this phenomenon led to experiments with selenium cells, ultimately resulting in the production of the modern light-ray apparatus.

LIGHT-RAY CONTROL

What the Apparatus Comprises. It is, in fact, a selenium cell, a compact and easily handled apparatus, having all the principles of the big selenium cell, but far less cumbersome, and of extremely low cost. In its commercial form it is housed in a bakelite case, is easily handled, and has all the properties and sensitivity to light that modern light-controlled apparatus requires.

The theoretical circuit of this device is shown in Fig. 229, and no difficulty should be experienced in the wiring of the components. There is no soldering necessary, as all wires are connected direct to terminals. Now, in order to feed current to the light-sensitive apparatus, and to supply power to the amplifying valve, two supplies of current are necessary, these being a 2-volt L.T. battery for the light-sensitive apparatus, and a 100-150-volt H.T. battery (see Fig. 230). The valve used is of the detector type, and is recommended because of its extreme sensitivity. Having completed the power supply, and inserted the valve, the apparatus may now be tested.

Testing the Ray. Remove the H.T. + and tap it on its socket, as this occasional contact releases the relay, and a click should be heard. This shows that it is operating suc-

cessfully. Now shine a light on the apparatus, having first turned the variable resistance to approximately the centre of its track, and break the beam of light by passing the hand through it. The relay will then give an instant click, showing that the light acting on the bridge has caused the relay to operate. It is necessary to shade from the sensitive cell as much stray light as possible, focusing on to it only the ray which operates it.

There are a number of different ways in which it will function. They are controlled by the relay on which will be found six terminals numbered 1 to 6. When terminals 1 and 2 are connected to a lamp, the connection between terminals 4 and 5 being removed, the lamp circuit is normally open. When the light ray focused on the bridge is intercepted, the lamp will light (Fig. 231), and will continue to burn until the lamp is switched off, as the apparatus is reset by temporarily shorting terminals 4 and 5 with a piece of wire. It will be seen how useful this connection is for burglar alarms (Fig. 235), where it is essential that the resulting alarm can only be switched off by the owner. Another simple experiment is to retain the connections to terminals 1 and 2, and replace the wire con-

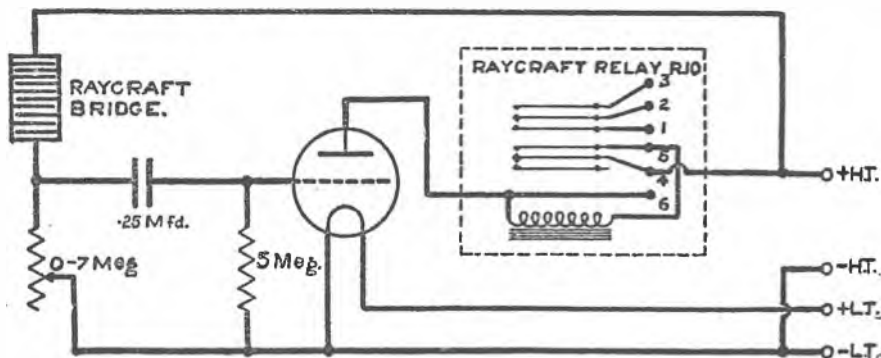


FIG. 229.—The circuit diagram for Light-Ray Control.

LIGHT-RAY CONTROL — LITZENDRAHT WIRE

necting terminals 4 and 5 (Fig. 232).

It will now be found that interrupting the ray will light the lamp, but that the restoration of the ray will

When the electric light is switched off, the bridge will automatically switch off the set. A diagram of the switch in the relay is shown in Fig. 234.

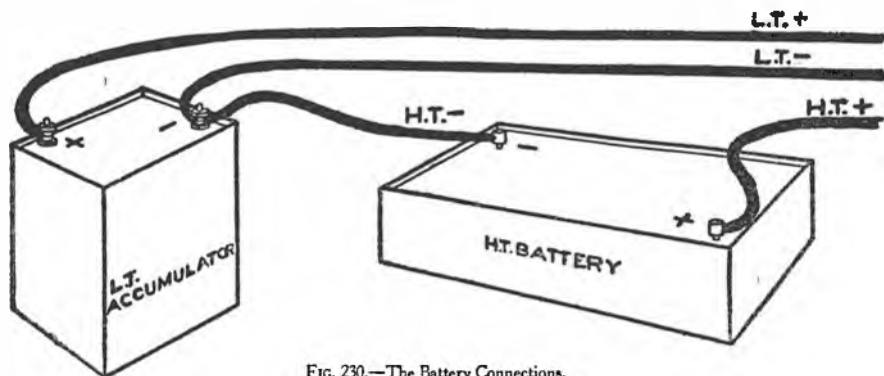


FIG. 230.—The Battery Connections.

immediately result in the lamp going out.

Connect your lamp to terminals 2 and 3 on the relay (Fig. 233) and remove the connecting link between terminals 4 and 5. The apparatus will now function in exactly the opposite way to the first experiment, the lamp remaining alight until the ray is broken. This connection can also be used to switch off a wireless set, the room's electric light acting as the ray.

LITHANODE CELL.—A secondary cell or accumulator which has its negative plate (its anode) pasted with litharge.

LITZENDRAHT WIRE.—This is a special wire for coil winding and other components which require minimum low-frequency resistance.

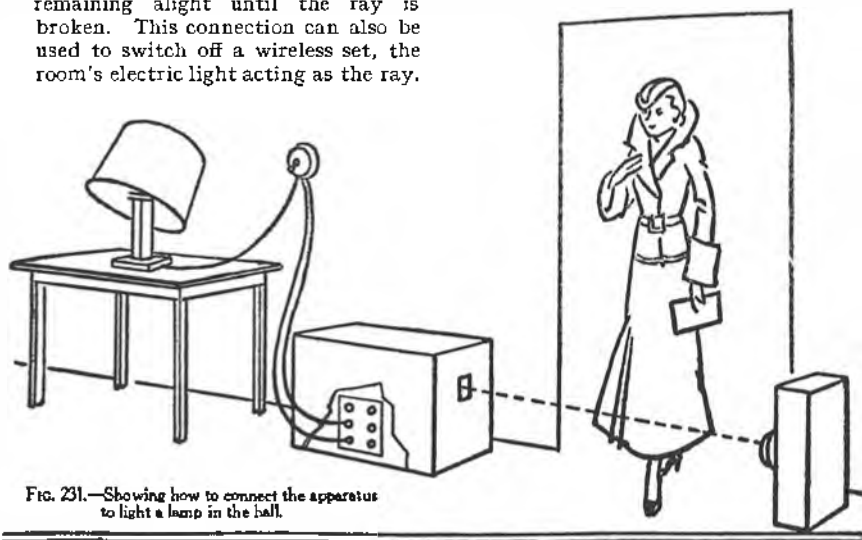


FIG. 231.—Showing how to connect the apparatus to light a lamp in the hall.

LOAD — LOUDSPEAKERS

It consists of strands of silk-wound copper wire plaited together in multiples of three with silk covering. The inductances of all strands are equal.

LOAD.—The amount of energy taken from a battery, motor, etc. The total work to be done.

LOADED AERIAL.—An aerial whose frequency or electrical length is varied by the addition of capacity or inductance in series with the aerial wire.

LOADING COIL.—A coil used to increase the range of an existing coil.

LOEWE VALVES.—Valves which contain in one glass envelope the electrodes of two or more valves, together with the requisite intervalve couplings. These are resistance-

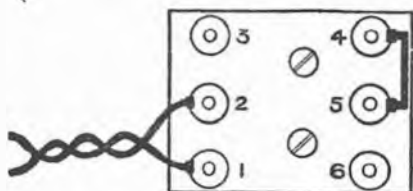


FIG. 232.—The connections to the relay for a burglar alarm.

coupled stages, either H.F. or L.F., and the resistances employed for the purpose are enclosed in small sealed glass tubes which are evacuated. The result of this method of assembly is to evolve a two- or three-valve receiver in which every part is in a vacuum and therefore cannot vary in its characteristics. It also provides a simple means of making up a receiver.

LOOP.—An antinode. The point of greatest amplitude in a wave train.

LOOP AERIAL.—American term for frame aerial. A single-turn aerial.

LOOSE COUPLING.—When inductive couplings can be varied by changing the relative position of the coils they are said to be loose coupled.

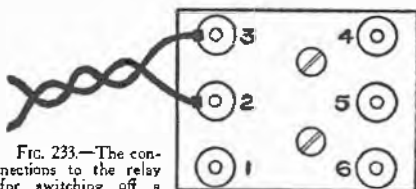


FIG. 233.—The connections to the relay for switching off a wireless set.

LOUDSPEAKERS.—A glance through a catalogue when trying to decide on the loudspeaker to buy for a given set will leave the listener rather puzzled at the different types of speaker. There is the simple cone type; the balanced armature; the inductor dynamic, and the moving coil, which induces the novice or newcomer to wireless to wonder which is the best type of speaker to get for a set. In this section we shall touch briefly upon the four above-mentioned types of loudspeaker, describing how they work, and their respective merits, so that one can decide just whether one has got the wrong type of speaker for the set, or what type is best for the new set it is proposed to make up.

The simplest type of movement is the one illustrated in Fig. 237. It consists of a strip of iron, fixed at one end, the free end being above and close to the pole of a small magnet. To the strip of iron, or armature as it is properly called, is

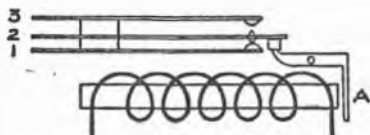


FIG. 234.—Diagram of the Switch in the relay.

fixed a thin rod on to which a cone diaphragm may be fixed. The windings of the magnet are connected in the output circuit of the last valve of the set. As the current changes, due

LOUDSPEAKERS

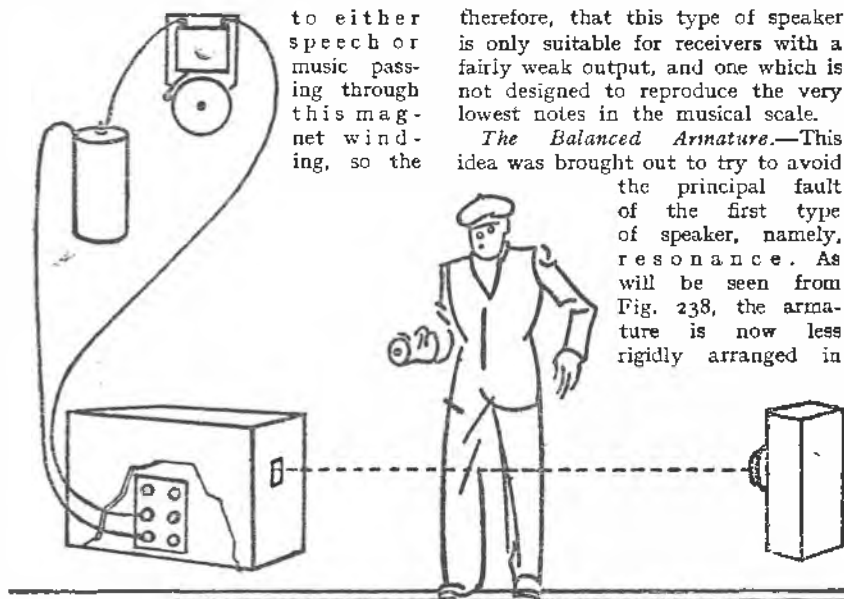


FIG. 235.—The connections for the invisible-ray burglar alarm.

pull on the armature is varied, with the result that the vibrations are transferred to the cone, and so the sounds are made audible. It will be obvious that the armature will always tend to return to its normal position, and this natural restoring force gives rise to its first fault, namely, resonance. Again, the current fluctuations due to a very low note, such, for instance, as the beat of a drum, are very great, and should result in a large movement of the armature. As the armature is rather rigidly held, it must be arranged close to the pole piece in order that the weak impulses may affect it. Therefore, on a low note it tends to come into contact with the pole piece, giving rise to "chatter," a fault which is also noticed when very loud signals are received. It will be seen from this,

therefore, that this type of speaker is only suitable for receivers with a fairly weak output, and one which is not designed to reproduce the very lowest notes in the musical scale.

The Balanced Armature.—This idea was brought out to try to avoid the principal fault of the first type of speaker, namely, resonance. As will be seen from Fig. 238, the armature is now less rigidly arranged in

between two magnets. There is therefore an equal pull in each direction, and this tends to make the armature move about a central position, avoiding the natural restoring

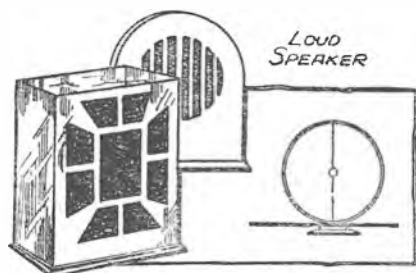


FIG. 236.—Theoretical and Pictorial Diagrams of a Loudspeaker.

force which was noticed in the simple type of movement. The gap between the magnets may be fairly large, and so greater signal strength

LOUDSPEAKERS

can be handled without the risk of "chatter." This type of speaker is therefore most suitable for receivers employing two or more valves and designed more on "quality" lines than the usual cheap set.

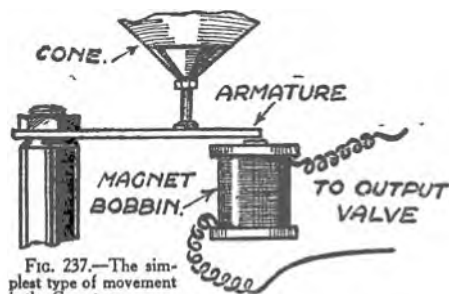


FIG. 237.—The simplest type of movement is the Cone type.

The inductor dynamic is the nearest approach yet obtained to the ideal in moving-iron speakers. In both of the previous movements it is obvious that as the iron armature is fixed at one end, there must necessarily be a certain amount of resistance to overcome in order to vibrate the armature, and the tendency of the armature to return to its position of rest is always present, no matter what electrical impulses are at work. This prevents the slow oscillation necessary to produce, say, a pedal note on the organ, and, in addition, the cone is not operated in a direct push-and-pull movement. The actual direction of the cone's movement, to produce true tones, should be what might be termed a "piston" movement; that is, it should move in a horizontal plane. Now, as one end of the armature in the speaker movements so far described is fixed, it is obvious that the operating reed is taken through a small arc during its to-and-fro movement. This gives rise to a form of distortion.

Inductor Dynamic Speaker. To overcome all these defects in a moving-iron loudspeaker seems rather

difficult. However, a certain inventor set to work, and the result of his endeavours to produce the ideal moving-iron movement is known as the inductor dynamic speaker. The actual arrangement is the subject of

Letters Patent, and only a few firms in this country are licensed to manufacture it. Fig. 239 shows the principle on which it works. There are four pole pieces to the magnet system and two armatures. The two armatures are held together by means of rigid, but light, rods, and the armature assembly is held at the front and back by very light springs. It is obvious that, by being held in two places, the strength of the springs

may be very much weaker than if only one end was held. Furthermore, when the armature is drawn to either side by the signal impulses it must travel in a true horizontal direction, and the restoring force in any direction is perfectly equal. The result of this is the nearest approach to the moving coil which has yet been designed, and consequently the reproduction is very faithful. This type of loudspeakers should therefore be chosen for multi-valve receivers designed for good quality reproduction, where it is not desirable to use a moving coil, either on the ground of initial expense or running costs.

Moving-coil Speaker. The moving-coil speaker, is, of course, the best type of speaker yet designed, and provided one of the best makes is ob-

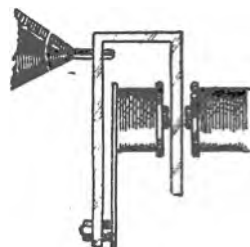


FIG. 238.—The Balanced Armature. As will be seen, the Armature is less rigidly arranged between the two magnets.

LOUDSPEAKERS

tained, will give on a suitable receiver a reproduction practically identical with the original. As will be seen from Fig. 240, at the point of the cone diaphragm a light ring of paper or similar material is fixed, round which is wound a coil of wire known as the "speech winding." A large metal cylinder, having a central

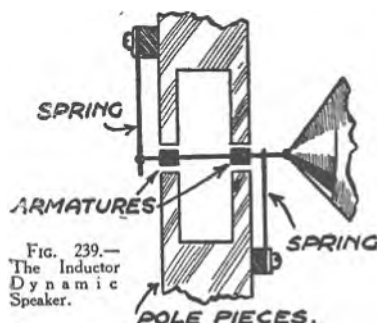


Fig. 239.—
The Inductor
Dynamic
Speaker.

rod, known respectively as the "pot" and "pole piece," contains a large winding which has to be connected to some source of direct current. The actual voltage depends on the design of the speaker, and varies in most speakers from 4 volts to 150 volts. The speech winding is supported in a small gap surrounding the pole piece, and this gap should be as small as possible. Usually it is approximately $\frac{1}{8}$ in. When the field is "excited," which means when the current is applied to it, a magnetic field is set up across the gap. The speech coil is connected to the output valve of the receiver, and when the signal impulses flow through this speech winding it vibrates, travelling in and out of the gap. The edge of the cone is supported in some way, either by a ring of leather or rubber, and therefore the cone makes a true "piston" movement, resulting in a faithful re-

production of the received sounds. The only faults with this type of speaker arise from faulty design, and are: too heavy a speech coil and cone; resonance set up by the rubber or leather fixing ring; resonance due to the material of which the cone is made, and one or two other little points.

To get the very best from a moving-coil speaker, a fairly strong signal is desirable, and as it can give such a good performance, the receiver should be designed to give out a signal to justify the use of such a speaker. Particular care should be taken to look after the lower notes in the musical scale, as these can be dealt with so effectively by the moving-coil speaker.

Matching the Impedance. No matter which type of speaker it is intended to use, there is one point which applies to the correct employment of any speaker, and that is, the impedance of the speaker must be matched to the output valve. This means that a certain valve will only give straight-line reproduction

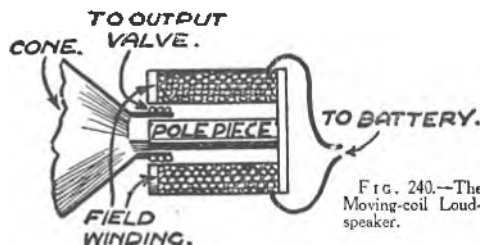


Fig. 240.—The
Moving-coil Loud-
speaker.

with a certain impedance in its anode circuit, and although valve manufacturers give this impedance figure in the leaflets accompanying their valves, unfortunately, loudspeaker manufacturers do not always give the impedance of their products. Usually, only the D.C. resistance is given, and this does not enable one correctly to match up the speaker. There are on the market, however, certain out-

LOUDSPEAKERS

put matching transformers which have various ratios, and if the listener desires to get the best from the set, one of these transformers or matching units should be included in the output circuit, and by adjusting it to various values it is possible suitably to match up the speaker. One final word. As the speaker can only reproduce what is fed into it, the choice of circuit should receive as much, or even more, care than the choice of speaker.

Electrostatic Speakers. The electrostatic type of speaker employs two plates separated by air (in the same manner as a condenser). The differences in potential applied to the two plates produce movement, and by suitable design of the plates, spacing, etc., it is claimed that the reproduction is better than any of the methods described above.

Loudspeaker Horns. Owing to the rapid advances in the design of loudspeaker movements as detailed above, the horn type of speaker has practically disappeared from the market. In spite of this, however, some of the best-known talkie installations employ a horn type of loudspeaker, and this has caused quite a number of wireless amateurs to wonder which is actually the better type—the horn or the hornless. Experts are divided on this question, some holding that the moving-coil speaker, correctly designed, is the best reproducer, and others that the horn type is unbeatable, provided it is of the right shape, and this means that it has to be very large, as the following figures will show. In order that a horn may reproduce *with a perfectly even response* all the notes in the musical scale, it must be of a certain shape and of a definite length. The shape will have to follow what is known as the exponential (or logarithmic) law, that is to say, the cross-sectional area of

the opening will have to double at equal intervals throughout the length of the horn.

An example will make this clear. Consider a speaker horn, the entrance (or throat) of which has an area of 1 square in. If at 1 ft. along the horn the area is 2 square in., then at 2 ft. it will have to be 4 square in.; at 3 ft., 8 square in.; at 4 ft., 16 square in., and so on. This rate of expansion determines the lowest frequency at which the horn will main-

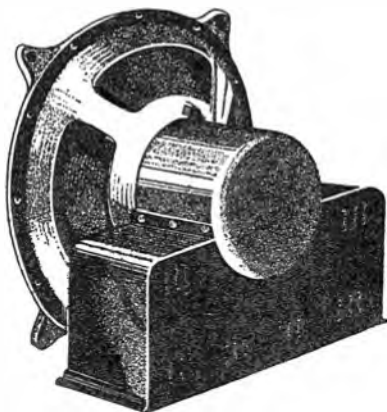


FIG. 241.—A mains energised Moving-coil Loudspeaker.

tain its straight-line reproduction, or in other words, it governs the "cut-off" frequency. The following table shows these figures:

Area doubling every 6 in.,	cut-off frequency is 128 cycles;
Area doubling every 12 in.,	cut-off frequency is 64 cycles;
Area doubling every 24 in.,	cut-off frequency is 32 cycles;
and so on.	

To understand what this means, one must remember that the middle note on the piano has a frequency of 256 cycles, and the lowest note a frequency of 26.6 cycles. If, there-

SOME DISTINCTIVE LOUD- SPEAKERS

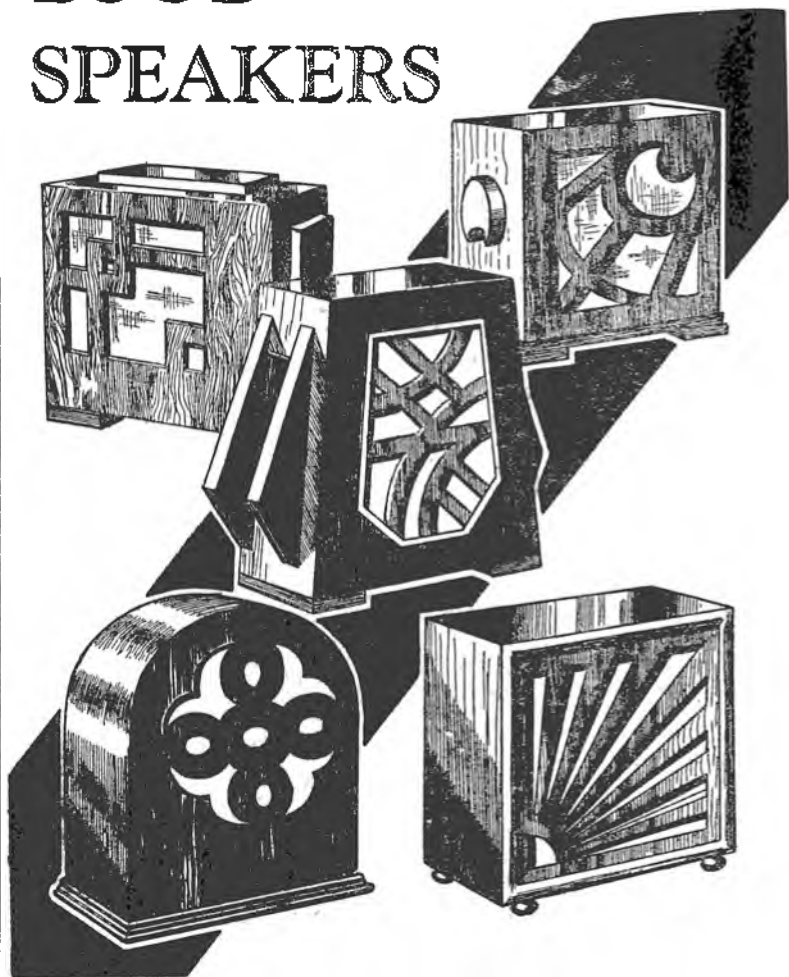


FIG. 242.—The modern style of Speaker Cabinet is exemplified in the designs shown here.

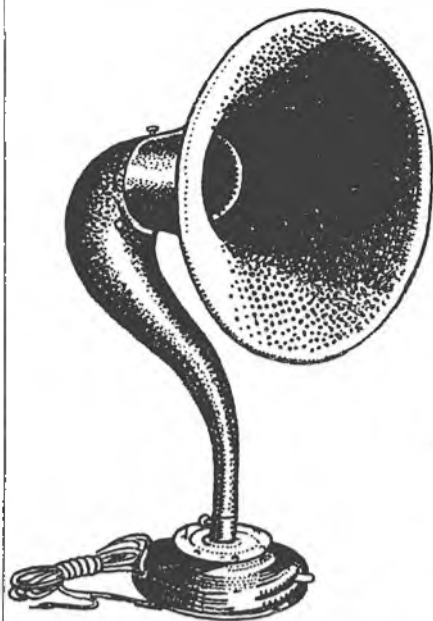


FIG. 243.—Old Pattern Horn Type.

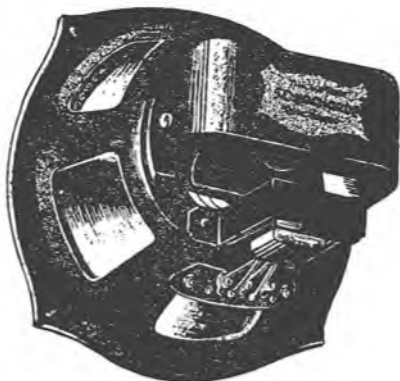


FIG. 245.—Permanent Magnet Moving-coil Speaker.

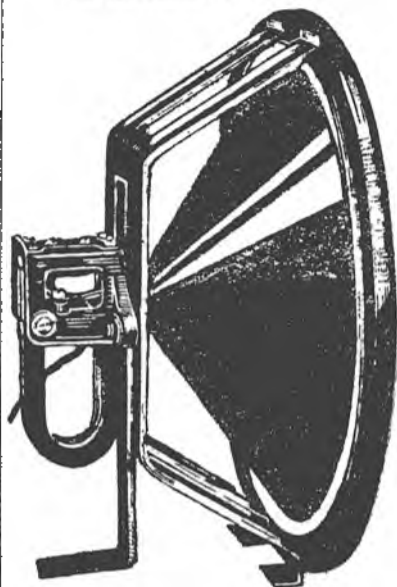


FIG. 244.—Inductor Dynamic Speaker.

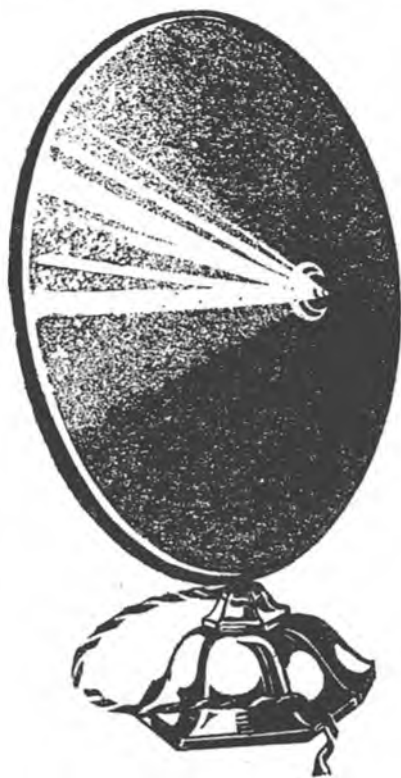


FIG. 246.—Single Cone.

FIGS. 243 to 246.—Types of Loudspeaker.

LOUDSPEAKERS

fore, one wishes the horn loudspeaker to reproduce the lowest note of the piano with the same degree of amplification as middle C, it must double

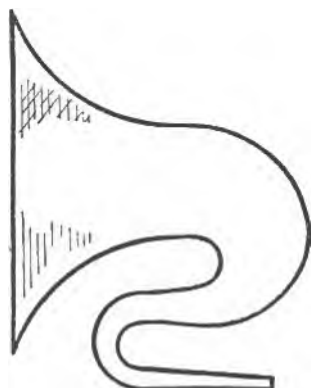


FIG. 247.—A method of forming to avoid bulkiness.

its area every 2 ft. So far the example has decided upon one figure in the design, and it is necessary to determine its length. This is governed by the size of the opening, or mouth. This must be of such a size as to permit the air column which is standing in the horn from

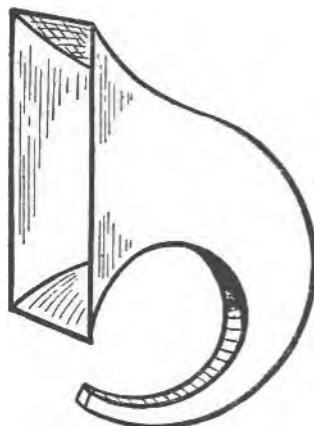


FIG. 248.—A method of curving to avoid bends.

having too great a damping effect on the diaphragm which is actuating it. The most satisfactory size for this opening will be obtained if the diameter is made equal to one-quarter of the wavelength of the cut-off frequency of the horn. This sounds very involved, but it is really quite simple to work out. The velocity of sound in air is 1,120 ft. per second. It has been shown above how to work out cut-off frequency, and

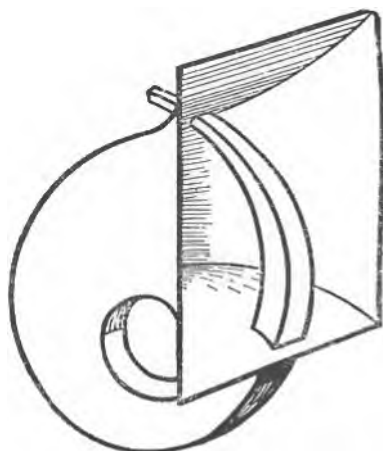


FIG. 249.—How the very large Cinema Horns are formed.

therefore to find the corresponding wavelength of this proceed to divide 1,120 by the frequency, and that will give the wavelength in feet. Dividing this by four will give the diameter of the opening, and one must therefore make the horn of such a length that it terminates when that diameter is reached.

Supposing one wishes to construct a horn with a cut-off frequency of 64 cycles, and the unit for the speaker has a fitting with an area of 1 sq. in. The rate of expansion will be every 12 in., and the mouth 4 ft. across. This means that the horn

LOUDSPEAKERS — LOW-FREQUENCY COUPLINGS

would have to be over 6 ft. long. It becomes obvious from these figures that the old-fashioned type of table



FIG. 250.—"Straight" Pattern Logarithmic Horn.

loudspeaker was a very poor performer as far as the bass was concerned, and it also accounts for the size of the talkie horns.

For those home constructors who are still sufficiently interested in the exponential horn, and would like to carry out some experiments, below are given some hints on construction. In the first place, for simplicity of construction, it must be stated that

there is no audible difference, on an ordinary home receiver, between a horn of round or square section. The latter is certainly very much easier to construct. Any wood may be used, and this should, theoretically, be thick to avoid resonance. (Do not employ metal because of resonance troubles.) However, plywood

$\frac{1}{2}$ in. thick may be used, and if resonance is noticed, putty pressed on at different spots will damp out the resonance, or at least, make it low enough to be unobjectionable. The horn may be curved and bent back upon itself to avoid clumsiness, but—and this is important—avoid angular bends. Endeavour, if possible, to get nice steady curves of the swan-neck type to avoid "echoes." Joints should be well screwed and glued, any unavoidable gaps being filled with putty. Several different types of speaker horn are illustrated in Figs. 247-250.

Speaker units for use with this type of horn should, naturally, be themselves capable of reproducing all frequencies equally, and for this reason balanced armature or moving-coil units should be used.

LOW-FREQUENCY AMPLIFIER.

—An amplifier which amplifies after rectification of the signal; it calls for low-frequency (iron-cored) transformers. (See also *L.F. Amplifier*.)

LOW-FREQUENCY COUPLINGS.

—The method of coupling L.F. valves together has a great deal to do with both the volume of the output of the wireless set and the quality of that output. As there are several different methods of carrying out this coupling, below is given a brief explanation of each method, together with its advantages and disadvantages.

The most popular method is, of course, the L.F. transformer. This consists of a core of soft iron stampings, around which is wound two separate coils of wire—either side by side or one upon the other (Fig. 251). The ratio of these windings determines the amplification given by the transformer, and thus a 3 to 1 transformer means that the primary is (roughly) one-third the size of the secondary. The primary winding is connected in the anode circuit of

LOW-FREQUENCY COUPLINGS

the valve, that is, one end of the primary is joined to the anode, and the other end to the H.T. supply. The oscillations in this winding are transferred by induction to the secondary winding, which is connected to the grid circuit of the following valve, and therefore this valve receives similar impulses to those which are operating the first valve, with the exception that they are

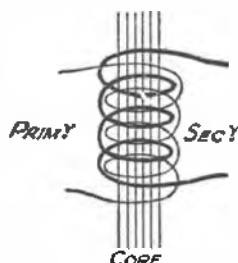


FIG. 251.—Diagrammatic illustration of the L.F. Transformer.

strengthened by the step up due to the ratio of the windings. The advantage of this type of coupling lies in this step up of strength, but there are a number of disadvantages. Firstly, the inductance of the primary should be of a certain value dependent on the impedance of the valve in whose anode circuit it is included. As, however, there is a steady D.C. current flowing through it, this impedance is reduced, the greater the current the lower the impedance. Therefore, it is not efficient if included in the anode circuit of a small-power valve passing an anode current of 10 milliams. or so, unless it is wound with a normal inductance of 20 henries approx. This means that the primary would have to be very large, and then when a secondary with the necessary step up in winding is included, a rather unwieldy component would result. Therefore, generally speaking, the intervalve transformer is equipped with a rather small primary, and will not take more current than 7 or 8 milliams. without seriously affecting the value of its inductance, and, there-

fore, introducing poor quality. To overcome this defect various schemes have been tried, such as using a core of metal other than soft iron; using different materials for the two windings, etc.

If the D.C. can be kept from the primary, it would obviously improve the working characteristics of the transformer, and that now introduces the next method of L.F. coupling. It is known as Parallel Feed—which means that the primary of the transformer is in parallel with the preceding valve—and to accomplish this a resistance is included in the first anode circuit (instead of the primary), and one end of the primary is joined to the anode, and the other end to earth (Fig. 252). The quality of the response given by this method is an improvement, but the disadvantage is the same as that occasioned by resistance-capacity coupling, which is dealt with in the following notes.

To get the best response from a valve we must have an impedance in the anode circuit which is as great as possible compared with the actual impedance of the valve. In practice we choose a value about four times as great as the valve's impedance.

Take a standard 2-volt valve with an impedance of 7,000 ohms and an amplification of 5. The impedance to be included in the anode circuit of

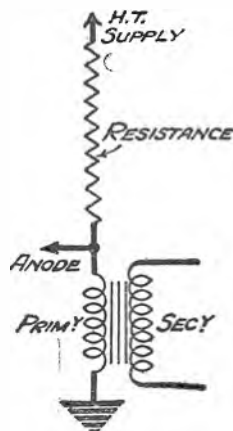


FIG. 252.—Resistance-fed Transformer Couplings. A condenser should be inserted between anode tap and primary.

LOW-FREQUENCY COUPLINGS

this valve should be at least 28,000 ohms. Suppose we use 30,000, which is the nearest commercial value made. The anode current of the valve in question will probably be about 5 millamps. From Ohm's Law we know that 150 volts are required to pass a current of 5 milli-

amps. through 30,000 ohms. As the valve requires 150 volts or thereabouts for H.T., this means that we shall require an initial voltage of 300 volts for the H.T. supply. Here is the disadvantage of parallel-fed transformers or resistance-capacity couplings.

For R.C.

couplings an anode resistance is included in the anode circuit of the first valve, the grid of the next valve being joined to this first anode via a condenser, and the junction of grid and condenser being earthed via a resistance (Fig. 253). As there is no iron in this arrangement (and provided good resistances and condensers are employed) this method of coupling should give us perfect amplification. However, in view of the voltage drop described above, a somewhat low resistance has to be employed. This means that the amplification falls below the normal amplification of the valve itself, which, in the case of a standard L.F. valve, is only about 4 or 5. Obviously, then, we shall require three or four R.C. stages to equal in

signal strength one good L.F. transformer-coupled stage. Further, the size of the coupling condenser and the grid leak are critical if true straight-line reproduction is required, and all sorts of distortion can be introduced by a wrongly balanced R.C. stage. If the grid leak is too large, the valve will choke; if too small, the output from the preceding valve will be affected, as the anode resistance and grid leak are virtually in parallel. A small condenser will offer a resistance to the lower musical frequencies, and so on.

The Parallel-fed Auto-transformer. To avoid the effect of the grid leak and to obtain an increase in amplification, the parallel-fed auto-transformer has been introduced. This is a combination of R.C. and transformer coupling, a resistance being included in the first anode circuit; a coupling condenser is used to feed the impulses to an auto-transformer, which steps up the impulses to the grid (Fig. 254). With this method of

coupling the condenser should be as large as possible, say 2 mfd. or so, to get straight-line amplification, but to get an improved response from a circuit or speaker which is deficient in bass the condenser may be made smaller, so as to make the coupling a resonant circuit and so give a bass "boost." The disadvantage here is the anode resistance again, in view of the high initial H.T. required.

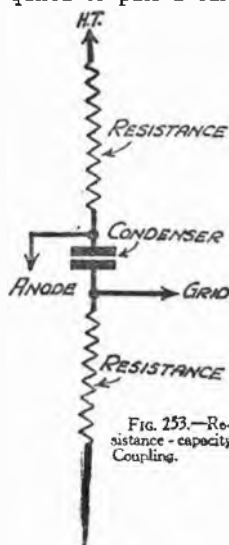


FIG. 253.—Resistance-capacity Coupling.

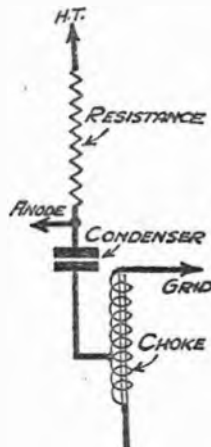
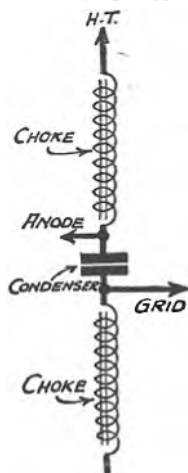


FIG. 254.—The Resistance-fed Auto-transformer arrangement.

LOW-FREQUENCY COUPLINGS

It should now be obvious from the foregoing remarks that an efficient choke in the anode circuit, and a choke in place of the grid leak—retaining the coupling condenser—should result in good quality and high amplification, and this method is known as the impedance-coupled circuit (Fig. 255). There is only one



commercial form of this coupling on the market. The anode impedance must have a high inductance with a low D.C. resistance, and the grid impedance must also be designed in conjunction with the anode impedance, with which it is in parallel, as explained above.

The above remarks should enable the experimenter to carry out alterations in his set to produce perhaps better quality than that at present obtained, and to enable the non-experimenter to ascertain whether his

set is built on the best lines.

Connections for a transformer-coupled stage are given in Fig. 258. It will be seen that an earth terminal is provided on the transformer illustrated, but many transformers do not possess this minor refinement. In some cases the same effect can be obtained by taking an earth connection from the metal casing. Again, some transformers having a bakelite case have one of the holding-down screw eyelets connected to the core, so that an earth connection can be made to the screw itself. The connections, shown in Fig. 258, relate to the average type of transformer, but some of the older ones have their terminals lettered "I.P.," "O.P.," "I.S.," and "O.S." These latter correspond to the newer letterings of "P.," "H.T. +," "G.B.," and "G." respectively.

A single transformer-coupled stage, if correctly designed, will give all the amplification necessary for most purposes, but when two stages are required a good deal of care must be taken to avoid L.F. instability. The transformers should be good ones of low step-up ratio, and should be mounted with their axes at right

FIG. 255.—Choke Impedance Coupling.

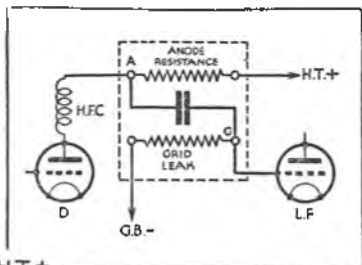
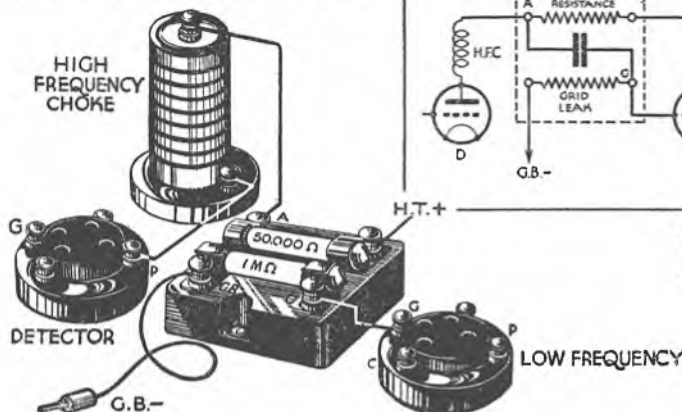


FIG. 256.—Resistance-capacity Coupling.

LOW-FREQUENCY COUPLINGS

angles. Earthing the cores is very helpful, and it is also very desirable to decouple the anode circuits of both the detector and first L.F. valves.

Tone-control Transformers. Transformers of this type operate in a similar manner to ordinary L.F. transformers, but have the added advantage that they can be "tuned." That is, by connecting a variable resistance across two of the terminals, the transformer can be made to give emphasis to notes of certain frequencies; when the resistance is removed the transformer functions in the normal manner. The tone-control transformer is especially suitable for use in a very selective receiver in which a certain amount of high-note loss takes place in the tuning circuits. By operating the variable resistance, the high notes can be restored to any desired extent. The method of connecting a transformer of this type is illustrated in Fig. 261, but in this case a circuit diagram is not given, because alternative arrangements are employed by different makers. Generally the "transformer" consists of both a transformer and special choke mounted together in the one bakelite case.

Push pull. The push-pull system of L.F. coupling is not very often employed in amateur-built receivers, principally on account of its greater cost, but it can offer very many real advantages in the way of undistorted output at high volume levels. The arrangement of a push-pull amplifying stage is shown in Fig. 260, where it will be seen that two transformers (input and output) are required. The primary winding of the input transformer is connected in exactly the same way as a transformer of the ordinary type, but the secondary has three terminals. Of these, each of the two outer ones feeds a separate amplifying valve; the third terminal, which is really a centre tapping, takes the grid-bias supply for both valves. It will be seen that half the output from the transformer is fed to each amplifying valve, and since the valves are connected to opposite ends of the secondary winding, one receives the negative half of any cycle, while the other receives the positive. The positive half-cycle is the only one which operates the valve, and consequently the two

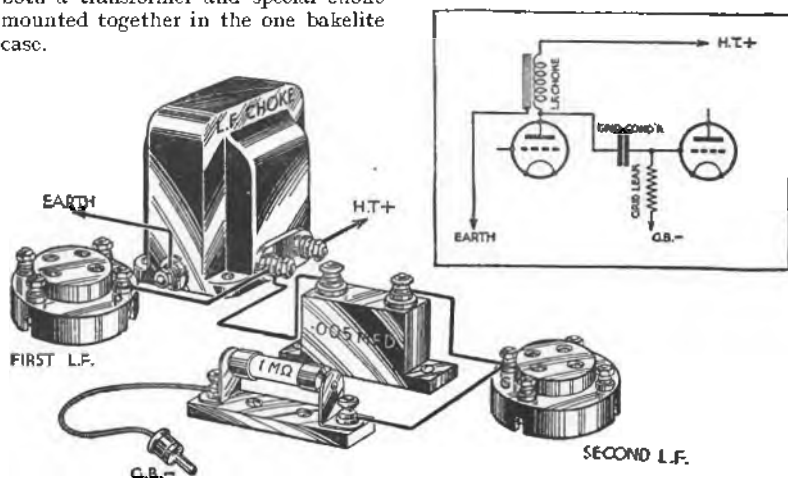


FIG. 257.—Choke-capacity Coupling.

LOW-FREQUENCY COUPLINGS

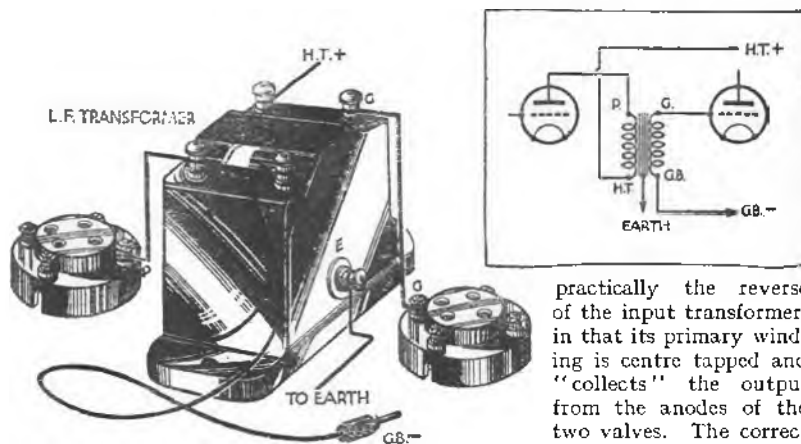


FIG. 258.—L.F. Transformer Coupling.

valves work in "turns"; but as one end of the winding is always positive, one valve is always functioning. The operation can be likened to that of two men sawing through a log with a cross-cut saw; one man pushes the saw, while the other pulls. The men in this case represent the valves. This analogy is not quite correct, because the man who pulls is actually doing part of the work, whilst it is only the "pushing" valve that contributes towards the output.

Where the Output Transformer Differs. The output transformer is

practically the reverse of the input transformer, in that its primary winding is centre tapped and "collects" the output from the anodes of the two valves. The correct ratio of this transformer is dependent upon the impedance of the loudspeaker to be employed. It will be seen that the push-pull system is more efficient than any other, since it utilises both half-cycles of the signal frequency. A push-pull stage will also handle twice the volume of a single transformer-coupled valve, but as it does not give any appreciably greater degree of magnification, it cannot provide any greater loudspeaker volume

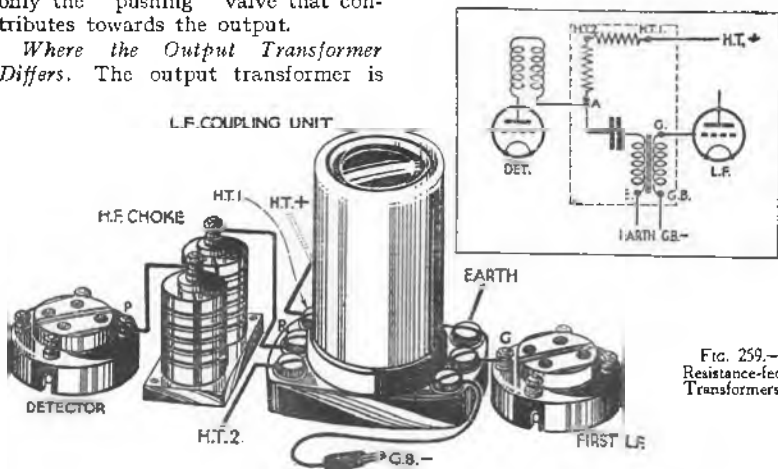


FIG. 259.—
Resistance-fed
Transformers.

LOW-FREQUENCY COUPLINGS — MAINS HUM

than a single valve unless the input to it is greater.

To sum up, push pull is best for use after one or more L.F. valves, when a good input is available. Comparatively small power valves can be used without overloading, and this makes it possible to obtain good results without the use of excessively high H.T. voltages. Any kind of power valves can be used in push pull, but the two should have similar characteristics. It should also be explained that the filaments of ordinary directly-heated valves used in push pull can be fed from raw A.C. without causing mains hum. The hum in each valve is, in fact, neutralised by

transformer secondary and the grid terminal of each valve holder. The positions of these resistances are indicated by two crosses in the circuit diagram of Fig. 260.

LOW-FREQUENCY CURRENT.

—Any current having a frequency of less than 1,000 per second.

LOW TENSION.—Low voltage or pressure—usually under 12 volts.

M

MAGNETIC INDUCTIVE CAPACITY.—The same as magnetic induc-

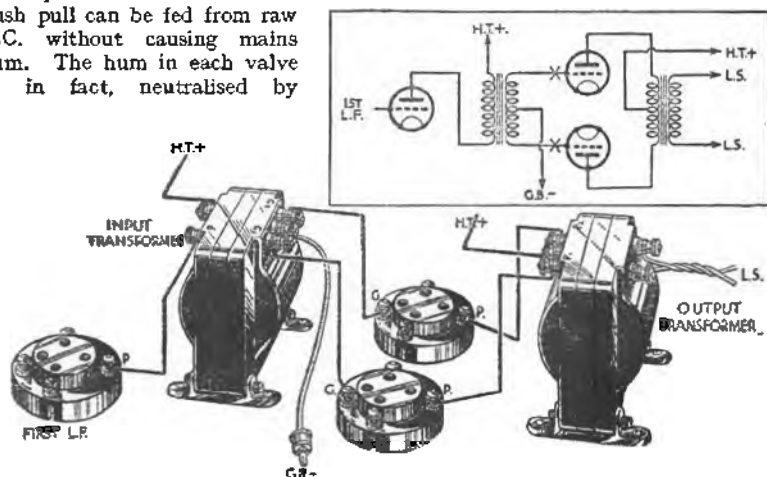


FIG. 260.—Push-pull system of L.F. Coupling.

that in the other. Valve makers will always supply matched pairs of valves for use in push pull, but, even so, the two valves often "wear out" at different rates, and in time tend to become "unmatched," if one may use such an expression.

Decouple the Grid Circuits. To obviate this difficulty, and to ensure freedom from certain forms of instability, it is usual, and better, to decouple the grid circuits by inserting a non-inductive resistance of about 100,000 ohms between the

tivity. Air is the unit. (See also *Dielectric Constants*.)

MAGNETO METER.—A device used for measuring the strength of a magnet.

MAINS ELIMINATOR.—See *Eliminator*.

MAINS HUM.—Hum is sometimes difficult to remove entirely from sets working off alternating current; a great deal may be done, however, to rectify this fault. A good earth connection is essential; reception may be stronger with less mains noises.

MAINS HUM

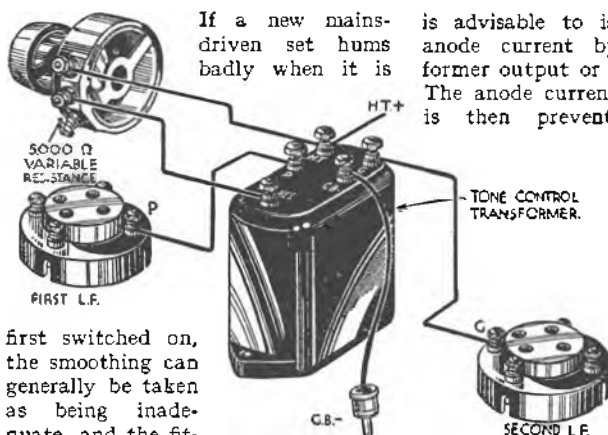


FIG. 261.—Tone-control Transformer Coupling.

first switched on, the smoothing can generally be taken as being inadequate, and the fitting of an additional smoothing condenser in the filter circuit will doubtless improve matters. Rectifier hum can be cured by wiring two .1-mfd. fixed condensers between the two rectifier anodes and high-tension negative (see Fig. 262).

Very often where a speaker is built into the same cabinet with the set and mains unit, ripple is caused by inductance of the speaker leads, especially if it is of the moving-coil pattern. The leads must be kept as far from the mains side of the set as possible. In some cases the detector valve is fitted too close to the speaker, and the valve will be affected by the sound waves, causing noises which may be taken as mains trouble. Shielding may be resorted to, but it is better and often a necessity to move the valve somewhat. The speaker can be tested by temporarily working it away from the set. With any type of speaker connected to a mains set it

is advisable to isolate it from the anode current by either a transformer output or choke-filter circuit. The anode current of the last valve is then prevented from flowing through the windings.

Only the low-frequency signal currents pass through the loudspeaker. This fact not only eliminates all

chances of shock if the L.S. terminals are accidentally touched, but also greatly helps in decreasing hum. It may be necessary to alter the position of the low-tension A.C. heater wires which run to the filaments of the valves from the power transformer. They should be kept as far as possible from the grid circuit.

Another point to look for is poor contact at the grid pin of the detector valve in its holder. The grid

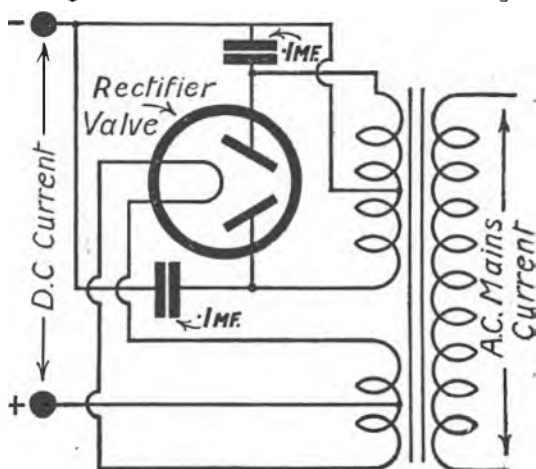


FIG. 262.—Rectifier Hum can be cured by connecting two .1 mfd. Fixed Condensers between the two Rectifier Anodes and High-tension Negative.

MAINS HUM

circuit of the valve is very sensitive, and the pin must therefore make proper contact with its socket; a lower value of grid leak may also be found beneficial.

Using Alternating Current. In utilising alternating current from the mains for high tension, the A.C. has first to be converted to D.C. Instead of the current rising and falling in one direction and then rising again in the reverse direction—in other words changing its polarity—some fifty times per second, as it does in alternating current, it has to be made to rise and fall in one direction only. This is the work of the rectifier. There are two distinct types of this piece of apparatus in use at the present time, one the valve and the other the metal rectifier.

To operate a wireless receiver it must be supplied with a smooth, direct current. Therefore, before the rectified A.C. can be utilised, it must first be filtered, that is to say, smoothed, for, although the rectified current flows now in only one direction, it still is changing in intensity, *i.e.* pulsating. To eliminate ripple it is made to pass through condensers and a choke. Across the D.C. leads are shunted fixed condensers of several micro-farads capacity. In series with these condensers is a low-frequency choke; this is placed between the first condenser, which is known as the rectifier condenser, and the last or reservoir condenser (see Fig. 263).

The first condenser receives the pulsating D.C. from the rectifier, so that owing to the reservoir action of this condenser the current which flows through to the choke is a great deal

more smooth. The choke in its turn does the work of opposing current fluctuations, passing on a still more steady flow to the second condenser; this is the final reservoir from which

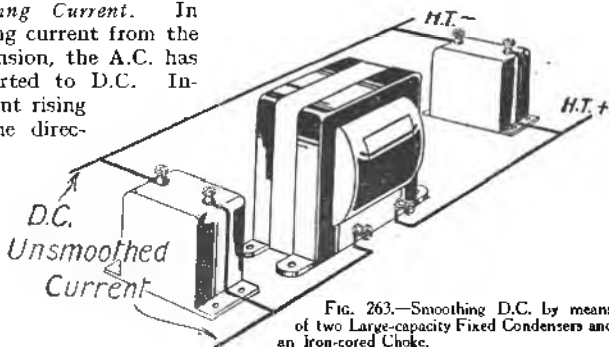


FIG. 263.—Smoothing D.C. by means of two Large-capacity Fixed Condensers and an Iron-cored Choke.

the high tension is derived for the set. Usually the inductance value of the choke is not less than 30 henries and the capacity of condensers at least 4 mfd. each.

Spacing Components in Mains Sets. Great care must be taken, when building a mains set, to see that all of the components are in their correct positions; place the power transformer as far away from the receiving side of the set as possible, also the smoothing choke; in fact, it is better to keep the whole of the mains unit at least 6 in. from the rest of the set, and, if possible, below the base-board.

Often what is supposed to be mains hum is actually L.F. oscillation. Some battery sets work perfectly with dry batteries on voltages in the neighbourhood of 100, but when they are connected to an eliminator giving voltages of 150 to 180, a hum is very noticeable. The obvious cure for this is the fitting of decouplers in the L.F. circuits and possibly in the H.F. circuit as well, especially in the case of a screen-grid valve. Decoupling tends to stop varying currents from entering or leaving the

MAINS HUM — MARKING OUT

transformer and valve circuits, and ensures a steady flow from the supply.

It is when the mains are exceptionally noisy that they show up little defects in the wiring of heaters, transformers, etc., and a hum is produced in the speaker. Sometimes, for instance, the set will be perfectly silent during most of the day, but at certain times, usually in the evening, when the generators are working at full load, it suddenly becomes noisy.

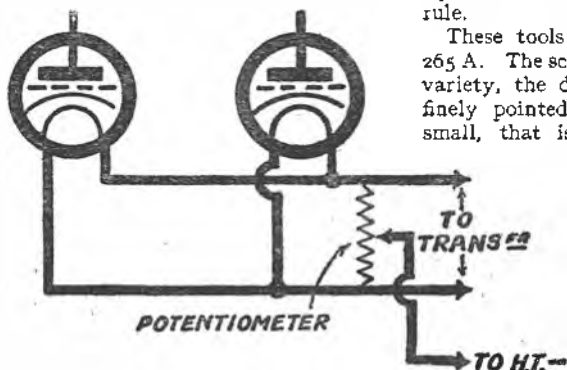


FIG. 264.—A cure for Mains Hum—Potentiometer is connected across the Heater Supply Wiring.

A device that is worth trying is the fitting of a 30- or 40-ohm potentiometer across the heater supply wiring. Of course, the usual practice is to connect the centre tapping of the heater wiring of the mains transformer to H.T. negative. The use of a potentiometer, however, allows the dead-true electrical centre to be obtained. Remember, the *mechanical* centre of the transformer is not always the same as the *electrical* centre. By moving the knob of the potentiometer one way or the other the hum can be exactly balanced out. In making the change, disconnect the wire going to the centre tap of the heater winding of the transformer and join it, instead, to the slider of the

potentiometer as in Fig. 264. The tapping on the transformer is left free. A point to remember is to place the potentiometer as near the valves as possible and not actually across the transformer terminals.

MAINS UNIT.—See *Eliminator* and *D.C. Mains Unit*.

MARKING OUT.—The most necessary tools required for marking out as applied to wireless construction are a scribe, a pair of dividers, a centre punch, a square (a plate square is also handy), and a steel rule.

These tools are illustrated in Fig. 265 A. The scribe is one of the pocket variety, the dividers a pair of 5-in. finely pointed, the centre punch is small, that is at the pointed end, the square has a blade that is movable on the beam and is also rule marked. The small 4-in. plate square needs no comment, and if a square such as that illustrated is used, a flexible steel rule will be best, but

otherwise a stiffer rule will be necessary.

In its simplest style marking out takes the form of laying a blueprint on a baseboard and pricking the necessary holes off with a scribe. Where a blueprint can be relied upon for accuracy this method has the advantage of being direct, but where the scale of the drawing is, say, half size, all dimensions will have to be doubled, that is, of course, where the distances are being picked off the drawing. In such cases the dividers are adjusted to suit the various hole centres and measured with a rule, and the measurement increased by the number of times that the scale of the drawing is under full size, or

MARKING OUT

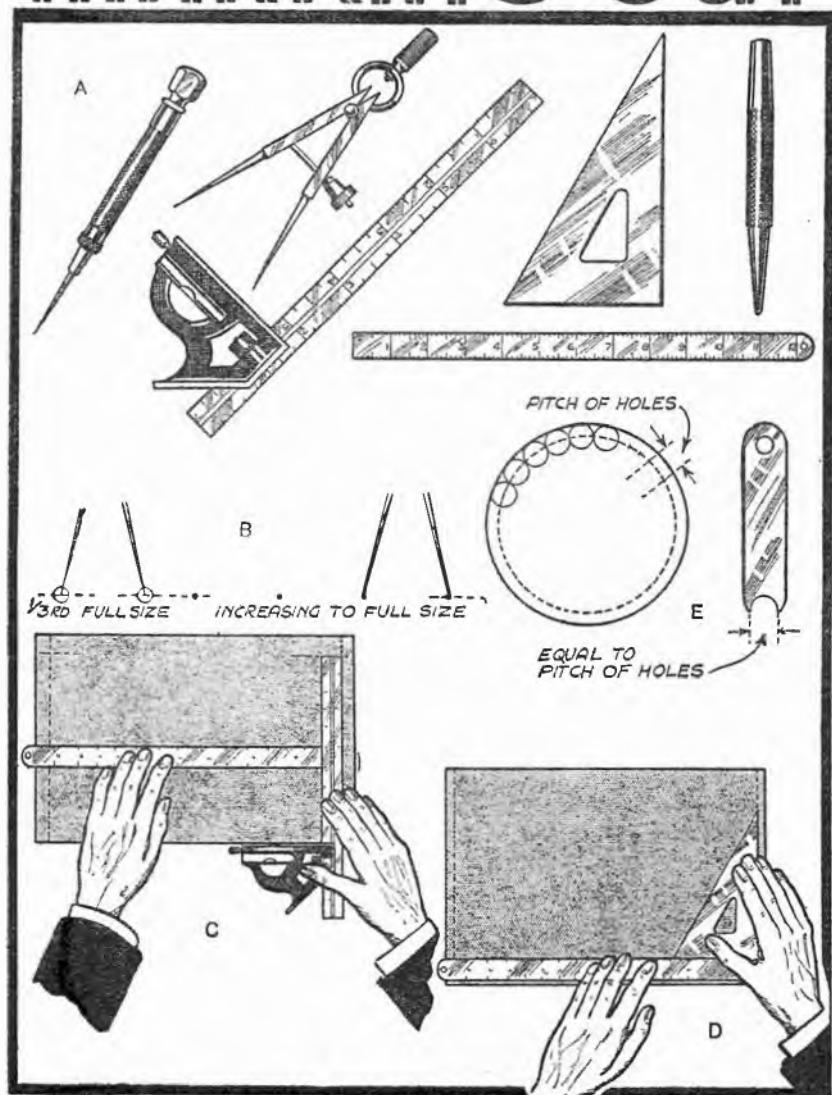


FIG. 265.—The tools used for Marking Out, and various methods of using them.

MARKING OUT — MATCHING THE SPEAKER

where practical the increase can be made as in Fig. 265 B. Thus, if the drawing was one-third full size the length between the divider points would be plotted three times.

Just a word about keeping the points of dividers in trim. They must be kept sharp and fine, and require oil stoning from time to time, but in doing so see that the points do not gradually become stubby; also see that the points are level when the dividers are shut. This condition is important for marking small circles.

Marking out squares or rectangles for baseboards or panels is carried out as follows. Either one edge of the material is prepared with a perfectly straight edge as a line to work off, or the steel rule is laid on to the material for this purpose. In the first case the blade of the square is set to the vertical height required and one end line is marked, also a line is made against the top of the blade of the square to indicate the height. The square is moved to the other end of the job and the process repeated, the distance between the lines being controlled by a rule held at the first line leaving the required amount overlapping as a gauge (see Fig. 265 C). Where the other method is adopted the set square is called into use, the rule being used as a guide for the base of the square, and also an indication is at once obtainable as to length by setting the right-angled portion of the square against the appropriate markings on the rule (Fig. 265 D).

When marking out panels for drilling, a very similar procedure can be adopted. All vertical heights can be made by adjusting the blade of the square so that only the correct amount of rule is projecting beyond the square face of the beam. All distances in the opposite direction are measured with the rule either off one edge or from a previously marked

centre line. If properly carried out a very accurate marking will result.

It remains to centre punch each hole position. The best way to do this is to make a mark with the point of the scriber at the point of intersection of two lines where a hole is located. This will make a guide for the point of the centre punch. By the way, panels, particularly if they are of ebonite, or surfaces which may be visible on the completed apparatus side, should be marked off on the inside or invisible portion when the set is assembled. For this reason it should be remembered that markings will have to be made in reverse, i.e. right-hand when viewed from the front becomes left-hand on the back side. Large holes that can be drilled direct should have an indicating circle scribed round the centre dot and will be a check on drilling after the centre dot has been removed by the point of the drill.

Large holes, such as cannot be conveniently drilled in the ordinary manner, are cut out by drilling a chain of holes. Thus, for a large circular hole, a circle of required diameter is first scribed with the dividers. Inside this a further circle is made (see Fig. 265 E).

MATCHING THE SPEAKER WITH OUTPUT VALVE.—For any given output valve there are certain limits within which the load of the speaker must fall if the full output of the valve and good-quality reproduction are to be obtained. But suppose that we have a pentode, requiring an anode load of 8,000 ohms, and a speaker the impedance of which is only 2,000 ohms. Or, again, suppose we have a valve the optimum load of which is 2,000 ohms and a moving-coil speaker of low resistance—say, 6 ohms only.

Obviously, it will not do to connect the speaker direct in the anode circuit of the valve, as its impedance is

MATCHING THE SPEAKER — METER

far too low. What must be done is to employ an output transformer, so designed that the impedance of the primary (which is connected in the anode circuit of the valve) matches the valve resistance, while the secondary is wound to match the speaker impedance. The correct ratio for such a speaker is found by dividing the optimum value of the load, as recommended by the valve-maker, by the impedance of the speaker, and extracting the square root of the answer.

It should be noted that it is the *impedance* of the speaker, and not its *resistance*, which should be used in this calculation. The majority of modern speaker manufacturers quote in their lists the actual impedance of their instruments—usually at a frequency of 1,000 cycles per second. If, however, this figure is not stated, a fairly accurate approximation can be obtained by using the resistance figure in the case of a moving-iron instrument, or one and a half times the resistance in the case of a moving-coil speaker. Here, again, the actual value of the ratio is not very critical, and it is usually quite satisfactory to take the nearest standard commercial ratio, even if this means a departure of as much as 20 or 25 per cent. from the ideal ratio as determined from the calculation.

MAXWELL.—The magnetic induction unit.

MEGA.—One million.

MEGGER.—A measuring instrument for very high resistances. The term is really an adaptation of the words Megohm-meter. It is used to ascertain the resistance of bodies which normally should have no electrical contact—such for instance as determining that the insulation between two terminals is sufficiently high.

MEGOHM.—One million ohms.

METAL-COATED VALVE.—A

valve sprayed on its outside with metal to act as a screen and avoid interaction.

METER.—An instrument for measuring. In wireless practice meters are used for measuring voltages and currents, and there are several different types of meter in general use. The most common form is known as a "moving-iron" instrument, and consists of a coil of wire inside which is mounted a piece of iron. The indicating pointer is attached to this piece of iron, and when a current is passed through the coil of wire the iron is rotated on its pivot, so causing the pointer to traverse a scale. This type of instrument can always be identified by the fact that the scale is not divided up into even divisions, but has the scale very cramped at the beginning, and then spreads out towards the maximum reading.

The other type of instrument in general use is known as a "moving-coil" instrument, and this consists of a coil of wire in the same manner as the moving-iron type, but instead of a piece of iron suspended in the centre of this coil, a further coil is utilised, and the pointer is attached to this second coil. The passage of current through the two coils causes rotation and movement of the indicating pointer in the same manner as just mentioned. The moving-coil type of instrument is very delicate, and the small moving winding has to be wound on an extremely light former in order to respond to small applications of potential. This instrument has the scale divided into equal sections. Both the moving-iron and the moving-coil instruments are invariably fitted with a small hairspring (in the same manner as the balance wheel of a watch or clock) in order to restore the indicating pointer to a zero position.

METER

In the more expensive types of instrument two hair springs are fitted, one in front and one at the rear of the moving portion in order to balance the rotation and restoring force.

The moving-iron instrument suffers from a fault which is not very easily remediable, namely, oscillation of the indicator. In other words, when the meter is joined to the circuit to be measured, the pointer swings over right past the correct point on the scale, drops back to a lower reading, swings over again, and so oscillates backwards and forwards for several seconds before coming to rest at the correct reading. This, of course, is irritating when a reading is wanted in a hurry. To overcome this defect a damper is sometimes fitted, and this generally takes the form of a fairly large "fin" to act as a kind of air brake.

The moving-coil instrument, on the other hand, moves across to the exact reading in a fairly gentle manner and consequently is known as "dead beat."

Another type of instrument often used for measuring currents is known

as the "hot wire" meter. This consists of a thin piece of wire firmly attached at one end, its other extremity being attached to a weak spring. The pointer is attached at the junction of spring and wire, and is pivoted just above this junction point. When a current is passed through the wire it heats up and expands, the spring taking up the slack. This pulls the end of the pointer, and by reason of the pivot just above, causes the other end of the pointer to make a radial movement.

A suitable scale enables the degree of expansion—or in other words, the applied current—to be measured. The thermo-coupled type of instrument is not in general use, but is often used in laboratories. In this type of meter two dissimilar metals are attached to each other, and these have different coefficients of expansion and contraction. Arranged near the point of juncture is a heating element, and upon the passage of a current this gets hot and transmits its heat to the junction of the metals. Owing to the variations in

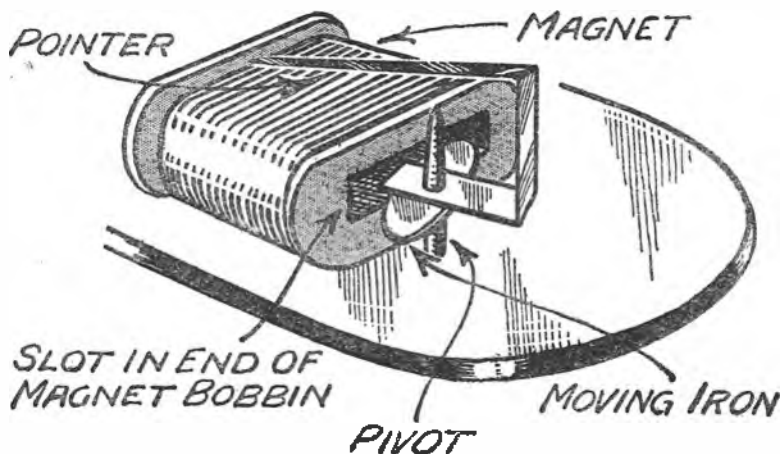
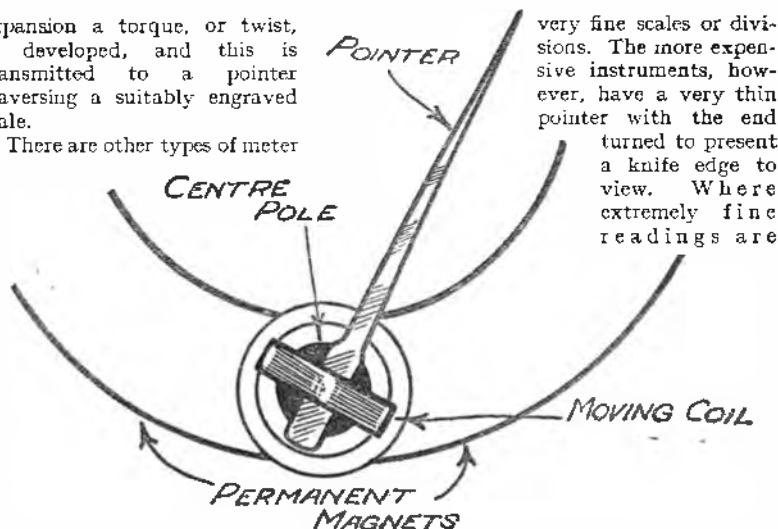


FIG. 266.—A cheap Moving-iron Movement. The top plate carrying bearing for pivot has been removed to enable the movement to be shown.

METER

expansion a torque, or twist, is developed, and this is transmitted to a pointer traversing a suitably engraved scale.

There are other types of meter



very fine scales or divisions. The more expensive instruments, however, have a very thin pointer with the end turned to present a knife edge to view. Where extremely fine readings are

FIG. 267.—A Moving-coil Instrument with the hair spring and bearings, etc., removed to show assembly details.

which are more or less experimental—but those described above are the types in general use.

For measuring a voltage (or pressure) the meter has to be joined in parallel with the source to be measured, whilst to measure a current (or flow) the meter has to be in series.

All types of meter may be made to indicate a reading higher than that shown on the scale supplied with the meter by shunting (or connecting in parallel) a resistance across the two terminals of the instrument. By suitably choosing the value of the resistance the scale on the instrument may be made to read double, treble, or even in multiples of ten. The pointers of cheap meters are rather thick, and therefore prevent accurate readings of

necessary, and the indicating scale is divided into very fine divisions, a portion of the scale is made of polished metal, or in some cases a mirror is used, and the true reading of the pointer is obtained when the knife edge and its reflection are

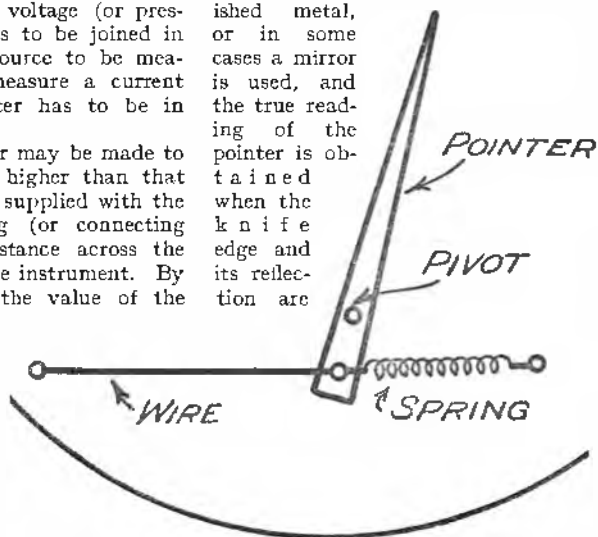


FIG. 268.—Elements of a hot-wire instrument. View showing Spring, Bearing and method of making connection.

METERBRIDGE — METERS, USING

in line. (See also *Voltmeter*, *Milliammeter*, *Ammeter*.)

METERBRIDGE.—A particular style of Wheatstone Bridge, in which ohms are substituted by units of length.

METERS, USING.—To obtain the maximum efficiency of quality and volume from the receiving set it is

to leads to connections, switches, etc.

The two most commonly used meters in wireless are the voltmeter, obviously for measuring volts, and the ammeter, which measures amperes. With these two instruments it is quite possible to see distortion in a set, although perhaps even the human ear does not detect it.

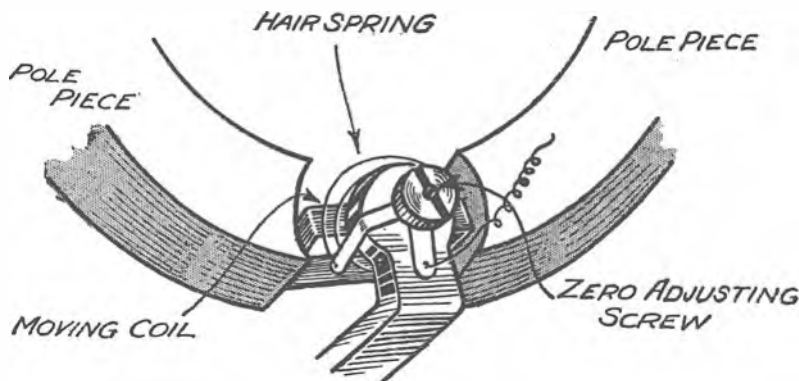


FIG. 269.—Perspective view of the active elements of a moving-coil instrument.

necessary to apply the correct voltages on the filament, anode, and grid of the valves. Some means of checking these various voltages are essential, and for this reason accurate measuring instruments are indispensable.

The valve makers supply with each new valve curves which definitely state the best voltage that should be applied to it, and users should endeavour to keep to these values both from an economical point of view and also to obtain the best results. Incorrect grid bias, for instance, will cause distortion, and if not sufficiently high will put a very heavy drain on the high-tension battery. It must first be understood that all meter tests should be made under load, that is to say, when the set is working, so as to allow for the potential drop in the current due

Choosing Meters. The greatest care must be taken in choosing measuring instruments, for some of the cheaper grades require more watts to deflect the needle over the dial than the whole current consumption of the set. The most expensive meters take the least current to operate them; it is for this reason, therefore, that a good voltmeter must have a very high resistance, it may be as much as 1,000 ohms per volt, and the current taken would be only 1 milliamperes, the best type being the moving-coil pattern. This type operates on the principle of a wound coil moving in the field of a permanent magnet. It is only suitable for use on direct-current circuits, and being of the polarised type the leads must be connected up in the correct manner to deflect the needle of the instrument across the dial in

METERS, USING

the right direction. If the leads are changed and connected the wrong way round then the needle swings over in the opposite direction; although a meter will often stand current in the reverse direction, it may possibly damage the needle by causing it to hit the reverse stop very hard, thus putting a strain on some of the mechanism. Accurate meters are generally fitted with an adjustment which will return the needle to zero, thus enabling it to be brought

pointer moves for thousandths of an ampere, or as it is known, milliamperes. In Fig. 271 is shown a milliammeter connected in the anode circuit of a valve, and in Fig. 272 is given the position of the meter when reading the whole consumption of the set in milliamps. The meter should be joined in series with the negative high-tension lead.

When a milliammeter is joined in the anode circuit of the power valve, as in Fig. 271, it is possible and very

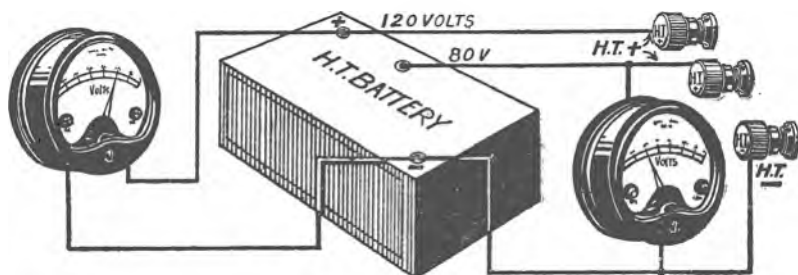


FIG. 270.—Voltmeters for checking different values of high tension.

to exactly 0 on the scale before the instrument is used.

Voltmeters. Voltmeters can be obtained in various voltage ranges, and also there are those on the market which cover several readings, enabling voltages to be taken of, say, 0 to 10 volts L.T. and 0 to 200 volts H.T. The lower readings are suitable for testing filament voltages and low-tension battery voltages when the set is working. In Fig. 270 are shown the correct positions for the voltmeter for checking different values of high tension, and for testing the condition of the high-tension battery. The voltmeter, it should be noted, is in parallel with the battery.

Milliammeters. The anode current taken by the valves in a set is so small that it is very seldom that an ammeter is used. To measure these minute currents a milliammeter is used, which is so arranged that its

interesting to test for correct values of H.T. and grid bias, also to see the movement of the needle when the latter is incorrect. The G.B. should be adjusted to that stated by the makers of the valve and the set switched on, it being tuned to a station giving a medium amount of volume. If the biasing is correct the needle will remain steady, and the reading on the dial should be noted. Switch off the set and reduce the bias a little. Switch on again, and it will be observed that not only will the needle no longer be steady, but the current from the H.T. battery will have increased, thus indicating that distortion is occurring, and, as before stated, H.T. current is being used wastefully.

If the same operation is gone through, but this time increasing the bias on the valve, it will be seen that the needle of the meter tends to kick

METERS, USING

upwards on strong signals, at the same time the anode current from the battery will decrease, coupled of course with distortion. This goes

assumed that the valve is overloaded, that is to say, that the input to the set is rather greater than the valve can handle. If the power valve is

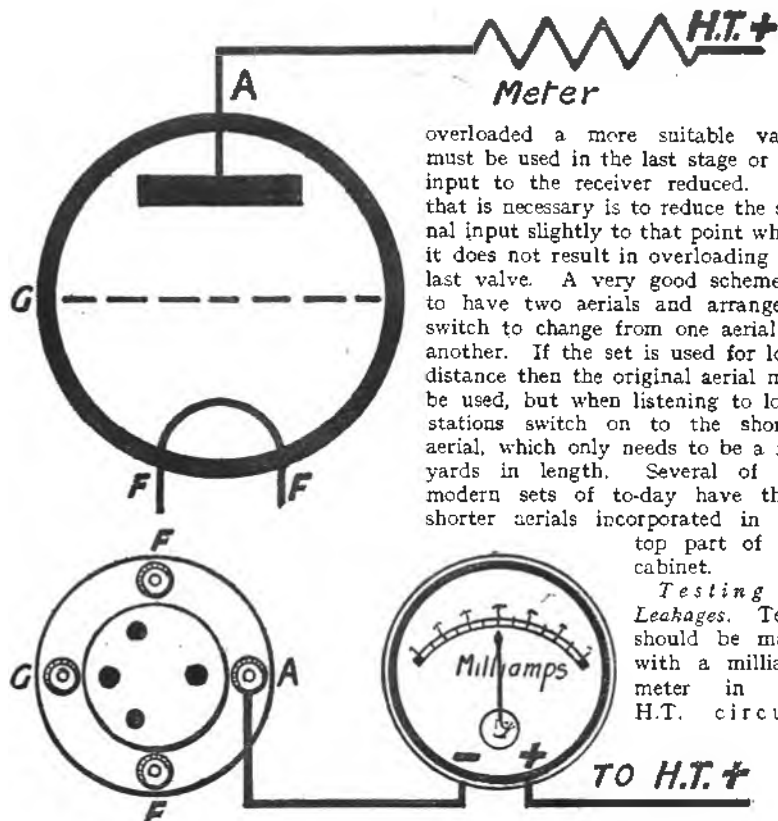


FIG. 271.—A Milliammeter connected in the Anode Circuit of a Valve to determine its consumption.

to point out that nothing is to be gained by having any but the correct high-tension value on the valve, and that upward kicks of the anode current indicate that the G.B. is too great and downward kicks that it is too small. When the needle of the milliammeter kicks both up and down the dial, and no alteration of the grid bias will correct it, it can be

when the set is not switched on to see if there are any slight leakages through bad insulation or other causes which would put a continuous load on the battery and considerably shorten its life.

Sockets for Meters. It is possible to fit on the panel or on the side of the cabinet sockets, wired from the set internally, enabling plugs at-

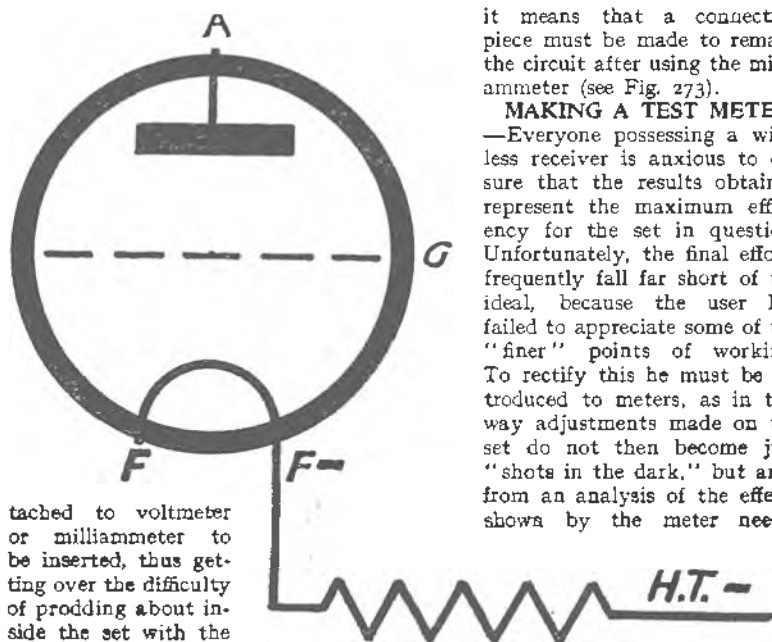


FIG. 271 A.—Theoretical diagram of the arrangement shown pictorially in Fig. 272.

tached to voltmeter or milliammeter to be inserted, thus getting over the difficulty of prodding about inside the set with the meter leads. In Fig. 273 is shown the method of fitting these sockets; the plugs are merely banana pins taken from old valve bases and soldered on to the leads which are wired to the instruments. As a milliammeter has to be inserted in series, that is to say, the circuit has to be broken and the meter inserted into the two leads,

movement when measuring the variable quantities. Any aids to achieve this end more than repay the trouble in making, and the unit here described is really quite straightforward.

In Fig. 274 is shown the theoretical circuit. Since the unit in the main

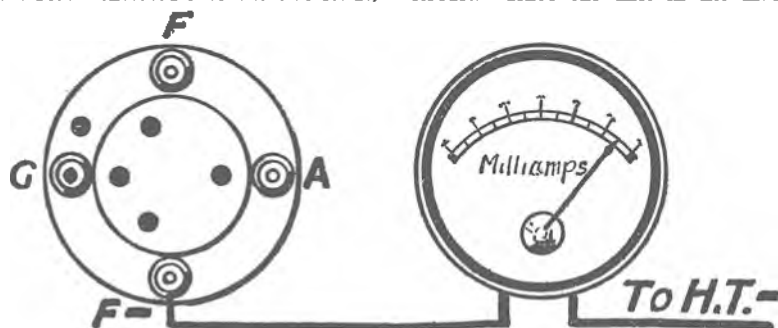


FIG. 272.—Reading the Anode Consumption of the Set in Milliamps.

MAKING A TEST METER

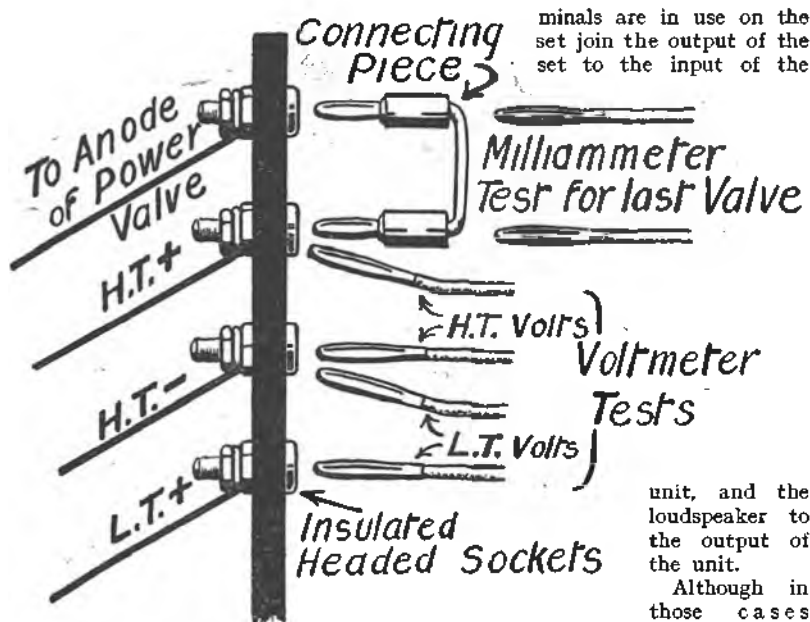


FIG. 273.—Fitting Sockets on the Panel enabling the milliammeter and voltmeter tests to be made from the exterior of the set.

will be employed between the output circuit of the wireless receiver and the input to the loudspeaker, not only are there input and output terminals, but a plug and jack have been incorporated also. In the case of the latter it is necessary with this unit merely to remove the loudspeaker plug from the jack in the set, place it in the jack of the unit, and finally insert the unit's plug into the set. This will interpose automatically the milliammeter in the output circuit, and its variations can be noted and

adjustments made according to the information which will be given in succeeding paragraphs. When ter-

minals are in use on the set join the output of the set to the input of the

unit, and the loudspeaker to the output of the unit.

Although in those cases where the loudspeaker is directly in the output plate

circuit it is regarded as conventional to join the long spring of the output jack to H.T. + and the short spring to the valve plate, and correspondingly the ball of the plug to

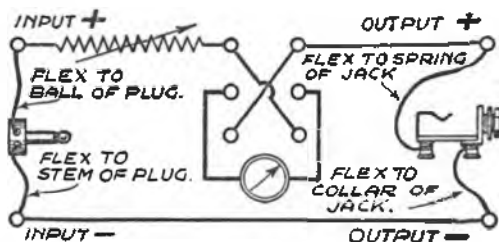


FIG. 274.—The Theoretical Circuit.

L.S. + and the stem of the plug to L.S. -, there are cases where this scheme is not followed.



FIG. 275.—An all-in-one instrument.



FIG. 276.—A Voltmeter.

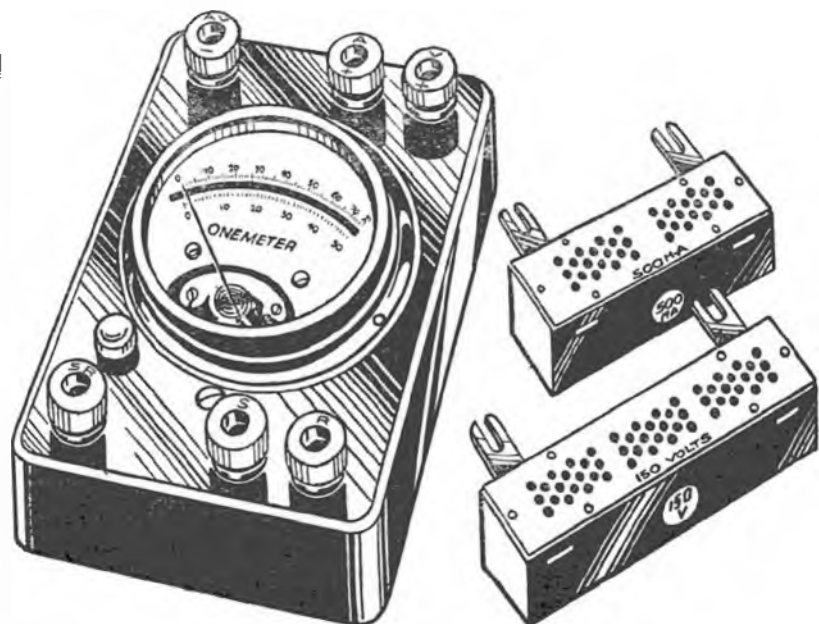


FIG. 277.—Another type of all-in meter.

MAKING A TEST METER

To allow for this, a double-pole double-throw change-over switch has been included, so that a positive reading of the instrument is ensured, irrespective of the type of connections.

In addition, a variable resistance has been incorporated, and this is used in conjunction with the milliam-

"quality" products, and ensure that they will fit in the space available. One ebonite panel, $6 \times 6 \times \frac{1}{4}$ in.; one sloping-deck type oak cabinet to take above panel; one 0-30 milliamp. range moving-coil milliammeter; one double-pole double-throw rotary switch; one single-pole double-throw rotary switch; one variable resistance (flat wire-wound type), 5,000 ohms resistance; four insulated terminals (engraved), marked output +, output -, input +, and input -; one single circuit jack with terminals; one embossed telephone plug; four cabinet corner cushions and mount-

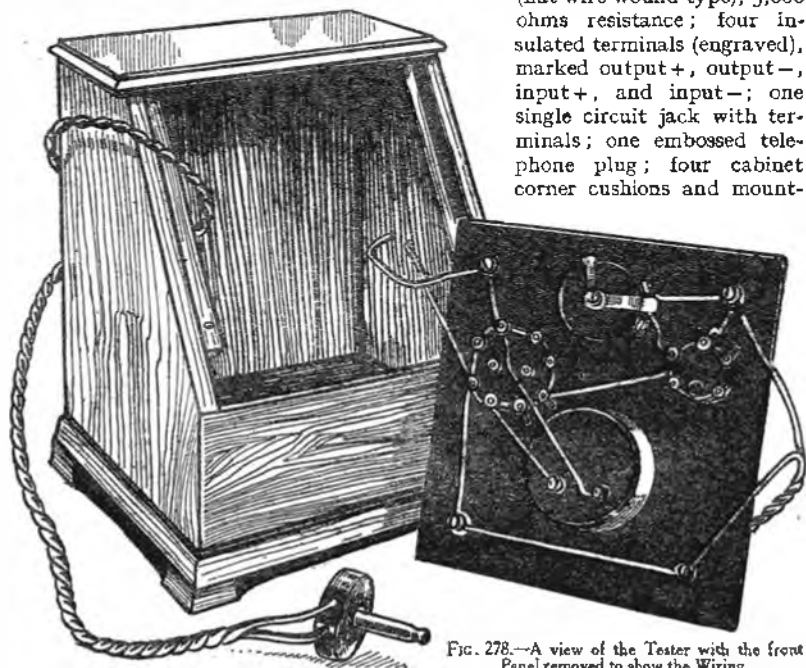


FIG. 278.—A view of the Tester with the front Panel removed to show the Wiring.

meter in a manner to be described later.

To meet those contingencies where the resistance is not required, however, a switch is shunted across the resistance so that it may be short circuited.

The Components Necessary. A list of the components required for making up the unit is given herewith. Alternatives can be chosen in lieu of those specified, provided the usual precautions are taken to choose

ings; small quantity of insulated connecting wire, and 3 ft. of red and black flex.

The construction of the unit should be quite a simple matter, even for the novice. Fig. 279 will serve as the panel-drilling diagram, it being important to remember that all of the holes must be symmetrically arranged. Do not forget to mark out on the back of the panel, so as not to damage the polished face; but owing to complete symmetry in lay-

MAKING A TEST METER

out no difficulty will arise at this juncture.

Just allow clearance holes for each component, and fix the four terminals, two switches, variable resistance, and meter in place. Figs. 278

is mounted directly on to the right-hand side of the oak cabinet. Two flexible leads then join the output + and output - terminals with the jack, as shown in the illustrations and diagram. Also the red and black

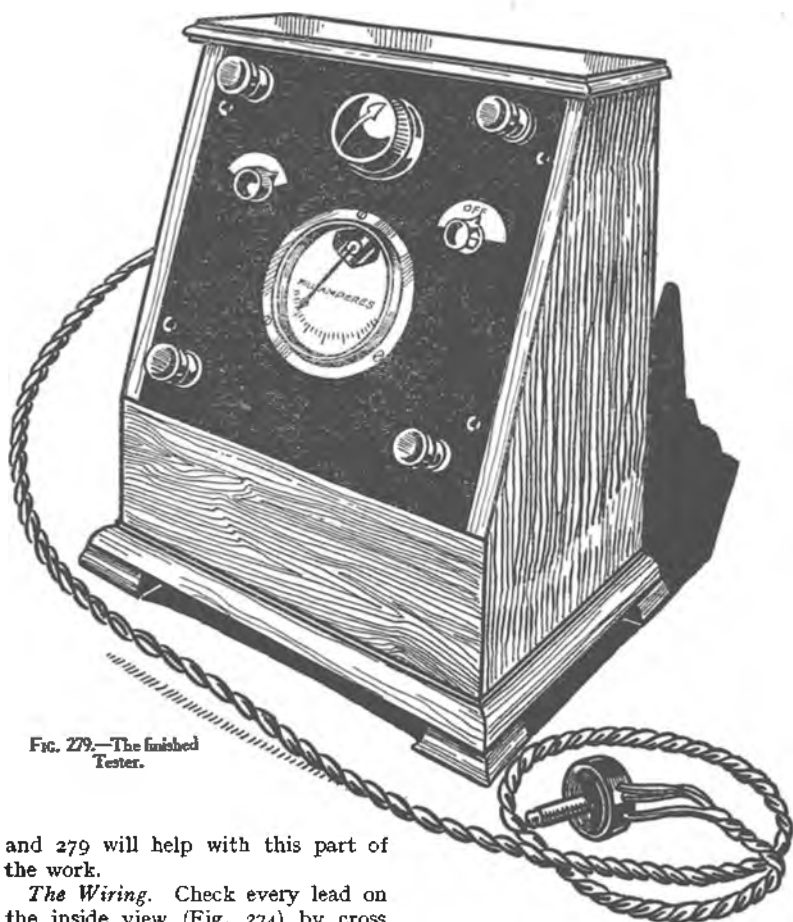


FIG. 279.—The finished Tester.

and 279 will help with this part of the work.

The Wiring. Check every lead on the inside view (Fig. 274) by cross hatching with light pencil strokes the lines shown in the illustration, and then the unit will not fail to function owing to the omission of a necessary link.

You will notice that the small jack

flexible lead which terminates in the plug has its free ends passed through the left-hand side of the cabinet, and is connected to the input + and input - terminals. This completes the construction of the unit, and the

MAKING A TEST METER

panel can be screwed into place in the cabinet.

To join up the unit to the receiver, assuming that the loudspeaker is connected directly in the plate circuit of the output valve, it is necessary only to remove the speaker and join it to the unit's output terminals (or in the jack). Then connect the input terminals (or the plug) of the unit to the vacant loudspeaker terminals on the set, and "short circuit" the variable resistance so that true current flow can be registered.

Provided the L.T. and H.T. sources are quite satisfactory (this is where a voltmeter of dual range is so valuable) under normal circumstances when signals are *not* being received, the needle of the meter will take up a steady reading, the actual milliamps flowing through the instrument being dependent upon the valve employed and its associated filament, H.T. and G.B. voltages. With the reception of signals, however, the plate current naturally varies, and if the variations are symmetrical about the mean value initially registered, then the needle will remain stationary, its inertia preventing it from following the rapid current alterations, and distortionless reception is taking place. Should there be any needle "kicks," then you are departing from distortionless reception, and alterations and adjustments are called for.

Overloading the Last Valve. If the needle movements are violent, and in any one particular direction, the cause is probably an overloading of the last valve, and two alternatives are open for curing the evil. Either cut down the input to a lower value, or replace the valve with one capable of handling the full grid voltage swing. Of course, there is a possibility that the valve has developed a deficiency, such as loss of emission, but even so, a replacement will be

necessary, and this falls within the second category.

Should the needle kick upwards violently and persistently there is probably too much grid bias, and it is necessary either to reduce the value applied or, alternatively, increase the H.T. voltage. Providing there is no overloading, either of these palliatives will cause the needle to cease kicking. On the other hand, if there is a tendency for the needle to kick downwards from its mean position, there is insufficient grid bias, and the cure is obvious. Make a point of adjusting both H.T. and G.B. values so that there is a minimum current flowing consistent with an absence of needle kick, as the drain on the H.T. source is thereby reduced.

It will be seen, therefore, that the meter connected in the anode circuit of the output valve in the manner described is a very faithful guide to correct operating conditions. In addition, however, there are several other uses for a piece of apparatus of this character.

Other Uses for the Unit. For these additional purposes, it is necessary to bear in mind that connections to the milliammeter itself are provided by the output + and input + terminals, the resistance being short circuited if accurate current readings are to be determined or, alternatively, left in circuit if the instrument is merely to be employed as a current-flow indicator.

Under these circumstances, the milliamp. consumption of individual valves can be ascertained merely by joining up the meter in series with the H.T. lead passing to each valve and noting the reading. If a "break" in a circuit or component winding is suspected, then the meter will prove or disprove the suspicions.

With the resistance switch open circuited, join one end of a 2-volt battery (or higher voltage according

THE METRIC SYSTEM

to the resistance of the circuit under test) to input +, and then the free ends of individual wires joined respectively to the other end of the battery and output+ become the "test leads."

If a current flow is indicated by the needle movement, then there is continuity in the circuit, but if the needle refuses to move, a "break" is present. When carrying out these tests always start with all the variable resistance in circuit so as to protect the meter against too high a current flow. Then, if desired, the resistance value can be reduced to give a good needle movement for observation purposes.

THE METRIC SYSTEM.—In the metric system all multiples and sub-multiples are decimal, and multiples are expressed by Greek prefixes and sub-multiples by Latin prefixes.

List of Prefixes

mega means a million times.
kilo means a thousand times.
hecto means a hundred times.
deka means ten times.
deci means a tenth part of.
centi means a hundredth part of.
milli means a thousandth part of.
micro means a millionth part of.

Square Measure

100 sq. metres = 1 are.
10,000 sq. metres = 1 hectare.

Weight

10 grammes = 1 decagramme.
10 decagrammes = 1 hectogramme.
10 hectogrammes = 1 kilogramme.
1,000 kilogrammes = 1 tonne.

Capacity

1 litre = 1 cubic decimetre.
10 litres = 1 decalitre.
10 decalitres = 1 hectolitre.
10 hectolitres = 1 kilolitre.
10 millimetres = 1 centimetre.
10 centimetres = 1 decimetre.
10 decimetres = 1 metre.

10 metres = 1 decametre.
10 decametres = 1 hectometre.
10 hectometres = 1 kilometre.
10 kilometres = 1 myriametre.

Linear Measure

1 inch = 2.54 centimetres, or
25.4 millimetres.
1 foot = 30.4799 centimetres,
304.799 millimetres, or 30.47
metre.
1 yard = 914.399 metre.
1 mile = 1.6093 kilometres =
5,280 feet.
1 millimetre = .0937 inch.
1 centimetre = .3937 inch.
1 metre = 39.370113 inches.
3.28084 feet.
1.093614 yards.
1 kilometre = 62137 mile.
1 decimetre = 3.937 inches.
1 decametre
(10 metres) = 10.936 yards.

METRIC CONVERSION FACTORS

To convert—

Millimetres to inches	×	0.3937 or ÷ 25.4
Centimetres to inches	×	0.3937 or ÷ 2.54
Metres to inches	×	39.37
Metres to feet	×	3.281
Metres to yards	×	1.094
Metres per second to feet per minute	×	197
Kilometres to miles	×	0.6214 or ÷ 1.6093
Kilometres to feet	×	3,280.8693
Square millimetres to square inches	×	0.00155 or ÷ 645.1
Square centimetres to square inches	×	0.155 or ÷ 6.451
Square metres to square feet	×	10.764
Square metres to square yards	×	1.2
Square kilometres to acres	×	247.1
Hectares to acres	×	2.471
Cubic centimetres to cubic inches	×	0.6 or ÷ 16.583
Cubic metres to cubic feet	×	35.315
Cubic metres to cubic yards	×	1.358
Cubic metres to gallons (231 cubic inches)	×	264.2
Litres to cubic inches	×	61.022
Litres to gallons	×	0.2642 or ÷ 3.78
Litres to cubic feet	×	0.035316
Hectolitres to cubic feet	×	3.531
Hectolitres to bushels (2,150.42 cubic inches)	×	2.84
Hectolitres to cubic yards	×	1.31
Hectolitres to gallons	×	26.42

(Continued on next page)

MFDS. — MILLIAMMETER

Grammes to ounces (avoirdupois) . . .	$\times .035$ or $\div 28.35$
Grammes per cubic cm. to lb. per cubic inch . .	$\div 27.7$
Joules to foot-lb. . .	$\times .7373$
Kilogrammes to oz. . .	$\times 35.3$
Kilogrammes to lb. . .	$\times 2.2046$
Kilogrammes to tons . .	$\times .001$
Kilogrammes per sq. cm. to lb. per sq. inch . .	$\times 14.223$
Kilogramme-metres to foot-lb. . .	$\times 7.233$
Kilogramme per metre to lb. per foot . .	$\times .672$
Kilogramme per cubic metre to lb. per cubic foot . .	$\times .062$
Kilogramme per cheval to lb. per h.p. . .	$\times 2.235$
Kilowatts to h.p. . .	$\times 1.34$
Watts to h.p. . .	$\div 746$
Watts to foot-lb. per second . .	$\times .7373$
Cheval vapeur to h.p. . .	$\times .9863$
Gallons of water to lb. .	$\times 10$
Atmospheres to lb. per sq. inch . .	$\times 14.7$

MFDS.—Micro-farads. (See also *Micro-farad.*)

MHO.—The unit of conductivity (the word *ohm* reversed). Equal to

$$\frac{1}{\text{ohms resistance.}}$$

The reciprocal of resistance.

MHYS.—Microhenries.

MICRO.—One-millionth.

MICROAMPERE. — One-millionth of an ampere.

MICRO-FARAD.—One-millionth of a farad.

MICROHM.—One-millionth of an ohm.

MICROPHONE.—A device for converting into electrical currents sounds which are produced in its proximity. A simple microphone consists of an electro-magnet with a soft iron disc arranged at the end of the pole piece. A very small space separates the pole face from the disc, and if a word be spoken close to the disc, or diaphragm as it is called, the diaphragm will vibrate, and by so doing will vary the magnetic field. This will give rise to variations in the

electric currents, and so may be conveyed over a distance to be reproduced by a similar arrangement. Another form of microphone consists of a block of carbon, with a number of carbon granules packed moderately closely in a small space in front of the carbon block. The vibration of the granules due to speech sounds, etc., will vary the density of the packing, and therefore will vary the resistance of the circuit in which these granules are included. The microphone used for broadcasting consists of a solid block of marble (to avoid the effect of extraneous sounds) and very fine carbon granules. One form of microphone employs a coil of wire suspended in an electro-magnetic field; another form utilises two plates separated by air, and this is included in circuit in the form of a condenser, and hence gets its name "condenser microphone."

MILLIAMMETER.—An instrument for measuring current in milliamps. The name is derived from the two words **MILLIAMP** and **METER**—a measurer of milliamps. This instrument is probably the most important type of instrument which is used in wireless practice. It provides the only certain way of ascertaining whether valves are in good condition; whether they are working in a receiver in the correct manner; whether distortion or overloading is taking place; the drain on a H.T. battery, and many other features which the real wireless man must know if he wishes to thoroughly understand his receiver. A milliammeter inserted in the anode circuit of a valve (that is, between the H.T. positive source and the component in the anode circuit, whether transformer primary, anode resistance, loudspeaker, telephones, etc.) will show the total anode current of the valve. If the correct voltage is applied and the current is higher than that which the makers state is the

MILLIAMMETER — MUSICAL NOTES FREQUENCY

normal value, it points to the fact that the grid-bias battery is not up to standard.

In theory, the needle of the milliammeter should remain perfectly stationary whilst music is being received. If the needle kicks in an upward direction—that is to a value above the normal reading given when no signals are being received—it shows that the grid bias which is being applied is higher than is required by the valve. If the needle kicks in a downward direction the indication is that insufficient bias is being applied. Should the needle oscillate backwards and forwards an equal amount each side of the normal reading, then the valve is being overloaded, and a larger valve (or more H.T.) must be used. Connecting the meter in the H.T. negative lead will indicate the total current consumption of the set, and enable you to ascertain whether or not the correct capacity H.T. battery is being used. To run the receiver in an economical manner the capacity of the H.T. battery should be well above the total consumption of the set, that is to say, if the total current shown on the meter is 10 milliamps., it is advisable to use a battery rated to give a discharge of 15 milliamps. A milliammeter has to be joined in series with the source to be measured. (See also *Meter*.)

MILLIAMPER.—A thousandth part of an ampere.

M.M.F.—Abbreviation for micro-micro-farad—one-millionth part of a micro-farad.

MODULATION.—A process of varying the frequency of a circuit by introducing the frequencies of the matter being transmitted.

MOLECULE.—A group of atoms in chemical union.

MOLYBDENITE.—See *Crystals*.

THE MORSE CODE.—The Morse

code (named after Samuel Morse) is as follows:

A . -	J . - - -	S . . .
B - . . .	K - - -	T -
C - . . .	L - . . .	U - -
D - . .	M - -	V . . .
E .	N -	W - -
F . . .	O - - -	X - - -
G - -	P - . .	Y - - -
H . . .	Q - - -	Z - - -
I . .	R - -	

MORSE DRILLS.—See *Drills*.

MOTOR BOATING.—The term applied to low-frequency oscillation.

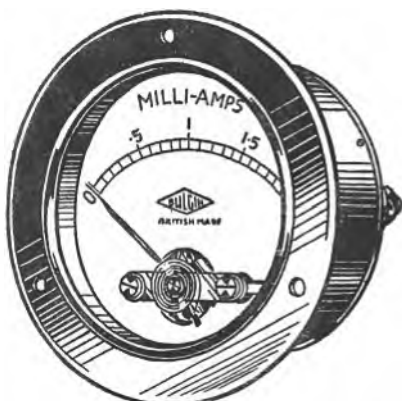


FIG. 280.—A Milliammeter.

This form of instability results in popping noises, which are of regular period, and hence sound like the exhaust of a motor cycle or motor boat—hence the name. The cure for this form of instability is to decouple the anode circuits. (See also *Decoupling*.)

MOVING-COIL SPEAKER.—See *Loudspeaker*.

MUSICAL NOTES FREQUENCY.—The frequency of the notes of the pianoforte covers the band from 26 to 4,096 vibrations per second. The lowest note, A, has a frequency of 26, middle C (the centre note of the

MUSICAL NOTES FREQUENCY — NEUTRODYNE CIRCUIT

standard piano keyboard) a frequency of 256, and the top note of the standard piano has a frequency of 4,096. The following table shows the piano notes and their frequencies:

A	26	F	341
B	30	G	384
C	32	A	426
D	36	B	480
E	40	C	512
F	42	D	576
G	48	E	640
A	53	F	682
B	60	G	768
C	64	A	853
D	72	B	960
E	80	C	1,024
F	85	D	1,152
G	96	E	1,280
A	106	F	1,365
B	120	G	1,536
C	128	A	1,706
D	144	B	1,920
E	160	C	2,048
F	170	D	2,304
G	192	E	2,560
A	213	F	2,730
B	240	G	3,072
C	256	A	3,413
D	288	B	3,840
E	320	C	4,096

MUTUAL CONDUCTANCE.—The relation of anode current change per volt grid-potential change. Another term for this is "Slope." (See also *Characteristic Curves*.)

MUTUAL INDUCTANCE.—The result of coupling together two inductances so that a change in the current in one winding produces an E.M.F. in the other. When this occurs the circuits are said to possess mutual conductance.

N

NATURAL FREQUENCY.—The natural frequency of a circuit is the frequency with which it oscillates when no external electromotive force is applied.

NATURAL WAVELENGTH. —

The wavelength of an aerial which is connected directly to earth (100-ft. aerial = 120 metres).

NEON TUBE.—A glass vessel filled with the inert gas known as neon, and fitted with electrodes at each end. When a high potential is applied to the electrodes the gas glows with a yellowish red glow. The well-known advertising signs employ tubes filled with neon, and it is the neon lamp which makes visible the images received by a television set.

NEUTRALISING CIRCUITS. —

See *Neutrodyne Circuit*.

NEUTRALISING CONDENSER.

See *Neutrodyne Circuit*.

NEUTRODYNE CIRCUIT.—The whole secret of obtaining successful H.F. amplification is the prevention of "feed-back" from the plate circuit of the H.F. valve to its grid circuit. In the modern S.G. scheme this is achieved by very complete screening, not only between external circuits, but between the actual electrodes in the valve itself. With an ordinary three-electrode valve the outside screening may be arranged in just the same way, but, obviously, a certain amount of "feed-back" will take place in the valve itself.

The well-known Hazeltine "neutrodyne" circuit very ingeniously got round this difficulty by arranging that energy should be intentionally fed back from the anode circuit to the grid circuit in such a way as to cancel out the amount of unwanted feed-back. This was done by extending the anode coil; the H.T. was tapped on to the centre of the tuned circuit so that both ends of the coil were "live" and at opposite phase. From the end remote from the plate a very small adjustable condenser was used to couple back directly on to the grid of the same valve (see Fig. 281). When the value of this con-

NEUTRODYNE CIRCUIT

denser was exactly right, the circuit was perfectly stable—an unheard-of state in those days. A really high amount of amplification could be obtained, and the only drawback was the fact that very complete screening was necessary—although it always is—and that the actual “neutralising” process—the adjustment of the condenser—was often rather tricky to the unskilled hand.

It is well known that a screened-grid valve will overload very easily, and that the signal, straight off the aerial, from a nearby broadcasting station is quite capable of exceeding the legitimate grid swing. In cases where people want a receiver with rather better distance-getting properties than the conventional “detector

and two L.F.,” and happen to be situated so near a broadcasting station that a screened-grid valve in the first stage will overload, the neutralised triode forms an excellent substitute for the S.G.

The circuit arrangement shown in Fig. 281 should provide no difficulties, if the anode coil is mounted at right angles to the grid (aerial) coil, and on the opposite side of the screen. A complete suggested layout is shown in Fig. 282.

A general-purpose type of valve—a “HL”—or a “H” type will suit the purpose admirably. If one is very near the local the “HL” is preferable. It should be remembered in such a case, however, that the detector now stands in danger of be-

ing overloaded, and that it may be necessary to use a “first L.F.” type or even a power valve for that purpose.

The Process of Neutralising. Little need be said about operation except for a description of the actual process of neutralising. Without trying to find the correct position, tune the set to the local, bringing it up to maximum volume.

Now remove one filament lead from the terminal on the H.F. valve holder. Leave the valve in position,

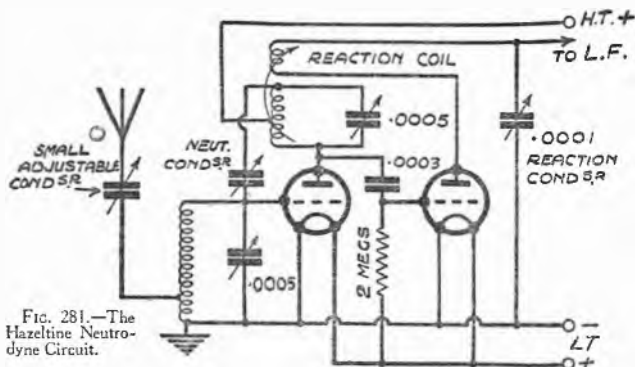


FIG. 281.—The Hazeltine Neutrodyne Circuit.

of course, but with its filament switched off. The local will probably be heard at quite good strength if the neutralising condenser is either “all in” or “all out.” Adjust the neutralising condenser until the signal from the local disappears altogether. Having obtained it, move the tuning condensers slightly to make sure that it does not come in again. If it does, readjust the neutralising condenser.

When the ideal state of affairs has been found, the filament of the H.F. valve should be switched on again, and the set should operate in a stable condition. It should be possible to make it oscillate by means of the usual detector reaction condenser; but when it does so, it should

NICKEL-IRON-ALKALINE BATTERIES

only be the detector that oscillates.

Remember that the true setting of the neutralising condenser depends upon the grid-plate capacity of the actual H.F. valve in use; this implies that if a different valve is used the whole process will probably have to be gone through again.

tion. The temperature of the solution is an important factor, and should be kept within similar limits to that of the lead-acid type. Acid must not be allowed on or in an alkaline cell, and considerable damage will result if this is permitted. Hydrometer tests are useful in deter-

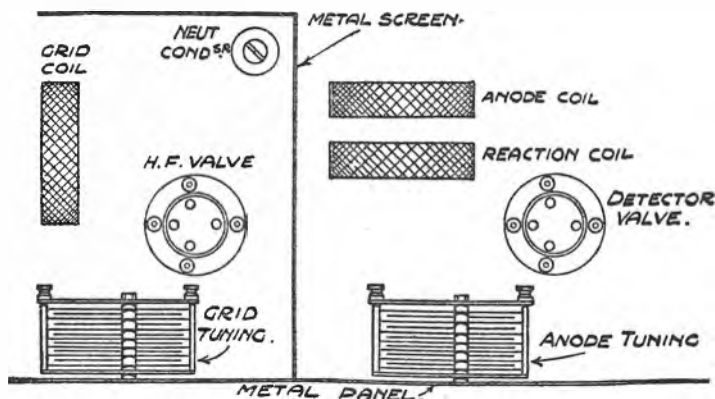


FIG. 282.—Suggested Layout for the Circuit shown in Fig. 281.

Tuning should be found to be very straightforward, and simply a matter of keeping the two controls "in step" with each other.

NICKEL-IRON-ALKALINE BATTERIES.—The nickel-iron-alkaline battery as used for lighting and starting purposes on commercial vehicles is capable of withstanding a considerable amount of neglect and rough usage. The state of charge when the cells are stored is not of very great importance, but the best conditions are maintained if the cells are fully charged and then half discharged before storing. The electrolyte consists of a solution of potassium hydrate in distilled water, and is supplied at the correct density by the battery manufacturer. The specific gravity does not alter with the state of charge, and gassing is not an indication of full charge.

Temperature of the Alkaline Solu-

tion. mining whether a change of electrolyte is desirable. These tests should not be taken during a charge, nor after adding distilled water for topping up until a further charge. The temperature of the solution should be noted, and corrections made to obtain the density readings at 60° F. The correction constant is .00025 for each 10° F. variation, and this amount should be added to the density readings for temperatures above 60° F., and subtracted for temperatures below that value. The normal specific gravity of the solution used in Ni-Fe cells is 1.190. This density will gradually decrease during the charge and discharge operations over a period of about twelve months, until a specific gravity of 1.170 is reached. At this point the battery will have lost its efficiency, and the electrolyte should be emptied out and renewed.

The normal density of the solution as used in Edison storage cells is 1.200, and when this decreases to 1.160 it should be renewed. Alkaline cells must not be allowed to stand empty. Glass or enamel ware should be used for filling purposes, and vessels previously used for acids must not be allowed to come in contact with the solution.

Defective vent plugs may cause excessive swelling of the steel cell cases, and the plugs should be tested periodically to ensure that efficient ventilation is maintained.

Charging Voltage of Alkaline Cells. The charging voltage of alkaline cells commences at 1.4 volts and rises to 1.8 volts per cell, so that it is necessary for the charging voltage of the D.C. supply to be not less than 1.85 times the number of cells charged in series. The first charge must be at the normal current for double the

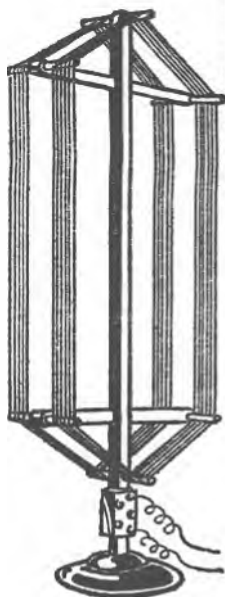


FIG. 283.—A dual-range Frame Aerial.

normal period. On discharge, the voltage of this type of cell should not be allowed to drop below 1.0 volt per cell. When the cells are charged the cases are electrified, and short circuits will occur if contact is made between them by metal spanners used for tightening terminals or for other purposes, and extensive damage may

result. The same types of charging equipment described for acid cells can be suitably applied for charging alkaline cells. (See also *Accumulator*.)

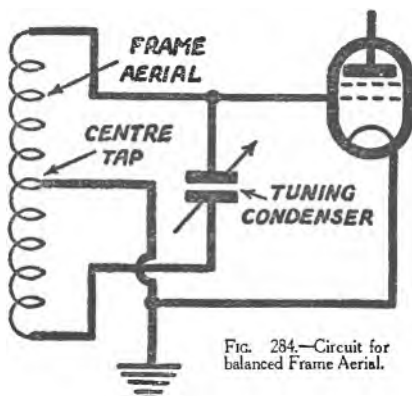


FIG. 284.—Circuit for balanced Frame Aerial.

NOCTOVISION.—A process of television, where the object is scanned by infra-red rays. By this means, the object to be televised may be in darkness, but owing to the action of the infra-red ray the television transmitter will receive impulses from the scanned object, and they may thus be transmitted in the same way as when they are placed in bright light. The received image bears all the light and shade of the ordinary method, and it is difficult to tell that the original object is in darkness. (See also *Television*.)

NODE.—A point of zero current or potential in an oscillatory circuit.

NODON VALVE.—See *Accumulator*.

NOISES.—Noises which occur from causes outside the set are usually far more difficult to eliminate than those which are caused through some defect in the receiver itself, since it is very rarely that they can be tackled at their source. That the source may be well known is not usually of much help for that reason.

The usual noises experienced are crackling and similar noises due to

electrical machinery, mains hum, atmospherics, and heterodyne whistles.

Interference due to Electrical Machinery. The problem of disturbances due to electrical machinery in the neighbourhood of the receiver is one of the hardest to solve. Amongst the more usual sources are trams, trains, electric signs, automatic traffic signals, charging plants, generators, etc. The radiations are apparently caused by sparking at com-

approaching owners of noisy plant, such as electric charging systems, sausage machines, etc. Often the fitting of such an inexpensive addition as a good earth connection or a pair of 4-mfd. condensers across the brushes, with the centre point earthed, will make all the difference.

Frame Aerial as a Cure. As regards the receiver itself, there are various dodges which may be tried, but probably the most successful of all is the

centre-tapped frame aerial. An ordinary frame will generally effect some improvement, but not to the extent that a properly balanced frame will. The merit of the frame is not due to the fact that it is less efficient than an outdoor aerial, and that therefore it picks up less of the disturbance. If that were so there would be no advantage, since signals

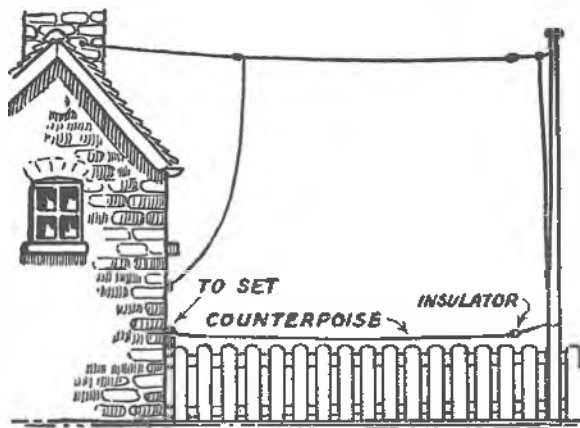


FIG. 285.—A Counterpoise Earth.

mutators and switches, etc. These act in much the same way as a spark station, the transmitting aerial being represented by the supply mains which feed the machinery. In the case of trams, the overhead trolley which collects current from the conductor is often a prolific source of crackles and crashes, and even the ordinary tumbler switches of the house lighting system cause a click in the loudspeaker every time they are operated.

In some of the worst cases a complete cure is often impossible unless the cause is removed. The B.B.C. are, of course, doing much useful work in this connection, but one can often supplement their excellent efforts by

would also be reduced in proportion, and any attempt to increase the signal strength would increase the disturbance again. Actually, however, the frame appears to be much more sensitive, at any rate, to the distant broadcast than to the local disturbance.

The circuit for the balanced frame is shown in Fig. 284. It is similar to that of an ordinary frame, except that the centre point of the winding is earthed. One end of the frame goes to the grid of the first valve in the usual way. The centre tap goes to earth, while the other end is joined to one side of the tuning condenser only. Points to remember in the fitting up of such a frame are:

NOISES

that each half of the frame should be as nearly identical as possible, electrically as well as mechanically. Both the outside leads should be the same length and equi-distant from

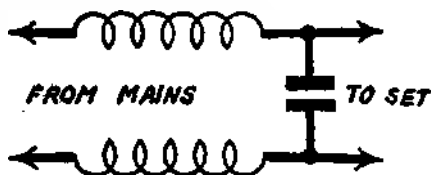


FIG. 286.—A Cure for H.F. Interference via the Mains.

the centre or earthed lead. Naturally, one will need a sensitive receiver with a frame if it is desired to get foreign stations with any degree of volume. A super-het. is ideal, but a straight four-valver, with a screen-grid stage, will usually meet all average needs. The placing of the receiver in a metal box or in some way screening it, will be an advantage when used in conjunction with the frame, although it is unlikely to

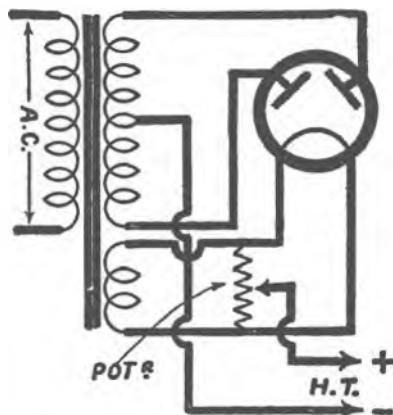


FIG. 287.—Another Cure for Mains Hum.

be of much help with an ordinary aerial.

Using a Counterpoise. The use of band-pass tuning and variable-mu

valves is sometimes very helpful in reducing electrical disturbances, as both tend to give a silent background. Another scheme is the use of a counterpoise earth. This has somewhat the same action as the frame aerial, although it is not so effective. In its simplest form it consists of an insulated wire similar to the aerial and placed directly underneath it. Naturally this is not always a practical arrangement, but for those who wish to try it, it is illustrated in Fig. 285. The earth terminal of the set is

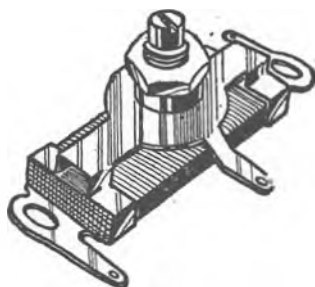


FIG. 288.—Suitable Potentiometer for eliminating Hum.

joined to the counterpoise instead of to earth.

H.F. Interference via the Mains. It sometimes happens that most of the noise arrives via the mains, and not down the aerial. This can be tested by disconnecting the aerial. If the noise continues then, one can be fairly certain that the mains are picking up most of the unwanted impulses. Try a good H.F. choke in each lead with a fixed condenser across them, as in Fig. 286. A 0.01-mfd. condenser (or larger in the case of D.C. mains) will be suitable.

NOISES, CURING.—Noises may be roughly divided into two classes—those which come from some cause within the set, such as motor boating, microphonic noises, and certain crackling noises, and those which ar-

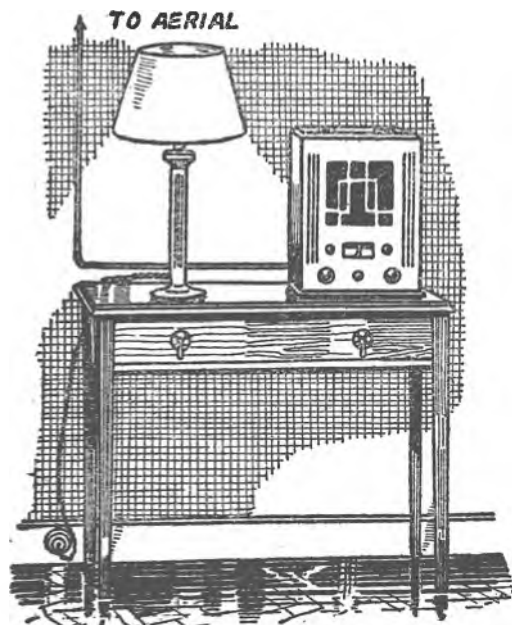


FIG. 289.—One cause of Hum is the Aerial, Earth or Speaker Leads running parallel to the Supply Mains.

rive via the aerial or the mains, such as atmospherics, mains hum, etc. Internal noises will be dealt with first.

Microphonic Feed-back. This particularly vicious form of disturbance practically disappeared with the improvement in valves, but, unfortunately, has returned to a certain extent with the introduction of so many self-contained sets. It is chiefly caused by the sound waves from the speaker impinging on the detector valve. If the electrodes of this are not absolutely rigid, it will act as a microphone, as can be demonstrated by tapping the valve sharply with your finger. A microphonic valve will give out a ringing sound from the speaker. In the

same way sound from the speaker itself, on striking the valve, will set it vibrating. This in turn causes the ringing sound in the speaker, and in bad cases this ringing sound gradually builds up to a volume which drowns everything. The fitting of anti-microphonic valve holders is obviously the first step towards a cure. Try also fitting a rubber ring round the bulb of the valve, or placing a jacket of cotton gauze round it, as in Fig. 292. If the trouble still persists, the cause may not lie only with the valve, but may be due to the vibrations from the speaker setting up sympathetic vibrations in the vanes of the variable condensers. In this case the building up usually occurs only when the set is tuned-in to a heavy carrier. Condensers without sup-

ports to the tips of the moving vanes (see Fig. 293) are usually the cause, and the remedy lies either in their replacement by more rigid types or the mounting of the speaker or the

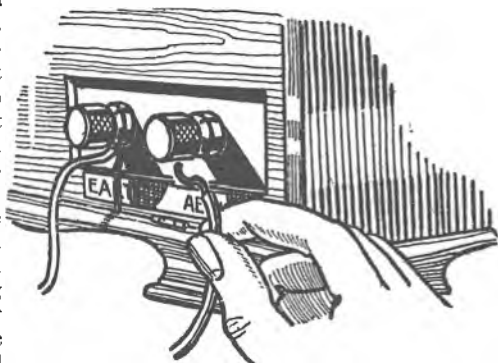


FIG. 290.—If crackling noises cease when the aerial is disconnected, this is certain proof that they are caused by atmospherics.

baffle on felt or sponge rubber pads as in Fig. 295.

L.F. Howling and Motor Boating. Most home constructors have encountered this at one time or another. It is usually so low a note that each separate beat can be distinguished, thus producing a regular

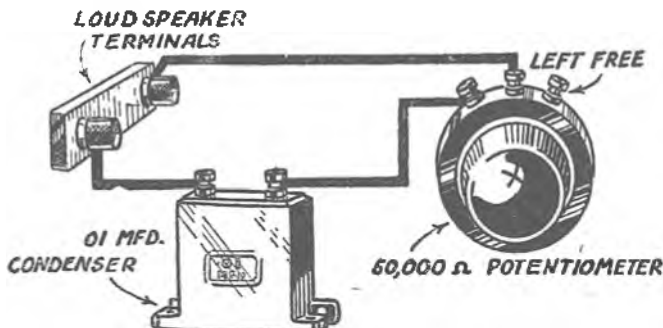


FIG. 291.—A high-note Filter—a cure for whistle, caused by heterodyning.

“plop, plop, plop!” In this latter form it is known as motor boating.

It may be due to a variety of causes, such as interaction between components resulting from bad spacing, feed-back caused by a worn-out H.T. battery, overloaded mains unit, etc. Fortunately, it is not difficult to overcome if tackled systematically. One of the oldest and simplest dodges is that of changing over one pair of leads to the L.F. transformer. Simply reverse the connections to either the primary or the secondary, but not to both. In the case of two-transformer stages, only one should be altered. Failing that, fit a decoupling resistance and condenser in the anode circuit of the detector valve as in Fig. 296. Also try a choke and condenser output filter if one is not already present. This is an almost certain cure where the trouble emanates from the mains unit. Fig. 297 shows the usual arrangement. In the case of receivers which derive their grid bias from the mains, decoupling should

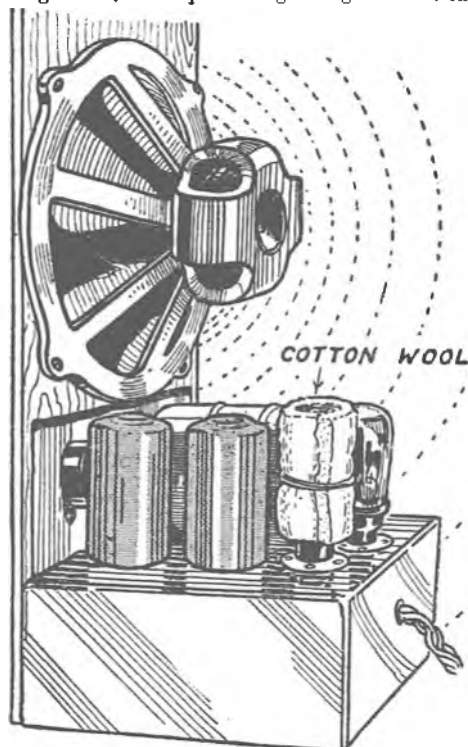


FIG. 292.—A jacket of cotton-wool round the detector valve, so as to prevent sound waves from the speaker impinging on it, will often stop a microphonic howl.

NOISES, CURING

be included, as is also shown in Fig. 297.

H.F. Oscillation. Unsuitable components, bad layout, and inadequate

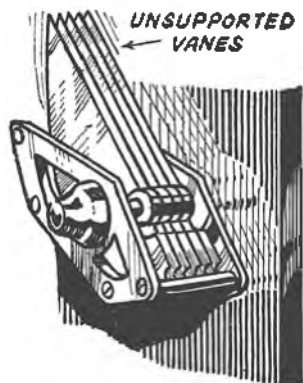


FIG. 293.—Vibrating condenser vanes may cause a microphonic howl.

screening all contribute towards instability in the H.F. stages, resulting in uncontrollable oscillation. Of course, with home-constructed sets built up according to the designer's specification the trouble is not likely to occur, since such troubles are cured before the design is offered to the

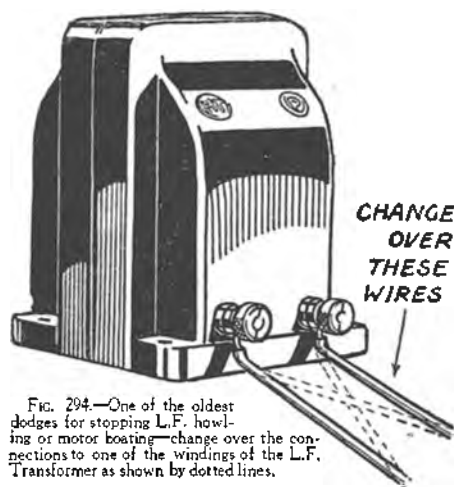


FIG. 294.—One of the oldest dodges for stopping L.F. howling or motor boating—change over the connections to one of the windings of the L.F. Transformer as shown by dotted lines.

public. Naturally, a few cases do occur where trouble arises through some unseen cause, such as exceptional local conditions or a bad component; but it is more often the set which is not to specification, or has been altered from time to time, which causes most trouble.

As regards a cure, one can only repeat what everyone has heard time and again—namely, pay particular attention to layout and wiring. Unshielded coils should be placed with their windings at right angles to minimise interaction. The same applies to H.F. chokes, which should

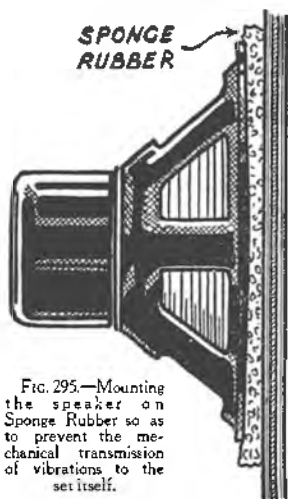


FIG. 295.—Mounting the speaker on Sponge Rubber so as to prevent the mechanical transmission of vibrations to the set itself.

not be placed with their windings in the same plane as those of an adjacent coil. Fig. 298 shows the proper way to mount them. Non-inductive-type condensers should be used where possible, especially for decoupling band-pass coils. Keep the connection from the grid of the detector valve to the grid condenser as short as possible, as in Fig. 299. The substitution of metallised valves for ordinary ones in the

NOISES, CURING

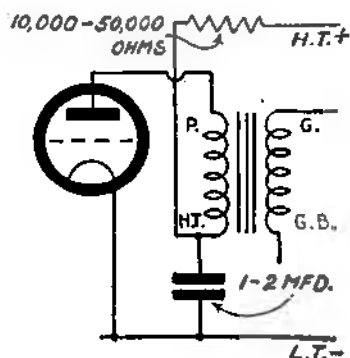


FIG. 296.—How to fit a decoupling resistance and condenser to stop motor-boasting.

S.G. and detector stages also helps where screening is inadequate.

Crackling Noises.

Some of the causes of intermittent crackling noises produced by the receiver itself are as follows: worn-out batteries, bad connections,

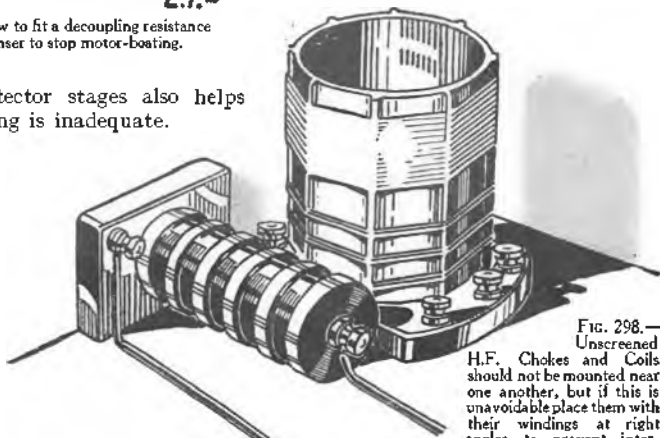
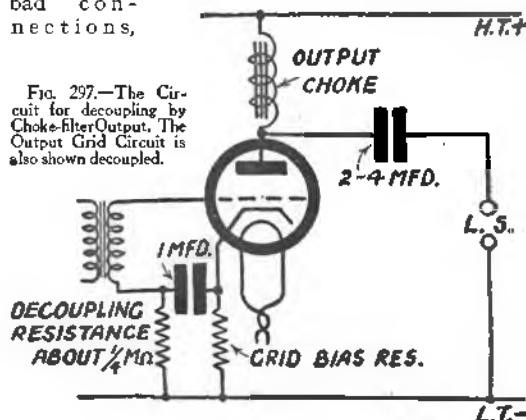


FIG. 298.—Unscreened H.F. Chokes and Coils should not be mounted near one another, but if this is unavoidable place them with their windings at right angles to prevent interaction and H.F. howling.

FIG. 297.—The Circuit for decoupling by Choke-filter Output. The Output Grid Circuit is also shown decoupled.



speaker and join it, or a pair of phones would be better, in the anode circuit of the detector valve, as in Fig. 300. If the cracklings are apparent in the phones, then the trouble lies in the H.F. or detector stages. Tighten all terminals and examine all soldered joints very carefully. A soldered connection may be cracked right across without the crack being

visible until pulled apart. Test the valves in their holders and open each valve leg slightly to ensure its making proper contact. Short the switch with a piece of wire while it is in the "on" position, as in Fig. 301. If the crackling ceases, the fault lies in the switch. Any spaghetti resistances present may be the culprits, especially if twisted or stretched. Of course, if there are others handy, they can be replaced, but sometimes moving them about or refitting them so as to avoid kinks or twists will prove whether

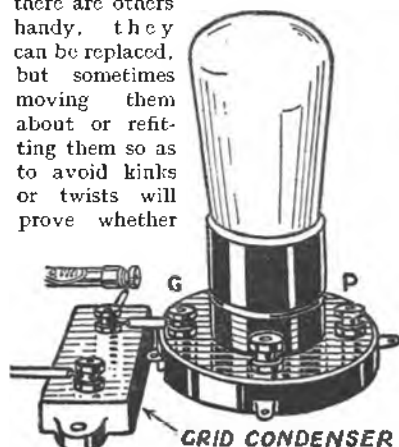


FIG. 299.—By placing the grid Condenser close to the Valve-holder the lead from Grid to Condenser is kept short—which makes for stability.

or not they are the cause. Test the grid leak in the same way. Here is a tip worth while—if one hasn't any spare grid leaks or resistances for comparison when making these tests, one can always borrow one from the idle L.F. stages. The valves may not be quite the same, but they will be quite all right for the purpose of locating the crackling.

If no crackling is heard in the phones when placed in the detector anode circuit (across A and B in Fig. 300), alter the connection to include the primary of the transformer. If the crackling appears, the transformer is the cause. If the set is still silent, and there is a decoupling

resistance fitted, join the phones across A and E, so as to include the resistance as well. The commencement of crackling would indicate that the resistance is the cause. If there are still no results, pass on to the next stage by connecting the phones (or rather the loudspeaker, as the signals will be louder in this stage) in the anode circuit of the next stage. If this is also the last stage, then, naturally, one will join the speaker to its usual terminals. Now test for loose terminals, faulty resistances, etc., in this part of the circuit, as in the previous stages. In the case of R.C. coupling, the coupling condenser is unlikely to give trouble, but the simplest way to test it is to replace it with another. The same applies to decoupling condensers.

Faulty Mains Unit. In this stage-by-stage test it has been more or less assumed that the set under test is battery operated. In the case of a mains set, procedure is the same except that there is just the possibility of the trouble being caused by a partial breakdown in the mains unit. In this case one would not get beyond the first stage, since, whatever test were tried, the crackling would persist. Fortunately, this is of fairly rare occurrence. The cure is obviously an overhaul of the mains unit and the replacement of any defective parts. Another rather rare cause of crackling noises is due to a defective L.T. accumulator. The positive plates of old accumulators of the block plate type are inclined to break up. Only intermittent contact occurs between the two parts. A broken lug will have the same effect.

Smoothing the H.T. Supply. A potentiometer may also be included with advantage across the filament of the usual full-wave rectifier valve, the H.T. positive lead being taken from the slider instead of from the centre tap of the transformer. This will

balance out any hum that would otherwise enter the filter circuit. The connections are shown in Fig. 287. There are several potentiometers on the market suitable as hum eliminators. The type shown in Fig. 288 is specially made for the purpose. It is inexpensive.

The shielding of all heater wiring in earthed sleeving and the use of earthed lead-covered wire from the

of the transformer in the power unit and the earth terminal of the set.

Atmospherics. These do not trouble us much in this country except during the few periods of thundery weather experienced each summer. In fact, what is often put down to atmospherics is nothing more than crackles caused by a worn-out H.T. battery or some faulty or dirty connection in the set. If there are no

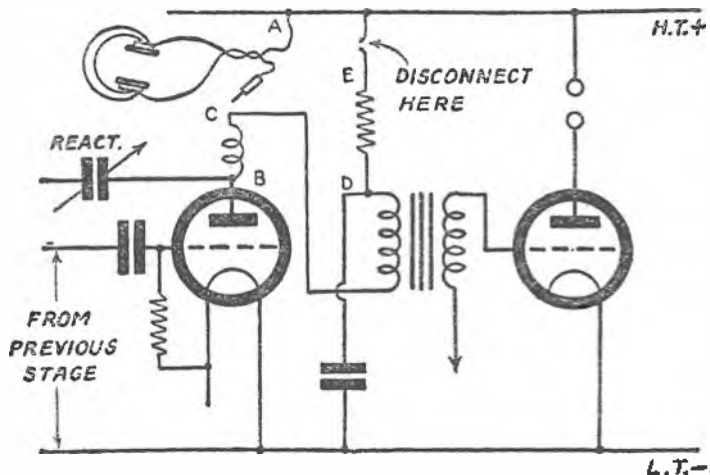


FIG. 300.—How to test for "crackling" noises. To test the H.F. and detector stages disconnect H.T. from E and join 'phones across A and B. To test H.F. choke as well join 'phones across A and C. To include transformer join them across A and D. To include decoupling resistance join across A and E.

mains to the set are other well-known dodges for eliminating hum. Take care also that the aerial, earth, and speaker wires do not run close to or parallel with the supply mains.

Tunable Hum. A hum may sometimes be experienced when tuned into a strong transmission like the local station. This must not be confused with the microphonic noise due to vibrating condenser vanes. Tunable hum is usually accentuated, if not caused, by a poor earth connection. Failing a cure when this has been attended to, try the following: connect a .01-mfd. condenser (1,000 volts D.C. test) between one mains terminal

doubts as to the cause, disconnect the aerial temporarily. If the crackles cease they are due to atmospherics. A cure is practically out of the question at the present time, but those means herein described for the elimination of electrical disturbances may be found helpful in reducing their effects. One thing to remember is that volume control should never be effected by detuning, since by this method the atmospherics, being untunable, remain at full strength, while the signal is reduced. The best way is to tune in the required station accurately and then reduce it to a workable volume with the reaction or

the volume control. This will at the same time reduce the atmospherics. It is perhaps not quite correct to say atmospherics are untuned, as they will often be found to be less troublesome on the medium waves than on the long. In this case, if there is a choice of using either band for the local programme, as for instance when Daventry National and London National are giving the same programme, one will naturally tune in

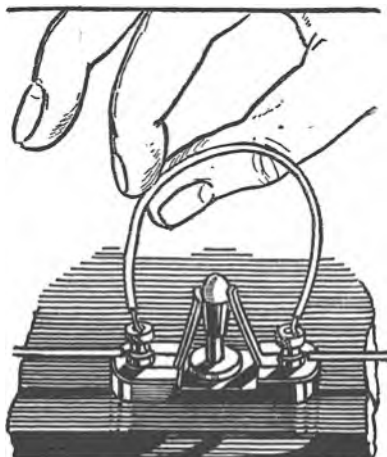


FIG. 301.—Shorting a Switch in this manner will indicate whether crackling noises are due to faulty contact.

to the one which has the least interference.

Heterodyne Whistles. A very shrill whistling sound is sometimes heard above the legitimate signal when tuned to a particular station. This is due to jamming by another station working on the same, or nearly the same, wavelength. It is not uncommon in these days of overcrowding on the broadcast wavebands. First of all make quite certain that it is not caused by the receiver being on the border of oscillation and itself heterodyning the incoming carrier. It is quite possible for this to

happen if one is trying to squeeze the last ounce out of the reaction. Again, the trouble may be due to a neighbour's receiver oscillating. Redress here lies with the Post Office. Assuming, however, that the trouble is due to jamming, and if the station affected is a favourite one, fit up a high-note filter. This is shown in Fig. 291, and consists of a .01-mfd. condenser and a 50,000-ohm variable resistance fitted across the speaker terminals. By varying the resistance the degree of cut-off is controlled.

NON-INDUCTIVE COIL.—An inductance which is wound back upon itself or otherwise doubled so that the self-induction of each section neutralises that of the other.

NON-INDUCTIVE CONDENSER.—A condenser in which the electrodes are so disposed that there is no inductance. A mica and copper-foil condenser is non-inductive, but a paper condenser of the type where a long strip of waxed paper and a long strip of foil are wrapped round and round is inductive.

NON-INDUCTIVE RESISTANCE.—A wire-wound resistance, having the wire element wound back upon itself or otherwise doubled so that the self-induction of each section neutralises that of the other. The term is also applied to a resistance which is composed of some element other than wire, such as a graphite composition. A resistance which possesses no inductance.

NON-OSCILLATORY.—A current which commences in a circuit and then dies away without reversal.

NON-SYNCHRONOUS.—The same as Asynchronous.

NOTE TUNING.—Tone tuning.

O

OHM.—The unit of resistance defined by that resistance offered by a column of mercury at the tempera-

MISTAKES YOU MAY MAKE !

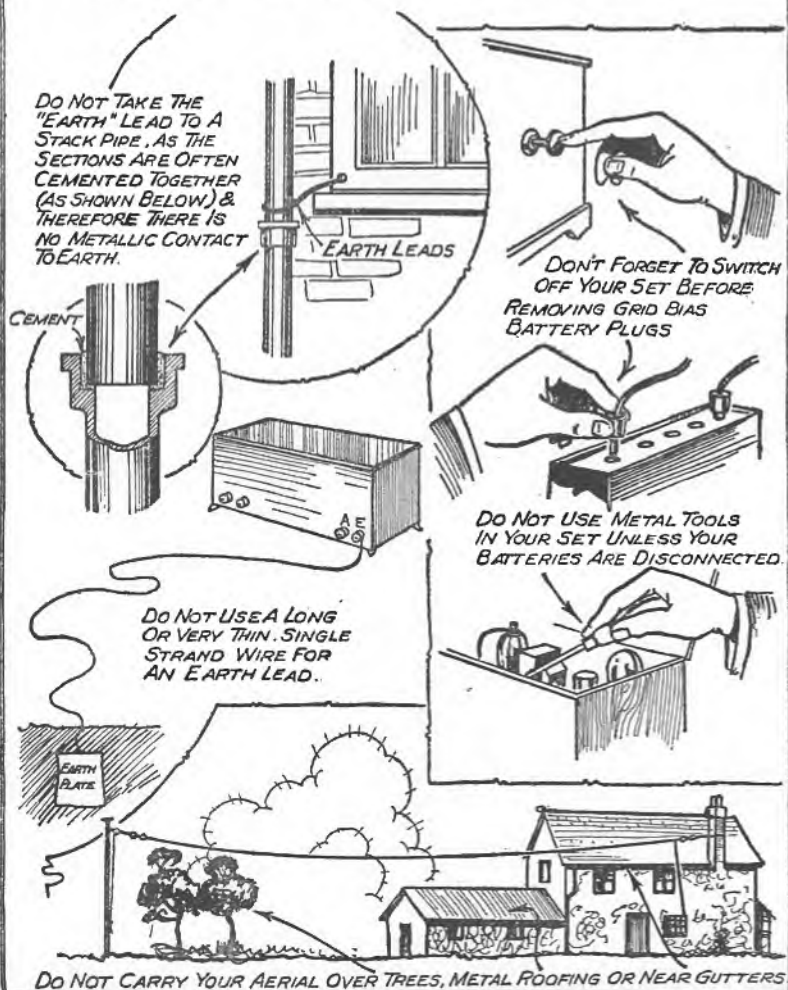


FIG. 302.—Various simple tests to apply.

OHM — OUTPUT STAGE

ture of melting ice; 14.452 grammes in mass, and of uniform cross section and with a length of 106.3 centimetres. When an electrical pressure of 1 volt is required to force a current of 1 ampere through a circuit, the circuit is said to have a resistance of 1 ohm.

OHM'S LAW.—A law which gives the relations existing in any circuit between current, voltage, and resistance. The formula is: $\text{current} = \frac{\text{voltage}}{\text{resistance}}$, which is set down in mathematical form thus:

$I = \frac{E}{R}$ (I being the electrical symbol for current, E the symbol for voltage,

ohms, and this results in a current of 2 amps.

$$\text{Current} = \frac{6}{3} = 2 \text{ amps.}$$

$$\text{Resistance} = \frac{6}{2} = 3 \text{ ohms.}$$

$$\text{Voltage} = 2 \times 3 = 6 \text{ volts.}$$

OMNIBUS BARS.—Bus bars.

OPEN CIRCUIT.—A circuit which is incomplete; for example, an accumulator which is not in use is in open circuit.

OPEN-CORE TRANSFORMER.—A transformer in which the two ends of the iron core are not joined. It is, therefore, similar to an induction coil.

OPPOSING E.M.F.—Back electromotive force.

ORDINATE.—In graphs, the distance of any point from the axis of abscissæ, measured on a line parallel to the axis of ordinates.

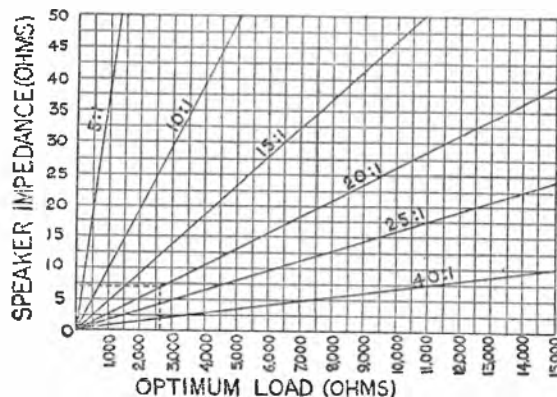
OSCILLATING CURRENT.—Alternating current possessing a frequency of hundreds of thousands a second.

OSCILLATORY CIRCUIT.—Any circuit having inductance and capacity.

OSCILLOGRAM.—The graph produced by an oscillograph.

OSCILLOGRAPH.—A device for obtaining a visible representation of the oscillations of an alternating current, which are transmitted in the form of reflected light rays to a screen. (See also *Cathode Ray Oscillograph*.)

OUTPUT STAGE.—It is a prevalent idea that an improvement in reproduction is naturally consequent upon the installation of a new loud-speaker. Without going into actual



[FIG. 303.—Graph for Moving-coil Speaker.

and R the symbol for resistance). From this equation it is obvious that the voltage can be found by multiplying the current by the resistance ($E = I \times R$), and the resistance is given by dividing the voltage by the current ($R = \frac{E}{I}$). In all the above equations the three terms must be in the units of the respective measurements, namely, I in amperes, E in volts, and R in ohms. For an example take a circuit consisting of a battery of 6 volts, across which is joined a resistance of 3

OUTPUT STAGE

details it can definitely be stated that disappointment is likely to follow if the speaker has been chosen without due regard to the set, or more correctly the output valve, with which it is to be used. Here let it be clearly understood that almost any good speaker will function satisfactorily with any efficient receiver *provided that it is connected in a suitable manner*. That last proviso is important. The whole secret lies behind the fact that if it is to give of its best the speaker must be matched to the output valve. This is because any valve operates most efficiently when the impedance connected in its anode circuit is of a fairly critical and definite value; this value is called the "Optimum Load," and is measured in ohms.

The Transformer Ratio. It is evident that a speaker of different impedance could not be employed for each type of output valve, and therefore some simpler system must be devised. All listeners know that a transformer can be used to "step-up" or "step-down" A.C. voltages, and it is this instrument which is used for the purpose under discussion. If one knows the optimum load required by any valve, and also the impedance of the speaker to be used with it, one can find a particular transformer ratio with which the valve and speaker will be matched. In the case of a moving-coil speaker the correct ratio is obtained by dividing the optimum load by the speaker impedance and taking the square root of the answer. Stated mathematic-

ally, the formula is:

$$\text{Ratio} = \sqrt{\frac{\text{Opt. Load}}{\text{Sp. Imp.}}}$$

As an example, suppose a 7-ohm speaker is to be used with a power valve such as the well-known 41 M.P., having an optimum load of 2,500 ohms. The correct transformer ratio would be $\sqrt{\frac{2,500}{7}}$ or approximately $\sqrt{400}$, which is, of course, 20 (to 1).

For the benefit of those amateurs who are not mathematically inclined, the graphs given in Figs. 303 and 304 have been prepared. To use these, first

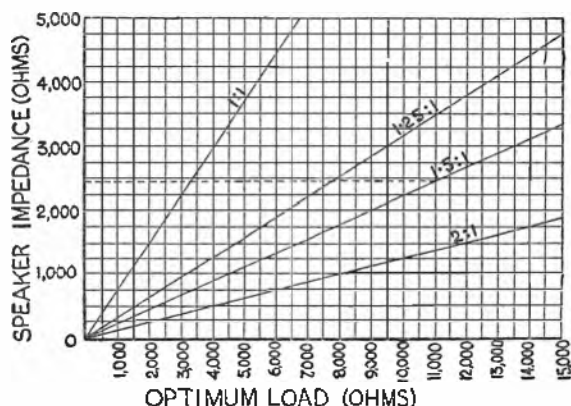


FIG. 304.—Graph for Matching Speaker.

find the optimum load on the horizontal ordinate and take up the vertical line to meet a horizontal one drawn from the position on the vertical ordinate which corresponds to the speaker impedance. The correct transformer ratio is given by the inclined line passing through (or near) the point of intersection. The lines corresponding to the example given above are shown on the graph. In the case of moving-iron and vibrating reed speakers (most types of cone or balanced armature instruments come within this class), the

OUTPUT STAGE

calculation is rather different, because the impedance of such speakers increases very rapidly with increase of frequency. To allow for this, "Half the Optimum Load" is substituted in the above equation. The formula thus becomes

$$\text{Ratio} = \sqrt{\frac{\text{Half Opt. Ld.}}{\text{Sp. Imp.}}}$$

To take another example, suppose one wishes to use a valve like the small power, having an optimum load of 11,000 ohms with a 2,400-ohm balanced armature speaker. The

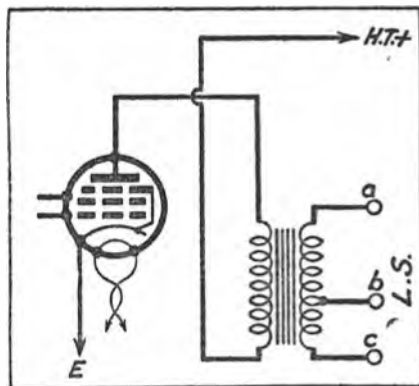


FIG. 305.—Transformer Output.

transformer ratio should therefore be $\sqrt{\frac{11,000}{2,400}}$ or approximately 1.5 : 1. This is shown on the graph in Fig. 304, from which other ratios can be obtained for any particular valve and speaker. Both graphs are equally applicable to either three-electrode or pentode valves, and they provide a very convenient "ready reckoner."

Unfortunately, some few manufacturers do not state the optimum load of their valves, but in these cases it will be sufficiently accurate to take it as being twice the A.C. impedance except for pentodes, where no definite ratio exists between optimum load and impedance. In any particular instance where the optimum load is

not known the makers will be pleased to supply figures.

Moving-iron Speakers. When dealing with moving-iron speakers, their impedance at about 250 cycles should be considered and not their D.C. resistance. Here again one is up against a difficulty, because some makers state only the D.C. resistance of their products. In such cases the impedance can be taken as being one and a half times the resistance. It is safe to assume the impedance of moving-coil speakers to be twice the D.C. resistance when the latter factor only is known.

Choke-capacity Output Filters. So far the ratio for output transformers connected as shown in Fig. 305 have been considered, but the same rules apply when a tapped choke is used with a condenser to feed the speaker. The latter arrangement is illustrated in Fig. 306.

The tapped choke serves the purpose of what is generally referred to as an "auto-transformer," and gives a step-down of voltage in exactly the same way as does a transformer having both primary and secondary windings.

By connecting the feed condenser C to tapings a, b, c, and d in turn, a number of alternative ratios are obtained and the correct one can be chosen as explained above. When C is connected to tapping d the ratio is 1 : 1, but when it is taken to a centre tapping at b the ratio is 2 : 1. It will be clear therefore that any desired ratio can be obtained by choosing an appropriate tapping point. In practice, however, it is seldom satisfactory to employ a choke for ratios greater than about 4 : 1, so when higher ratios are necessary the transformer is to be preferred.

Special Cases. There are two special cases which require some little extra consideration. These are: (1) when two or more valves are connected in

OUTPUT STAGE — PENTODE

parallel to enable the output stage to handle more signal power, and (2) when a push-pull output stage is employed. In the former case the *effective* optimum load is found by dividing the O.L. of one valve by the number of valves in parallel. Thus, the effective load of two battery P220 valves (optimum load 9,600 ohms) connected in parallel is just half of 9,600 ohms, or 4,800 ohms.

In the case of a push-pull stage the effective optimum load is twice that of a single valve, since the valves are virtually in series. In other words, the optimum load of two battery P220 valves in push pull is twice 9,600 ohms, or 19,200 ohms. It is the latter figure then which must be used when finding the correct ratio for an output transformer.

The same rules apply to loud-speaker connections; if two speakers are connected in parallel, the effective impedance is halved, whilst when in series the impedance is doubled.

The Value of Accurate Matching. If maximum efficiency and quality of reproduction are aimed at, matching is necessary. This can easily be verified by connecting the speaker through a different number of transformer ratios in turn and comparing results. It will at once be apparent that at one ratio the volume is noticeably greater and tone appreciably better. With three-electrode valves the exact ratio is not quite so critical as with pentodes, but it is, nevertheless, sufficiently so to justify careful attention and consideration.

Fortunately, most transformers and chokes are supplied with two or three tapings, so that different ratios are readily available, but the ratios are always, of necessity, fairly "close." For instance, one well-known firm of transformer manufacturers supplies

one transformer having ratios of 1:1, 1.6:1, and 2:1, and another having ratios of 15:1, 22.5:1, and 33:1; it would obviously be useless to buy a transformer of the latter type when a ratio in the region of, say, 2:1 were required.

P

PANEL SIZES.—Standard panel sizes recommended by the British Engineering Standards Association are as follows: 6 × 9, 6 × 12, 7 × 14, 7 × 18,

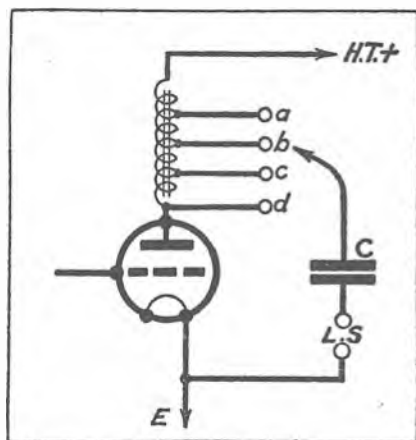


FIG. 306.—Choke-capacity Output.

7 × 21, 8 × 12, 8 × 16, 8 × 20, 8 × 26, and 8 × 30. (Sizes in inches.)

PAPER CONDENSER.—A fixed condenser having a dielectric of paraffin waxed paper.

PARALLEL.—When more than one path is open to a current they are "in parallel." The term "shunt" is sometimes used.

PARALLEL FEEDING.—See *Low-frequency Couplings*.

P.D.—Potential Difference. The pressure in volts existing between two parts of a circuit.

PENTODE.—The five-electrode valve. (See also *Valve*.)

PERIKON DETECTOR — PHOTO-ELECTRIC CELL

PERIKON DETECTOR.—A crystal detector consisting of zincite in contact with copper pyrites.

PHASE.—The difference between two identical oscillating currents at any instant is known as the phase difference. If one oscillating current is zero and another is at maximum,

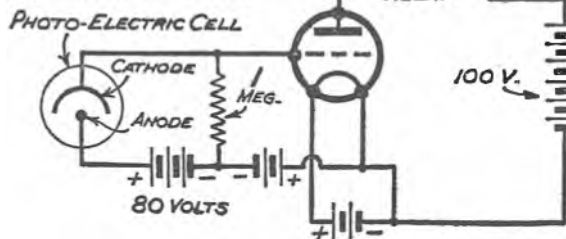


FIG. 307.—The standard method of connecting the Photo-electric Cell.

the phase difference is 90° . If both currents are at the same value, or "in step," they are said to be in phase.

PHASE DIFFERENCE.—The time difference between maximum voltage and maximum current in alternating current.

PHONES.—Abbreviation for telephones.

PHONOVISION.—An adaptation of noctovision. Electric current variations are made to operate a special pick-up which makes grooves on a record. A pick-up is used in conjunction with copies of the record, and suitably amplified operates a neon lamp, and thus enables the picture transmitted to be seen. It is a form of television.

PHOTO-ELECTRIC CELL.—The cell consists of a small glass tube—very similar to a wireless valve—and it contains two metal plates—a cathode and an anode. In the type shown in Fig. 308, an ordinary valve base is fitted, the anode being joined to the anode pin, and the cathode to the grid pin. The glass envelope is not evacuated, but contains a

gas. The peculiarity of this cell is that when a light is applied to the cathode electrons are emitted, and if a positive potential is applied to the anode (as in a wireless valve) these electrons are attracted to the

anode. The circuit shows how the cell may be arranged in the grid circuit of a small L.F. or power valve, so that the application of any light on the cell will operate the relay in the anode circuit of the valve. If the cell connections are reversed the

method of operation is also reversed, that is, a light shining on the cell will give a steady current in the anode circuit of the valve, holding

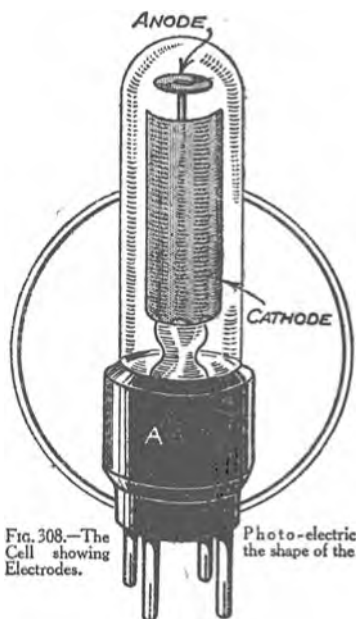


FIG. 308.—The Cell showing Electrodes.

Photo-electric the shape of the

PHOTO-ELECTRIC CELL

the relay closed and, on the light source being interrupted, the relay will open.

There are a great many uses to which this cell may be put, amongst which may be mentioned burglar alarms, switching lights on or off at

and then gradually brought towards the cell. If before the lamp has been brought at the required distance from the cell the relay is operated, then it is necessary to reduce the cell

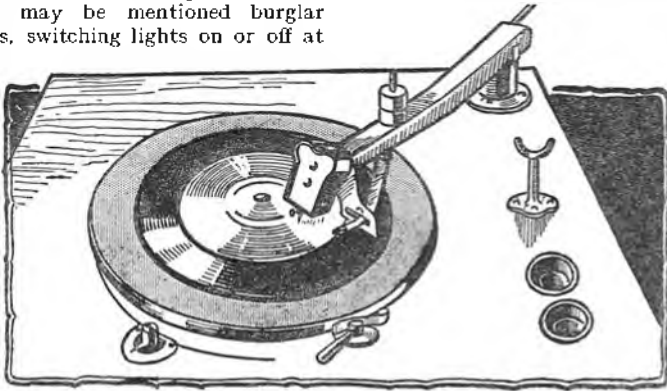


FIG. 309.—The Recorder in process of cutting a Record.

predetermined times, or giving warning of the arrival of a customer in a shop. The enthusiastic amateur may devise many interesting experiments which will be made possible by the operating of a relay by means of light control.

One or two suggestions may be given. A 60-watt lamp is most suitable for this particular cell, and it should be arranged, with the circuit shown, at a distance of 3 ft. or so,

potential. Alternatively, if the lamp has to be brought closer than 6 in. before the relay is operated, then the resistance across the grid circuit must be increased in value. Where it is desired to operate the relay with only a weak source of light, the grid bias should be lowered until the anode current is brought just below that value required to operate the

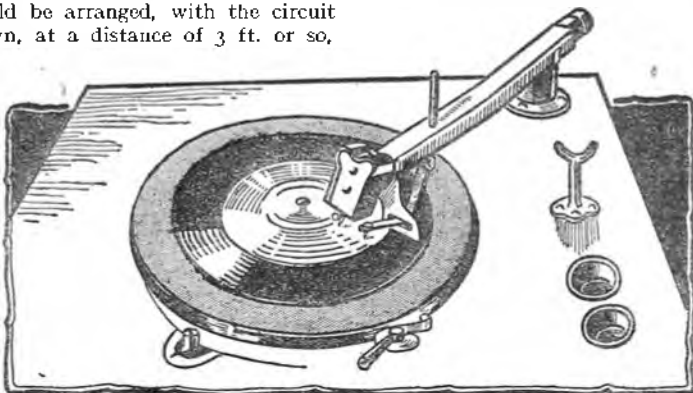
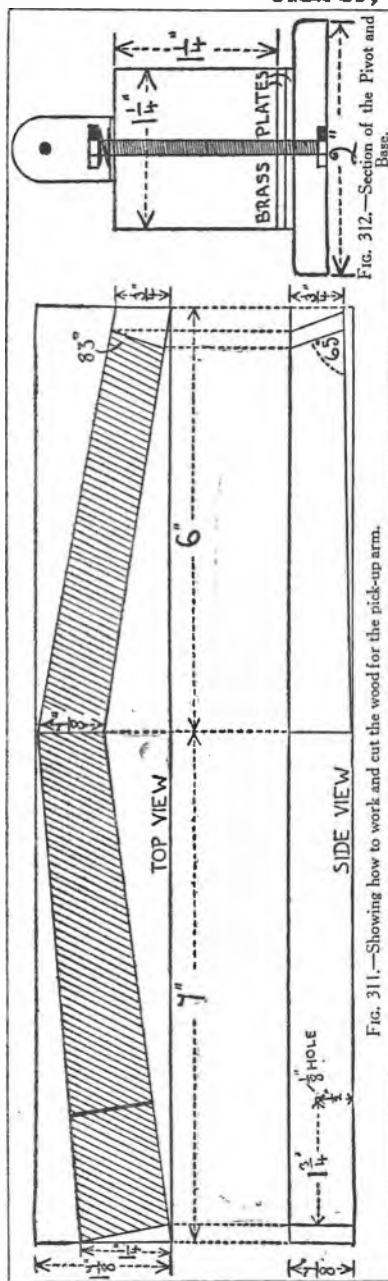


FIG. 310.—The Recorder as a reproducer. The Tracking Arm is out of action, and weights are placed on the back of the arm.

PICK-UP, RECORDING



relay. A slight increase in current caused by a weak light on the cell will then be sufficient to work the relay.

PICK-UP, RECORDING.—In order to make gramophone records of one's own voice, or the voices of one's friends, a wireless set and a special recorder are needed. By constructing the apparatus about to be described, it is a simple matter to make long-playing records of favourite radio stars, at an extremely moderate price, and if one can buy or construct a microphone one can record the musical accomplishments of oneself and friends.

The discs on which the records are made are of aluminium, and are 6 in. in diameter, but they play for as long as an ordinary 10-in. record and are double-sided.

Fig. 309 shows the recorder mounted on the motor board of a gramophone, and in process of making a record. As can be seen from the illustration, the apparatus consists of a pick-up mounted on a long wooden arm. Fixed to the latter is a small brass arm terminating in a needle holder. To make a record, a tracking disc is placed on the gramophone turntable. (The tracking disc is simply an ordinary record with grooves, but with no sound waves impressed on them.) On top of this is placed an aluminium blank, which is smaller than the tracking disc by about 2 in. all round. A special hard steel needle is fitted in the pick-up, and a special reproducing needle is fixed in the tracking arm. The pick-up is connected to the output terminals of a wireless set tuned to good loudspeaker strength, the turn-table released, and the point of the cutting needle placed about $\frac{1}{4}$ in. from the edge of the aluminium disc. The needle in the tracking arm runs on the tracking disc, making the pick-up arm move towards the centre of the record.

PICK-UP, RECORDING

Thus the cutting needle makes a spiral groove on the aluminium similar in pitch to the groove on the tracking disc. The speech or music from the wireless set, however, causes the needle in the pick-up to vibrate sideways in the same way as the

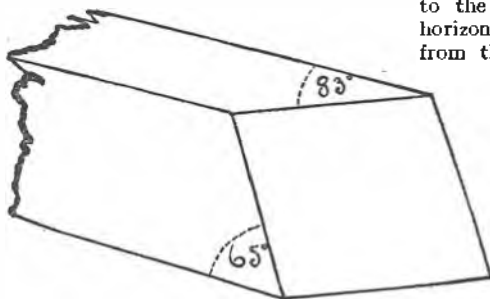


FIG. 313.—The end of the arm is cut as shown here.

armature of a loudspeaker. Thus the groove in the aluminium is modulated with minute waves corresponding to the original broadcast.

The record is now cleaned to remove the small pieces of metal which have been left by the cutter. By fitting a fibre needle to the pick-up and connecting the latter to the pick-up terminals of the set the record can be played in the same way as a commercial one. The tracking-disc, aluminium blanks and the necessary needles can be obtained from any wireless or gramophone dealer.

The Construction. Now for the actual constructional work. Make the arm first out of a 13-in. length of $1\frac{1}{2} \times \frac{3}{4}$ -in. oak. Fig. 311 shows how to mark and cut the wood. Take great care, in cutting the narrower end of the arm, to get the angles of the face correct, as the accuracy of the tracking depends on this.

Fig. 313 gives an enlarged view of the face, and should make the dimensions quite clear.

The thickness of the arm is decreased from $\frac{1}{2}$ in. to $\frac{1}{4}$ in. from the

bend to the smaller end, as can be seen in Fig. 311. Round off the top of the arm with chisels and sandpaper to give the apparatus an elegant appearance. Along the centre of the underside cut a channel $\frac{1}{4}$ in. wide and $\frac{1}{8}$ in. deep to hold the flex lead to the pick-up. Drill a $\frac{1}{8}$ -in. hole horizontally through the arm $1\frac{1}{2}$ in. from the wider end and $\frac{1}{4}$ in. from the bottom.

The Pivot and Base. The pivot and base for the arm come next, a section of which is shown in Fig. 312. Cut a 2-in. circle in $\frac{1}{2}$ -in. oak for the base and drill a $\frac{3}{8}$ -in. hole through the centre. Also drill three equidistant $\frac{1}{4}$ -in. holes around the edge of the base about $\frac{3}{8}$ in. in. Now ob-

tain a round piece of oak or other hardwood for the pillar, $1\frac{1}{2}$ in. in diameter, and $1\frac{1}{4}$ in. long. Drill a $\frac{1}{8}$ -in. hole down the centre of this, using a bench drill if one is available, as it is very important to keep this hole upright. Cut two $1\frac{1}{4}$ -in.

circles from 13 gauge sheet brass, using a coarse metal fret-saw for the job. Drill $\frac{1}{8}$ -in. holes a l s o through the centre of each of these, and a l s o

two $\frac{3}{32}$ -in. holes as shown in Fig. 314. These latter are countersunk. Screw one of the brass discs to the oak base, making the centre holes coincident, and fix the other to one end of the oak pillar. Make sure that the screw heads are sunk well below

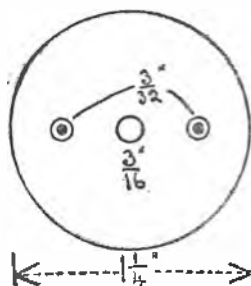


FIG. 314.—Bearing Discs for the pick-up.

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the brass, as the two surfaces have to run over one another.

The fork on which the arm pivots is made by bending a $\frac{1}{2}$ -in. strip of stiff brass to the shape shown in Fig. 315. Drill the holes as indicated, and screw the fork on to the top of the pillar, using round-headed brass screws.

On the end of a 2-in. length of 2 B.A. threaded rod screw a nut and solder it in position. Push the rod through the oak base, after having chiselled a recess for the nut. Now slip on the oak pillar complete with the brass fork. Put a spring washer and a nut on the top of the rod, and

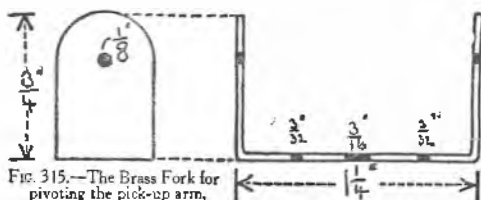


FIG. 315.—The Brass Fork for pivoting the pick-up arm.

tighten up sufficiently to prevent any play, but allowing the pillar to revolve freely. A trace of petroleum jelly between the brass faces will act as a lubricant. Mount two small brass terminals on the base for the pick-up connections.

The Pick-up. A pick-up will now be required, but no doubt many listeners have one already, complete with arm. In this case remove the pick-up from its present arm and fix it to the wooden one just constructed, for the recorder will play commercial records just as well as an ordinary pick-up and arm. If a pick-up has to be purchased they can be obtained without an arm quite cheaply. The method of fixing depends on the type one possesses. The one illustrated is a typical model and is fixed by means of a brass bracket; most others can be fixed in the same way. Make a bracket

to fit the smaller end of the arm. Fig. 318 will give the idea. Leave two flanges and drill two $\frac{3}{16}$ -in. holes in each for screws to fix into the sides of the arm. The pick-up is fixed to the front of the bracket by two small nuts and bolts passing through the back plate of the pick-up. Screw the bracket tightly to the arm.

The Tracking Arm. The parts for the tracking arm are shown in Figs. 316, 317, and 319. Cut the fixing plate and arm from 18 gauge brass, and drill the holes indicated. The arm is bent approximately as in the sketch and bolted to the fixing plate.

Screw the latter to the underside of the wooden arm, so that the ends of the tracking arm come level with the needle holder of the pick-up.

Now obtain the needle holder from an old sound box, and cut it off with a backsaw as in Fig. 321 (top). Solder it to the end of the track-

ing arm.

The distance plate (Fig. 316) is cut from 22 gauge brass. Drill three $\frac{3}{16}$ -in. holes as shown, and bend the "tabs" back at right angles. The plate is fixed to the pick-up arm by these, just behind the pick-up. The position of the slot in the plate is dependent on the size and shape of the pick-up, but Fig. 320 shows how to determine it. When the tracking arm is passed through the slot and locked at x , the distance between the cutting and tracking needle must be $1\frac{1}{2}$ in. Cut the slot with a metal fretsaw. The device for locking the tracking arm tightly in position in the slot consists of a cam, fixed just above the arm on the distance plate. When the cam is pushed over towards the pick-up, it presses on the arm, preventing it from moving while a record is being made. The arm can be released and slid to y when the

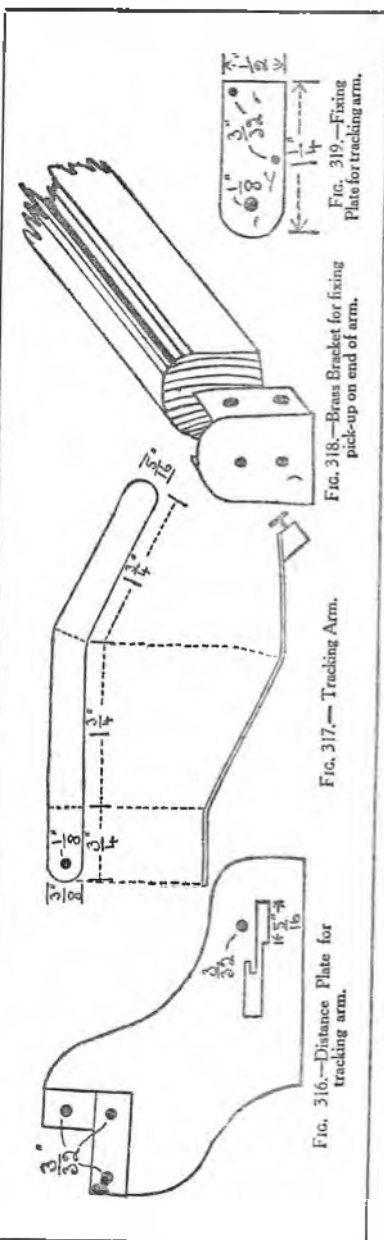
PICK-UP, RECORDING

recorder is being used for reproducing purposes.

The cam is cut from 18 gauge brass and a $\frac{3}{16}$ -in. hole drilled in it, as in Fig. 321. Fix the cam to the distance plate with a nut and a bolt, using a lock nut to prevent it coming undone.

Assembling the Recorder. The recorder can now be put together for a test. Fix the pick-up arm to the pivot by pushing a thin piece of steel wire through it and the brass fork. The wire should be thin enough to allow a little play. Solder the ends of the wire in place in the holes in the fork. It will be found necessary to cut a recess in the underside of the wooden arm to make room for the nut and washer on top of the pillar (see Fig. 322). Just behind the pick-up drill a $\frac{1}{8}$ -in. vertical hole through the arm to take the pick-up lead. A small eyelet is pushed in the top of the hole to make it look neat. Bring the lead through the hole and along the groove underneath the arm. Keep it in place by screwing on small brass plates at intervals. Take the lead through the base and solder the ends to the terminals. Chisel two shallow grooves in the bottom of the base, so as to sink the wire below the level of the wood. A piece of green baize glued on the base will protect the leads from damage.

The Weights. In a piece of $\frac{3}{4}$ -in. oak drill a 1-in. hole, and in a small piece of 3-ply fix a piece of $\frac{1}{16}$ -in. iron rod. Fix the 3-ply to the oak so that the rod runs down the centre of the hole (Fig. 323). This forms a mould in which to case the necessary weights for the recorder. Melt some oddments of lead pipe in a tin and cast five weights. Dust the inside of the mould with French chalk to prevent the lead sticking to the wood. Clean the rough castings with a file and emery cloth. Drill two



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$\frac{1}{8}$ -in. holes $\frac{3}{8}$ in. deep in the pick-up arm, one in the back end, and the other on top, about 4 in. from the pick-up. Into each of these cement a $2\frac{1}{2}$ -in. length of $\frac{1}{8}$ -in. steel rod, and bend the back one upwards a little to prevent the weights sliding off when the arm is raised.

Recording. Mount the recorder on

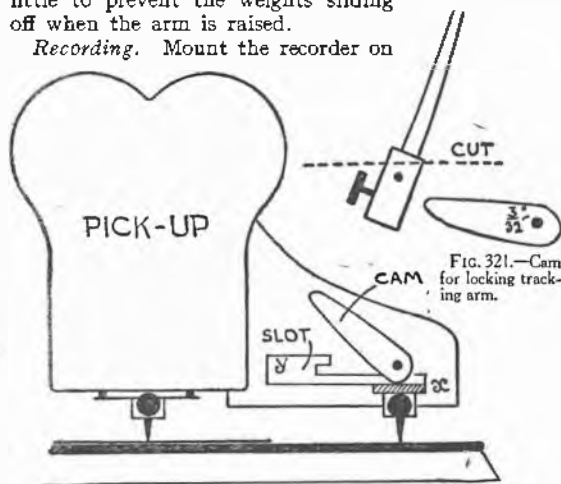


FIG. 320.—Diagram showing relative positions of Cutting and Tracking Needles.

the motor board of a gramophone. Put a needle in the pick-up and place the point on the central peg of the turn-table. Keeping the needle there, find a convenient position for the base and fasten it down with three screws, passing through the holes made for them. Fix a pick-up arm rest on the board to keep the arm raised.

Place the tracking disc on the turn-table, and on it an aluminium blank. Lock the latter, by giving it a slight twist in an anti-clockwise direction, when the little slots in the blank will engage with the brass studs on the tracking disc. Now put a cutting needle in the pick-up and a special reproducing needle in the tracking arm, taking care that they are locked tightly in their holders. Select a suitable item from the wire-

less programme to record and tune it to good loudspeaker strength. A military band is a good subject to start with. Connect the recorder across the loudspeaker, and if the pick-up is in working order, you will be able to feel the needle vibrating on holding your finger against it.

Wind the gramophone motor up fully in order to develop the maximum power, and place one or two weights on the upright rod nearest the pick-up. Two or more can be placed on, so long as the pressure of the cutting needle does not tend to slow the turntable. A little experimenting will show the best number to use. Now start the turntable, and when it has attained full speed,

place the cutting needle on the edge of the aluminium disc. If the needle does not run smoothly, but grates as the record revolves, turning the

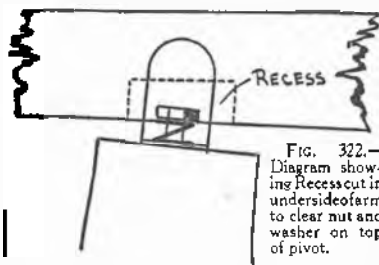


FIG. 322.—Diagram showing Recess cut in underside of arm to clear nut and washer on top of pivot.

needle round in its holder will remedy matters. The pick-up will gradually move across the record, cutting a spiral groove as it goes.

Do not use the whole of one side of a blank for the first test. About

$\frac{1}{2}$ in. of recording should be sufficient to determine whether the first effort has been a success.

Replace the cutting needle in the pick-up with a fibre or special reproducing needle, remove the tracking needle, and transfer the weights to the back of the arm. This is to take the pressure off the needle, otherwise the rather soft point would soon wear away. On no account must a steel needle be employed on an aluminium record, or the recording will be ruined.

Connect the recorder to the pick-up terminals of a set, and if the pick-up is a sensitive one, it will be necessary to connect a volume control across it. Before playing the record, clean it with petrol to remove any dirt and grit. Play the record in the usual way, and if all has gone well, listeners will be rewarded by the sounds of the item recorded being reproduced loudly and clearly.

To make personal records, a microphone of some kind is necessary, and one of these can be purchased fairly cheaply, complete with transformer. Connect the microphone to the pick-up terminals of the set, with a dry battery of the voltage recommended by the makers of the microphone. Play the items into the "mike," and record them in the usual way.

If listeners do not wish to buy a microphone, a passable substitute can be found by connecting up a sensitive loudspeaker to the pick-up terminals, and playing into that.

To obtain the best results with the recorder, a little experience is necessary to determine the best volume to record at, and the number of weights to use, both when recording and playing the discs. It will be found an interesting pastime, and with a little patience the experimenter will soon produce good, clear records.

When the completed apparatus is working well, a coat of dark-brown

enamel paint given to the recorder will make it resemble bakelite, and it will harmonise with the cabinet.

PITCH.—The tone produced by the frequency of the diaphragm of a loudspeaker or telephone. The distance from the top of one screw thread to the top of another.

PLANTE PLATES.—See *Accumulator*.

PLATE CIRCUIT.—The part of the circuit of a valve wireless receiver in which the amplified current flows.

PLIODYNATRON.—A dynatron, with the addition of plates to control the negative resistance effect.

PLUG.—A device used in conjunction with a jack providing two insulated contacts and hence enabling a circuit quickly to be completed or broken.

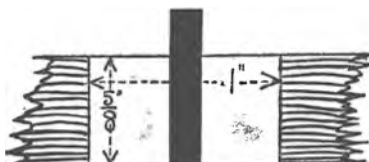


FIG. 323.—The Mould for casting the weights.

Briefly the uses of plugs and jacks are as follow:

- (1) They can be used as a convenient means of plugging-in the loudspeaker—either at the set itself or at extensions in other rooms of the house.
- (2) The plugging-in of the speaker can be made to switch on the receiver.
- (3) They can be used as a means of cutting out the last amplifier valve.
- (4) As a means of making a quick change over from speaker to phones when ether searching.
- (5) The gramophone pick-up can be easily plugged-in to either detector or L.F. stage, the grid bias being automatically adjusted.
- (6) They provide a quick method of connecting or disconnecting the

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batteries, and even the aerial and earth. (*Note.*—For this latter duty in order to reduce H.F. losses to a minimum special low-capacity jacks should be used.)

that the stem is really a metal tube and that the ball is attached to the end of a rod which passes through the stem. Rod and stem are kept concentric and insulated from one another by means of an ebonite or fibre washer at each end. The rod is not surrounded with ebonite for its whole

length, as this is unnecessary and would only add to the self-capacity of the plug. The rod and stem are each connected to a separate terminal or binding screw. In connecting the plug to the speaker or pick-up the two wires forming the leads are

joined to the two binding screws and are thus in direct electrical contact with the ball and stem. The body of the plug being of bakelite insulates the hand from any of the metal parts when plugging-in.

Jacks. These vary in detail ac-

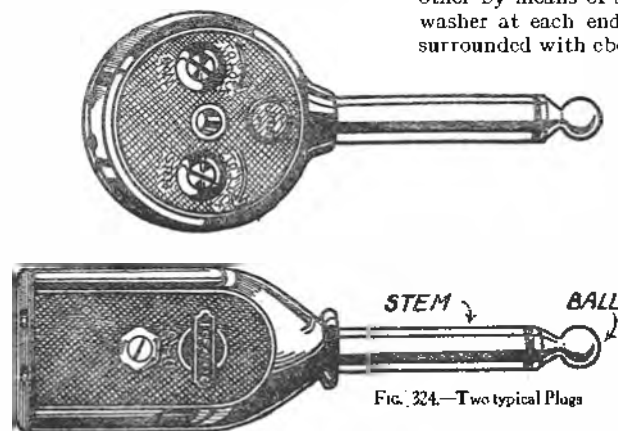


FIG. 324.—Two typical Plugs

Construction of the Plug. For those who are not familiar with the elements of jack switching an explanation of the construction of the plug and jack and how they work will not be out of place. Fig. 324 shows two popular plugs. The "business" parts are the ball and stem and these are standard as regards size and shape. The only difference between one make and another is in the shape of the body or "shell" of the plug and the method of connecting the leads. Fig. 325 is a sectioned drawing showing the construction of a plug. It will be seen

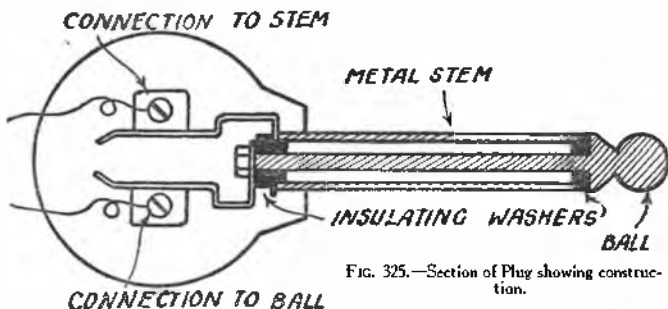


FIG. 325.—Section of Plug showing construction.

cording to the particular switching they have to perform, but all comprise a socket to receive the plug and one or more insulated spring contacts. Figs. 326 and 327 illustrate a

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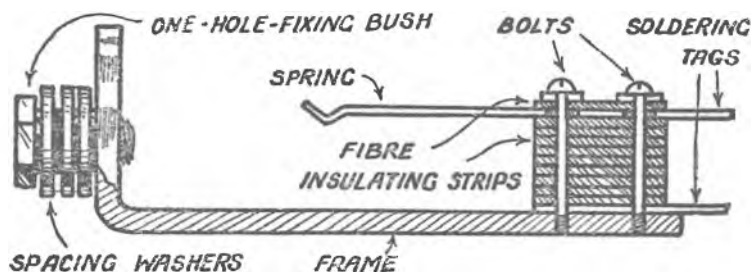


FIG. 326.—Details of Single-circuit Jack.

single open circuit jack. The socket which receives the stem of the plug is in the form of a metal bush which screws in to the frame of the jack and also serves as a means of fixing the jack to the panel of the set. The single spring is mounted on a pile of fibre strips which insulate it from the metal frame and at the same time hold it at just the right height to make easy but firm contact with the ball of the plug. The spring is usually of nickel or German silver.

The lower sketch in Fig. 327 shows just what happens when the plug is inserted. The stem of the plug makes contact with the frame of the jack and the ball connects with the spring.

However, by the multiplication of springs in the jack, other and more varied operations can be performed. For example, the jack shown in Figs. 331 and 332, will complete *two* circuits on insertion of the plug. Here *three* springs are used, and if you examine the illustrations you will see that normally all three are separated from one another. When the plug is pushed home it not only makes contact with the frame of the jack and with the lower spring, thus completing the speaker circuit, but also in raising the lower spring it connects the two upper ones together. There is a little fibre peg underneath the middle spring

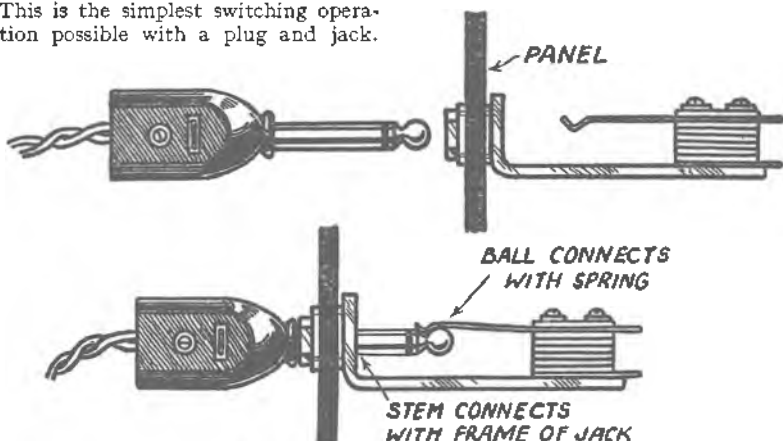


FIG. 327.—How the Plug and Jack connect.

PLUG

against which the lower spring presses when it is forced upwards by the ball; thus the middle spring is also bent upward. It does not actually make contact with the lower spring because the fibre peg is an insulator, but it does connect with the upper one which has

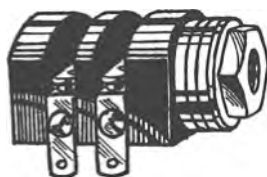


FIG. 328.—A Midget Jack for use in H.F. circuits.

the lower spring because the fibre peg is an insulator, but it does connect with the upper one which has

frame and parallel springs is the most common, but is not the only variety obtainable. Notable exceptions are the Midget Jack shown in Fig. 328 and similar jacks of a small size. The former is specially designed for use in H.F. circuits and one type is of unusual design in that it has a bakelite frame and springs fitted with convenient terminals. Owing to the shape of the springs it does not project so far from the back of the panel, but on the other hand it takes up more room on the panel itself. Another type of jack is the wall jack shown in Fig. 329.

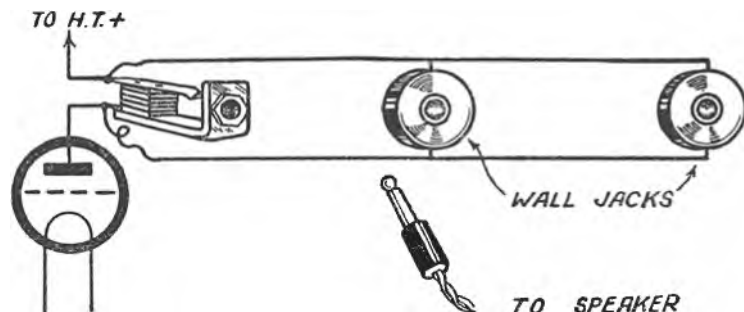


FIG. 329.—Speaker Points can be arranged in different rooms by means of Wall Jacks.

a special silver contact for the purpose.

Various Circuits. Now consider what jacks to use, and how to connect them up to perform the various functions previously enumerated.

The first use is the provision of a quickly made speaker connection. Of course, the circuit is simplicity itself. It is illustrated in Fig. 330. Instead of having two terminals marked "L.S."

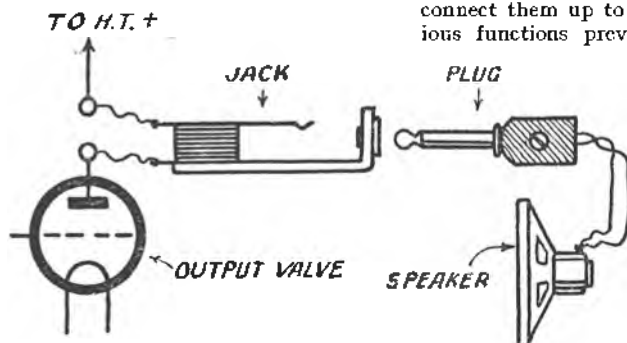


FIG. 330.—Plugging-in the Speaker.

Other Types. The type of jack on your receiver, you use a single open circuit jack. The two wires

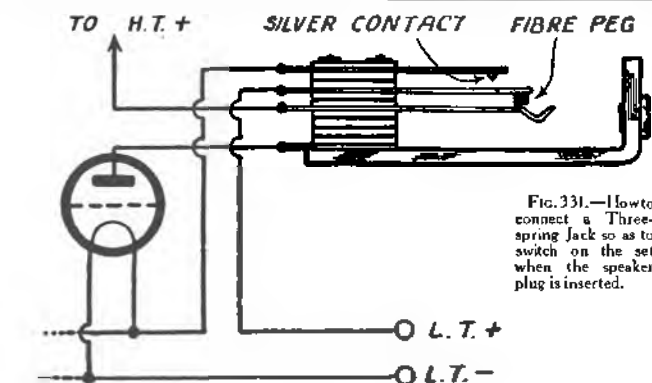


FIG. 331.—How to connect a Three-spring Jack so as to switch on the set when the speaker plug is inserted.

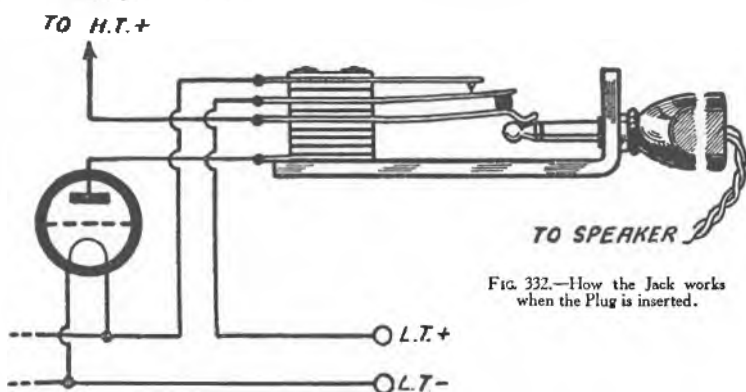


FIG. 332.—How the Jack works when the Plug is inserted.

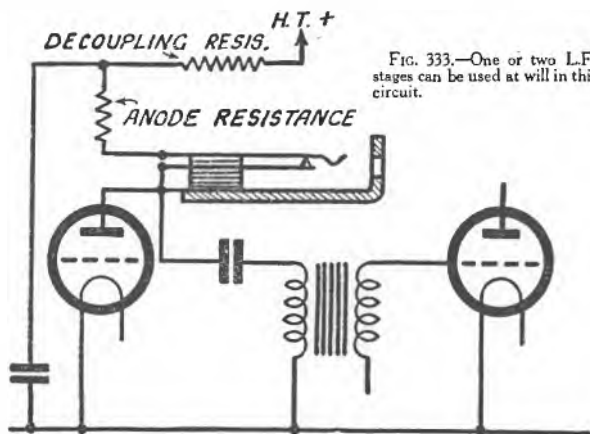


FIG. 333.—One or two L.F. stages can be used at will in this circuit.

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which would normally be joined to the "L.S." terminals are connected instead to the two tags of the jack.

from the set, or from the set to the first point, and from there to the next one, and so on. Use whichever ar-

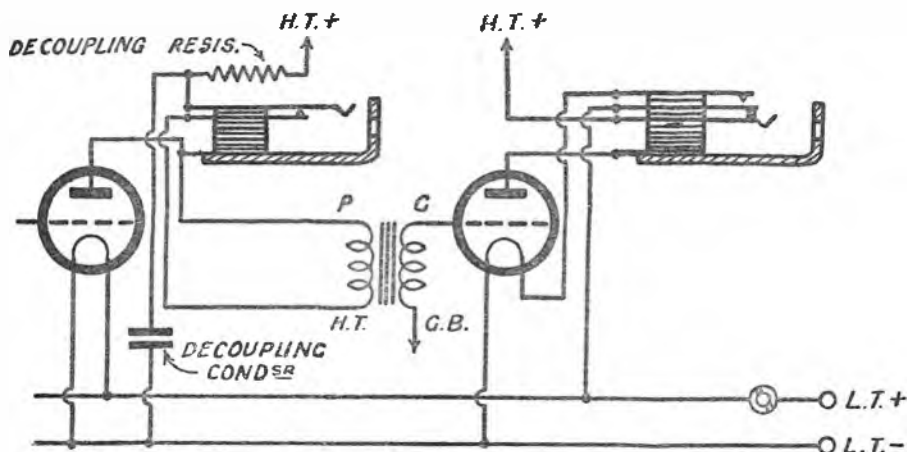


FIG. 334.—The modification necessary to the circuit in Fig. 340 when parallel-fed is used.

The plug is joined to the two leads from the speaker. A further elaboration of this arrangement is shown in Fig. 329. Here, several jacks are connected in parallel. An ordinary jack is fitted to the set and wall jacks are fitted in any rooms where the

arrangement is most convenient, or that which requires least wire.

A very useful method of switching on a battery receiver is illustrated in Figs. 331 and 332. On plugging-in the speaker the filaments are automatically switched on. This is some-

times a good scheme where there are children about, as no on-off switch is required on the panel of the set. If the speaker is placed on a shelf with the lead and plug well out of the way of inquisitive little fingers, there is no chance of the set being switched on while

the grown-ups are out of the room. The working of the particular three - spring

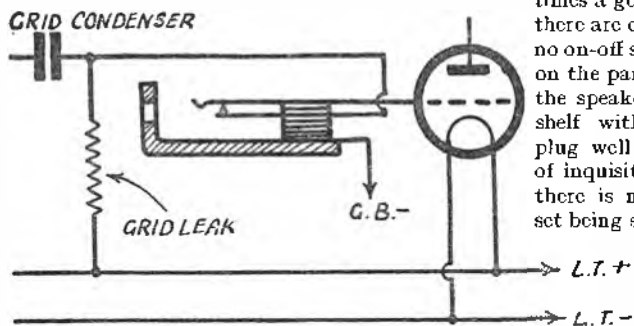


FIG. 335.—An easy way to plug in the Pick-up to the Detector Valve of a battery set.

speaker is likely to be used. Good quality rubber-covered double wire or double flex should be run along the picture-rail or skirting to each point

jack which is used has previously been described, and a further study of the illustrations should make the connections quite clear. The two

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upper springs are connected to the wires which normally go to the filament switch, and the lower spring and

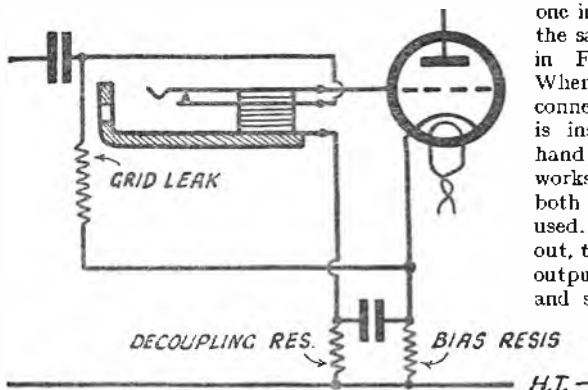


FIG. 336.—The mains version of Fig. 335. Note grid bias is cut out when the radio is in use.

the body of the jack are joined to the wires which would otherwise connect to the terminals marked "L.S. -" and "L.S. + " on the receiver. The plug is naturally connected to the speaker.

Cutting out the Last Valve. Some years ago it was quite common to have several low-frequency stages of amplification, but, nowadays, with the general improvement in H.F. amplifiers and the introduction of the pentode, one stage is often sufficient. However, there is undoubtedly a large number of listeners who prefer the extra punch provided by two or three L.F. valves, especially when receiving dance music. Naturally, the full volume is not always required, although it is nice to know it is there if needed. This means that there are many occasions when drastic use has to be made of the volume control. At such times, the ability to cut out the last valve would be a great boon, and in the case of a battery set would result in no small saving of "juice." Fig. 334 shows how this can be done in a transformer-coupled set. The jack

on the left, that is, the one in the plate circuit of the first L.F. valve, is of the single, closed-circuit type. The one in the output circuit is the same type as that used in Figs. 331 and 332. When the plug, which is connected to the speaker, is inserted in the right-hand jack the receiver works in the normal way, both L.F. stages being used. On taking the plug out, the plate circuit of the output valve is broken and so is its filament circuit. If the plug is now inserted in the other jack it connects the speaker in the plate circuit of the previous valve, the upper spring connecting with the bail and the frame

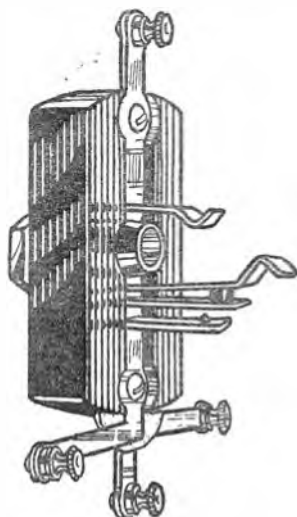


FIG. 337.—A Two-circuit Jack.

with the stem of the plug. The raising of the upper spring causes it to break

contact with the lower one, which is connected to the primary of the L.F. transformer, and thus the transformer is cut out while the speaker is in circuit.

It will be noticed that the decoupling resistance is not shown as being disconnected as well as the transformer, although this could easily be arranged by altering the connections. The reason for this is that the cutting out of the decoupling resistance would produce a rise in the plate voltage applied to the valve, with the probable necessity for an increase in the grid-bias voltage. Rather than complicate the circuit by arranging for automatic readjustment of the bias the resistance is left out of circuit. The same remarks apply to any resistance of a high value in the plate circuit, whether it be for voltage controlling purposes, decoupling or anode coupling. It is better to leave them in than endeavour to work the valve at a higher rate voltage, and so get distortion owing to insufficient bias. However, automatic adjustment of bias can be arranged by using a five-spring jack with its attendant complication of the circuit.

Phones or Speaker. Now as regards the method of coupling the L.F. transformer. Fig. 334 is the circuit to use when ordinary series coupling is employed, but in the case of a parallel feed it will have to be modified to that of Fig. 333. Here, again, the resistances in the anode circuit are left connected so as not to disturb the working conditions of the valve. One advantage of the jack method of cutting out the last valve is that by fitting another plug to a pair of headphones these can be used in place of the speaker. They will very often be found useful for D.X. work. If necessary, of course, a jack can be fitted in the plate circuit of the detector valve, and often ample strength will be provided with the phones

plugged-in here. The connections would be substantially the same as those in Figs. 331 and 332.

Plugging-in the Pick-up. One of the chief "snags" in connecting a gramophone pick-up in the detector circuit of a receiver is that the detector valve has to be biased while the pick-up is in use. Nevertheless, this drawback can easily be overcome by the use of jack switching. A single closed circuit jack is used, as in Figs. 335 and 336. These show the connections in the case of a battery and mains receiver respectively. Grid bias is automatically applied as soon as the pick-up is plugged in. The decoupling resistance, shown in Fig. 336, is optional, and is not included in all sets. If it is not used, the connections from the frame of the jack and from the left side of the decoupling condenser are joined direct to H.T. —.

Where a mains receiver employing resistances for various voltage dropping purposes is in use there are one or two points which must receive attention. We refer particularly to the use of a detector valve as the valve to which the pick-up is joined. If this employs a decoupling resistance in the anode circuit, the voltage drop through this will depend upon the anode current when the valve is in use as a detector. When used with a different bias, there will be a different voltage drop in the anode circuit, and generally speaking this will be greater than when the valve is employed as a detector. It will therefore be necessary to arrange that the value of the decoupling resistance is also altered when the pick-up is plugged into circuit. The multi-contact jack may be used for this purpose, as has already been shown.

POLAR FLUX.—The magnetic field of an electric generator. The magnetic flux produced by the poles thereof.

POLARISATION — POLISHING AND STAINING

POLARISATION.—Another term for local action in a cell, indicating the changing of the polarity due to bubbles of hydrogen forming on the negative plate.

POLARITY.—See *Accumulator*.

POLARITY OF A MAGNET.—The North Pole of a magnet is that which seeks the geographical north. It is, of course, actually its South Pole, as unlikes attract, and likes repel.

POLE - FINDING PAPER.—A special paper known as litmus which is used for determining the polarity of the mains, etc. The paper is moistened and the two wires laid on it, when the area in contact with the negative pole turns black.

POLISHING AND STAINING.—There are several methods of polishing woodwork, and it is always largely a matter of opinion as to which method is preferable. Most work is finished with a highly polished surface, but certain classes of work should be left dull. Again, there is the work which is merely oiled, whilst another worker will prefer to add a coat of varnish and leave it at that. Oak looks very nice fumed, which is another method of finishing the work. Plain woodwork can be painted or enamelled, or, of course, the wood can be left in its natural state, without treatment of any kind.

Thus, the worker has six different methods of completing his work.

Varnishing. Varnishing is certainly the easiest method, but this process merely adds a thick transparent coat to the wood, which allows the grain to be seen, but does not add to its appearance. There are numerous kinds of varnish—water varnish, for the protection of paper; elastic varnish, which has to stand expansion and contraction of weather; church varnish, and so on. Do not use

varnish on new wood, but first treat the surface with glue size. This will give a body for the varnish, which would otherwise be bright in some places and dull where the finish had sunk in. Varnish is very glutinous, and needs special brushes which have had their bristles fixed to withstand the pull of the work. Paint brushes are kept in water when not in use, but varnish brushes should be hung in linseed oil or the varnish itself. The best time to do varnishing is in the early morning. If the work is done in a dry atmosphere, a peculiar milky appearance will show, due to moisture getting on the varnish when it is nearly dry.

Varnish must not be put on too thickly, but an even amount must be spread over the whole surface. Several coats may be applied if necessary, but a streaky surface must be avoided. The brushes used are flat, but small ones can be used for edges or moulding. See that it does not drag, and apply evenly in one direction.

Polishing with Linseed Oil. Oil polishing is quite a simple process, and is merely a matter of rubbing the wood with raw linseed oil to bring up the grain or "figure," and at the same time to give the work a nice colour. The work, however, is a lengthy process to get the best results, for any number of coats can be given with a long space of time between each. Mahogany, beech, or oak are all greatly improved by the application of oil. Everything, however, depends on the continued rubbing until the oil has soaked right in. A polish will not be obtained for some time, and the rubbing must be frequently repeated with as much pressure as possible.

How it is Done. The oil is applied by means of a rubber as shown in Fig. 339, where a piece of flannel is wrapped round a pad of

POLISHING AND STAINING

wool. It is most suitable for large flat surfaces. It cannot always be applied to fretwork, as the oil rubs over the edges without actually staining the interior parts. For the same reason, oiling cannot be done on moulding or carved ornaments. The longer the rubbing is continued the better the resulting polish will be. Certain woods naturally take more oil than others, but in every case constant rubbing is essential. It should

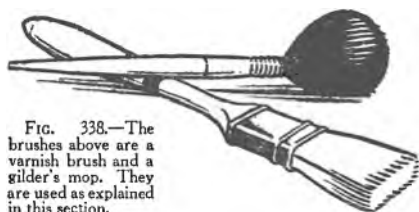


FIG. 338.—The brushes above are a varnish brush and a gilder's mop. They are used as explained in this section.

not be applied too freely, but just sufficient to rub into the wood until it becomes gradually stained and coloured. Raw linseed oil is quite cheap, and a little goes a long way.

Very few boards of timber are ever exactly the same shade, even when all of the same class. Trees differ in age and texture, so the boards from them vary in grain and colouring. In consequence, unless the timber is picked with special care (which is not often possible), something must be done to bring all parts of the work to the same shade. Stains must be used to secure this result, and the amateur is now fortunate in being able to obtain these quite cheaply and ready to use. The professional uses a number of chemicals to obtain the result—dragon's blood, bichromate of potash, turmeric, saffron, cochineal, and so on. The amateur need not worry over these, because he buys his material mixed, ready to apply.

The stain, as its name implies, is a coloured liquid which soaks into

the wood and dyes it the colour required, and serves to bring out the grain. There are stains for almost all kinds of wood—oak, mahogany, walnut, and so on, and a wide range of colour is obtainable by their use. One coat of stain will colour the surface—further coats will darken it down to the shade desired. The two principal classes of staining, so far as the amateur is concerned, are the water stain and spirit stain, which implies the liquid in which the stain is mixed. Both kinds are used in the same way, but each has advantages and disadvantages. Both kinds are obtainable in all the shades used by the amateur.

Home-made Stain. Water stains are not so powerful as spirit stains, nor are they so quick in action. A spirit stain will soak in and often dry very quickly, whereas the water takes some time. It must not be dried by putting in front of the fire or anything of that sort. One disadvantage of water stain is its tendency to "raise the grain." The application makes the wood swell, and the surface becomes rough. In consequence, it must be rubbed down with glass-paper between each coating of

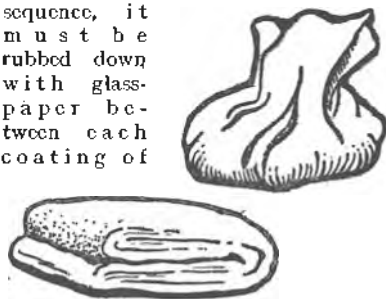


FIG. 339.—The pad below is of wadding or similar absorbent substance—to be used as a polisher. It is wrapped in linen to the shape shown by the upper drawing.

stain. Use a fine paper and be careful not to rub off the actual colouring. One way of overcoming this is to damp the wood first without any stain, and then rub it down

with glasspaper before commencing work. Water stain is naturally cheaper than spirit stain, and is usually sold in the form of crystals. These are mixed with water in a saucer, putting in just the quantity to make the desired shade. Be sure to mix sufficient to complete the job, as it is difficult to make a second quantity exactly the same. Make sure the crystals are dissolved, and try out the colour on some waste piece of wood first. A tin of stain (or dye crystals), costing 4d., will do a large number of jobs if used economically.

Points to Remember. Stains are applied with a flat brush, similar to that used in varnishing, or a gilder's mop, or can be put on with a sponge or a wad of rag. Apply in the direction of the grain quickly and evenly, but do not splash it on in too big a quantity. As mentioned, spirit stain dries very quickly, and, in consequence, the work must be done quickly. Do not overlap the work with a second coat or a darker patch will result. The end grain always soaks up more than the surface, and additional coats must be given. Take care it does not run.

One of the big advantages of stain is that it can be used to alter the wood to imitate other kinds. The grain itself, of course, cannot be altered; beech can never be made into

amateur, however, is confined to darkening the actual woods in their natural shades.

Wax Polishing. A special polishing process, as its name implies, in

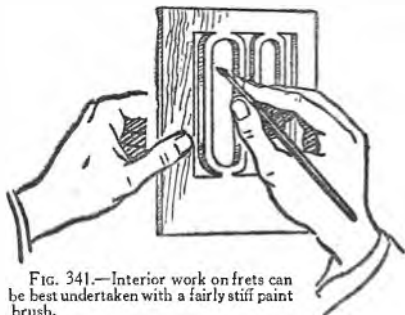


FIG. 341.—Interior work on frets can be best undertaken with a fairly stiff paint brush.

which beeswax and turpentine, or some similar preparations, are used. Wax polishing creates a surface of soft, milky appearance, but has not the high gloss of french polish. It is to be seen in "period" or antique furniture generally, and is most commonly used as a finish to mahogany, oak, or satin walnut. The great advantage of wax polish is that it is simple in application and gives pleasing results. It is most easily used on large plain surfaces, and cannot

be recommended for intricately fretted work. Professional polishers, of course, mix their wax, but the amateur is saved the time and trouble by using Waxine, sold in small tins for 6d. This is ready to use, and a tin contains sufficient for several large jobs if applied economically.

It is yellowish in colour, and is of the consistency of butter. Occasionally it becomes hard, and needs melting down. This can be done by holding it on a tin over a flame. Be careful, however, not to

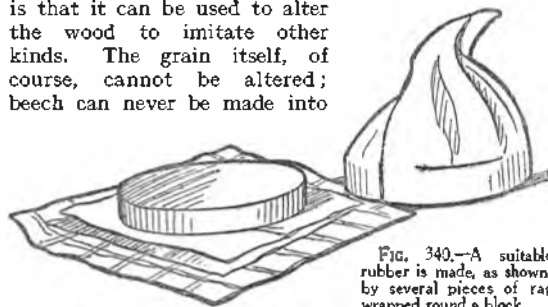


FIG. 340.—A suitable rubber is made, as shown, by several pieces of rag wrapped round a block.

oak, for instance. But whitewood can be stained so that it looks like walnut, or pine can be coloured to look like satinwood, which is yellow. The general use of stains for the

and is of the consistency of butter. Occasionally it becomes hard, and needs melting down. This can be done by holding it on a tin over a flame. Be careful, however, not to

let the flame get to the wax, because, as it contains turpentine, it will easily ignite and blaze up.

The Foundation. The work to be treated should first be cleaned thoroughly, and then given a coat of Lightning polish to form a bed for the wax. The polish must be allowed to harden in before the waxing is done—otherwise satisfactory results cannot be obtained. Do not overdo the coating of polish, however, for the grain should not be entirely filled up if the best appearance is to be obtained. Care must be taken, too, to see that neither the wood nor the rubber is damp. The wax is rubbed into the wood with a piece of clean

and it is often helpful to use a block of wood as a rubber, wrapped well round with several layers of rag. Again, much energetic rubbing is necessary to obtain a good result, but one advantage is that the work can be given further treatment periodically, in a similar manner to furniture cream being used on furniture. Oak, and similar open-grained wood, needs more work than, say, walnut, but the waxing of oak gives a pleasing and very popular result. Fumed oak is generally treated in this way. The work should be polished, where possible, before being put together, and if there are any ornamental or fretted parts, the wax can be rubbed in by means of a close, fairly stiff, small boot-brush or nail-brush.

Fumed Finish. Mention has been made of fuming, and this is another process which those who are fond of oak may like to know something about. Fumed oak is a particularly dark shade of wood produced by treating the work to the penetrating fumes of ammonia. This chemical is a liquid obtainable

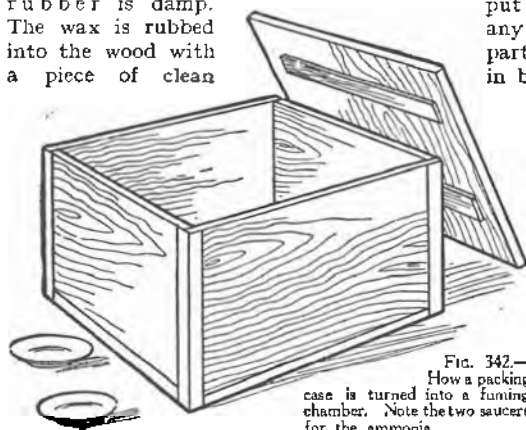


FIG. 342.—How a packing case is turned into a fuming chamber. Note the two saucers for the ammonia.

from any chemist for a few pence. It is very strong—usually with a gravity of .880, so one must be careful of the choking effect of its vapour.

The Work of Wax Polish. When the wax has been rubbed well in, leave the work for a few hours to allow the turpentine to evaporate. Then take another clean soft rag for polishing, and go over the whole surface again. Naturally, the more it is rubbed the better will be the result,

from any chemist for a few pence. It is very strong—usually with a gravity of .880, so one must be careful of the choking effect of its vapour.

An Airtight Fuming Box. When the oak is placed in an airtight chamber with the ammonia, the fumes of the latter penetrate the wood and the resultant action brings the colour down to a dark brown. The process is quite simple—the most important feature being to obtain a chest or packing case large enough to contain the work, and so constructed that it can be made airtight without a lot of trouble.

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To make the packing case airtight, it can be lined with paper and, when the lid has been put in, the cracks are covered with strips glued along. The ammonia is placed in saucers on the floor of the case—two being sufficient for ordinary amateur work. The

FIG. 343.—This is the shape of a polishing bob or rubber.



more ammonia, naturally, the greater depth of colour, and it is wise to fit a little glass window in the case to know when the work is sufficiently fumed. Another method is to have a slot cut, and through it push a strip of the same wood, as a sort of colour stick. This can be withdrawn periodically for examination. The time required varies with the depth of colour required, and the strength of the ammonia. Light colouring will take place in about five hours, whilst a day and a half may be required for a dark shade.

The work should be fumed before the parts are assembled, and must be laid in the box without any overlapping. Otherwise the parts which are covered will be unaffected by the ammonia. All the work, too, must be thoroughly cleaned with glasspaper, care being taken to get off all grease and greasy finger-marks. Uneven results may come from the use of different varieties of oak. Dark patches, however, may be made lighter by applying oxalic acid dissolved in warm methylated spirit,

and put on warm with an old brush.

Another treatment of wood on certain occasions is to make its surface dull black. This is a method which can be applied to the background for overlays in cabinets, or to panels of small doors to make a striking contrast. The most common use, however, is on the edges of cabinet fronts and edges of speaker cut-outs, where the colour serves as a relief and gives the wood a thinner appearance. This black is obtainable by application of Eggshell Black, so called because the surface it gives has a dull level appearance like an egg. The liquid is applied by means of an ordinary soft paint brush, a smaller one being used to get to the interior frets, or along the thin edges of the work.

A Polished Black. There is a good amount of spirit in the black, so it dries fairly quickly, and if a glossy surface is desired, white polish can be mixed with it before use. Hold the work carefully, and see that the fingers do not come in contact with any part of the surface which has been coloured until it is thoroughly dry.

French Polishing. This finishing

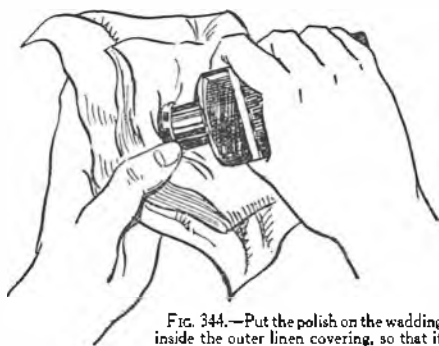


FIG. 344.—Put the polish on the wadding inside the outer linen covering, so that it just squeezes through.

process requires a great deal of time and practice to acquire perfection, and many an amateur who has tried his hand at it has become tired of his

attempts without making any real success. There is, after all, no secret in it. The wood is given a number of coats of french polish, applied with a circular motion and the right pressure on a wad or rubber. The art has to be learned by experience, and the amateur naturally wants something quicker and more certain of results. Anyone can undertake pol-



FIG. 345.—How to hold the polishing rubber.

ishing, but a special preparation is now available which is made for the beginner in woodwork. The process is the same; indeed, the work is the same, whether ordinary french or Lightning polish is used, but the worker who has been discouraged with the former will find his results much more certain and satisfactory with the latter.

Clean the Wood First. The work to be polished must be thoroughly clean and free from grease, in order that the liquid may soak in. For it must be remembered that a job cannot be satisfactorily patched up. If the polish is not put on evenly, or develops an "egg"—that is, a kind of bald patch—the only remedy is to clean the work down again with glasspaper. The work, too, should be polished before it is finally constructed. Having satisfactorily built up the piece of work temporarily, it must be taken apart again so that each piece may be treated independently. When put together again after polishing, remember that the glue will not grip on this coated surface. In consequence, all portions to which glue is to be applied must be scratched clean of polish so that the

adhesive may hold to the natural wood.

To obtain the same colour throughout, the parts must be stained in the manner previously described, taking care that the work has been thoroughly cleaned first. Finish off with a grade 0 of glasspaper to give a perfectly smooth surface. If the wood is soft and the grain open, woodfiller must be rubbed well into the grain as usual. The method adopted in the best work, and before woodfillers were known, was to apply the polish to provide the body. This is undoubtedly the best way, but a good many applications have to be made before the wood will even commence to polish, due to the wood absorbing so much before the grain is filled. This method is thus more expensive, as well as more tedious than the use of a proper filler.

Having stained the work down and got a proper surface with filling, the operation of polishing can be commenced. It is important to have a perfectly smooth, clean surface, and after the final rubbing with grade 0 glasspaper the work must be wiped to rid it of any dust. Another point to remember, too, is that the polishing should be undertaken in

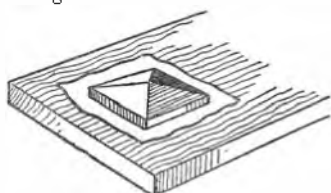


FIG. 346.—An ornament is glued to a piece of paper on a board when polishing.

a fairly warm room. The liquid is much more workable, and the results better if the temperature is a little above the ordinary heat of a living-room. If the polish is used very cold it will drag and be too sticky to produce good results.

Unlike varnish or paint, the polish

POLISHING AND STAINING

is applied to the work with a "bob" or "rubber," and the shape of one is given in Fig. 343. This is pear-shaped and just large enough to be held comfortably in the hand, so that the fingers may maintain an easy and even pressure on the "toe."

Forming the Polishing Rubber. The "bob" is composed of a pad of wadding wrapped inside a piece of linen. The wadding is pressed into a pear-shaped pad not too tightly squeezed. A square of clean linen or rag is then cut to provide an ample wrap for the pad. This cloth must be of fairly fine texture and nothing which is hairy or liable to fluff up must be used. If it is, it will stick to the polish and not produce a good surface to the work. Lay the wadding in the centre of the linen and

cular motion. Do not let the rubber remain still on the wood, but keep it working in fairly wide circular sweeps (Fig. 347). Do not press too hard, or attempt to use the bob when the polish is used up.

Pour in some more polish and continue over the surface until it has been covered entirely. Take the bob straight off the edge and be careful not to scrape it in coming on again. It is not the pressure or the amount of polish which produces a good surface, but the continued rubbing.

The first coat of polish forms the body to the work, and cannot be expected to bring up a surface. Leave the wood for about ten minutes to allow the polish to become set, and then repeat the process. This time keep the bob moving in slightly smaller circles, and do not polish one part more than another. As the grain of the wood becomes gradually filled, less polish will be needed, and more time must be allowed to elapse before repeating the rubbings.

After the second coat the

then bring the corners over to form a satisfactory hand grip. It is essential that the bottom of the rubber be perfectly smooth, whilst the ends above are twisted into a handle.

Open the rubber up again and pour a quantity of polish on the wadding as shown in Fig. 344. Let it be nicely saturated, so that when squeezed the polish will ooze out. Do not put the polish on the wrapper of linen, but do the wadding pad up as before. Hold the whole rubber lightly in the hand between the fingers and thumb (see Fig. 345), so that enough pressure can be exerted to squeeze the polish on the wadding through the linen surface. The work is commenced by rubbing the wood with the bob, gradually squeezing the polish on to its surface with the cir-

work must be rubbed down lightly with very fine glasspaper. The beginner is apt to use this too firmly, and care must be taken to see that the polish is not actually cleaned away. The finest paper should be used, and then only to lightly touch the surface of the work to smooth it out.

Three rubbings with Lightning polish are sufficient to bring up a very polished surface, providing the rubber has been used correctly.

Hints to Remember. Speed does not matter, but rather an even steady movement with an even pressure on the work. The constant application of the bob will bring about the desired result. Do not put on too much polish, nor work the bob when it is dry and stiff. The work should be

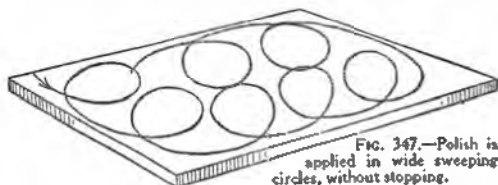


FIG. 347.—Polish is applied in wide sweeping circles, without stopping.

POLISHING AND STAINING — PORTABLE ACCUMULATOR

completed at one operation, because the bob will get stiff and hard if allowed to dry. It can be used again if kept in an airtight tin, but on no account must it be used if the surface is hard. This will only scratch the work and blemish it.

Working on Shaped Pieces. The work must not be handled so that greasy fingers come in contact with the polished surface. The wood should be laid flat on the bench against a stop of some kind to prevent it moving about. A good plan is to drive screws in so that the heads project above the top of the bench just far enough to act as a stop. Or if the work must be held, put a screw into the edge of the wood to serve as a handle. The final strokes must be given with the rubber from end to end, carrying the bob right off the wood each time in the direction of the grain. In polishing moulding, it should be held by a frame at each end, whilst the small wooden ornaments which are so popular now in decorating can be fixed for polishing by gluing them to a piece of coarse paper and then gluing the whole down to another board (Fig. 346).

In this way, the ornament can be taken off after polishing has been completed.

A Useful Outfit. Special polishing outfits can be obtained which contain all that is necessary for the polisher. There are stains and woodfiller as well as polish and rubber and glass-paper. It must be remembered that polish itself will not colour up the wood. For this reason, and to do away with staining, the amateur can obtain a Lightning Colour Polish. This is, as its name suggests, the special french polish in which the colouring stain has been mixed. In consequence, it colours as it polishes—the work being done with a "bob" as previously described. The Colour Polish is obtainable in oak, mahogany, and walnut, and although primarily intended for use on boards of that particular class, it can be used on suitable whitewood or similar boards. This information is given on the authority of Hobbies Ltd.

POLYPHASE.—When two or more circuits have a rise and fall of electromotive force which is not in step they are said to be polyphase.

PORTABLE ACCUMULATOR.—See *Accumulator*.

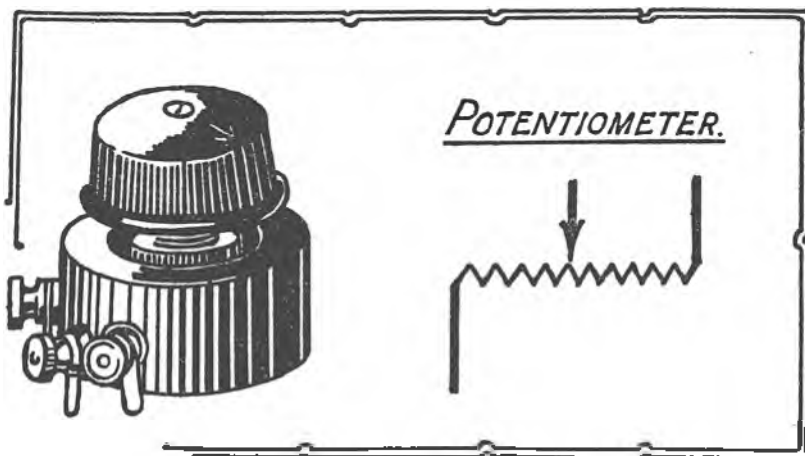


FIG. 348.—A Potentiometer shown pictorially and theoretically.

PORTABLE SET — PUSH-PULL CIRCUIT

PORTABLE SET.—Any self-contained receiver which may be carried. Such a receiver includes a compartment for high- and low-tension batteries and a frame aerial and speaker.

POSITIVE POLE.—A positive pole of an accumulator or cell is that connected to the positive plate.

POTENTIAL.—Any voltage above or below zero. (See also *Potential Difference* and under *E.M.F.*)

POTENTIAL DIFFERENCE.—The difference in electrical pressure which exists at the ends of an electrical circuit. The voltage drop across a resistance.

POTENTIAL DIVIDER.—Another name for a potentiometer.

POTENTIAL RECTIFIER.—A type of crystal rectifier requiring an initial current before it becomes sensitive.

POTENTIOMETER.—A component for tapping off a portion of a potential difference. It should not be confused with an ordinary rheostat or resistance, for it is shunted (that is, connected in parallel) across the circuit.

POUNDAL. — The foot-pound-second unit of force. The force which gives a mass of 1 pound a velocity of 1 foot per second. Its equivalent in C.G.S. units (centimetre-gramme-second) is 13,825 dynes.

POWER GRID DETECTION.—The essential features of this method of detection are large-standing anode current, with a good, strong signal applied to the valve so as to produce a drop in current of about 15 per cent. Owing to this large anode current, it is necessary to use a valve with an impedance of between 10,000 and 25,000 ohms, and it is also impracticable to use the majority of L.F. transformers owing to saturation troubles. This means that either

resistance-capacity coupling or a parallel-fed transformer must be used, and it is quite obvious that a large current through a resistance to match an impedance of the order stated will result in a very heavy voltage drop. Owing to the convenience of A.C. mains, it is possible to use 400 or 500 volts for H.T., and the drop through a suitable anode resistance still permits the valve to receive its maximum H.T. voltage. An alternative method is to use an iron-cored choke, with a very high inductance value. Small values are chosen for the grid leak and condenser, usual values being .0001 and .25 megohm.

PRESSPAHN.—A proprietary insulating material manufactured from wood fibre.

PRIMARY CELL.—A cell of the bichromate, Bunsen, Daniel, Leclanché, or dry-cell type, producing voltage by chemical action as distinct from a secondary cell or accumulator which needs to have a current of electricity passed through it, a proportion of which it stores. An accumulator is a secondary cell.

PRIMARY CIRCUIT.—Any circuit which supplies current to another; the latter is hence the secondary circuit.

PRIMARY CELLS AND SECONDARY CELLS.—A primary cell is one in which energy is produced by the chemical action of bichromate and other solutions on two elements such as carbon and zinc. A secondary cell or accumulator will merely store a proportion of an electric current passed into it, as already explained.

PUSH-PULL CIRCUIT. — The push-pull circuit is best described by aid of the usual diagram. Here it will be seen that the coupling of the penultimate stage is by transformer, the secondary of which feeds the grids of two power valves Gr and G₂ in opposite phase, i.e. when the one swings positive the other is nega-

PUSH-PULL CIRCUIT

tive. The centre of the said secondary is tapped and goes to earth via the grid-bias battery B, which supplies the required bias to both G_1 and G_2 alike. The anodes of the two power valves A_1 and A_2 connect to the terminals of the primary of the O.P. transformer respectively, and the H.T. is supplied by way of a centre tapping T. The secondary of the O.P. transformer is arranged in the usual manner, and couples to the speaker circuit "L.S."

Advantages derived from Push Pull.

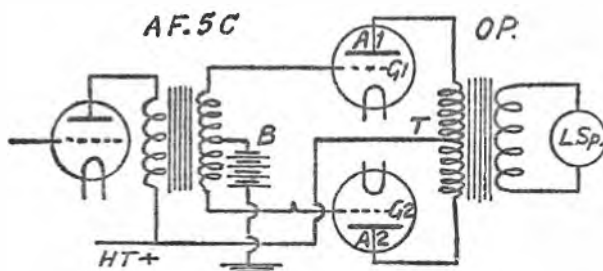


FIG. 349.—Diagram explaining the Push-pull Circuit.

Firstly, it may be noted that the constant component of the H.T. current is divided and flows equally and in opposite directions round the two halves of the O.P. primary winding. It consequently has little or no effect as inducing magnetisation in the core; that is to say, there is no constant magnetising current, and the transformer core is normally without field. Under these conditions the effective inductance is higher, commonly about double or treble what it would be in a transformer carrying the H.T. current in the ordinary manner. This results in the bass, or low, frequencies being more fully transmitted.

Secondly, since one of the power valves is taking more H.T. current when the other takes less, the draft on the H.T. battery is almost constant, instead of flowing in waves

or jerks, hence the main cause of "motor boating" is disposed of, and the need for decoupling is far less urgent.

Thirdly, distortion, due to the curvature of the valve characteristic, is very greatly reduced; the valves being in opposite phase result in the two curves mutually correcting one another, and "octave contamination" is disposed of and certain other forms of distortion that go with it.

Fourthly, consequent upon the foregoing, the valve swing that may be usefully employed is considerably increased, and two valves coupled in push pull will give far more output than the same two valves mounted in parallel. This has been variously assessed at two or two and a half times as much. In other

words, the conversion of a set to push pull and the addition of one valve (duplicate of the power valve) is, so far as undistorted output is concerned, equivalent to adding three or four valves instead of one.

With all these advantages, it is amazing that the push-pull system has not become almost universal, at least on sets with any pretensions to quality and efficiency. From a purely economic point of view, the greater output from a given expenditure in valves, the better service from a given output transformer, and the elimination of the prime cause of motor boating, far more than justify the additional expenditure in the push-pull inter-valve transformer, and the trifling expenditure in other directions. Possibly the current belief that the choke-filter output circuit is in some way better than an

output transformer (an entire fallacy in the opinion of some experimenters) is in part responsible; perhaps it is the view that the push-pull system is something that comes under the head of *unnecessary complication* that holds it back; though how this can be is a mystery, when most home-made sets look just as complicated. Push pull is, as a matter of fact, a far simpler arrangement, although possibly more costly. It certainly is more stable. Probably the real reason is that the overwhelming advantages enumerated above are not realised by the general public, and those who design or manufacture sets for the market are too shortsighted to make use of transformers bearing a trade name. Whatever the reason may be, there is sound reason in recommending push pull to all who would strive after the best radio reception, musical or otherwise.

Furthermore, when designing or laying out a set or gramophone amplifier, whether push pull or otherwise, a *milliammeter in the power circuit* should be regarded as an essential. Men who neglect this simple expedient ought to be as rare as is the mariner who puts to sea without log or compass.

PYRITES.—Compound of sulphur of iron, of which bisulphide and ferrous sulphide are the chief.

PYRON DETECTOR.—An iron pyrites crystal. A copper cat's whisker should be used in connection with it.

R

REACTANCE.—Another term for the resistance or impedance offered to a current passing through a coil and distinct from the resistance due to the current acting back on itself. Back electromotive force.

REACTION CIRCUIT.—The circuit of a wireless valve connected so that part of the energy in the anode circuit is fed back and made

to react upon the grid circuit. This results in greatly increased energy. The system of coupling may be either electric or magnetic. There are certain special circuits such as the Franklin, Ultraudion, and the Armstrong regenerative.

RECTIFICATION.—The process of converting an alternating current into a uni-directional current. In the crystal detector this is carried out by means of a piece of mineral in contact with a metal, or other piece of mineral. The application of an alternating current to this junction results in one-half of the wave being suppressed, and the result is that a D.C. current is passed on, this D.C. current bearing the variations corresponding to the applied signals. The valve is caused to rectify by inserting in the grid circuit a condenser and grid leak, and this acts in the same manner. In anode-bend rectification a large negative potential is applied to the grid, and this results in only the positive half cycles of the applied signal oscillations being reproduced as changes in the anode circuit, negative applications producing no apparent change in anode current. For power-grid rectification a condenser and leak are employed, together with a large anode voltage. The usual values of condenser and leak for normal rectification are .0002 or .0003 mfd. with 2 megohms, and for power-grid rectification the condenser is .0001, with a leak of only .25 megohm.

RECTIFIER, METAL.—See *Accumulator*.

RECTIFIER, TUNGAR.—See *Accumulator*.

RECTIFYING VALVE.—A valve having two anodes and a filament, used in a mains eliminator for converting A.C. to D.C.

RADIO ACTIVE.—A term applicable to substances like radium, which unceasingly emit electrons.

RADIO FREQUENCIES — REMOTE CONTROL

RADIO FREQUENCIES.—Frequencies exceeding audio frequencies; hence any frequency over 20,000 cycles per second.

RADIO GONIOMETER.—An instrument with two aerial coils and a swinging coil similar to a Bellini-Tosi direction finder. It is used purely for direction finding. (See also *Bellini-Tosi*.)

RADIOGRAM. — An American

term for any message sent by wireless telegraphy. The English meaning signifies a radio gramophone.

REINARTZ CIRCUIT.—See Fig. 350.

REJECTOR CIRCUIT.—A tuned circuit which rejects certain frequencies. (See also *Wave Trap*.)

RELATIVE INDUCTIVITY. — Specific inductive capacity.

RELAY.—A device having a sensitive magnet to which is applied a weak current from one circuit which energises it for controlling another circuit. (See also *Remote Control*.)

REMANENCE. — The magnetism retained in iron, etc., after magnetic induction has stopped.

REMOTE CONTROL BY

RELAY.—Quite a number of people object to the presence of a wireless set in the drawing-room, especially if the receiver is home made and has a number of tuning knobs or dials. There are also a number of listeners who only build their receivers in an experimental way, or who have a workshop or spare room where all the wireless apparatus is stored. In any case, where the loudspeaker is fitted in one room, and the receiver in another, some method of controlling the set is desirable, or even necessary, if one does not wish to run backwards and forwards to switch the set on and off for various items. There are quite a number of different ways in which this can be carried out, and a few of these are described in this section.

The cheapest, and at the same time the simplest way is illustrated in Fig. 351. All that is required for this is a simple switch and a length of good quality bell wire or flex.

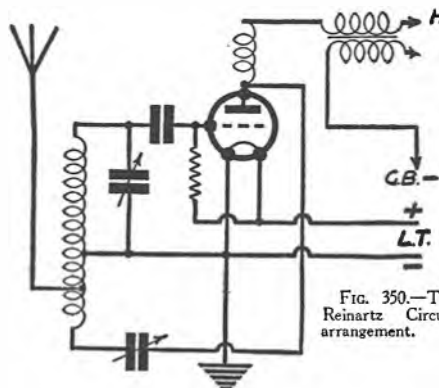


FIG. 350.—The Reinartz Circuit arrangement.

term for any message sent by wireless telegraphy. The English meaning signifies a radio gramophone.

RATIO OF TRANSFORMATION.—The ratio between the number of turns in the primary of a transformer to the number of turns in the secondary of a transformer.

R.F.—Radio Frequency.

REFLEX.—A circuit employing a valve for the dual purpose of amplifying at high and low frequencies. The arrangement most commonly employed is to include the secondary of a L.F. transformer in the grid circuit of a valve acting as a H.F. amplifier.

REFLEX CIRCUIT.—See *Circuit*.

REGENERATIVE CIRCUIT.—See *Circuit* and *Armstrong Circuit*.

REINARTZ.—A circuit employing a single coil for grid reaction and aerial circuits. The aerial is tapped

REMOTE CONTROL BY RELAY

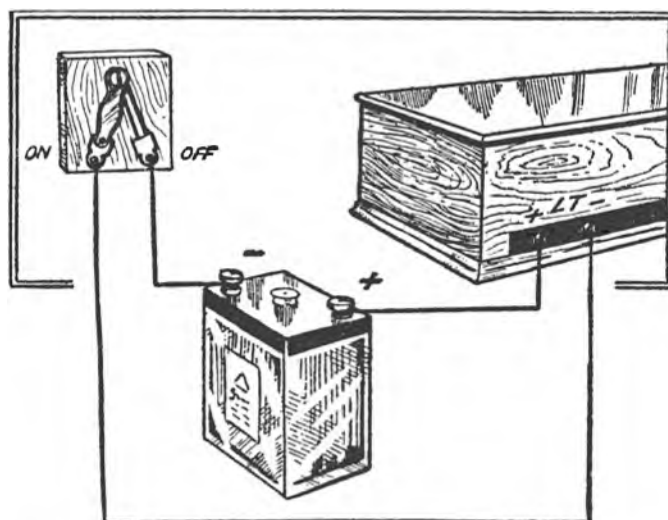


FIG. 351.—The method of Wiring-up when the Loudspeaker is in one room and the Receiver in another.

The wire must be of heavy gauge, or there will be a substantial voltage drop through it, and this will result in the valves not working at their

L.T. negative terminal of the set, and the remaining wire to the negative terminal of the accumulator. The positive terminal of the accumu-

maximum especially in the case of the 2-volt class. As will be seen from the diagram, the switch is fitted in the room containing the speaker, and from the switch the wires run to the accumulator and receiver. One wire is taken to the

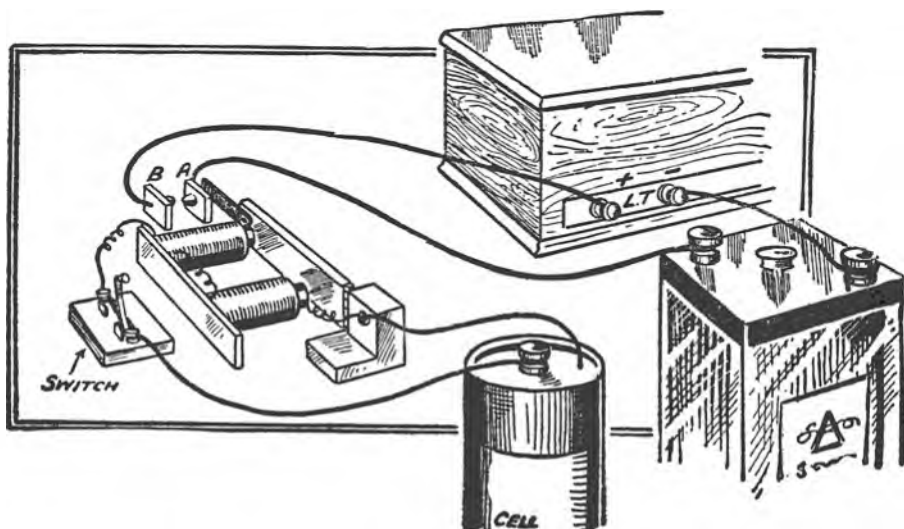


FIG. 352.—A Relay which consists of the Magnets and Armature of an electric bell

REMOTE CONTROL BY RELAY

lator is then connected to the L.T. + terminal of the set. If the set is fitted with an on-and-off switch this will, of course, have to be left in the "on" position.

A Relay from Bell Parts. The other methods described here will entail the use of a relay, which may conveniently consist of the magnets and armature from an ordinary electric bell.

In Fig. 352 the armature of the bell has been extended by a piece of thin ebonite or fibre cemented on. Two small contacts, (A) and (B), made from brass or from an old dismantled bell push, are then mounted close together so that when the armature is attracted to the magnets the piece of fibre will press the two contacts together.

A small dry cell and a switch are then connected as shown, whilst the accumulator leads are arranged as for the method first described. If, now, the switch is operated the magnets will attract the armature, the contacts will close, and the valves will be switched on. With

this method the magnets are consuming current all the time the valves are in use, although the current is not taken from the accumulator. Whilst satisfactory, a better scheme is available, and is detailed in the next paragraph.

Another Method. A more ambi-

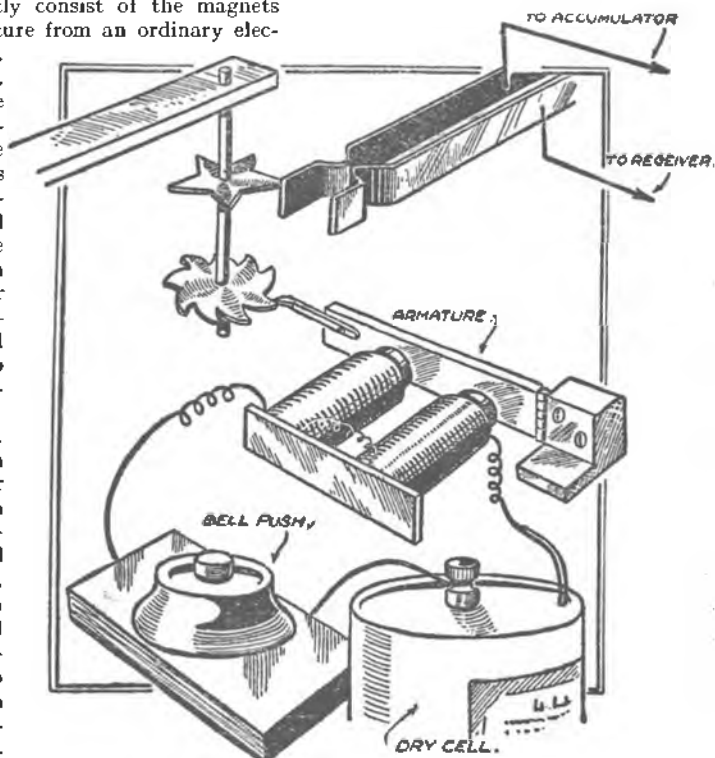


FIG. 353.—A more ambitious scheme for a Relay.

tious scheme is next illustrated (see Fig. 353). This method is no doubt the best, but a certain amount of labour and skill will have to be expended in its construction. Again the bell magnets are employed, with an extended armature. In addition, a small-toothed wheel will be required, the actual size and number

REMOTE CONTROL — RESISTANCE

of teeth depending on the movement made by the armature of the relay in use. At the end of the armature a small piece of metal is hinged, and kept in a position at right angles to the armature by a small spring. This may be the rear half of a small safety pin. The toothed wheel is soldered to a small spindle upon which is mounted a star-shaped piece of ebonite or other fairly strong material, having half as many teeth as the other wheel. Two contacts, for which the long arms from an ordinary pocket-lamp battery may be called into use, are then arranged as shown. A certain amount of adjustment will have to be carried out to get this little piece of mechanism working smoothly. A dry cell to operate the relay and, this time, an ordinary bell push are then arranged as shown.

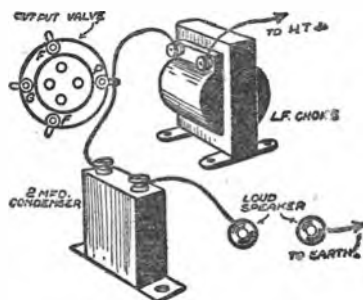


FIG. 354.—The Filter Output Circuit. See also Fig. 191.

With this method of control, current is only used when the set is switched on or off, and it is therefore most economical. When the set is to be switched on, the bell push is depressed. The armature is attracted to the magnets, the little arm engages on the toothed wheel, and the spindle is thereby rotated slightly. One of the points of the star-shaped wheel presses the contacts together,

and so the valves are switched on. To switch the set off, the bell push is again depressed, and this causes the spindle to be rotated once more, bringing the point off the contacts and so breaking the accumulator circuit. It will be seen, therefore, that this control works alternately: one push to switch on, the next push switching off, and so on.

Of course it should be understood

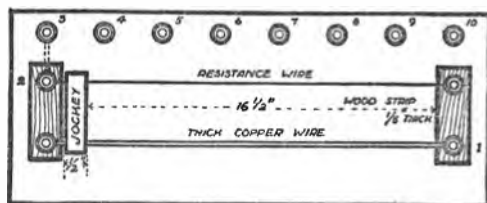


FIG. 355.—A plan view of the Box.

that these methods of remote control are only applicable to battery-operated sets, and in any case where the loudspeaker is employed at a distance from the receiver an output transformer or filter output circuit must be used. It should be kept well in mind that the filter output circuit consists of low-frequency choke and a condenser of 2 mfd. arranged as shown in Fig. 354.

REPAIRING ACCUMULATORS.

—See *Accumulator*.

RESIDUAL CHARGE.—The charge remaining in a condenser after its first discharge. It is caused by electric absorption.

RESIDUAL MAGNETISM.—The magnetism retained by iron, etc., after contact with a magnet, or after the application of a magnetising force.

RESISTANCE.—The opposition to flow in an electric current. The resistance of a wire is directly proportional to its length, to its specific resistance and inversely to the area of its cross section. Unit of resistance is the ohm.

RESISTANCE BOX

RESISTANCE BOX.—Many experiments in electricity need a resistance which can be adjusted to different values, and below is described a simple, cheap, and efficient instrument for performing this duty. If made carefully, it will give very accurate results. First procure a 2-oz. reel of "Eureka" resistance wire, 22 gauge. Such a reel, double silk covered, costs about 1s. 5d. Fig. 355 shows the top of the box, which is 1 ft. 8 in. $\times$ 4 in. Mount two terminals with a space of exactly 17 in. clear between them, and stretch a piece of the resistance wire lightly between them. This piece of

resistance wire must be bared by having the whole of its silk covering stripped off. Now mount a second pair of terminals an inch away from these, and between them stretch a piece of thick copper wire (about $\frac{1}{8}$ in. thick). This, too, must be bared.

All terminals must be raised $\frac{1}{8}$ in. above the board by placing thin pieces of wood under them, as shown. The two parallel wires should be fastened under the base of each terminal, so leaving the upper part free for temporary connections.

The "jockey" is a piece of brass $1\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$ in. File two grooves in it, as shown in Fig. 356, so that it will ride nicely on the parallel wires.

Mount the eight terminals 3, 4, 5-10 at equal distances, and join 2 and 3 by a stout copper wire underneath the board.

The Former. Fig. 357 shows the "former" upon which the resistance is wound. It is a cylinder of wood, cardboard, or one of the many preparations used in wireless coil formers,

with a circumference of exactly 11 in. The accuracy of the instrument depends upon this being correct. The best way is to make or get one slightly smaller and wind on a sheet of thin paper until the exact size is obtained. Drive in a small brass screw (or bolt and nut) $\frac{1}{8}$ in. from the edge A. Start winding the resistance wire from this screw. At



FIGS. 356 and 357.—(Left) Details of the "Jockey," and (Right) the Former on which the Resistance is wound.

the end of three complete turns twist the wire round a second screw, B. After six more turns twist it round a third screw, C; six more turns, round the fourth screw D; fifteen more turns, round the screw E; thirty more turns, round the screw F; thirty more turns, round the screw G; sixty final turns, round the screw H. This gives a total of 150 turns, spacing them about $\frac{1}{6}$ in. apart. The wire must be bared where it is twisted round the screw.

Before driving the screws home, hook about 2 in. of thick copper wire under the head of each.

Fix the former into the box and join each of the copper wires to the base of one of the terminals, as shown.

How to work the Instrument. The resistance of the wire is 1 ohm per 33 in., so three complete turns on the former give 1 ohm. The resistance of the entire coil at terminal 10 is thus 50 ohms. Suppose one terminal of a battery is connected to

terminal 1 (Fig. 355) and the other to a terminal of a piece of apparatus. The other terminal of the piece of apparatus is joined to 10, and the jockey is pushed over to the left in contact with 2.

The current enters at 1, passes along the copper wire and jockey to 2, through the entire resistance to 10, through the apparatus to the battery again. If less resistance is required, join the apparatus to one of the other terminals.

RESISTANCE CALCULATIONS.

—In the light of modern-set design, it is interesting and instructive to view the practice indulged in not so very long ago of choosing resistances for their values, regardless of the current-carrying capabilities and self-capacities. Indeed, many ardent constructors of the early days can remember when the acquisition of a resistance of a certain value was deemed a "find," and it was no uncommon thing to be forced to make one from questionable material, such as Indian ink, blotting-paper, etc.

Nowadays the position seems to be entirely the reverse. There are literally dozens of makes available, and each in three or four different types, each of which again is available in about four or five dozen resistance values. Add to this multitude the question of a wattage rating, or in other words, a current-carrying capacity, and it will be realised what a difficult task it is for the average constructor to arrive at a suitable selection for his proposed set. Of course, such difficulties do not arise when a published set design is followed, since the designer is invariably careful to name makes, types, and ratings, while the resistances chosen are usually capable of withstanding 50 to 75 per cent. overloads.

There is another type of constructor, however, who has just sufficient technical knowledge to design his

own receiver. He is the man who sometimes takes a fancy to the H.F. side of one receiver and the L.F. stages of another, and attempts a combination of the two. Often his practical knowledge is sufficient to allow him to make a success of the arrangement, but in rearranging the voltage-dropping resistances or H.T. battery eliminator he encounters difficulty.

In such circumstances the constructor, owing to his unfamiliarity with Ohm's Law, resorts to "hit-and-miss" methods, often with disastrous results. Ohm's Law is here repeated.

Voltage = current $\times$ resistance
or ($E = I \times R$).

Resistance = $\frac{\text{voltage}}{\text{Current}}$

$$\left(R = \frac{E}{I} \right)$$

Current = $\frac{\text{voltage}}{\text{resistance}}$

$$\text{or } \left(I = \frac{E}{R} \right)$$

Wattage = voltage $\times$ current
or ($W = E \times I$).

Where

E = voltage

I = current

R = resistance

W = wattage.

As an interesting example, let us assume an output valve requires a 100-ohm non-inductive resistance in its anode circuit. We require to compute the wattage of a resistance, and we know the maximum anode current of the valve is 63 mA from the data slip supplied by the makers. Since it is not possible to apply the formula $W = E \times I$ until the voltage drop across the 100 ohm resistance has been decided, we utilise $E = I \times R$, which in this instance will be $E = 0.063 \times 100 = 6.3$ volts (0.063 is 63 mA/A

RESISTANCE CALCULATIONS

expressed as a fraction of 1 ampere).

Thus, $W = 6.3 \times .063 = .3969$ watt. From a commercial aspect, a .5-watt (half-watt) resistance would be chosen, though as surges of current sometimes take place, or as resistances of 100 ohms are rarely available between .25 and 1 watt, the latter would be the wisest choice.

A further example is a power grid detector, with a positive bias of 1.5 volts on the grid. This valve has an applied H.T. potential of 450 volts, which on test shows an anode current of approximately 8 mA when a 20,000-ohm anode resistance and 15,000 decoupling resistance are employed. We require to know the wattage rating of the resistances, also the voltage on the anode.

By Ohm's Law $E = I \times R$, or, in one case, $E = 20,000 \times .008 = 160$ volts, and in the other $E = 15,000 \times .008 = 120$ volts. Ignoring the resistance of the H.F. choke, which is negligible, the voltage drop is $160 + 120 = 280$ volts. Subtracting 280 from 450, the actual voltage applied is therefore 170 volts. Reverting to $W = E \times I$, in the first case, $W = 160 \times .008 = 1.28$ watts; in the case of the decoupling resistance $W = 120 \times .008 = .96$ watt. Strictly suitable resistances would be one 20,000 ohms, 2 watts, and one 15,000, 1.5 watts. However, two 2-watt resistances would suit.

Non-inductive Resistances. From technical considerations it is always advisable to employ an anode resistance, of a non-inductive nature, as a wire resistance, wound in the form of a solenoid on a heat-resisting former, invariably possesses inductance and, consequently, a definite self-capacity. However, from past experience, we are unable to stress the point, as the internal electrode capacity of the

valve, plus the valve-holder capacity, are often of a greater dimension than the anode resistance alone. Consequently, unless one has taken extreme precautions to avoid high-note loss in a resistance-coupled L.F. stage, by using a low-loss valve holder, decapping the valve, etc., the choice need not be a narrow one. The choice nowadays inevitably depends on the price, and it is a matter for congratulation that some of the most

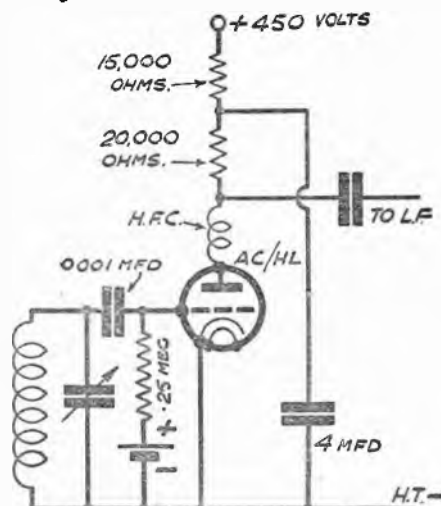


FIG. 358.—The Resistance necessary in a Power Grid Rectifier which is also decoupled.

cheap and reliable of resistances are also non-inductive.

Decoupling Resistances. Decoupling resistances can be of any convenient form, so long as they are of suitable wattage. Wire-wound resistances, with adequate ventilation to avoid overheating, are undoubtedly the best, as they are always silent in operation, and rarely change their values under different loads, so long as the maximum ratings are not exceeded.

On the other hand, the manufacturing costs of a modern set do not allow for wire-wound resistances, and

RESISTANCE CALCULATIONS — RESISTANCE VALUES

synthetic carbon resistances have been commissioned in great quantities. Chemistry has played a very large part in the perfection of graphite compounds, and considerable ingenuity has been shown in some of the designs at present on the market.

Metallised Resistances. The metallised resistances, which have achieved a high degree of success, are examples of evaporated water colloidal carbon deposits hermetically sealed in practically non-porous porcelain tubes. It is possible to run these resistances at considerable overloads (not that it is advisable or desirable) before any signs of disintegration

not only disintegrate, but cause "frying" noises in the process. By allowing a generous margin for overload, therefore, no trouble should be experienced; the resistances behave to all intents and purposes as if they were wire wound. The strict difference lies in their physical properties, wire windings increasing in resistance with increase of temperature, and carbon resistances decreasing slightly in value with similar increases.

Finally, a few words about grid-leaks. For H.F. and detector circuits, ordinary grid-leaks of reputable make can be relied upon not to break down, but for L.F. circuits, particularly in mains sets and in power-valve grid circuits, the .5-watt type are to be preferred, since occasionally grid current may flow, and the higher rating of the latter type will satisfactorily deal with the momentary loads imposed.

Decoupling grid resistances of .1 to .25 meg. should always be of the .5-watt (or larger) type. Automatic grid-bias resistances, as

a matter of good practice, should normally be wire wound.

RESISTANCE CAPACITY COUPLING.—See *Coupling*.

RESISTANCE VALUES IN ANODE CIRCUIT.—If the value of the load resistance is made too great, the drop in voltage due to the passage of the standing anode current will be very great, with the result that the working anode voltage will be small, and the valve will not be working under the most favourable conditions.

occur. Another resistance of a highly successful nature is the Loewe, which is a carbon deposit on a glass rod suspended in an exhausted glass tube. The resistance operates on the lines of a carbon lamp, except that it runs at "black" heat. Carborundum compounds, compressed at great pressure, are features of certain other makes, which dissipate heat over their entire surfaces, and which are rated according to their area.

It must be borne in mind that all synthetic compounds, if overloaded,

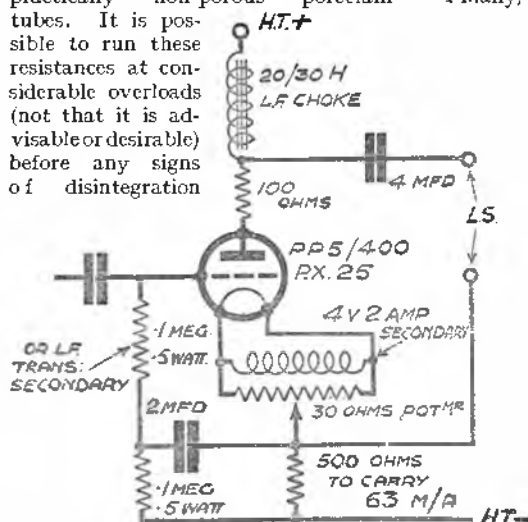


FIG. 359.—An Output Valve which is Mains Operated, and the Power Rating of all Resistances which are included in the Circuit.

RESISTANCE VALUES — SCRATCH FILTER

For low-frequency amplification, the impedance of the external anode load should be from twice to about five times the valve resistance, which will give an overall gain of from two-thirds to five-sixths of the valve's amplification factor. Thus, if a valve has an anode resistance of 50,000 ohms, the resistance employed for a resistance-capacity circuit should be from 100,000 to 250,000 ohms. The higher the resistance, within these limits, the larger the percentage of the valve's amplification factor which can be utilised. If, however, a resistance greater than the maximum recommended be used, it is probable that the diminution in working anode voltage would seriously reduce the efficiency of the stage.

RESISTIVITY. — Specific resistance.

RESISTOR. — Another name for a fixed resistance.

RESONANCE. — A state brought about when the natural frequency of a circuit is of equivalent value to the frequency of the alternating (periodic) E.M.F. created in it, thus inductive reactance will neutralise capacity reactance, and reactance will therefore be at zero. Two circuits are in resonance when they have the same frequency.

REVERSED CHARGE. — See *Accumulator*.

RHEOSTAT. — A variable resistance connected in series to vary the amount of current flowing in a circuit. It differs from a potentiometer which is connected in parallel with the voltage.

RONTGEN RAYS. — Another name

for X-rays, named after their discoverer, Röntgen. The ray is really the electronic discharge from the cathode of a vacuum tube which is directed on to a platinoid plate which radiates waves of extremely short-wave length. The rays will penetrate opaque substances and are visible on a fluorescent screen.

ROTARY CONVERTER. — A direct-current dynamo capable of generating alternating current.

ROTARY TRANSFORMER. — A rotary converter.

S

SAL-AMMONIAC. — Ammonium chloride which is used in Leclanché and dry cells.

SATURATION. — That state of a magnetic substance when it is impossible further to intensify its magnetism. Saturated solution. A liquid completely soaked with a certain substance. The point at which it can absorb no more of that substance.

S.C. — Silk Covered.

SCANNING DISC. — See *Television*.

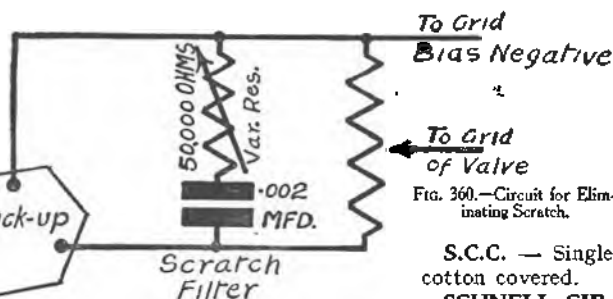


FIG. 360.—Circuit for Eliminating Scratch.

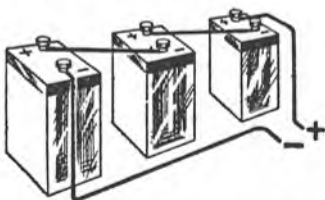
S.C.C. — Single cotton covered.

SCHELL CIRCUIT. — A circuit not much used nowadays, but it is claimed to be extremely selective and to bring in stations outside the range of a normal receiver.

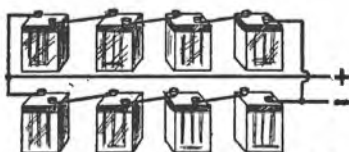
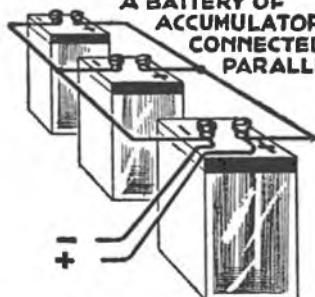
SCRATCH FILTER. — A device included in a gramophone amplifier for reducing surface noise. It may consist of a high resistance shunted across the pick-up terminals, or a

SERIES & PARALLEL WIRING

A BATTERY OF ACCUMULATORS CONNECTED IN SERIES



A BATTERY OF ACCUMULATORS CONNECTED IN PARALLEL



A BATTERY OF ACCUMULATORS CONNECTED IN SERIES PARALLEL

VASELINE TERMINALS TO PREVENT CORROSION.

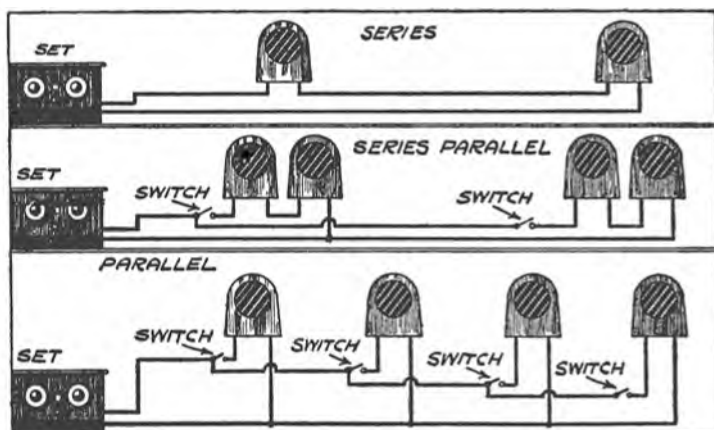
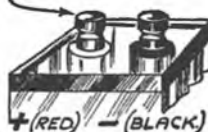


FIG. 361.—Methods of connecting apparatus in series, series parallel and parallel.

SCRATCH FILTER — S.G.

combination of resistance and condenser employed with the low-frequency transformer. The simplest method is to join a variable resistance of 100,000 ohms across the pick-up, and adjust this to give the degree of noise reduction required. By using this method radio reproduction is not affected. The suppression of the surface noise also results in the suppression of the higher musical frequencies, and therefore must be judiciously applied.

SCREEN-GRID VALVE. — See *Valve*.

SCREWS BRITISH ASSOCIATION (B.A.) GAUGE

This is adopted as the Standard Gauge by the Post Office Telegraphs Department and most large electrical firms, and approved by the Engineering Standards Committee.

No.	Absolute Dimensions in Millimetres.		Approximate Number of Threads per Inch.	Approximate Dimensions in Inches.	
	Full Diameter.	Pitch.		Full Diameter.	Pitch.
25	0.25	0.070	362.8	0.010	0.0028
24	0.20	0.080	317.5	0.011	0.0031
23	0.33	0.09	282.2	0.013	0.0035
22	0.37	0.10	254.0	0.015	0.0039
21	0.42	0.11	230.9	0.017	0.0043
20	0.48	0.12	211.6	0.019	0.0047
19	0.54	0.14	191.4	0.021	0.0055
18	0.62	0.15	169.3	0.024	0.0059
17	0.70	0.17	149.4	0.028	0.0067
16	0.79	0.19	133.7	0.031	0.0075
* 15	0.90	0.21	121.0	0.035	0.0083
14	1.0	0.23	110.4	0.039	0.0091
* 13	1.2	0.25	101.6	0.047	0.0098
12	1.3	0.28	90.7	0.051	0.0110
* 11	1.5	0.31	81.9	0.059	0.0122
10	1.7	0.35	72.6	0.067	0.0138
* 9	1.9	0.39	65.1	0.075	0.0154
8	2.2	0.43	59.1	0.087	0.0169
* 7	2.5	0.48	52.9	0.098	0.0189
6	2.8	0.53	47.9	0.110	0.0209
* 5	3.2	0.59	43.0	0.126	0.0233
4	3.6	0.66	38.5	0.142	0.0260
* 3	4.1	0.73	34.3	0.161	0.0287
2	4.7	0.81	31.4	0.185	0.0319
* 1	5.3	0.90	28.2	0.209	0.0354
0	6.0	1.00	25.4	0.253	0.0394

* The Engineering Standards Committee recommend that for general use these sizes be dispensed with. The Committee also recommend that for screws less than $\frac{1}{4}$ -in. diameter British Association Threads should be adopted. It was originally proposed by the British Association in 1884, and finally adopted by them in 1904. It is, however, not yet the usual practice in this country to use the sizes ranging from No. 17 upwards. Moreover, makers of taps, dies, screwplates, etc., usually supply sizes only to No. 16.

(See also *Drills*.)

SECOHM.—The henry—the unit of inductance.

SECONDARY CELL.—Another name for an accumulator. (See also *Accumulator*.)

SECONDARY CIRCUIT.—A circuit whose current is supplied by the primary circuit. (See also *Primary Circuit*.)

SELENIUM.—An element allied to sulphur. It exists as a red powder soluble in carbon bisulphide, as a crystalline grey solid which is insoluble, and as metallic selenium which is insoluble. The resistance of selenium is reduced by light rays. (See also *Light-ray Control*.)

SELF CAPACITY.—A term used in connection with coils to denote the condenser effect of the turns of wire and their insulation.

SEPARATE HETERODYNE.—A component for generating oscillations of a frequency almost equal to those existing in the circuit in which it is coupled. It is used to give a damping effect.

SELF INDUCTANCE.—In a circuit the inductance caused by the current flowing in it.

SELF INDUCTION.—A back electromotive force is caused when a current changes in a coil. This effect is known as self induction, and is sometimes referred to as electro-magnetic inertia.

SEPARATORS.—The substance used to separate the positive and negative plates of accumulators. The chief materials used are grooved wood, celluloid, and glass. (See also *Accumulator*.)

SERIES.—A number of cells, coils, components, or instruments connected in such a manner that the current must pass through each unit of the series successively.

SERIES PARALLEL.—See *Accumulator* and Fig. 361.

S.G.—Specific Gravity.

SHELLAC — SIDE-BAND CUT OFF

SHELLAC.—A species of rosin obtained from the sap of Indian trees. It is soluble in methylated spirits and alcohol, and it is an excellent insulator. Specific inductive capacity is three.

S.H.M.—Simple Harmonic Motion.

SHORT CIRCUIT.—Any circuit having negligible resistance. To cut out a component by connecting its terminals together.

SHORT WAVES.—All wavelengths below 100 metres are referred to as "short waves," those below 10 metres usually being referred to as ultra-short waves. These short waves, instead of following the surface of the earth as with higher wavelengths, shoot off into the atmosphere, and are deflected back to earth by the Heaviside layer. The angle at which the signal shoots off varies according to the frequency of the trans-

mission, or in other words, the wavelength. Owing to this "shooting off" and "reflecting back," there are certain areas in which the signals are inaudible, and this is known as the "skip distance effect." Some signals pierce the Heaviside layer (or at least that is the effect), and are never heard at all. The principal short-wave stations of the world are given in the tables below.

SHORT-WAVE COILS.—See *Coil*.

SHUNT.—Another term for parallel (which see).

S.I.C.—Specific Inductive Capacity.

SIDE-BAND CUT OFF.—The term applied to the suppression of the upper and lower frequencies of a received signal. For good quality reception a receiver should be designed so that it receives a band of at least 10 kcs. This is the separa-

SHORT-WAVE STATIONS

(100 metres and below)

Kcs.	M.	AMP.	Station.	Country.	Call signs and Notes.
3,750	80	—	Rome	Italy	12RO
3,917	76	—	Maracaibo	Venezuela	YV
4,273	70.2	20	Khabarovsk	U.S.S.R.	
4,795	62.56	—	London	Ontario	VE9BY
4,800	62.5	—	Long Island	—	W2XV
5,172	58	—	Prague		
5,502	54.52	—	Brooklyn	N.Y.	W2XDH. Relays WCGU
5,692	52.7	0.5	Tananarive	Madagascar	FIUI
5,714	52.5	—	Quito	Ecuador	HCJB
5,857	51.22	20	Chapultepec	Mexico	XDA
5,923	50.6	—	Medellin	Colombia	HKO
5,969	50.26	10	Vatican City	Italy	HVJ
6,000	50	—	Barcelona Radio	Spain	EA125
6,000	50	—	Barranquilla	Colombia	HRD
6,000	50	—	Bucharest	Romania	
6,000	50	—	Kuala Lumpur	Fed. Malay States	VS2AB
6,000	50	—	Moscow	—	RW50. Relays Moscow T.U.
6,005	49.96	4	Drummondville	—	VE9DR
6,005	49.96	2.5	Tegucigalpa	Honduras	HRB
6,020	49.83	5	Chicago	—	W9Xf. Relays WENR
6,023	49.8	—	Mexico City	Mexico	XEW
6,040	49.67	2.5	Miami Beach	Florida	W4XB
6,050	49.59	0.02	Halifax	N.S.	VE9HX. Relays WLW
6,060	49.5	10	Cincinnati	—	W8XHX. Relays XAL
6,060	49.5	—	Havana	Cuba	CMCI
6,060	49.5	5	Nairobi	Kenya	7LO

SHORT-WAVE STATIONS

Kcs.	M.	W.	Station.	Country.	Call sign and Notes.
6,060	49°5	0.5	Philadelphia	Pa.	W3XAU. Relays WCAU
6,069	49°43	—	Vancouver	B.C.	VE9CS
6,072	49°4	—	Vienna Experimental	Austria	UORz
6,080	49°34	0.5	Chicago	Ill.	W9XAA. Relays WCEL
6,095	49°22	0.2	Bowmanville	Canada	VE9GW
6,096	49°2	5	Johannesburg	S. Africa	JB
6,100	49°18	20	Bound Brook	N.J.	W3XAL
6,109	49°1	0.5	Calcutta	India	YUC
6,127	48°05	—	Maracaibo	Venezuela	YV11BMO
6,140	48°86	40	Pittsburgh	—	W8XK. Relays KDKA
6,147	48°8	3.5	Winnipeg	Canada	VE9CL
6,167	48°65	—	Mexico City	—	X1F
6,205	48°35	—	Bogota	Colombia	HKC
6,220	48°2	9	Rome	Italy	2RO
6,243	48°05	—	Barranquilla	Colombia	HKD
6,250	48	—	Casablanca	N. Africa	CN8MC. Relays Rabat
6,382	47	—	Quito	Ecuador	HC1DR
6,425	46°67	—	London	Ontario	VE9BY
6,611	45°38	—	Moscow	Russia	REN
6,620	45°31	—	Rioabamba	Ecuador	PRADO
6,667	45	0.01	Guatemala City	S. America	TGW
6,667	45	0.2	Constantine	Algeria	SKR
6,976	43	—	Madrid	Spain	EAR110
7,211	41°6	0.05	Teneriffe Radio Club	—	EAR58
7,444	40°3	—	Radio Nations	Switzerland	—
7,556	39°7	—	Bogota	Colombia	HKF
7,612	39°4	—	Nuevo Laredo	Mexico	X26A
7,880	38°07	—	Kemikawoa-Cho-Chiba-Ken	Japan	—
8,650	34°68	—	Tokio	—	—
8,650	34°68	—	London	Ontario	VE9BY
8,928	33°5	—	Long Island	—	W2XV
9,090	33	—	Guatemala City	S. America	TGX
9,230	32°5	—	Radio LL	France	—
9,300	32°26	6	Paris	France	FLJ
9,500	31°58	—	Rabat	Radio Maroc	—
9,510	31°55	5	Rio de Janeiro	Brazil	PRBA
9,520	31°51	0.5	Melbourne	Australia	VK3ME
9,530	31°48	40	Skamleback	Denmark	OXY
9,560	31°38	8	Schenectady	N.Y.	W2XAF
9,570	31°35	1	Zeesen	Germany	DJA
9,570	31°35	5	Poznan	Poland	SR1
9,590	31°28	0.5	Springfield	Mass.	W1XAZ
9,590	31°28	12	Philadelphia	—	W3XAU
9,596	31°27	2	Sydney	Australia	VK3ME
9,675	31	0.015	Eindhoven	Portugal	CT1AA
9,860	30°43	20	Heredia	Costa Rica	T14NRH
10,000	30	—	Madrid	Spain	BAQ
10,350	28°08	20	Belgrade	—	—
11,181	26°93	0.05	Buenos Aires	—	LSX
11,705	25°63	2	Funchal	Madeira	CT3AQ
11,715	25°6	12	Radio Colonial Paris	France	—
11,750	25°53	20	Winnipeg	Canada	VEJR
11,763	25°5	20	Chelmsford	—	G5SW
11,810	25°5	—	Chapultepec	—	XDAW
11,810	25°4	9	Bowmanville	Canada	VE2GW
11,870	25°37	40	Rome	Italy	2RO
11,905	25°2	—	Pittsburgh	—	W8XK
12,880	23°38	20	Radio Colonial	France	—
14,630	20°5	—	Rabat	Radio Marno	—
15,075	19°19	—	Chapultepec	—	XDA
15,123	19°84	10	Heredia	Costa Rica	T14NRH
15,200	19°73	8	Vatican City	Italy	HVJ
15,210	19°82	—	Zeesen	Germany	DJB
15,243	19°68	—	Pittsburgh	—	W8XK
15,330	19°56	20	Radio Colonial	France	—
15,490	19°36	—	Schenectady	—	W2XAD
17,730	16°78	20	Kemikawoa-Cho-Chiba-Ken	Japan	—
20,730	14°47	—	Bound Brook	N.J.	W3XAL
21,540	13°92	—	Buenos Aires	Argentina	LSV
			Pittsburgh	—	W8XK

tion which is laid down by the European Broadcasting authorities (Berne). If a receiver is so sharply tuned that it accepts a band of less than 10 kcs., then side-band cut off is taking place.

SIDE BANDS.—An amplitude modulated wave can be considered as a combination of several frequencies. If it is assumed that the modulation is due, say, to an orchestra, a large range of frequencies is obtained, from about 50 to 10,000. We can consider the wave as being built up of many simple ones of frequencies which vary between $X -$, say, 12,000, and $X + 12,000$, where X equals the carrier frequency and 10,000 the highest sound frequency emitted. Hence is created a sort of band of frequencies extending above and below the carrier frequency. These waves are of audio frequency, and are known as side bands.

SIGNS, CONVENTIONAL.—The most commonly used signs in wireless circuits are shown in Fig. 1, while the practical interpretation of them is shown under appropriate headings.

SINGLE-FLUID CELL.—A cell in which only one liquid is employed.

SKIP EFFECT.—See *Short Waves*.

SLAB COIL.—An inductance coil wound in the form of a flat slab. Usually this consists of a length of wire wound in the form of a spider's web, but with adjacent turns touching. Sometimes, however, the turns are wound round spacing pins so that the turns do not lay parallel for their whole length. This type of slab coil has a lower capacity. (See also *Coil*.)

SLIDER.—A moving contact for an inductance, resistance, or any similar wireless component which has to be tapped at various points. In the older forms of inductance coil the wire was wound round a cylinder and a brass rod was fixed on the end supports of the coil. Running

along this rod was an ebonite block fitted with a spring brass plunger. This was the slider, and contact was made by removing the insulation from the coil and connecting a lead to the brass rod. The spring plunger pressed on the bare wire and so provided the requisite connection. Potentiometers and resistances now are generally of the rotary type, and the slider is attached to a rotating centre rod to which is connected the control knob. The slider rubs on the wire or element of which the resistance is composed and so taps off the required amount.

SOCKETS.—Sections of metallic tubing for providing electrical connection. Some types of socket are provided with solid walls, and the plug which fits into the socket is provided with some form of spring. In this manner perfect contact is made between the inner wall of the socket and the outer wall of the plug. Other types of socket are slotted and bent slightly inwards, and are used with a solid plug. This serves the same purpose. The most common example of a socket in a wireless set is the valve holder.

SODIUM.—A monad metallic element recognised as a distinct substance by Duhamel in 1736 and obtained in the metallic state by Davy in 1807. Symbol is Na. It occurs as chloride in sea water and salt springs, and as nitrate in South America. It is prepared by introducing an intimate mixture of 30 parts dry sodic carbonate, 13 parts coal, and 3 parts chalk into an iron cylinder, heated in a reverberatory furnace, the pure metal distilling over. It rapidly oxidises in the air, and when dropped upon water decomposes it, liberating hydrogen which, if the water is previously heated, catches fire.

SOFT VALVE.—A valve which is not completely vacuated, or which

contains a gas. This type of valve is not used at the present day, but was previously used for detection purposes (cf. *Hard Valve*). When electrons are emitted from the filament of a valve they pass outwards towards the anode. If gas is present in the bulb, then collisions take place between the electrons and gas atoms, with the result that the force of impact detaches electrons from the gas atom. These electrons join in the electronic filament stream, and by so doing increase the total anode current. The softer the valve the greater the chance of collisions and therefore the greater the anode current. The disadvantage of this process is that the gas atoms which have been in collision are left positively charged, and these are attracted to the filament, and the attraction is so great that they bombard the filament, eventually breaking it. The soft valve therefore gives a greater anode current for a given potential supply, but has a shorter life.

SOLDER.—A metal (or alloy) used to join metals. It must have a lower fusing point than the metals to be joined, and this entails that various solders must be used for different classes of work. For wireless work the principal soldering is for the junction of copper or brass parts, and for this purpose what is known as "Tinman's" solder is most suitable. This consists of 50 parts of tin and 50 parts of lead. The greater

the tin content the lower the melting-point. Some proprietary brands of solder consist of a hollow tube of the metal with a resinous preparation for the core. This enables soldering to be carried out easily, as it is "self-fluxing." In view of the fact that heat is necessary to melt the solder, oxidation takes place very often on the surface of the pieces to be joined. To avoid this a "flux" is employed. (See also *Flux*.)

SOLDERING.—To become skilful with the soldering bit get together the



FIG. 362.—How to make a simple angle joint.



FIG. 363.—A wire to be attached at right angles to another should be looped together as shown.

necessary equipment and try jointing up scraps of tinplate, brass, steel and copper wires in various formations. You will soon be able to judge the right heat for the iron, the importance of working with a well-tinned bit, and also that main essential, perfect cleanliness, in the work being operated upon.

Processes of Soft Soldering. To be entirely successful in the process of soft soldering, there are many little

devices, other than those that are to be purchased at a tool dealer's store, that can be made up by the amateur for his own use. In addition,

there are numerous "dodges" known to the practical

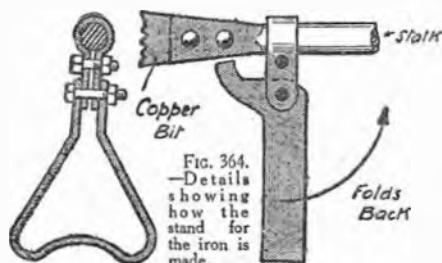


FIG. 364.—Details showing how the stand for the iron is made.

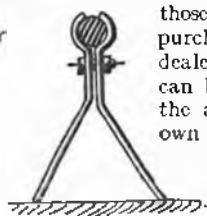


FIG. 365.—How to make a permanent fixing for the foot of the stand.

SOLDERING

man which, if adapted to the job in hand, will not only speed up the work, but tend to produce very much sounder, cleaner, and more workmanlike joints.

The Weight of the Soldering Bit. The term "soft soldering" covers all those lower temperature metal-jointing processes in which the base

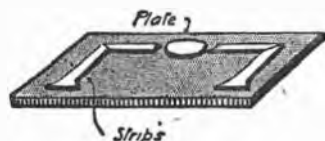


FIG. 366.—Arrangement of ornamental strips.

of the solder is a mixture of tin and lead. These solders are all fusible by the stored heat in a "soldering iron." A soldering iron is really a copper bit, held on to an iron stalk, which terminates in a wooden handle. Copper is used because of its conductivity and capacity for holding heat, and the bit is placed in a fire or over a gas ring until it is hot enough to melt solder. A certain weight of copper is necessary, and for all average work the most useful is a 12-oz. bit. For very light work, a 6-oz. copper head will do very well, but, at the same time, it is very annoying to find that the solder cannot be melted because the bit has got cold,

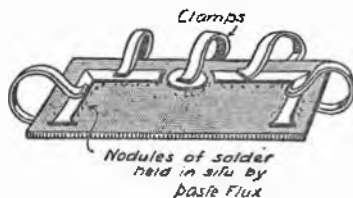


FIG. 367.—Strips held in position by spring Clamps.

just as you are engaged in an intricate piece of work.

Fluxes. The use of a flux is to stop the formation of an oxide on the surface of the metal and thus prevent

the amalgamation of the solder and the metal. The solder adheres because the metal being soldered together forms a local alloy. This is why metals which have a natural affinity for the solder are joined together more strongly than otherwise.

Metals like aluminium are difficult to solder because their readiness to oxidise prevents the soldering alloy to be created. Special solders and fluxes are therefore sold to get over these difficulties, and it is also necessary in some cases to scrape the surface of the metal while it is being soldered. Welding aluminium is, however, a much more satisfactory process.

Fluid Flux. Paste fluxes (see also *Flux*) can be recommended for some

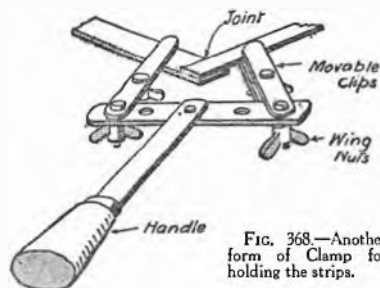


FIG. 368.—Another form of Clamp for holding the strips.

forms of electrical work so long as the job is cleaned of all flux after it is completed. For steel, tin-plate, brass and copper strips and sheets, fluid flux is to be preferred. By fluid fluxes are meant those which have as their base "killed spirits," viz. chloride of zinc, obtained by putting scraps of zinc into strong hydrochloric acid (spirits of salts). In making this flux always put in an excess of zinc to the mixture to make sure that no acid remains. While any hydrochloric acid is there it will continue to attack the zinc and become converted to the new compound chloride of zinc. If there is insuffi-

cient zinc, then free acid is present in the mixture.

The reaction should be performed in an open earthenware jar and also in the open air, as the fumes of hydrogen and acid which are given off are, to say the least of it, not very pleasant gases to breathe in.

When the bubbling has ceased pour on about three times as much water as there is fluid in the jar, picking out the larger lumps of remaining zinc. Then strain off through a piece of rag into another receptacle, and add a few crystals of sal-ammoniac. This is the common chemical used to replenish Leclanché electric batteries, and is easily obtainable. The mixture may be bottled (and, be it observed, properly labelled) for future use when diluted with a further equal quantity of water.

Place Flux in Strong Container. A heavy, bulky pot—something like a small edition of the old-fashioned earthenware pickle jars or an old marmalade jar made of the same material—should at all times be used to hold a liquid flux. Something that will stand knocking about and which cannot be easily overturned is essential to success.

Using a Soldering Bit. When the iron—as it is often called—is taken out of the fire or off the gas ring, as the case may be, and presuming its working point is already properly tinned, it should be dipped into the pot of flux—quite a quick dip—and then poked into another jar of sal-ammoniac. An experienced workman will always for preference use a very large lump of sal-ammoniac which will be laid on the bench and used in this way for “cleaning the iron.”

The fumes accompanying soft soldering and the danger of splashing flux are both so deleterious to adjacent tools that it is always ad-

visable to reserve a special bench in the workshop for soldering. If this is impossible, do the work as far away as possible from the better and finer workshop appliances.

Paste Fluxes. All fluxes should be applied to the work by a piece of stick—a wooden meat skewer is quite a handy tool, and paste fluxes should be placed in heavy pots. Much petty annoyance in working is caused by not transferring a paste flux from the light tin in which it is purchased to a more massive con-

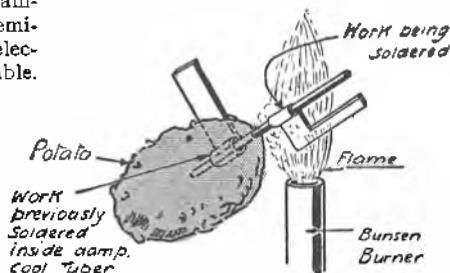


FIG. 369.—A typical case where a potato comes in useful.

tainier. If it is attempted to use the paste from the original tin, the stuff is so sticky that just at the critical moment, when it may be necessary to improve the flow of the solder by a touch of flux, you will find that the dibber stick picks up flux, tin and all. Therefore, keep the original tin as a store, and transfer enough for use to either a heavy pot or one that is fixed down to the bench.

Where it is advisable for the particular job in hand—say, wiring up a wireless set—to employ a past flux, do not use it for dipping the end of the soldering bit into. Always provide the jar of fluid flux and the sal-ammoniac already referred to for cleaning the “iron” as it is removed from the fire.

Soldering Small Work. For jointing or “sweating up” small objects

SOLDERING

which can be brought to the heat, soft soldering can be successfully done by a small Bunsen gas burner, methylated wick flame, or a blow-lamp.

A mechanical attachment of the two or more parts to be soldered is recommended in such cases, in addition to the soldering. A wire to be attached at right angles to another

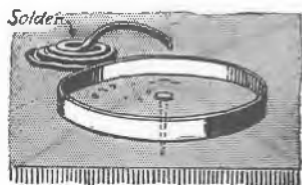


FIG. 370.—Coil of solder with a tin lid underneath to catch the drips of solder.

may be either looped round as shown in the sketch (Fig. 362), or if it is an angle joint that is required, like that at the corner of a lampshade, the wires may be flattened and wrapped round each other, as in Fig. 363.

After hammering or working in any way which may similarly introduce foreign matter into the surface of the metal, the wires, or metal being worked on, must be cleaned and tinned. Even tinned iron wire gets "dirty" if hammered, and refuses to solder afterwards. To tin a wire or other small object, clean it with sand—or emery paper—a scraper or a file, coat it with flux, preferably a fluid flux, heat up in the flame, and reflux when it is hot with the stick of solder being used dipped into the flux. If there is any solder on the job reflux with the wooden "dibber," guiding the solder where it is wanted. Rubbing the solder up and down the job will soon coat it so long as the right heat is preserved.

Burning a joint. But don't over-heat it. This burns the solder and

the tinning, and prevents the job being completed. The work must never be brought to anything approaching red heat. Even the dull red heat represents a temperature of over 800° F., whereas the finest grade of soft solder melts at about 440°.

A Stand for the Soldering Bit. Where small work is being operated upon, the end of the "iron" may be used instead of the naked flame. To facilitate work of this nature a clip may be fitted on to the iron stalk of the soldering bit, and to this clip a triangular foot, made of strip metal, is arranged as shown in Fig. 364. This may be fitted to almost any iron. If it is thought that this foot is better if made to fold down, the clip should be provided with two holes, one to grip it to the stalk of the bit and the other, as shown by the sketch (Fig. 364) to carry the bolt holding the foot.

There is no real need to either remove or to fold foot. It may be a permanent fixing, as shown in Fig. 365, and will then be found most

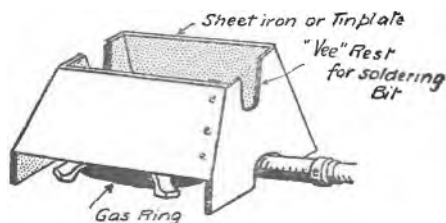


FIG. 371.—An easily-made Cowl that can be fitted over the gas ring.

useful in ordinary soldering. It is often necessary to lay the "iron" down for a moment. The foot saves the bench from being burned by the hot copper bit.

Where one or more pieces of metal in close proximity have to be joined on to a rather heavier part, the ordinary processes must be modified. Take, for example, the arrangement of

SOLDERING — SOLENOID

ornamental strips on the surface of a plate shown in Fig. 366. The soldering iron is out of the question for such a job. The parts must be sweated in position at one heat.

The surface of the plate should be cleaned tinned, any superfluous solder being wiped off with a damp rag while the plate is hot. The strips may be similarly tinned at the back, although, if they are quite clean, edges as well as back, they will sweat up quite satisfactorily if well fluxed.

The positions of the strips are then marked out, and are held in position by spring clamps (see Fig. 367). These may be of strip brass of horse-shoe form, or like miniature cycle trouser clips, arranged as shown in the next picture.

The whole plate is then brought up to required heat with a blowpipe or over a gas flame, with little nodules of solder laying up against the strips.

A further supply of flux soon makes the solder sweat into all the crevices, and a neat job will result. It is easy to shake off superfluous solder and reheat and reflux, as occasion may require. The clamps save all the trouble of drilling and riveting on the strips.

Another form of clamp may be made up out of strip metal and can be employed to solder two separate parts which may require to be held firmly in a given position while they are being soldered.

Don'ts. It is of no use attempting to solder work which is not clean where solder has to be applied. There is just "ordinary dirt" and the oxidation due to burning on of previous solder, or of the tin coating of tinfoil, but the mere heating of metal, in a more or less degree, forms a certain amount of oxide on the surface, which prevents a successful jointing.

Don't overheat the bit, as this burns off the tinning at the end. To

re-tin the bit the copper end must be filed quite clean; finally, while it is hot, immediately rub it on a piece of tin (the inside of a fixed-down tin lid) with solder and flux until the point is quite bright all over with solder.

Always wipe a soldering iron as it is withdrawn from the fire on a piece of old mat, or anything else of a rough textile character, to remove the soot. Then dip it in the flux and sal-ammoniac as already recommended.

Don't use "killed spirits" for soldering zinc. A dilute solution of the natural hydrochloric acid (spirits of salts) is required.

Have a coil of soft solder with extended arm over the tinning lid (Fig. 370). The dribbles of solder then fall into the lid and are useful for future tinning.

Cowl for Gas Ring. Where an ordinary gas ring is used and the jets are apt to spread out to too great an angle away from the copper bit, a cowl can be made up out of sheet iron or tinfoil to conserve the heat, and at the same time provide a rest for the "iron" in the heating process (see Fig. 371). By adjusting the amount of flame it can, by using such a cowl, be retained at just the right heat—neither too cool nor, however long it remains over the stove, so hot that the tinning is burnt off the end.

Electrical soldering irons are now superseding the ordinary iron.

SOLENOID.—A coil of wire either wound on a former or air-spaced and self-supporting. When a galvanic current is passed through a solenoid it becomes possessed of many of the properties of a magnet due to lines of force which surround the solenoid. Examples of solenoids in a wireless receiver are: tuning coils, chokes, telephone or loudspeaker windings; the speech coil of a moving-coil loudspeaker.

SOUND WAVES.—The vibrations of the air produced by the motion of a body. An example is the beating of a large drum. If the skin of the drum is driven inwards the air will follow the skin, producing a slight rarefaction in that spot. As the skin flies out it will tend to compress the air, and this rarefaction and compression will travel through the air, due to the motion being transmitted from one molecule to another. When it reaches our ear it causes the drum of the ear to vibrate in sympathy with its motion, so reproducing the sound originated by the drum. Sound radiates, that is, distributes its effect equally in all directions, and not in a straight line in one direction only. Consequently, it diminishes in intensity in inverse proportion to the square of its distance. It is possible to control sound waves by means of reflection, inflection, and refraction. In reflection we get "echo"; with inflection we get a bending; and with refraction we get a convergence. Sound waves are divided into two classes: (1) musical sounds, and (2) noises. A musical sound has a regular period of vibration, and a noise has an uneven rate of vibration. Musical sounds are *felt* if they are below 16 vibrations per second. That is to say, no musical note can be heard, but there is a consciousness of sound. Above 20,000 vibrations per second the consciousness of sound ceases, although in old people the number of vibrations may be much lower than this and yet still be inaudible.

SOUNDER.—A device used in telegraphy for making audible the transmitted telegraphic signals. It consists of an electro magnet with a heavy armature spring suspended. When a current passes through the magnet the armature is attracted to the pole piece of the magnet, and as soon as the current ceases the spring

returns the armature to a contact piece. The "click" produced by the armature hitting the pole piece (or back contact) corresponds with the key depressions of the transmitter, and in this way the signals are read. In some types of sounder, in order to emphasise the "clicks" the instrument is partially enclosed in a wooden structure, and this results in a slight echo and amplification of the sounds.

SPACE CHARGE.—Residual negative electrons which remain in proximity to the filament, and so prevent the full emission to be made use of.

SPARK.—The electric discharge which takes place between two electrodes when the voltage which is applied is sufficient to break down the air resistance separating them. The spark consists of damped oscillations, and these oscillations are transmitted through the surrounding air. It is thus possible to receive the oscillations from even a small spark, such as an electric bell will produce, provided the receiver is sufficiently sensitive. In wireless telegraphy certain transmitters (principally ships and ship stations) employ a spark transmitter instead of telephony. The transmitter employs oscillating condenser spark discharges across an air gap, and the sparks are obtained by the depression of a key in the circuit. In this manner the operator may send the dots and dashes of the Morse code, and the sparks will be generated in accordance with the manipulations of the key. By including the spark gap in the aerial circuit, and by employing a suitable power, these damped oscillations may be broadcast.

SPARK COIL.—An induction coil employing a primary and secondary winding, and a vibrating armature. A battery connected across the primary will induce a current into the secondary winding.

SPARK GAP.—The contacts across which the spark discharge takes place.

SPEAKERS.—See *Loudspeakers*.

SPECIFIC GRAVITY.—The relative density of a substance, or the weight of a body compared with the weight of another body having the same magnitude. The S.G. of a body is obtained by weighing it in air and then in water. The ratio between the two weights is the S.G.

SPECIFIC RESISTANCE.—The resistance of a piece of material which is 1 cm. in length and 1 sq. cm. in cross section.

SPELTER.—A commercial name for zinc. It is also an abbreviation of the words "spelter-solder," which is a zinc substance for soldering brass.

SPLICE.—To unite two parts together. A rope is spliced by interweaving the individual strands so as to make one continuous length. Wire of the stranded variety may be spliced in the same manner.

SPREADER.—The rod or stick used for separating the wires of a two or more wire aerial. Where two wires are employed for the aerial the spreader should be not less than 3 ft. long, and at either end an insulator (or chain of insulators) should be attached.

SQUARED PAPER.—Paper used for preparing graphs for valve characteristics, etc. The squares may be of any size, the most common being 1 millimetre or $\frac{1}{4}$ in. With the latter the lines corresponding to the inches are ruled in heavy ink, the small subdivisions being ruled lighter. The paper is also known as "graph paper."

SQUIRREL-CAGE AERIAL.—An aerial formed by using circular spreaders at each end. Round the periphery of the spreaders many wires are disposed, so that the result is a cylinder with the wires running from

end to end. Another name for this type of aerial is the "sausage aerial."

SQUIRREL-CAGE ROTOR.—A rotor formed in the same manner as the squirrel-cage aerial.

S.R.—Specific Resistance.

S.S.C.—An abbreviation for Single Silk Covered. A term applied to wire which is insulated by being wrapped with a single layer of silk thread. This thread is wound round and round the wire after the fashion of cotton upon a reel.

STAGE GAIN.—The amount of amplification which is provided by a complete valve and its couplings. It may be measured by connecting an A.C. generator to the grid circuit of a valve, and measuring the output from the output end of the particular circuit.

STAGGERED.—Arranged in steps.

STAINING.—See *Folishing*.

STALLOY.—An alloy of steel. This is a proprietary name for a special preparation of steel used for the cores of transformers, etc.

STAND-BY.—A nautical term, signifying the position of the tuner where waves of different lengths are received. The term is also employed to denote "wait."

STARBOARD.—The right-hand side of a vessel, airplane, etc., when looking to the front of the vessel. Opposite side is *port*.

STATIC.—Stationary electricity. It is the name also applied to atmospheric, and accumulations of electricity (from the atmosphere) on an aerial.

STATIC ELECTRICITY.—Electricity which remains stationary on the surface of a body in the form of an electro-static charge.

STATICS.—Plural of Static.

STENODE.—A circuit arrangement in which a piezo crystal is used to obtain selectivity. The varying resistance of the quartz crystal is employed to vary the H.F. by-

passing effect, and it is claimed that this results in a degree of selectivity much higher than can be obtained even with a super het. It is claimed that a square tuning peak of only 3 kcs. can be obtained.

STEP-DOWN TRANSFORMER.—A transformer in which the secondary winding is smaller than the primary, with the result that if a voltage is applied to the primary a smaller voltage is obtained at the secondary terminals.

STEP-UP TRANSFORMER.—A transformer in which the secondary winding is larger than the primary. If a voltage is applied to the primary, therefore, a larger voltage will be obtained at the secondary terminals.

STRAYS.—Another term for "Static," which see.

SULPHATE OF COPPER.—Chalcantite. The result of copper being acted upon by a salt of sulphuric acid.

SULPHATING.—The action of the sulphuric acid (employed as the electrolyte of an accumulator) upon the plates of the accumulator. This results in a deposit being formed on the plates, and is deleterious to the plates. The principal causes of sulphating are insufficient charging, over discharging, or allowing the battery to stand in a discharged condition. (See also *Accumulator*.)

SULPHATION.—See *Accumulator*.

SULPHUR.—A hexad non-metallic element found native in many volcanic districts, and largely distributed through the mineral kingdom. Symbol—S. For commercial purposes it is purified in an iron still, the sulphur being received either in a brick chamber, when it is called "Flowers of Sulphur," or condensed in a liquid state, and then cast in stick form. It is brittle, tasteless, practically inodorous, insoluble in water, and yellow in colour. Dissolves in carbon

disulphide, oil of turpentine, and benzine. Specific gravity in crystal form—2.05. It melts at 114–120°, boils at 440°, and combines directly with the majority of elements.

SUPER - HETERODYNE.—A method of obtaining high selectivity by converting a received signal into a different, and lower, frequency and then carrying out amplification of this new frequency. The signal is detected, the frequency changed, amplified by two or more H.F. stages, again detected and then passed to the L.F. stages.

SUPER REGENERATIVE.—See *Circuit and Armstrong Circuit*.

SUVERSED SINE.—The difference of a versed sine from the diameter of a circle.

S.W.G.—An abbreviation for Standard Wire Gauge.

SWITCH.—A device for completing a circuit, or for joining circuits, or for breaking circuits. There are many forms of switch used in wireless receivers, the most common being the on-off switch, used for switching the filament battery supply on and off, the wave-change switch, used for changing the wavelength range of a tuning circuit; and the radio-gramophone switch, used for changing from radio reception to gramophone record reproduction. Where large currents have to be carried it is essential that the contacts shall be made and broken extremely quickly.

SWITCHES AND SWITCHING.—

A switch might be described as a device for connecting one circuit with another or for breaking a circuit. Naturally this definition could be amplified since, for instance, a switch often deals with more than one circuit, but nevertheless it serves to show the primary function of the component. A more complete definition will, no doubt, be formulated after a study of the ensuing pages.

SWITCHES AND SWITCHING

Switches figure very prominently in the circuits of all modern radio receivers and transmitters. The number of different types is enormous, ranging from the simple "on-off" switch to the complicated mechanisms that are used in some large broadcast transmitters. Naturally it is impossible to deal here with the construction and function of *all* kinds that are used, so we must confine ourselves to a study of some of the principal types.

To explain the use of a switch take an elementary example: Fig. 390 shows a lamp connected to an electric battery. Suppose we wish to put out the lamp or to light it again. Obviously we could disconnect or connect one of the wires each time. This crude method would hardly meet with modern requirements. What we do, therefore, is to include a switch in the circuit. This is shown in Fig. 390. There the switch takes the form of a lever, the moving of which "makes" or "breaks" the circuit. Of course, the same result can be achieved by other simple mechanical movements, such as pressing the two wires in contact by means of a "button" or by turning a knob, but in any case the principle is the same, namely, that of connecting and disconnecting two wires. This in fact is the basis of all switches, however complicated they may be. With the more elaborate types it simply means that a number of such connections or disconnections, or both, are made with the one switch.

Single-circuit Types. If you look at Figs. 372, 373, etc., you will see that even the simple "make-and-break" or "on-off" switch, as it is sometimes called, is made in several patterns. Each pattern is designed primarily for use in some specific place in a receiver—the design being evolved to meet the peculiar requirements of the particu-

lar circuit in which it is to be used.

Let us examine the different types of switches likely to be met with in modern receivers, starting from the aerial and finishing at the loud-speaker. In this connection particular attention is directed to Fig. 372 which shows a typical circuit with illustrations of the switches used.

The illustration (Fig. 372 opposite) shows a switch designed for use under exacting conditions. It is called a knife switch, since the action of the arm is like that of a knife. A similar switch, but with two arms, is shown in Fig. 381. As this type of switch is often used out of doors it must have robust non-rusting and non-corroding contacts, and these must be supported in a base which is a good insulator at all times, that is to say, one that will not allow a leakage of current between the contacts when the switch is off. Such switches usually have phosphor-bronze contacts (including the knife arm) mounted on a rectangular base of porcelain. The phosphor-bronze stands up very well to the elements, and so long as the porcelain is cleaned occasionally to prevent leakage of current through any film of dirt, which may otherwise collect on the surface, it will retain its insulating properties indefinitely.

The switch is operated by swinging the "knife" over from one side to the other. The inset shows how the knife enters the spring contacts. In order to prevent current traveling through the operator's hand an insulated handle is fitted to the knife.

Switches for H.F. Circuits. The switch shown in Fig. 376 is a popular type for use as a wave-change switch. It is used to short circuit some of the turns of a tuning coil so as to alter its wavelength. This is shown in Fig. 377. It operates on the push-pull principle. When the knob is pushed in as shown the two springs press against the insulated shank of



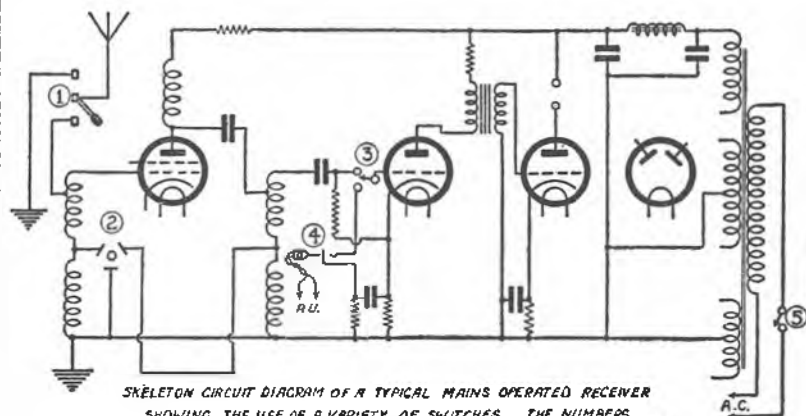
① KNIFE SWITCH
SINGLE POLE, DOUBLE



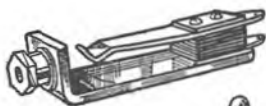
② THREE-POINT
SHORTING SWITCH



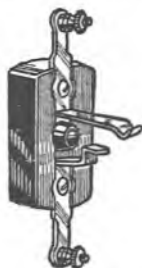
③ SINGLE POLE, CHANGE OVER SWITCH
EITHER TYPE IS SUITABLE



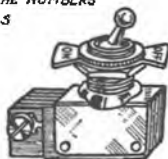
SKETCHED CIRCUIT DIAGRAM OF A TYPICAL MAINS OPERATED RECEIVER
SHOWING THE USE OF A VARIETY OF SWITCHES THE NUMBERS
CORRESPOND WITH THOSE ON THE ILLUSTRATIONS



④ SINGLE OPEN CIRCUIT JACK
WITH PLUG



ANOTHER
SUITABLE JACK



⑤ "ON-OFF" Q.M.B. SWITCH
FOR MAINS USE

FIG. 372.—Various Switches and how to use them.

SWITCHES AND SWITCHING

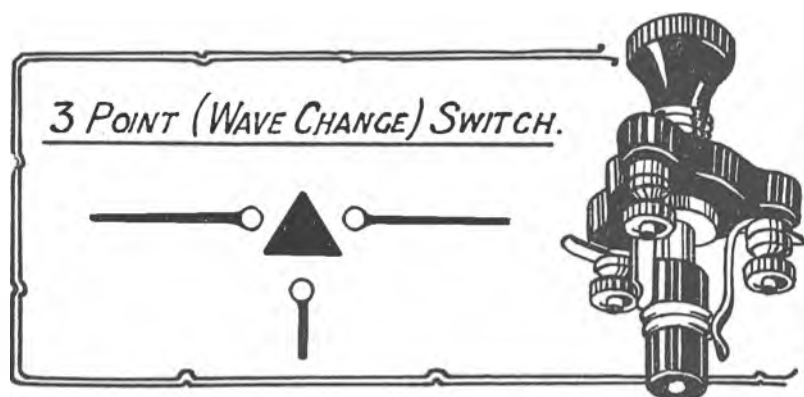


FIG. 373.—Theoretical and actual diagrams of a 3-point wave-change Switch.

the plunger, but when the knob is pulled out the metal end of the plunger comes between the springs and so connects them together. The qualifications of such a switch must be as follows: definite contact, finest insulation, and low capacity. The first is secured by employing strong springs, and by nickel-plating both springs and plunger to prevent corrosion. Good insulation is obtained by using a base made of ebonite (a hard black substance made from rubber and sulphur), or some similar

compound such as "bakelite." Low capacity is a necessary property of all switch gear used in high-frequency circuits, such as the aerial circuit of a wireless receiver. It means that the contacts must not be too near together or of too great an area, otherwise they will tend to act as the plates of a condenser and thus allow the H.F. currents to pass from one to the other. Such "leakage" is quite distinct from that caused by bad insulation. It may also lead to the upsetting of the tuning or other

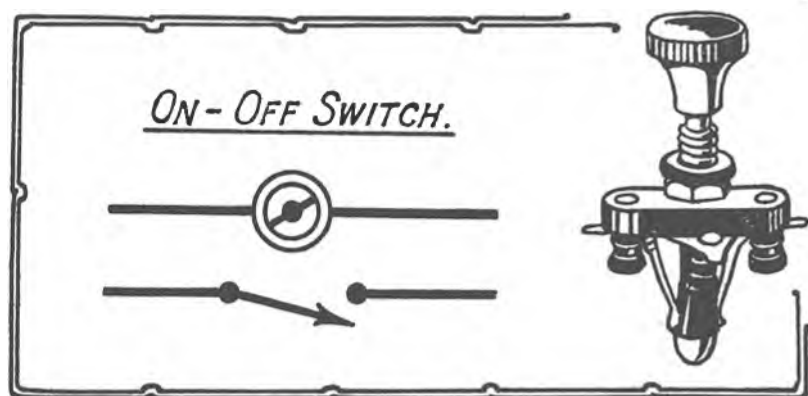


FIG. 374.—Theoretical and actual diagrams of an on-off Switch.

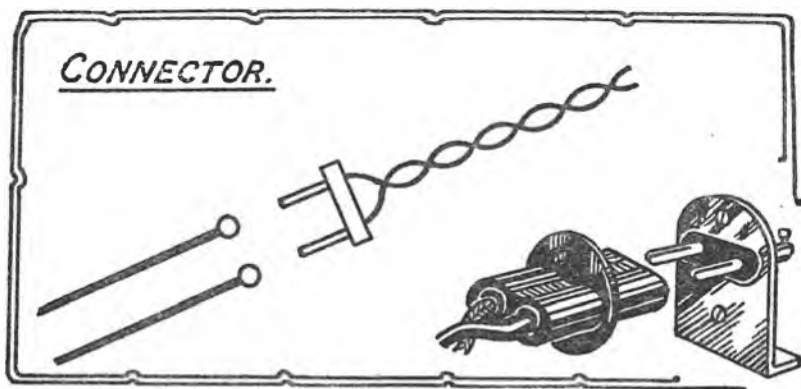


FIG. 375.—Theoretical and actual diagrams of a plug-in Connector.

function of the circuit in which the switch is connected.

The question of losses due to self capacity only occurs in the design of switches used in high-frequency circuits. With the switch under consideration the self capacity is kept low by keeping the springs fairly wide apart. A similar switch to this one is illustrated at the top of Fig. 372. Here three contacts are employed, the plunger itself forming the third. The use of this switch is clearly shown in the circuit diagram in the centre of the plate. It will be seen that it is used to short circuit the tuning coils with one movement. It thus replaces two of the single type of switch. It is generally designated "a three-point shorting switch." Other varieties of the same type do not use the plunger as the third contact, but employ three separate springs.

Multiple Types. Much ingenuity has been used in designing switches for more complicated operations in the H.F. circuits of a receiver. It is here that the problem of self capacity becomes really vital, and a compromise often has to be made between efficiency and compactness. It

is obvious that there would be no very great difficulty in producing a multiple switch of low self capacity if size were of no account, but more often than not such switches are required for portable sets and where space is restricted. A typical operation which has to be performed is that of changing over the connections from one winding on a frame aerial to the other, and also at the same time switching on and off the current supplying the valves. Figs. 380 and 382 show two efficient switches of the anti-capacity type suitable for such operations, and Fig. 384 shows the connections to the frame aerial and filament circuit of one of these "long - wave - off - medium - wave" switches.

Ganged Switches. In many receivers the operation of wave changing where several circuits are concerned is carried out by separate switches which are "ganged." This means that they are linked together by means of some such mechanical devices as rods or levers, so that they may all be operated by one control. A very common method is to make up the tuning coils and switches in one unit, as in Fig. 389. In this

SWITCHES AND SWITCHING

case three shielded tuning coils are mounted in line, the switches being contained in the base of each. A rod passes through the whole unit and controls each switch. Usually the rod has to be turned to right or left by means of the knob, but some types work by the push-pull method.



FIG. 376.—On-off Switch.

Another method is to gang the switches with the tuning condensers. The switches are somewhat similar to the rotary type in Fig. 387, and are made integral with the condensers: the

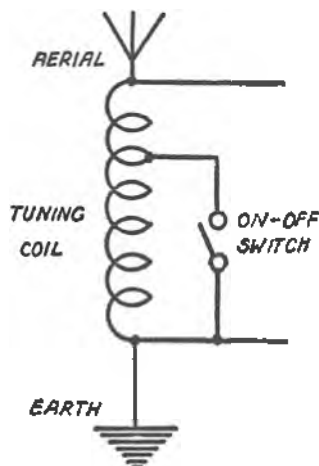


FIG. 377.—On-off Switch used for wave changing.

complete unit, comprising variable condenser and switch, is called an *extender*. The condenser is operated in the usual way, except that when

the dial has been tuned through 180° instead of coming against a stop, as with the ordinary variable condenser, it operates the switch and continues its rotation through another 180° . This time of course it tunes to a different wave band.

Rotary Switches. Proceeding now to the low-frequency stages of the typical receiver we are here catered for with an almost endless variety of switches of all types capable of performing many different operations. The choice is so extensive, partly because nearly all the H.F. types are also available. With one or two exceptions a H.F. switch is always suitable for L.F. or direct-current circuits, although one intended for L.F. or D.C. work is not necessarily adaptable to H.F. circuits. The illustration, Fig. 390, shows a H.F. type of single-pole change-over switch which may well be used in the grid circuit of the detector valve for changing over from radio to gramophone or *vice versa*. The other switch shown is designed purely for this operation, and might not be equally suitable for H.F. use. It is of the rotary type, the operation being performed by turning the knob left or right.

Small rotary switches of this type have recently come into great favour for radio to gramo. switching and similar purposes. Apart from the fact that the knob works with a rotary action there is often very little similarity between one make and another. Fig. 387 shows the back of one type in which flat springs are used. The disc "D," which rotates under the springs, is shaped on its face in such a way that its rotation



FIG. 378.—Snap Switch.

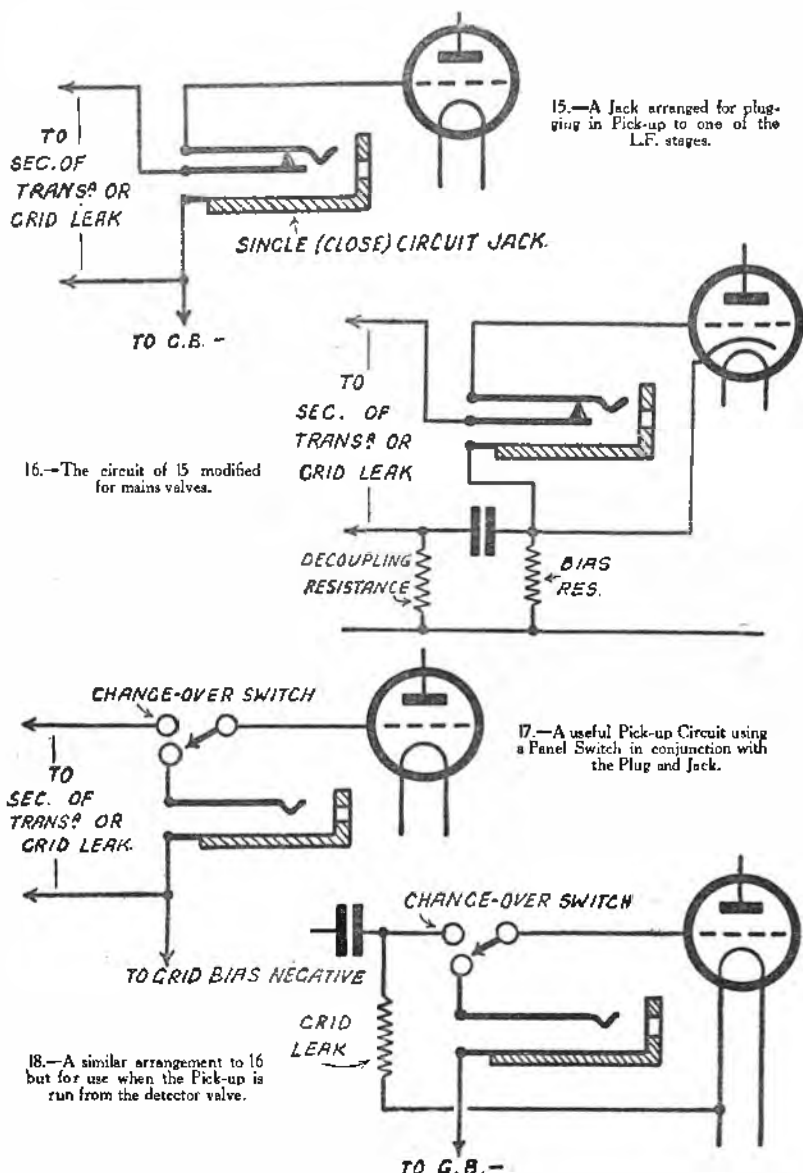


FIG. 379.—Various methods of Switching by means of Plugs and Jacks.

SWITCHES AND SWITCHING

forces the pairs of springs in contact, or allows them to separate according to its position. It thus makes and breaks the circuit. The example shown has two sets of contacts so that two circuits are dealt with at once.

Another rotary switch is shown in Fig. 391. This has a metal rotor shaped something like the blades of an electric fan. The contacts are in the form of springs, which touch the "blades" as the rotor is revolved. In the "off" position the springs occupy the spaces between the vanes.

Filament Switches. Probably there are more filament switches sold to the radio public than any other type, and yet it is also probable that they give more trouble than all the others put together. One would think that, with the experience the manufacturers have at the back of them, the construction of such simple components would be mere child's play.

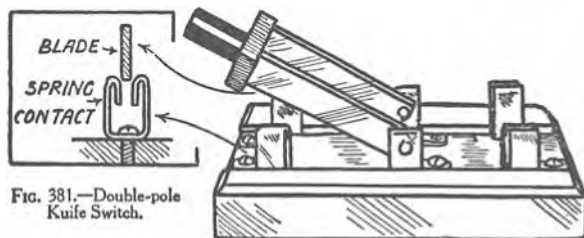


FIG. 381.—Double-pole Knife Switch.



FIG. 380.—Anti-capacity Switch.

Actually it is harder than appears at first sight. The difficulty here is not to obtain low self capacity, adequate insulation, or large current-carrying capacity, but to get perfect contact, not only at first, but after the switch has been in use for years. The fact that most battery valves only require 2 volts causes the trouble. A slight piece of grit or a few tiny flakes of metal from the contacts is sufficient to raise the resistance of the switch. There is usually, of course, only a slight increase, but as the voltage

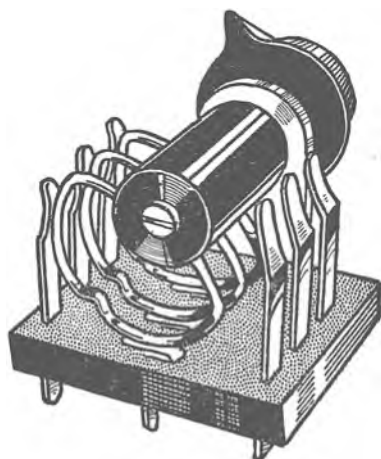
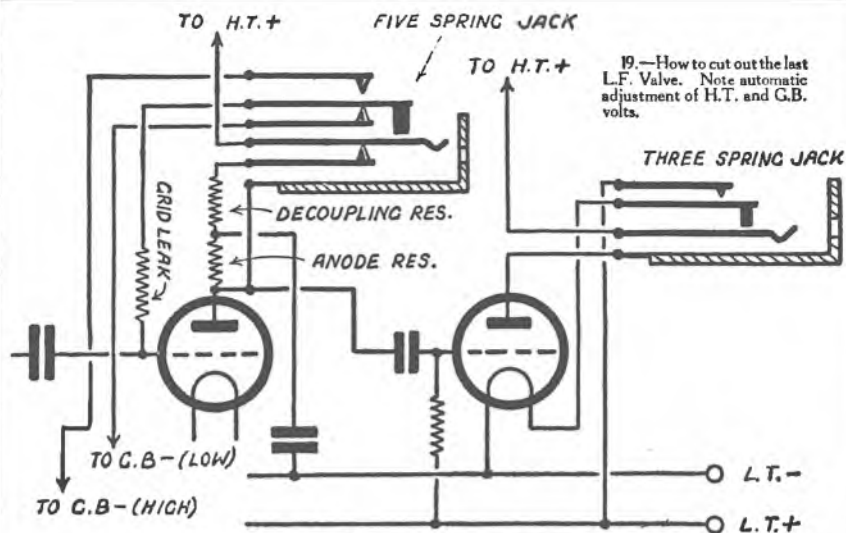


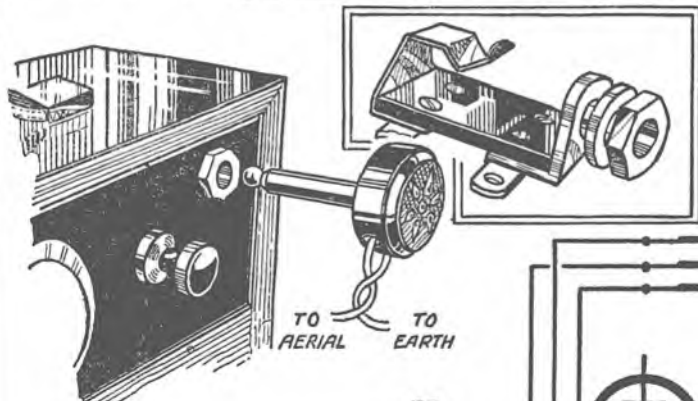
FIG. 382.—Another form of low-capacity Switch.

applied is so low this small resistance has a comparatively large effect, and reduces the current sufficiently to impair reception. What it means therefore is that the contacts must be of generous size, plated to prevent corrosion, and with springs just sufficiently strong to give a firm grip, but not so hard as to cause a scraping away of the contacts.

Two of the

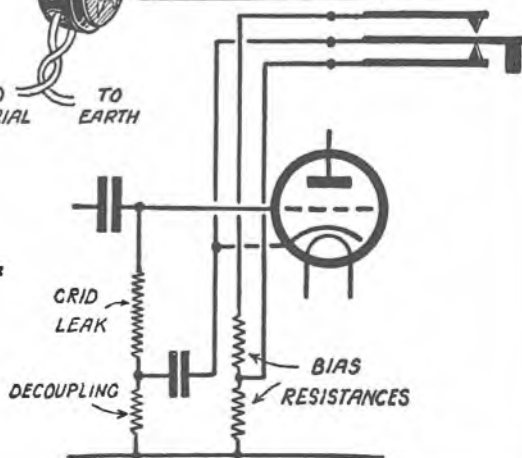


19.—How to cut out the last L.F. Valve. Note automatic adjustment of H.T. and G.B. volts.



20.—How to modify 18 when using mains valves.

FIG. 383.—Other methods of switching by Plugs and Jacks.



21.—A portable set may be quickly attached to an outside aerial by using a Plug and Jack. Inset: details of the Jack.

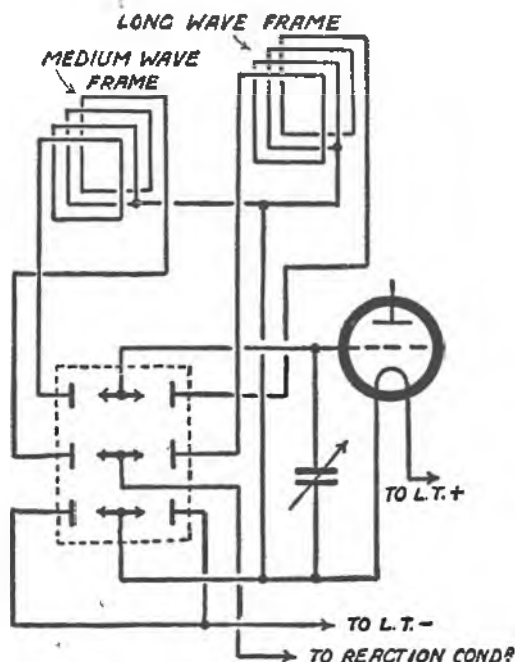


FIG. 384.—Three-pole change-over Switch used for wave changing with Frame Aerials.

many types of on-off filament switch are given in Figs. 374 and 378, while Fig. 386 shows how such a switch is connected.

Jack Switching. A very handy method of switching is provided by plugs and jacks. The plug, a typical example of which is shown in Fig. 385 below, consists of a bakelite handle holding a metal stem which has a small metal ball at one end. The stem is insulated from the ball. The jack is really a socket into which the plug fits. It has one or more springs which make contact with the ball or stem when the plug is inserted. The insertion of

the plug causes the springs to bend. In this way a number of circuits can be operated, the bending of the springs causing the breaking and making of the contacts. Fig. 385 shows a multi circuit jack and what happens when the plug is inserted. In the centre of Fig. 372, a single-circuit jack is used to enable the pick-up which is attached to the plug to be plugged in to the set or removed at will.

Jacks can be obtained which will solve many difficult switching problems, such as cutting out a stage of low-frequency amplification in a multi-valve receiver. The plug is attached to the loudspeaker, and jacks are fitted in the various L.F. stages of the receiver. The speaker is then plugged in to the one giving the required degree of amplification.

Unfortunately, owing to the nature of their construction, most types of jacks are unsuitable for inclusion in high-frequency circuits as the placing of the springs so close together gives them high self capacity.

Besides the ordinary jacks and plugs there are also what is known as jack switches which embody the same principles. One type is similar to the jack in the middle of the bottom row of switches in Fig. 372,

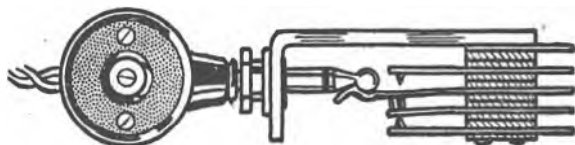


FIG. 385.—Typical Plug and Jack.

SWITCHES AND SWITCHING

but a plunger takes the place of the plug. The switch is operated by moving the plunger in or out.

Mains Switches. With the advent of mains-operated receivers, the provision of miniature power switches becomes necessary. Obviously an ordinary house-lighting tumbler switch, although quite excellent for the purpose for which it is designed, is entirely out of place on a radio receiver.

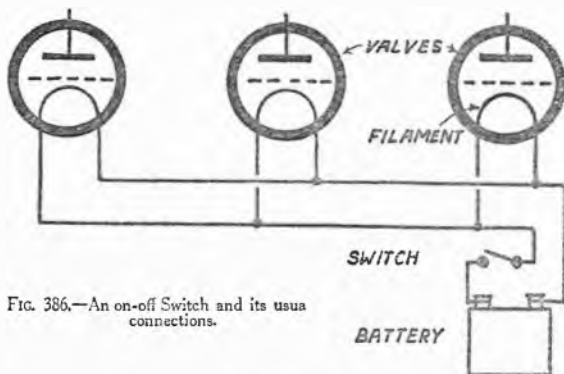


FIG. 386.—An on-off Switch and its usual connections.



FIG. 387.—Rotary Switch.

However, smaller editions working on the tumbler principle have been designed. An example is shown in Fig. 378. The essential requirement of a mains switch is that it will make and break the circuit *very quickly*. This is because with the power it is required to handle there is a strong tendency towards "arcing." This is the fat flaming spark which occurs when a power circuit is broken. If the two contacts of the switch were parted very slowly this spark would continue to bridge the gap until they were some small distance apart, and during that time would badly

burn them. If, however, the contacts snap apart quickly the spark is of such short duration as to do no damage.

A very popular Q.M.B. (quick make and break) switch is that shown in Fig. 372, number 5. The lower sketch is a sectional view showing how it works. It is shown in the "off" position. On moving the pivoted toggle arm over to "on," the other end of it which is inside the switch moves over to the right, compressing the spring. When about half-way across the spring is fully compressed. Any further movement then makes its lower end, which is attached to a roller, jump from the right side to the left, so that the positions inside the switch are exactly reversed. This means that the roller is now

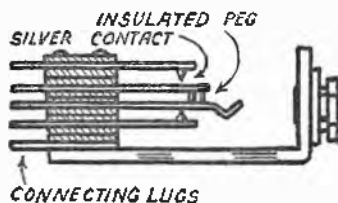


FIG. 388.—Contact points of a Jack.

SWITCHES AND SWITCHING — TANTALUM

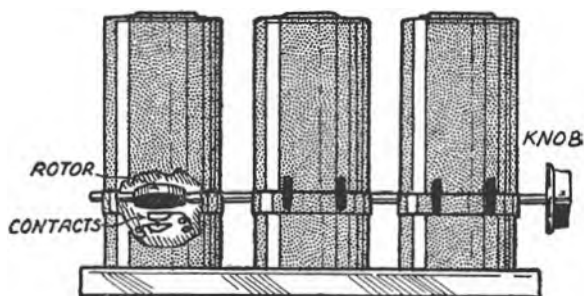


FIG. 389.—Three-gang Tuning Coil with self-contained Switch.

touching the shaped metal contact on the left. Actually there are two of these, and as the roller touches both they are therefore shorted, and so the circuit is "made." Returning the toggle arm to the right again makes the spring and roller jump back to their former positions, and so break the circuit once more. (See also *Plug*.)

SYLVANITE.—An ore of tellurium.

SYMBOLS. — The signs which are used in electrical and wireless practice for certain units and terms.

SYNCHRONOUS.—In step; occurring at the same time; simultaneous.

lated, and may be easily cut with a knife or scissors. When bare wire-

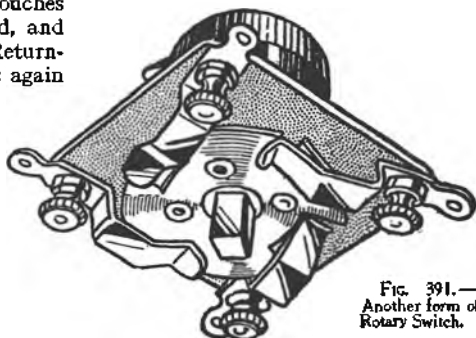


FIG. 391.—Another form of Rotary Switch.

is used for making connections in a wireless receiver this material proves extremely useful for carrying the wire and so avoiding short circuits.

There are many similar forms of insulating sleeving.

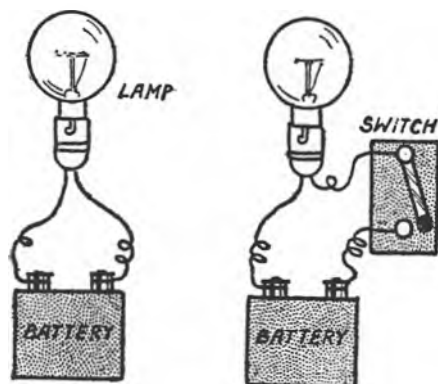


FIG. 390.—How the on-off Switch functions.

T

T AERIAL.—An aerial in which the leading-in wire is taken from the centre of the horizontal portion. It is essential that the lead-in is joined to the electrical centre if full efficiency is to be obtained.

TANTALUM.—A pentad metal-

TANTALUM — TAPE MACHINE

lic element. Symbol—Ta. The metal is obtained by heating the fluotantalate of potassium or sodium with metallic sodium in a covered iron crucible. When cool it is washed out with water. It is a black powder, insoluble in sulphuric, nitric, hydrochloric or even nitrohydrochloric acids, but is slowly dissolved in warm aqueous hydrofluoric acid. It is dissolved very rapidly when nitric acid is present.

**TAPE MACHINE FOR RE-
CORDING MORSE.**—This machine is interesting to use and make; also, it is a great help to the Morse-code learner, for by its aid one is able to send messages and then correct them from the tape. A motor, either clockwork or electric, is required to draw the paper past the brush (see Fig. 393). This can be taken from an old alarm clock, and will serve the purpose admirably.

The balance wheel and escapement should be removed, and the paper threaded between the teeth of the second and third gears. This gives a fairly good speed—the motor running from four to five minutes with one wind.

The Base. Commence the construction by cutting a base $11 \times 5 \times \frac{1}{2}$ in., and mounting the motor, by means of brackets, as shown in Figs. 392 and 393. The guide tubes through which the tape passes are made by cutting two pieces of sheet zinc, and folding them to the given shape (see Fig. 394). The first piece is mounted so that the paper passes from it and immediately between the teeth of the gears. The second is fixed before the brush and in line with the first. The paper tapes used are carnival streamers, twenty of which may be obtained for twopence. A reel to hold the tape is made by cutting two

discs of sheet metal 2 in. in diameter. One disc is fixed to a wooden centre, 1 in. in diameter and $\frac{1}{2}$ in. thick. Two brackets, $2\frac{1}{2} \times \frac{1}{2}$ in., are cut from mild steel, drilled to take a $\frac{1}{2}$ -in. wire axle and fixed on the base with $\frac{1}{2}$ -in. wood screws. Each piece of the reel is now drilled to take the axle and mounted between the brackets. A

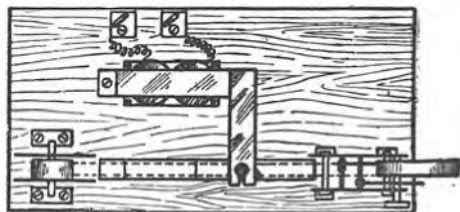


FIG. 392.—Plan view of the Tape Machine.

roll of tape is mounted by removing the reel, slipping the paper on to it and replacing; the paper is then threaded through the two tubes and between the gears.

The Coils. Obtain two $1 \times \frac{1}{2}$ -in. carriage bolts and file the heads flat. Cut two discs of cardboard 1 in. in diameter, put one on each bolt, and press it close up to the head (see Fig. 395). For a yoke cut a piece of

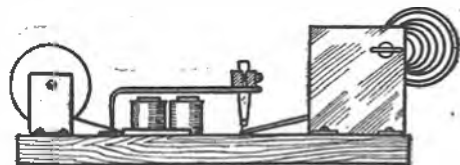


FIG. 393.—Side view.

mild steel $1 \times 2\frac{1}{2}$ in., and drill two holes to take the bolts $1\frac{1}{2}$ in. apart. Slip this on to the bolts, screw on the nuts, and wind the bolts with 24 D.C.C. wire. The coils should be wound in opposite directions, leaving about 3 in. of wire at each end for connections. Mount the magnets by means of $\frac{1}{2}$ -in. nails through the corners of the yoke, cutting a hole

TAPE MACHINE

in the base for the nuts (see Fig. 396). Connect the ends of the coils to two terminals on the base. The armature is a strip of mild steel $4\frac{1}{2} \times \frac{3}{8}$ in., drilled at each end to take $\frac{1}{2}$ -in. wood screws. The brush holder

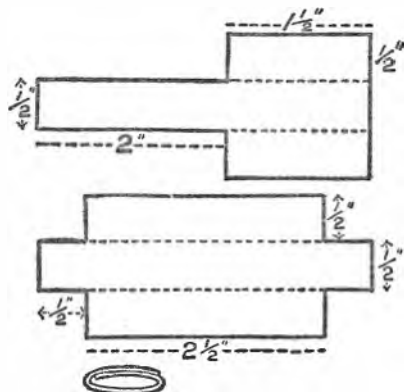


FIG. 394.—Details of the Guide Tubes through which the Tape passes.

(see Fig. 397) is a piece of wood $2\frac{1}{2} \times \frac{3}{8} \times \frac{1}{2}$ in., fixed on the steel strip. The brush is held in position by means of a $\frac{1}{2}$ -in. round-headed wood screw. The armature is bent as shown in Figs. 392 and 393, and mounted on the base so that the hole in the brush holder comes above the paper strip. The brush, an ordinary water-colour one with the handle cut off, is fixed in the holder so that, when the armature is pressed down on to the mag-

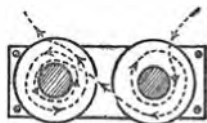


FIG. 395.—Showing how the Magnets are wound.

nets, it just touches the paper. Now make the tapper key, as shown in Fig. 398.

Testing the Instrument. To test the instrument connect it up to two dry cells and a tapper key. Press the

key and see that the brush just touches the paper. Ink the brush by transferring ink to it by means of a larger and thicker brush. Wind up the motor and tap out a message, which should come through the machine as a series of long and short marks on the tape. A relay must be used when the wiring exceeds 20 yds. in all; that is, both return and line wire. Fig. 399 shows the connections without a relay. Only one station is shown, as the other is exactly similar.

The relay, shown in Figs. 400 and 401, is an instrument by means of which local circuits may be closed from a distance. If the relay de-

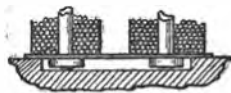


FIG. 396.—The method of mounting the Magnets.



FIG. 397.—The Brush Holder.

scribed here is carefully made, it will be sensitive to currents of the order of 20 milliamperes.

The Magnet. The magnet is a carriage bolt mounted on a $3\frac{1}{2} \times 5\frac{1}{2} \times \frac{3}{8}$ -in. base, as in the tape machine. The top disc of cardboard is $1\frac{1}{2}$ in. in diameter and the bottom metal plate $2\frac{1}{2} \times 1\frac{1}{2}$ in. The magnet is wound with No. 32 S.W.G. wire, the ends of which are connected to two terminals on the base. The armature is a strip of metal, cut from a cocoa tin $4\frac{1}{2} \times \frac{3}{8}$ in., with a $\frac{1}{8}$ -in. hole drilled in each end. A small nut is soldered over one hole, so that a bolt will easily screw through it. The strip is bent, as shown, and fixed to the base with a small nail and a screw eye to act as a terminal. The bridge which carries the screw to adjust the tension of the armature is a $4 \times \frac{3}{8}$ -in. strip of mild steel fixed on the base with small wood screws (see Fig. 402). The tension screw is a $1 \times \frac{1}{2}$ -in. bolt, which screws through a nut soldered

TAPE MACHINE

in the centre of the bridge. The armature is one terminal of the local circuit and the magnet the other. The bottom plate of the magnet is connected to a terminal on the base.

The Line Current. When a current flows through the magnet coil of the



FIG. 398.—The Tapper Key.

relay, the armature is drawn down until the bolt in the end comes into contact with the magnet. This closes the local circuit.

The relay is connected as in Fig. 403, only one action being shown, as the other is exactly similar. Two dry cells should be used in the line circuit, and two more to operate the tape machine. The tapper key consists of a $4 \times \frac{1}{2}$ -in. strip of springy brass mounted on a 5×2 -in. base.

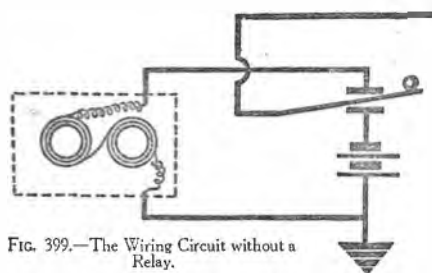


FIG. 399.—The Wiring Circuit without a Relay.

A bridge is fixed over the key, so that when it is not in use the two make good contact. The end of the key is always connected to the line wire, while the bridge is connected to the instrument, and the lower contact to the battery.

It is possible, by means of remote control relays such as those described elsewhere, to control electrical apparatus from a distance, and the reader will no doubt be able to devise, from the information in this

and the previous constructional notes, control relays to suit any particular piece of apparatus he has in mind. Relays, as stated before, are actuated by a weak electric current, and can be used to operate a switch in a local battery.

TAPPER.—The key used for transmitting Morse signals by completing the circuit. Usually consists of a solid brass bar furnished with a substantial ebonite knob. It is pivoted towards the centre, and the rear is held down by an adjustable spring. A



FIG. 400.—Side view of the Relay Instrument.

contact is fitted below the knob, and upon depressing the knob the circuit is completed, or if desired, the circuit may be continuous, and the depression of the knob may break the circuit. The spring pulls the arm up when pressure is removed, and by this means the dots and dashes of the Morse code may be transmitted, a sharp thrust downwards producing a dot, and a slightly sustained pressure producing the dash.

TAPPING.—The introduction of a lead into a coil, resistance, etc. Wherever a current is flowing, and

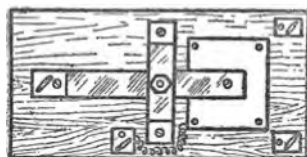


FIG. 401.—Plan view.

a lead is introduced to provide an alternative path, a tapping is made. Examples are in the introduction of the aerial lead into a tuning coil; insertion of plugs into a battery

TAPE MACHINE — TELEPHONE TRANSFORMER



FIG. 402.—The Bridge which carries the Screw to adjust the tension of the Armature.

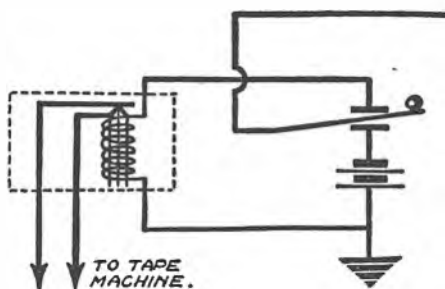


FIG. 403.—The Wiring Circuit showing how the Relay is connected.

a sounder or buzzer (which see), or other device; and in the second category one may employ a lamp or similar device.

TELEPHONE.—A device for transmitting sounds over a distance. (From the Greek *tele*=afar; and *phone*=a sound.) The simplest form of telephone consists of two small tin tubes provided with a membrane stretched across one end. The membrane may consist of paper, skin, etc. From the centre of the membrane a string stretches to a similar apparatus. Any sounds made at the mouth of one of these tins will be conveyed, via the string, to the other tin, and thus speech may be carried on over the string. For best results the string must be stretched tightly. The electrical telephone consists of an electro

magnet, with a disc of soft iron fixed just in front of the pole piece of the magnet. The speech is uttered close to the iron disc (which is known as a "diaphragm"); it vibrates, and so produces variations in the magnetic field. These variations may be conveyed along a wire and passed through a similar electro magnet at the other end. The variations in the magnetic field at this end will vibrate the diaphragm, and in so doing will reproduce the sound. Philip Reis was undoubtedly the first inventor of the electric telephone (1861). Graham Bell perfected the device. A modern form of telephone employs, instead of the electro magnet, a carbon-granule microphone, in which granules of carbon are caused to vibrate by the speech sounds. The resistance of the circuit is varied as the pressure upon the granules varies, and so the variations may be carried along a wire in the same manner as in the previous example.

TELEFUNKEN.—The abbreviation or trade name of the large German wireless concern, the full name of which is Gesellschaft für drahtlose Telegraphie m.b.H. The name is composed of the words "Funken," which is the German plural of "Funk," a spark, and "Tele," which has the same meaning as the English, namely "afar" (from the Greek *tele*).

TELEGRAPH.—Any method of communicating intelligence to a distance. (From the Greek *tele*=afar; *grapho*=to write.) The methods of so communicating a message may be divided into three classes—audible, visible, and tangible. The electric telegraph may be audible or visible. In the first category we may employ

which is provided with sockets at different points; the moving arm of a filament resistance or potentiometer; the centre-point of a push-pull transformer; the output choke which is provided with various points throughout its winding for matching purposes.

TELEPHONE TRANSFORMER.—A transformer included in the

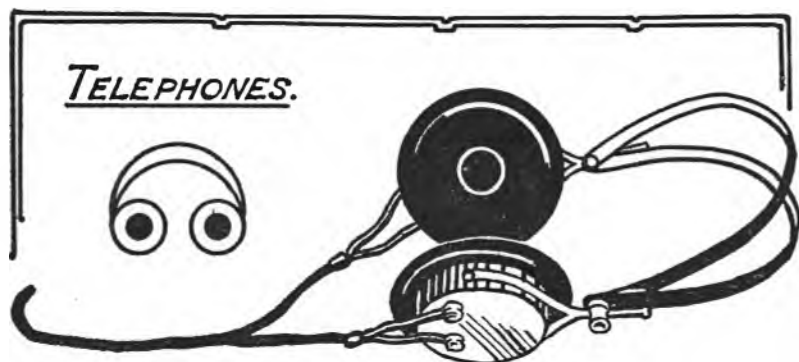


FIG. 404.—Theoretical and actual illustration of Telephones.

anode circuit of an output valve for matching the impedance of the telephones. The ratio is designed so that normally high-resistance phones may be employed.

TELEVISION.—The process of being able to see (through the medium of electrical methods of transmission) the reproduction of images of moving, living, or stationary objects which are at some distance from the observer. In other words, it can be regarded as the reproduction of sight, for the "looker" visually witnesses what is happening at a distance just as if he were an eyewitness on the spot.

Readers have been accustomed, by means of "wireless," to hear voices which come from hundreds or even thousands of miles away. Television, therefore, is all the more important, as when perfected it will complete the process of hearing by adding wireless vision.

There are certain analogies existing between the process of television and that of telephone communication between two individuals, or of wireless broadcasting from studio to listener. When you speak into a telephone mouthpiece the sound waves created by your voice impinge on a

small metal diaphragm or plate, and it is thus made to vibrate in sympathy or in exact consonance to the sound waves.

The resultant varying movement of the plate is then impressed upon carbon granules rather loosely packed at the back of the instrument. This brings about a variation in the electrical resistance of the circuit of which they form a part, and thereby sets up a fluctuating current which alters exactly in unison with the voice waves.

This process is really the conversion of speech in the form of sound waves into current alternations in a wire circuit which are then sent along to the receiving end, where they pass round the coils of a magnet mounted behind another metal diaphragm (see Fig. 405). Now, the action of this varying current is to alter continuously the attraction of the magnet on to the plate, and these movements will be in unison with those taking place at the transmitting end. Sound waves are, therefore, set up corresponding with the original speech at the sending end of the line, and communication is established.

Now turn to wireless broadcasting. The artist stands or sits close to a

sensitive microphone, and the sound waves of his voice are converted by this device into electrical current variations. After amplification these variations are superimposed ("made

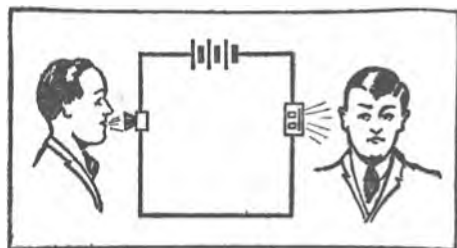


FIG. 405.—The Conversion of Speech.

to modulate" is the correct term to use) upon the high-frequency carrier wave of the broadcasting station and sent into space as electromagnetic waves.

With a wireless aerial and receiver you can detect these signals, since they produce minute voltages in the aerial circuit. After being rectified and amplified in the set, they are finally passed on to the loudspeaker,

the whole scheme being indicated diagrammatically in Fig. 406. Since the loudspeaker operates on a principle somewhat similar to the telephone earpiece, there is reconstructed an aural replica of what is taking place at the broadcasting studio.

The Principles of Television. Coming now to television, and bearing in mind the two everyday occurrences which have been described briefly, the process is seen to be very similar. The individual to be televised stands or sits before a special transmitting apparatus and a rapidly moving spot of light "explores him." The light which is reflected from his features or clothes influences what is called a light-sensitive device or photo-electric cell (see also *Light Control*) and, owing to its very unique and peculiar property, the cell converts this reflected light into a current variation. According to the different spots upon which this light plays, so differing light values will be reflected, and con-

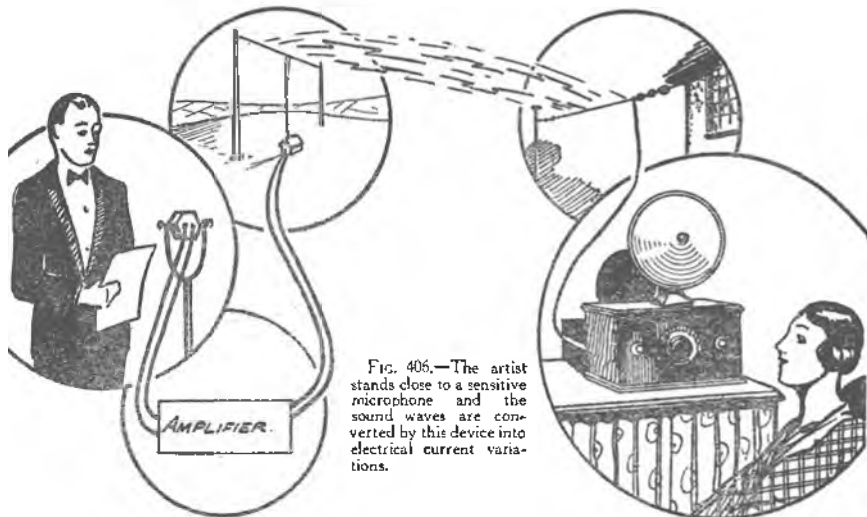


FIG. 406.—The artist stands close to a sensitive microphone and the sound waves are converted by this device into electrical current variations.

TELEVISION

currently there will be a varying current in the photo-cell circuit which is sent along to the receiving end by wire or wireless (see Fig. 407).

Here the current variations, after amplification in the receiving set or amplifier, are turned back into light variations by means of a special lamp—a neon lamp. This effect, together with associated apparatus which will be detailed later, recreates an image of the person at the transmitting end.

a wireless receiver selective enough to receive a clear audible signal of good strength and without distortion from the Brookman's Park station can very easily add the necessary equipment for this new purpose.

Try this little experiment. When you have tuned in a wireless signal to give the strongest volume on the loudspeaker, substitute a neon lamp—say one of the ordinary beehive pattern which is so popular as a

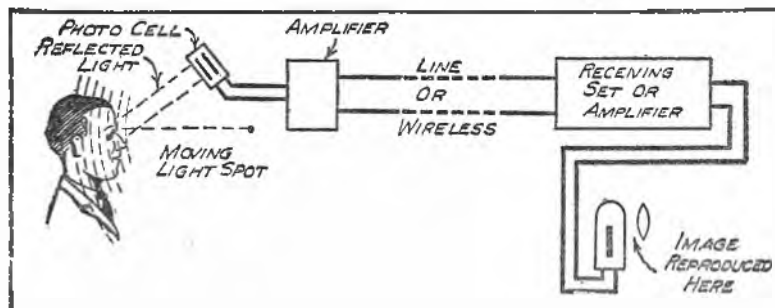


FIG. 407.—The individual to be televised stands before a special transmitting apparatus, while a rapidly moving spot of light explores him.

As in telephony no actual sound passes through the transmitting medium, so in television no actual light is transmitted, but merely an electrical replica in each case. The cells, to which reference was made, can be looked upon as acting in the nature of a sensitive *light microphone*, while the neon lamp and associated apparatus which recreate the image serve the eye in a manner similar to that in which the loudspeaker serves the ear.

There are many schemes which have been propounded both at home and abroad in order to bring television to fruition, but it is impossible to describe each of these in detail.

It must be pointed out quite early that seeing by wireless is only slightly more complicated than hearing by wireless. Anyone possessing

nightlight—for the loudspeaker. Now, this lamp has the peculiar property of responding instantly to any varying currents which pass through it, the pinkish glow altering in intensity as the current alters.

The signals from the output circuit of the wireless receiver will in consequence make the lamp flicker continuously, and you are then in a position to watch speech, song, or music, whichever is being broadcast at the moment, instead of hearing it. The Baird system makes use of this property and is essentially mechanical in its principle.

But since all the changes take place at a relatively high speed, the eye does not dwell on the mechanics of the process. This is because the scanning apparatus brings about a surface spread, and it is opportune now

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to examine in detail what television really is.

Hence it is advisable to guide the reader step by step through the stages of transformation that take place in the television system. The two most

The Disc. Now, this disc has a series of thirty small square holes pierced through it near the periphery or outside edge, and they are arranged in the form of a spiral as indicated in Fig. 409, where the rect-

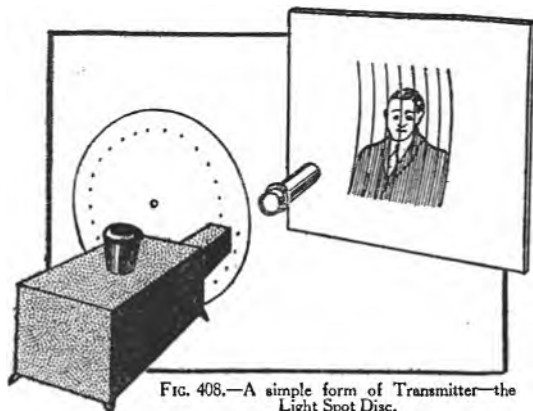


FIG. 408.—A simple form of Transmitter—the Light Spot Disc.

popular types of transmitter are known respectively as light spot disc and mirror drum. Their function is similar, so for the purposes of explanation attention is confined to the former. First of all a powerful source of light is needed, and in practice this is either a specially designed metal filament lamp or an arc lamp. The light source is housed in a metal container provided with a truncated funnel at the front, while at the rear is a reflector to concentrate the rays down the funnel. As the resultant rectangular beam of light emerges from the funnel exit it plays upon a flat metal disc purposely made heavy so that it acts as a flywheel, and in this way tends to run at a constant speed. Fig. 408 gives a rough perspective view of the arrangement, while some of the accompanying illustrations show how transmission of a pictorial image is carried out.

angle ABCD is drawn to represent the light area thrown on to the disc face. The holes have equal angular displacements around the disc, the performance being so positioned that the outer edge of one hole is on the same circumferential arc as the inner edge of the next hole, and so on all the way round. By correctly positioning the disc with reference to the rectangle of light playing on the disc surface, it can then be arranged that on

revolving the disc each hole passes through the light. This causes a square beam to be thrown right

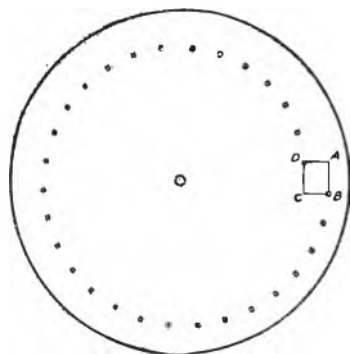


FIG. 409.—The Disc used for scanning the image, showing the spiral arrangement of the holes.

through the disc hole, and if a screen is interposed in the path then a definite-shaped light area is built up, somewhat as indicated in Fig. 410. A

duitable lens is included, so that the beam can be focused on the screen, and if the disc was kept stationary a clean-cut square area of light would be seen, such as A in Fig. 410. Obviously the actual size of the light area on the back screen will be dependent, not only upon the distance between the lens and the screen, but also upon the difference between the radii of the first and last holes and the circumferential distance between each hole.

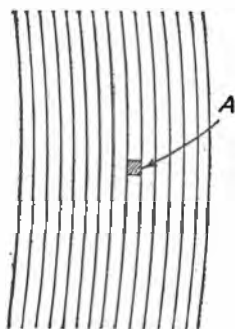


FIG. 410.—How the picture area becomes divided into a series of light sections.

"Scanning." This operation of "scanning" is carried out vertically, while some of the other systems abroad show a preference for horizontal scanning. Referring once more to Fig. 409, then, we must bear in mind that the direction of rotation of the disc and the position of the light source with reference to the disc are such that the scanning operation starts in the bottom right-hand corner of the area. Each spot then moves from the bottom to the top of the picture as a strip, and each strip is traced out on the left of its predecessor until one revolution is completed. This is an important point, for if not followed correctly then confusion will arise later at the receiving end—spot movement bottom to top and strip movement right to left.

Now a brief mention as to the shape of the hole in the scanning disc. Actually any shape can be employed, but for reasons of detail, absence of streaks, most economical use of the

"etherical sideband," and one or two other points which are really too theoretical to deal with here, a square hole is chosen. Furthermore, that is the most economical way of using a given area, and the holes must be very accurately positioned to overcome any likelihood of underlap or overlap, a point which can most appropriately be deferred until migrating to the receiving end.

The Light Source. Very well, then; with the light source fixed in position behind the revolving perforated disc a definite-shaped light area on a screen is focused. The spot, or spots, of light which create this effect carry out their work at a relatively rapid rate, namely, 750 complete disc revolutions in one minute, corresponding to twelve and a half complete explorations in one second. A small amount of flicker is noticed, but this is quite small, and for all practical purposes one has the impression of a flood-lighted area. This scheme is all very simple so far, but what is the purpose underlying the arrangement of this rapidly moving spot of light? It is here we make our formal acquaintance with the conversion of light into electricity, one of the most important links in the television chain.

The Discovery of Selenium. We must now consider the action of selenium. It is a metal which offers a great resistance to electricity, and the history of television is really linked up with the discovery of selenium. Many years ago a cable operator noticed that one of his instruments behaved in a very erratic manner every time a sun ray touched the resistances which were made from selenium. Investigations of this peculiar phenomenon were undertaken, and the fact that selenium was sensitive to light was discovered. If connected up in a circuit and exposed to light an electric current will flow in the circuit of which it forms

a part, but on shielding the selenium from the light rays the current flow will cease.

Now, scientists were quick to perceive that in the selenium cell they had a means for providing vision by telegraphy, but after considerable experiment it was found that unfor-

border on the miraculous. Do not run away with the idea, however, that one or more cells, because they turn light into electricity, are capable of converting an entire scene or image into equivalent and electrically intelligent current variation. Oh no, the problem is not so simple as all that; perhaps the television authorities wish it was.

Light Values. Any one scene or object if illuminated is found to be made up of countless differing light values spread over the whole area. Since the photo-electric cell gives a proportional current response for every light value to which it is exposed, our large area would only produce one average light value which, of course, is useless. We are therefore forced to split up the area into elemental light values, and allow the cell to deal with each one in turn in great rapidity. Now you see the

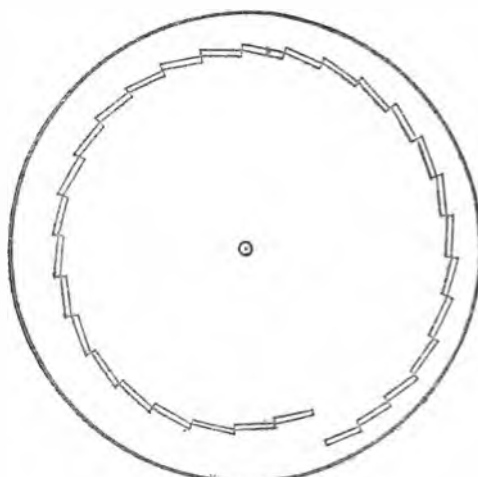
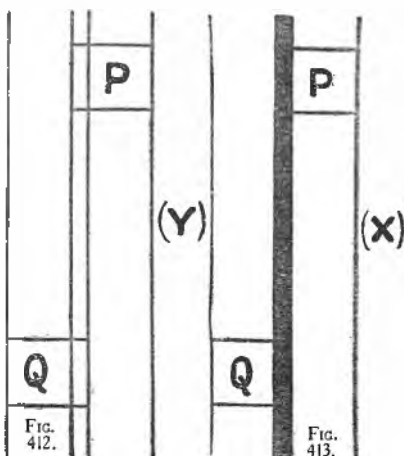


FIG. 411.—The bottom edge of one strip will just touch the top edge of the next strip as shown.

tunately selenium was much too slow or sluggish in action, and in consequence television as a science stood still. Luckily in 1888 Hertz discovered the photo-electric effect, and built up cells working on this principle. These cells turn light into electricity and, although only a minute current flows, they are instantaneous in action, a quality which television demands for its successful accomplishment. The small current response is easily made good by suitable valve amplifiers, as used in ordinary wireless practice. There is no need therefore to consider that aspect.

Undoubtedly we can look upon the photo-electric cell almost in the light of a magician's lamp, for its characteristics, to the unscientific mind,



FIGS. 412 and 413.—Details of the Light Strip.

justification for installing our light spot transmitter. A definite geometrical movement is imposed upon it so that it sweeps over the whole area or scene in a predestined path. At any one instant during the travel of the beam of light passing through the holes in the rotating disc, a minute area is illuminated. By correctly positioning the photo-electric cells their active surface can be made to pick up or absorb the light which is reflected from the subject being televised. A corresponding current variation is produced in the cell circuit which, as will be seen later, can be translated into a similar form at the receiving end.

We have the photo-electric cell causing a current to flow in the circuit of which it forms a part, through the effect of the light reflected back from the  elemental square of the scene illuminated. At the next instant, when the spot has moved to its adjoining position in the light strip, so a different amount of light is reflected

and the cell responds accordingly.

In this way the scene is analysed, spot by spot and strip by strip, into values of light and shade, which are handled and changed to current variations, and with each revolution of the disc so that one complete scene conversion takes place. The current values are dependent upon the reflective properties of the televised sub-

ject, anything white reflecting more light than anything black, and so on, for intermediate values.

It is important to understand thoroughly this dissecting action of the disc, so it may help matters if another method is given of looking at the scheme. The circumferential length between individual holes represents the length of our resulting picture; so if we take an ordinary photograph of that length and cut it into the same number of vertical strips as we have holes in the disc, then each strip will represent the amount of picture covered by the light spot in its vertical travel.

Dissecting the Photograph. One revolution of the disc is therefore equivalent to dissecting the photograph into the strip manner suggested, and placing each strip round

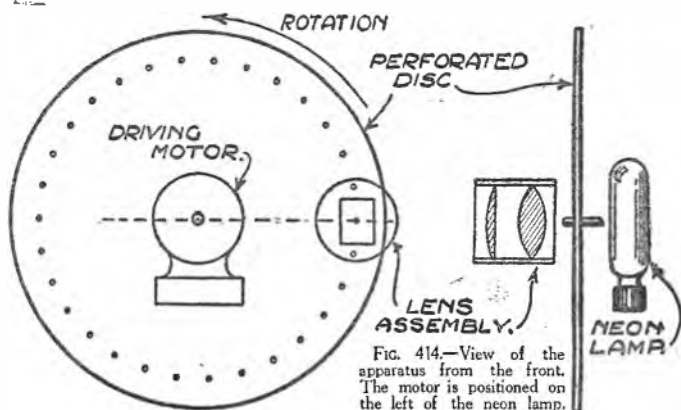


FIG. 414.—View of the apparatus from the front. The motor is positioned on the left of the neon lamp.

the outer edge of a disc somewhat in the fashion shown in Fig. 411. The bottom edge of one strip will just touch the top edge of the next strip, the long inner edge of the first strip being on the same circumferential arc as the outer edge of the next strip.

If these strips are pasted on a large disc in the manner shown, they will constitute the individual scans

of each hole, and it is possible to make up a cardboard disc in this fashion, spin it about its centre, and by properly observing the strips through a lens and mask, to form and see the complete photograph originally cut up.

Having appreciated how the scene is broken up and translated into terms of varying current, movement of the subject must now be considered. This is a simple matter, and is brought about by arranging the transmitter to make ten or more complete explorations in one second.

Visual Persistence. Pictures seen on a cinematograph screen are only optical illusions. Actually a series of still pictures are thrown on the screen, and the eye, owing to a phenomenon known as visual persistence, conveys a moving impression to the brain. It is the rapidity of the process which brings about the continuous action. The same sort of thing happens with television. By means of the moving disc it is possible to arrange for as many complete scanning movements as is desired, and the effect is blended into an harmonious whole, and beyond a slight flicker the mechanics of the process are lost to the observer.

The whole thing is very intriguing and yet so simple when shorn of its technicalities. The amount of detail which can be transmitted in the present state of development of the art is limited, but, obviously, the more strips into which a transmitted scene can be dissected and the greater the rate with which the operation is repeated, the greater the detail, and flicker will vanish.

Sidebands. Any form of broadcast must be made within 9,000 cycles. The more we aim at finer graduation the greater will be the sideband required and, in consequence, a compromise has to be effected between the shape of the picture, the number

of scanning lines, and the number of complete images which are transmitted in one second. With the present transmissions, these have been worked out as a picture with a ratio of 7 vertical to 3 horizontal, 30 scanning strips, and $12\frac{1}{2}$ pictures per second.

If any attempt is made to transmit an object or objects possessing essential detail which is much smaller in comparison with the flying light spot, then faithfulness of reproduction is lost. For example, objects with sharply defined outlines when televised come over with a somewhat softened effect. On the other hand, most of the characters are undergoing continuous movement during the course of their turn before the "light microphone," and this, coupled with the self-accommodating character of the human eye, and its tolerance, impart to the observer quite a lot of detail.

When you look at any scene yourself you unconsciously scan it by allowing your eye to wander over it in much the same way as a television scanning spot. Before there has been an opportunity of absorbing all the detail of a televised subject or a person in one position it has moved to another, and thus *unconsciously* the amount of noticeable detail is less than would be the case for stationary objects.

The Strip Effect of the Scanning Disc. Again, when you examine any television image quite closely, you can trace the strip effect of the scanning.

By standing two or three feet away from the apparatus you will have the effect of the light and shade in the image being distributed throughout in the form of a wash drawing or continuous surface. Once the signal impulses, emanating from the travelling light spot's reflections being translated into terms of current, have

been amplified, they are made to modulate the high-frequency carrier wave of the wireless broadcasting station in a manner similar to "sound currents" from a studio microphone.

A wireless receiver is required to pick up these signals and pass them through the various set stages. The loudspeaker, however, is replaced by special vision apparatus to act as a recorder and appeal to the sense of sight instead of to the sense of hearing.

Receiving Television. In many respects this is perhaps the most fascinating aspect, for although it is wise to have a working knowledge of how the vision signals are brought into existence, it is at the receiving end where the bulk of the amateurs are able to display their constructive capabilities. Just as in normal aural wireless reception one can build apparatus to give results, so with tele-

vision the same statement holds good, except that the final appeal will be to the eye as well as to the ear.

Since at the moment the wireless receiver does not enter into the principles involved in the transformation of the signals into intelligible images, attention will first be directed to the apparatus acting as the "vision recorder." First of all a short list has to be compiled of the essential component parts which must be em-

ployed. These are four in number, and consist of:

1. A light scanning disc complete with its spiral of holes to conform geometrically with that used at the transmitting end.

2. A small motor to drive the disc at its correct speed.

3. Some form of neon glow lamp.

4. A lens assembly to magnify the size of the image so that it can be watched in comfort.

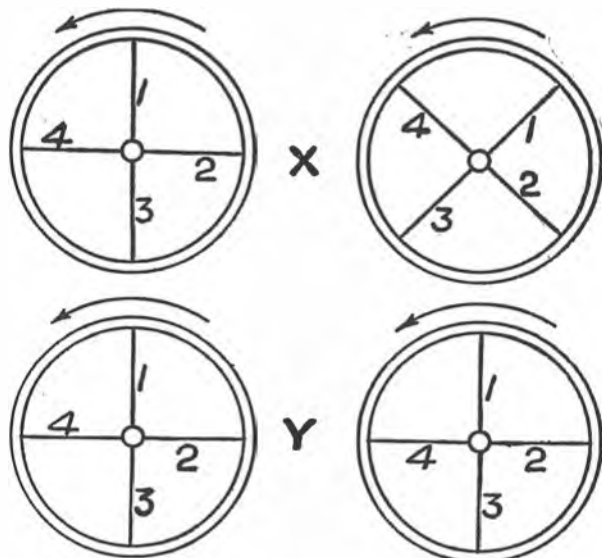


FIG. 415.—Diagram X shows conditions of isochronism in two wheels of equal diameter, and Y indicates equality of both speed and phase.

In addition to these four items there is another important one whose inclusion, while not essential, makes a material difference to the success of the reception. This item is some form of synchronising mechanism to "hold the image," which is dealt with later.

The Construction of the Scanning Disc. The disc should be made from fairly light material—No. 32 S.W.G. sheet aluminium is very satisfactory.

In order still further to aim at this factor of small weight, it is better to make it up with spokes, five or six in number, the space between the spokes being removed.

At first sight a disc made up in this manner may seem "flimsy" and will bend easily, but when run up to speed on the motor shaft it will whip out flat and function just as a solid flat disc. A diameter of 20 in. will be found very suitable. The spiral

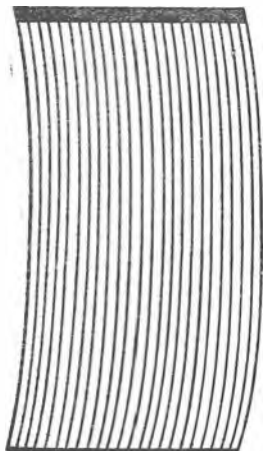


FIG. 416.—A black band introduced artificially. The spot light is marked out, and there is a momentary period of darkness, and thus no light is reflected on the photo-electric cell.

operation will be in order, that is, hole movement from bottom to top and strip direction from right to left.

One very important point arises with the scanning disc, and that is, the accurate positioning of the holes. If thirty holes are used, then each hole will lie on a radius separated by an angle of 12° . In addition, the outside edge of one hole must be in line exactly with the inside edge of the preceding hole. If this is not watched lines will show up, or in other words, the junctions between individual light tracks become visible.

Suppose we let P and Q represent two adjacent holes (see Fig. 413), the vertical lines being the limits of the light track created by these holes. Now, the track made by the inner edge of P does not coincide with the track made by the outer edge of Q. This gives us the condition known as underlapping, and the result is an unpleasant black line running from top to bottom of the picture, the width of the line depending upon the magnitude of the underlap existing between these two consecutive disc holes.

The Light Strip Holes. Fig. 412 represents the opposite condition, namely, overlap. The light strip edges of holes P and Q now overlap one another, and a narrow white line is produced, and while not so bad as the black line, the combined effect of these black-and-white lines, if pronounced, is often sufficient to mar the whole image. Every effort must therefore be made to reduce or almost "erase" these streaks, and herein lies the secret of a well-made disc.

The next item is the motor. To achieve the best results it is obvious that a reliable machine is necessary. It must be capable of running at its normal speed for long periods at a stretch without continual adjustment. This effectively lightens the load on the synchronising mechanism which, as will be seen later, if of the electrical and automatic type, is only meant to be a form of speed control within certain narrow limits.

The Necessary Power. Where a mains supply is available it is, of course, the best plan to use this to furnish the power for driving the motor. Whether this is A.C. or D.C., some form of speed control is essential. Clockwork motors, sewing-machine motors, vacuum-cleaner motors, fan motors, etc., may be pressed into service for the purpose. For those houses without an electrical

supply laid on, recourse must then be made to a motor deriving its supply from a 6- or 12-volt accumulator. The simplest form of speed control is a wire-wound rheostat made from wire capable of carrying the motor current. It is wise not to have a definite "off" position, otherwise one is liable to move the contact arm to this position when the hand is on the control and the eyes are on the image. The motor speed will at once start to drop, and you will have to start resolving the picture into an intelligible image or picture again.

In order to see the resultant image at the receiving end some form of light source is necessary, and this introduces the

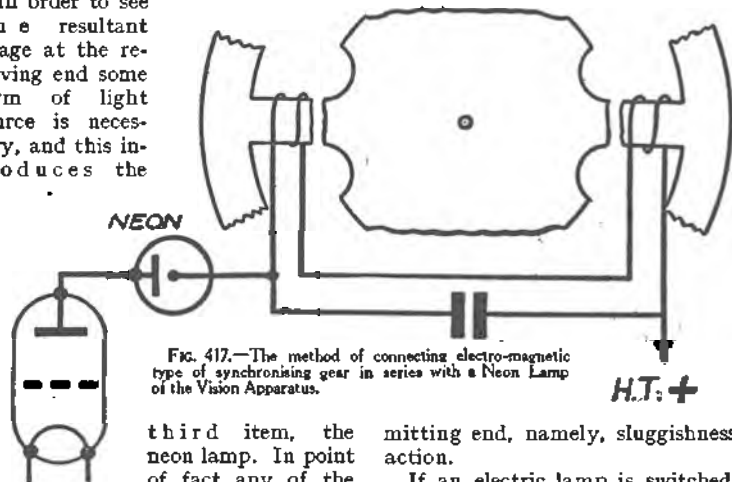


FIG. 417.—The method of connecting electro-magnetic type of synchronising gear in series with a Neon Lamp of the Vision Apparatus.

third item, the neon lamp. In point of fact any of the types of neon lamp (discussed under that head) will do for this purpose. The beehive or spiral pattern, so useful for domestic purposes, especially as nightlights, or again the shaped letter pattern normally employed for advertisement signs, are both satisfactory.

The best type of all, and incidentally the most expensive, is what is known as the flat plate, which is more expensive. Here the metal plate glows uniformly over the whole flat surface, and this is scanned by the

disc. The lamp itself is filled with a gas called "neon" at a very low pressure, and this familiar reddish orange glow is brought about by the neon atoms becoming heated through atomic bombardment.

The Illumination. Unfortunately, the magnitude of the resultant illumination is quite small, and it may occur to readers to suggest that use be made of the ordinary electric lamps, such as are employed in the home. This would be an excellent scheme if at all practicable, but they suffer from the same sort of defect which ruled out selenium at the trans-

mitting end, namely, sluggishness of action.

If an electric lamp is switched on it will be noticed that a small fraction of time elapses before the lamp assumes its full brilliancy. The same thing occurs when switching off, and these defects are quite sufficient to make this form of illumination unsuitable for television work.

The Lens Assembly. At the receiving end the form of illumination must be *instantaneous* in its responses to the current variations produced by the television signals. It must also be able to withstand the shock brought about by the speed



FIG. 418.—The image split vertically, due to the synchronising mechanism pulling the disc into place when its holes are out of phase with those at the transmitting end.

with which these current changes take place, and, up to the moment, the neon lamp has proved itself to be the only one which fulfils all requirements.

The fourth item is the lens assembly. A combination of two lenses, say a simple convex and a double convex, is quite suitable for this purpose. It is obvious that the *true* image size is governed by the disc dimensions, and a magnification of two to four times is advisable to allow the image to be watched quite easily.

Having described the simple apparatus required for the vision equipment at the receiving end, next proceed to examine how it is assembled and performs its prescribed functions. First of all, for vertical scanning, the neon lamp in its bayonet-type holder is mounted vertically and held on some form of frame or support, so

that its centre is on the same horizontal line as the centre of the shaft.

Viewing the apparatus from the front the motor is positioned on the left of the neon (see Fig. 414), and when rotating in an anti-clockwise direction, the disc, secured to the motor shaft by a grub screw passing through its boss, allows its spiral of holes to pass in front of the neon lamp and hence "scan" this source of light. It is a very good plan to have some form of mask used in conjunction with the magnifying lenses. This will serve to "black out" any section of the light which is not required during the process of image reconstruction.

The Reception of Television Transmissions. For the reception of television transmissions from Germany (and in addition this is the practice of the United States) the scanning is horizontal,

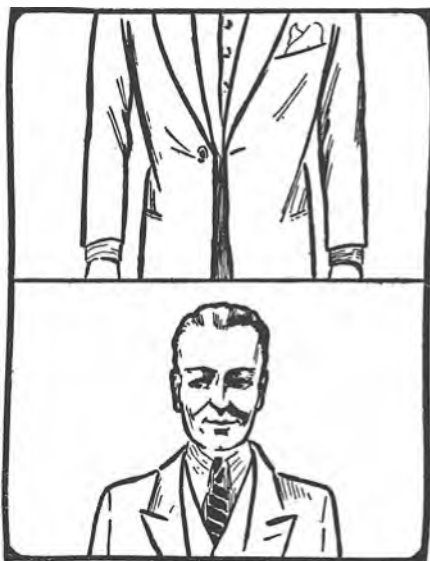


FIG. 419.—The horizontal splitting of the image is caused by the field coils of the synchronising mechanism being set incorrectly with reference to the disc holes.

and in consequence the neon lamp must be held horizontally, with its centre vertically above the motor shaft. To meet those cases where the reception of both British and Continental transmissions is desired, both these types of mountings must be allowed for. One of the special systems uses what is known as a universal receiver, and this has an image adjuster and a double-spiralled disc to make it suitable.

Irrespective of the style of neon lamp mounting decided upon, the method of working is essentially the same. The wireless receiver is tuned in to the station broadcasting the vision signals, and these then pass to the neon lamp and synchronising mechanism (if added) in much the same way as ordinary sound broadcast signals are handed on to the loudspeaker. Under these conditions the neon lamp changes the intensity of its illumination in accordance with the signal strength, these changes taking place with the same rapidity owing to the neon lamp's inherent properties referred to earlier.

Perfect Synchronism. When the motor is driving round the perforated disc in front of this continuous but fluctuating neon glow it is possible to watch the light changes through the small holes. To simplify explanation at this stage imagine that the discs at the transmitting and receiving ends are running in perfect synchronism (a condition to be explained later, but meaning the same speed and in the same phase relationship).

Under these circumstances a hole in the receiver disc at any one instant will expose a very small area of the neon glow—say, for example, in the bottom right-hand corner—when there is a correspondingly similar position then undergoing exploration at the transmitting end.

But the intensity of the neon glow at this instant bears a direct pro-

portion to the amount of light reflected from the illuminated spot of the object or scene being televised, since it has passed through the stages (all proportional) of reflected light to photo-electric current, amplification, broadcasting, received on wireless set, amplified, and thence turned back to light by the signal passed to the neon. Hence, a degree of light or shade is observed at that instant which must conform to the transmitting end conditions, and in effect we are thus able to reproduce those conditions.

In undergoing its prescribed disc hole motion over the glowing neon area a strip of incandescence is created, reproducing in miniature all the corresponding light and shade existing at the transmitting end. As soon as this hole has completed its path the next hole undertakes the work and performs an exactly similar task, following faithfully its "partner" at the transmitting end.

Creating an Image. In this way, strip by strip, each lying side by side, a complete rectangular area is built up, the various degrees of light and shade intermingling to create an intelligible image. If this process were carried out slowly, then the effect would be very mechanical; but since there are at least twelve and a half complete pictures of thirty strips built up before the eye in the small space of one second, it is possible to show all the light, shade, contour, and movement of the person or subject before the photo-electric cells at the transmitting end.

It is also possible to transmit moving-picture films by cathode ray television—a method which is being developed, but which up to the present is expensive.

In operating the vision apparatus there are certain peculiar effects which are certain to be observed, such as negative images, split images, wrongly framed images, and so on;

but since some of these have a direct bearing on the question of synchronism it is advisable to deal with this next.

Synchronism. The term "synchronism" is one which is often confused, owing to a failure to comprehend its *exact* meaning. It can perhaps be explained best by giving one or two simple examples.

First of all, imagine two clocks, one of which is situated in America and the other in England. If their accuracy is beyond dispute, both the minute and the hour hands of each clock will go through similar movements or, in other words, the angular movements of the hands will be identical. There will be a difference, however, in the times registered by the individual clocks at the same instant, for noon in America occurs at a different time from noon in England.

The condition which has been satisfied under the facts mentioned is known as isochronism. Now, imagine both the clocks housed under the same roof. They will not only show the hands moving at the same rate, but will point to the same time at every instant. They are said to be "in step" and bear the same "phase" relationship to one another as well as possessing identical speeds. It is this double condition which needs to be satisfied for synchronism to be established.

For the second example, refer to Fig. 415, illustrating two wheels revolving in the same direction at the same number of revolutions per minute—say two wheels of a bicycle on a straight run. Spoke No. 1 of the left wheel, however, is not in the same angular position as spoke No. 1 of the right wheel.

At X, therefore, is illustrated the condition of isochronism, or equal speeds, and at Y equality of both speed and phase, which is the re-

quirement of synchronism. Not only are the speeds identical, but spoke No. 1 of each wheel has the same angular position at every instant of the motion.

Isochronism. While it is possible to achieve isochronism without being in synchronism, it is impossible to establish synchronism without having first brought about isochronism. In the television system isochronism is achieved through the agency of the mechanism incorporated in the apparatus, and this is done automatically, but the question of phasing has to be undertaken by each individual operator.

In the development of television it is only reasonable to suppose that many schemes have been proposed to bring about synchronism. One of the first ideas was to use alternating-current synchronous motors, and under limited conditions this is quite successful; but the limitations mean that both the transmitter and receiver motors must be run from the same mains supply, and a moment's reflection will show that the area over which results can be achieved is necessarily small. This condition of affairs will be simplified when the electricity scheme now being developed for Great Britain is brought to fruition.

Another proposal put forward was the transmission of a special synchronising signal of definite frequency and tune to both the receiver and transmitter mechanisms. Apart, however, from the practical difficulties and the high power that would be required, it is necessary to provide an extra communicating channel to bring the scheme to a successful issue. This is, therefore, a retrograde step, for two channels already are required, one for sound and one for vision, and any addition to these would only tend to overcrowd an already congested ether.

It became imperative for some simple means to be devised which was inexpensive and would bring television within the scope of the ordinary amateur or domestic use irrespective of situation or distance from the transmitter. The first success in this direction was shown in 1928. No separate synchronising signal was sent out, but the television picture itself was made to provide the necessary impulses required to keep the receiver in a state of isochronism or equal speed with the transmitter.

For this to occur, it is logical to assume that there is some component part of the television signal which varies in direct proportion with the transmitter disc or mirror drum, and is in no way influenced by the type of scene or subject which is being televised.

Recalling for a moment the elements of the television process, a spot of light moves from the bottom to the top of the scanned area to create a narrow light strip, and a sequence of thirty strips is built up, side by side in this way, owing to the orientation of the holes in the exploring disc. It is the fundamental component of the actual strip sequence which is employed in practice, for this is unvarying, assuming a constant speed for the transmitter motor. This signal, with a well-defined beginning and ending, and, of course, an intervening period, occurs 375 times per second, if $12\frac{1}{2}$ pictures per second occur, the present standard in this country.

A black band is introduced artificially, that is to say, at the top of its sweep the spot light is masked out, and there is a momentary period of darkness, and thus no light is reflected on to the photo-electric cells. This is shown in Fig. 416, and we have now a definite signal depending entirely upon the transmitter mechanism, which is introduced into the

normal picture signal. The receiver mechanism must therefore in some way be made to respond to this, and by so doing, the condition of isochronism will be established.

Automatic Electro-magnet Synchronising. Two small electro magnets are so mounted on a metal ring that they are diametrically opposite to one another. This framework, in turn, is secured to the carcass of the small driving motor. A cogged wheel is held on the motor shaft by grub screws, and is so positioned that it can rotate exactly between the pole faces.

In Fig. 417 is shown the method of connecting this electro-magnetic type of synchronising in series with the neon lamp of the vision apparatus and also the output valve of the wireless receiver used for tuning in the television signals. The current passing through the small field coils will make them of opposite polarity, and if the speed of the disc at the receiving end is identical with that at the transmitting end, then the resultant magnetic pull on the teeth of the cogwheel will balance out in each cycle of changes. If the disc tends to run fast, however, there will be a magnetic pull on the "teeth," tending to drag them back, and this retarding impulse acts as a brake, and the disc is forced to drop back to its normal isochronous speed.

This method works very well in practice when set up correctly and fed with sufficient current, but there is always a tendency for a slight vertical "shunting" motion.

Looking-in. First of all tune in the wireless receiver to the transmitting station sending out the vision signals. It is a good plan here to check these on a loudspeaker, and when a peculiar sort of rhythmic hum—it is not a musical note—is heard at full strength, change over the output connection on the set so that you feed the vision apparatus.

Start up the motor and see that the neon lamp is glowing at normal brilliancy. On looking into the lenses, you will probably notice first of all a number of whirling reddish patches, which will ultimately take on a definite shape as the receiver motor speed approaches that of the transmitter motor.

A succession of images will then be seen to be moving *downwards* rather rapidly, and one must vary the motor speed until the black lines at the top and bottom of the picture are horizontal. It is important to remember that lines sweeping downwards signify that the motor is running too slowly, while lines sweeping upwards indicate that the motor is running too fast. In either case the procedure to rectify matters is quite obvious.

Once the speed has been adjusted to its normal value, the synchronising mechanism (if any has been included) will come into operation and hold the image steady, or alternatively permit only a slight "floating" action. When the image is steady a peculiarity may be noticed—with a thirty-line picture the chances are thirty to one—namely, that the image is split vertically (*i.e.* two portions lying side by side), somewhat as indicated in Fig. 418. This is due to the synchronising mechanism pulling the disc into place when its holes are out of phase with those at the transmitting end. Depending upon the amount of phase difference the picture will be split so many holes to the right or left.

The matter is easily rectified, however, by increasing the motor speed very slightly (adjust the control ever so gently), until the images start drifting upwards. Let this go on until the double picture resolves itself into a single one, and then quickly bring back the speed of the motor to normal again. The knack of this is

soon acquired after a little practice.

Horizontal Splitting of the Image. Another effect which is sometimes noticed is reminiscent of the early days of the cinema. Then one sometimes saw a picture which for a few seconds had the actor's head at the bottom of the screen and his feet at the top. This horizontal splitting of the image is shown in Fig. 419, and is brought about by the field coils of the synchronising mechanism being set incorrectly with reference to the disc holes.

To raise or lower the picture and thus properly "frame it," it is necessary to move the disc round slightly on the shaft or alternatively alter the position of the field coils by rotating them a little round the motor carcase.

Just the same as it is impossible to receive two normal broadcasting stations on one receiver and listen intelligently to each programme separately and without interference, so it is out of the question, at the present stage of television development, to expect one set to handle both the vision and the sound signals, and pass them over individually to the loudspeaker and vision apparatus.

Two distinct sets are required, one for the sound and one for vision. In the case of the former a portable is quite satisfactory, with the home outside aerial used in conjunction with the vision set; but, if preferred, the same outside aerial will do for both receivers, provided precautions are taken in coupling the sets to the aerial.

The item which needs the most careful attention and consideration is the type of wireless set best suited to handle the television signals.

Operating Home-made and Commercial Models. Hard-and-fast regulations cannot be laid down, for much depends on environment and the local nature of signal reception.

But to work, say, the commercial models of "televisors," and also many of the home-made replicas of this apparatus, the vision receiver should be capable of delivering good quality output of the order of 1.5 watts on optimum load.

It is not necessarily the strongest signal which gives the best image, so there is ample scope for experiment.

With regard to the "detector" stage, two methods are in general use: (a) grid leak and condenser, and (b) anode bend. The essential differences between these two can be summed up quite simply. With anode bend, the high-frequency currents are amplified in the valve first, and then rectified in the anode, or plate, circuit. With the grid leak and condenser, rectification takes place in the grid circuit of the valve, and the resulting low-frequency current undergoes magnification in the valve itself, and of the two it is found generally that anode bend gives somewhat better results.

Tuning. The important fact to note in connection with vision wireless receivers is that the tuning circuits must not be too sharp, or the higher frequencies will suffer. As far as the low-frequency side of the set is concerned bear in mind that quality is the factor to be aimed at. If transformers are used they should be preferably those of high grade, but where possible resistance capacity coupling is the better scheme. Within a radius of about forty miles from Brookman's Park, a three-valve receiver will give good images if it consists of a screened grid, detector, and pentode.

Mention must be made of positive and negative images. By a positive image is meant one with the true light and shade relationships, and this is dependent upon the correct signal-current direction in the output valve. Obviously an increase in the plate

current will increase the neon glow, whereas a decrease lessens it, and it is quite easy to reverse these effects and produce a negative image, that is, one which resembles the photographic plate from which a print is taken. All the light parts are dark and the dark parts light, and to rectify matters, if this should occur, try one of these cures:

(a) Reverse the primary or secondary windings of your low-frequency intervalve transformer.

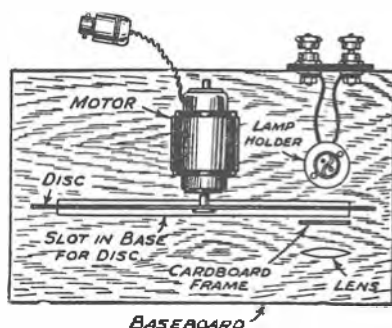


FIG. 420.—Diagram showing the complete Television Apparatus.

(b) Reverse the output leads on the set.

(c) Add another stage of low-frequency coupling.

(d) Change the method of rectification in the set—anode bend to leaky grid or vice versa. (See also *Noctovision* and *Phonovision*.)

TELEVISION RECEIVER, MAKING A.—The television receiver now described, although not of a very elaborate nature, will enable listeners to receive quite good images from the present television broadcasts, provided they possess a good three-valve wireless receiver, working from a mains eliminator delivering about 200 volts H.T. Dry batteries are unsuitable. (The completed instrument is shown in Fig. 420.)

TELEVISION RECEIVER

The Scanning Disc. The most important part of the instrument is the scanning disc. This can be constructed of either cardboard or aluminium, and although cardboard is the cheaper, it has the disadvantage that it is not very rigid unless fairly thick, and the disc should be as light as possible in order that it may be rotated easily. It is, however, much easier to mark out and cut. Whatever material it is decided to use, mark out a circle 20 in. in diameter, and with the aid of a protractor and

and very carefully punch a hole at each of the dots. This must be done very carefully, as the sharpness of the detail of the received image depends on the accuracy with which this part is done.

Mounting the Disc. The finished scanning disc has to be rotated at 750 revolutions per minute, and for this purpose it is preferable to mount the disc direct on to the spindle of a small electric motor. It is possible, however, to suitably gear a clockwork motor, or to use an electric fan (with the fan, of course, removed). Whichever method of rotation is decided upon, make sure that the whole thing is mounted solidly, and that there is no shake transmitted to the rotating disc, as this will spoil the clarity of the image.

The next part of the apparatus is the Neon lamp, and for this purpose a special nightlight (of the beehive pattern), or a special letter lamp (preferably the letter "H") can be quite effectively employed. A holder to take the lamp is next wired up, the two wires being taken to two ordinary terminals spaced about 2 in. apart on a small strip of ebonite, and the lamp holder is mounted on a piece of wood so that the centre of the bulb of the lamp will be in a line with the spindle of the disc, and directly behind the row of holes (see Fig. 421). The lamp should be mounted as close as possible to the disc, so as not to lose too much light.

To enable one to see the picture more clearly, it is preferable to mount a large reading glass or other magnifying glass in front of the disc, and to mount a piece of cardboard (having a piece cut out $1\frac{1}{2} \times 2\frac{1}{2}$ in.) between the lens and the disc. This cuts off all extraneous light, and makes the image stand out. Fig. 420 shows the arrangement of the complete instrument.

Now, to use the televisior, discon-

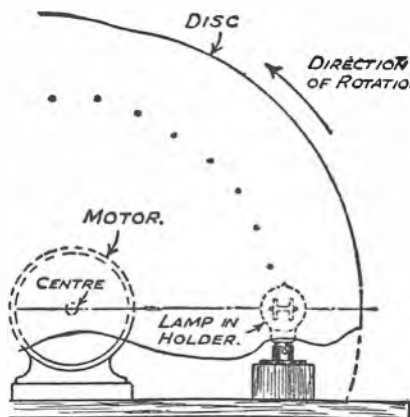


FIG. 421.—How to mount the Neon Lamp.

dividers mark out thirty lines, each 12° apart (Fig. 422). Now mark one of these lines with the figure 1 as a guide, and along this line make a dot (with a finely pointed pencil) exactly $9\frac{1}{2}$ in. from the centre. On the line immediately above this make a dot $\frac{3}{8}$ in. nearer the centre, and carry out this procedure on each line, each succeeding dot being $\frac{3}{8}$ in. nearer to the centre than the last. This gives a spiral track of thirty dots, the outer one being $9\frac{1}{2}$ in. from the centre, and the inner one $\frac{1}{16}$ in. from the centre. Now obtain a sharp nail (or better still, a leather punch), having a thickness of $\frac{3}{16}$ in.,

nect the loudspeaker from the receiver, and connect the two terminals of the television to the loudspeaker terminals of the set. Switch the set on, and look at the lamp through the holes in the disc. Switch on the motor, and as the disc gets up speed the holes will form a series of lines which gradually form into a broad band of light, and if the set is tuned to a station which is transmitting music or speech, a series of fascinating patterns will be seen on the "screen" (which is the name given to the lighted area seen through the lens).

When television is being received, a series of narrow lines will be seen to pass either downward or upward across the lighted area. The speed should be adjusted until the lines are horizontal. If the lines run downward, it is an indication that the disc must be speeded up, while if the lines run upward the disc must be slowed down. To regulate this speed you can arrange a resistance in series with the motor, or press the tips of the fingers of one hand against the disc itself. This is quite a good way, and is, in fact, preferred by some people, as it enables quick changes to be made to compensate for surges in the motor due to fluctuations in the mains.

When the image of a person is received, it is quite possible that it will not at first be in the centre of the screen. It may be split into two sections, either vertically or horizontally. In this case, allow the disc to gather speed for a moment or two until the correct image occupies the centre of the screen, and then hold it there. This is known as "phasing," and is a necessary procedure even on the commercial instruments. If, of course, during a television transmission nothing can be seen on the screen but rows of dots, it is an indication that the

speed is relatively incorrect, and therefore it must be speeded up or slowed down until the narrow lines are seen passing downward or upward.

Many refinements will no doubt suggest themselves to the interested listener, but the apparatus as described has been put to practical use and has given good results, although it should be understood that the commercial television gives a much brighter and larger picture, and is equipped with a "synchroniser" which enables the picture to be held quite steady during the transmission.

Refinements. The voltage of the lamp is immaterial, as all the commercial types of lamps are fitted in the base with a wire-wound resistance which reduces the actual voltage on the elements to quite a low value. However, greatly improved results are obtained if this resistance is removed. This is not a very difficult thing to do—a soldering iron, a small quantity of methylated spirits, and some Chatterton's compound being the only things required. Heat the soldering iron and apply it to the oval lumps of solder at the bottom of the lamp, and as soon as the solder runs give the lamp a smart shake.

The solder will come away, leaving a small hole exposed, through which will be seen projecting a thin wire. When both holes are uncovered, stand the lamp in a cup or other vessel and pour in the methylated spirits until the cap is covered. Allow this to stand all night, and in the morning it will be found that the brass cap can be easily removed. Inside will be found a small red fibre former containing a large quantity of thin wire. Unsolder this, and connect a short piece of wire in its place; thread this wire and the remaining wire through the holes in the base of the cap, resolder, and replace the

TELEVISION RECEIVER — TESTING A RECEIVER

cap, using the Chatterton's compound to make all firm. It will now be found that a much brighter image can be obtained with the lamp, although it must be borne in mind that on no account must the lamp in this condition be connected to the mains, as the lamp will be destroyed. A further improvement in the lamp consists of sticking ordinary silver paper to the part of the bulb farthest from the scanning disc, and placing a piece of thin ground glass (or greaseproof paper) between the lamp and the disc.

Improving the Image. A tunnel-

in the scanning disc of a square shape instead of round. This cuts out the dark patches seen on the screen of a disc which is cut with round holes. The holes should, of course, be $\frac{3}{16}$ in. square. Any overlap (or underlap) of these holes will result in the screen having light or dark lines running down it, and the utmost accuracy is needed if the screen is to be perfectly evenly illuminated.

TELLURIUM.—An element of rare occurrence found in a few minerals in association with gold, silver, and bismuth. Symbol—Te. It possesses many of the characteris-

tics of a metal, but bears so close a resemblance to selenium in its chemical properties that it is generally placed in the sulphur group. It is very brittle, and is a bad conductor of heat and electricity. It melts at a very low heat (below red), and volatilises at a higher temperature. (See *Crystals*.)

TERMINAL.—An end. In electricity it is a clamping screw provided at the end of a wire for the purpose of making connection. The screw may take many forms, but its application is invariably the same,

namely, to provide a ready means of connection, or in some instances, to lengthen a wire. In wireless receivers, terminals are provided for the purpose of joining the batteries, aerial, earth, and loudspeaker or telephone leads to the respective parts of the circuit.

TESTING A RECEIVER.—Assume that the receiver gives out no signals

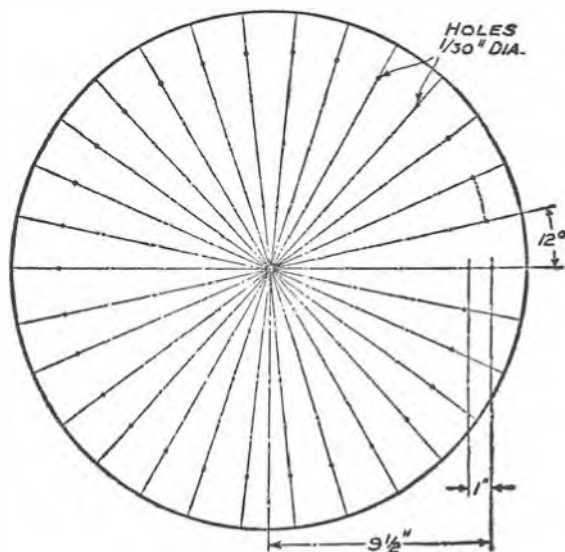


FIG. 422.—How to mark out the Scanning Disc.

shaped mask may be made from cardboard or thin wood, and affixed to the board holding the lens. If the inside of this is coated with camera black, still further crispness and brilliancy will be added to the image.

A still further refinement, and one which gives better detail to the received image, is to make the holes

TESTING A RECEIVER

and both H.T. and L.T. batteries are O.K.

Disconnect the wire which is joined to the detector valve-holder terminal lettered "A" or "P." Connect one lead of a pair of headphones to the terminal, and take the other lead straight to H.T. positive 60. Switch on the set and see if signals come through. If you can hear nothing at all tap the glass bulb of the valve lightly with the tip of your finger. If no noise is heard the valve is broken. To ascertain this simply remove the valve and plug one of the other valves from the set in its place. Supposing that no matter which valve you plug in you can still hear nothing. Remove the wires which are joined to the "F" terminals of the valve holder, and get two new pieces of wire and attach them to the "F" terminals, and straight on to the accumulator. If the valve now works, then the filament wiring in the set or the leads from the terminal strip down to the accumulator are at fault.

With all leads of the flexible variety having clamped-on spade connectors or similar devices, it often happens that the wire gets broken, but the connector is held in position by the cotton covering. Carefully examine all connections of this type, which will be the H.T. and L.T. leads, and the grid-bias leads.

At the accumulator end it often happens that the acid attacks the wire, and it may be found that there is a very poor connection. Make sure that the connectors and terminals of the accumulator are quite clean and not covered with green deposit. Now that the leads have been checked over and found O.K., therefore there only remains the connections from the L.T. terminals on the set to the valve holder and the terminals on the valve holder itself.

Supposing when joining the ac-

cumulator direct to the valve holder nothing is heard in the phones. The only lead left which can cause this trouble is the H.T. negative lead, and if this is joined on the set to one side of a fuse only, look at the fuse. If this is all right, remove the H.T. negative lead from the terminal strip and join it to the L.T. negative terminal. If the set works now then obtain either a new fuse, or a new fuse holder. If it still refuses to work, then only the valve holder can be at fault.

Now take the case where on connecting the phones no signals can be heard, but the valve "pings" on tapping it. This shows that filament and anode circuits are O.K. and the trouble must lie in the tuning arrangements. Try a different coil, or if some complicated switching arrangement is used in the set, wind or obtain a simple 60-turn coil and connect one side of it to aerial and one side to earth. Disconnect the lead from the aerial terminal to the tuning coil, and also the lead from the tuning coil and/or condenser to the grid condenser. Join the aerial terminal to the grid condenser, and again observe whether signals come in. If they do, then the tuning coil is at fault. Supposing you hear nothing with this simple coil. Then the grid condenser is broken inside, and the substitution of another should definitely prove this. Again, the grid leak may be either disconnected or short circuited. Substitution can soon decide this.

The reaction circuit consists of only a reaction condenser and coil, so that one can soon find any fault arising here, and the absence of reaction, when the maximum H.T. is applied to the valve, will show that the reaction circuit is faulty.

Now pass on to the first L.F. stage. If, when one attached the phones to the anode terminal of the detector

TESTING A RECEIVER — THREE-ELECTRODE VALVE

valve, signals were heard quite O.K., then proceed according to the following plan.

Remove the lead joining the anode terminal of the second valve, and join the phones to this as before described, taking one side of the phones direct to the H.T. battery in order to eliminate any decoupling resistances or other parts included in the anode circuit of the valve. If signals are still quite in order pass on to the following valve, and so on. If, however, nothing can be heard, the first thing to do is to test the valve. If it is O.K., then the only components used to couple the detector valve to this one are the L.F. transformer or a R.C.C. unit. Sub-

the 3-volt socket and gradually work upwards. Do not omit the resistance, and do not apply too high a voltage. If nothing can be heard at 12 volts or so, then the primary is broken. Do the same thing with the secondary. (*Note.*—The primary winding terminals are marked either IP and OP or P and HT, according to the particular make of the component: whilst the secondary terminals are marked IS and OS, or G and GB.)

There is no ready way of testing resistances and small condensers without instruments, so that the R.C.C. unit would have to be changed to ascertain whether or not that was broken.

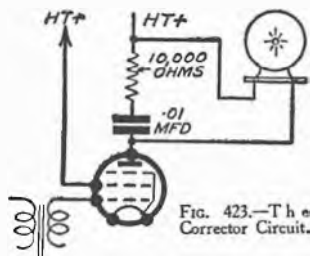


FIG. 423.—The Corrector Circuit.

stituting another one is the easiest way of finding out what is wrong. If one cannot obtain substitutes, the primary and secondary windings of the L.F. transformer may be tested for breaks in the following way. Disconnect all leads from the transformer first of all, and then join one primary terminal to the positive socket of a grid bias or pocket-lamp battery. To the other primary terminal join one side of the phones. Now join the other lead of the phones to one side of a high resistance—such as a grid leak—and the other side of the resistance should be carefully touched to the 1½-volt socket. If a scratching sound can be heard in the phones then the primary is unbroken. If, however, nothing can be heard, try

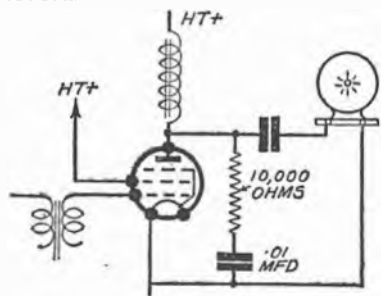


FIG. 424.—Tone Corrector for using a standard Speaker with Pentode.

THERMIONS.—See section on *Valve*.

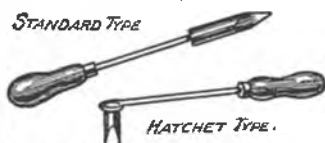
THREE-ELECTRODE VALVE.—

A valve containing three electrodes—the filament (or cathode), the grid, and the anode (sometimes called the plate). When the cathode is heated electrons are emitted. These electrons are negatively charged, and are attracted to the anode by applying a positive potential to the anode. The grid is joined to the tuned circuit, and therefore receives the signal oscillations which, owing to the fact that the grid is interposed between cathode and anode, affects the electron stream. This results in variations in the anode current which

Tools *for the* Wireless Constructor.

SOLDERING IRONS

STANDARD TYPE



HATCHET TYPE.



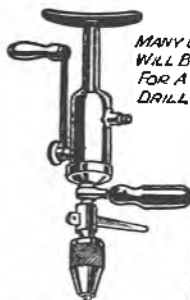
AN ELECTRIC IRON.



A GAS HEATED IRON.



A SET OF FILES WILL BE FOUND TO BE INDISPENSABLE



MANY USES WILL BE FOUND FOR A BREAST DRILL.



A SET OF TWIST DRILLS SHOULD BE IN EVERY CONSTRUCTOR'S KIT.



A JEWELLER'S SCREWDRIVER IS HANDY FOR SMALL SCREWS.



A RATCHET SCREWDRIVER SAVES MUCH TIME.



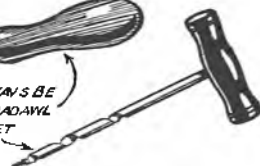
A STEEL-POINTED SCRIBER IS USEFUL FOR MARKING OUT THE POSITIONS OF COMPONENTS ETC.



A PATTERN MAKER'S HAMMER IS CONVENIENT FOR RADIO WORK.



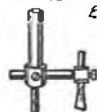
A USE WILL ALWAYS BE FOUND FOR A BRADAWL & A TWIST GIMLET



A COUNTERSINK DRILL MAKES FOR NEATER RADIO



A SET OF PANEL CUTTERS IS INVALUABLE FOR CUTTING TRUE HOLES IN EBONITE ETC.



ADJUSTABLE PANEL CUTTER.

DIVIDERS ARE ESSENTIAL FOR ACCURATE WORKING



FIG. 425.—Special Tools of use to the Home Constructor

THREE-ELECTRODE VALVE — TRANSFORMER WINDINGS

correspond with the signal oscillations, and the result is that amplification of the signals takes place. By suitable arrangements the valve may be made to rectify as well as amplify.

TOPE CONTROL.—A method of emphasising, or subduing, certain frequencies. The pentode valve, for instance, is inclined to give a high-pitched reproduction, and to cure this a tone control is included across the output transformer of the pentode. In this case the control consists of a resistance and condenser in series. Some makes of L.F. transformer are provided with a high resistance or potentiometer which may be joined across primary or secondary for the purpose of giving tone control. (See Figs. 423 and 424.)

TONIC TRAIN.—A process of signalling in which interrupted continuous waves are employed. The interruptions are generally provided by using a valve fed with an interrupted source of high tension.

TOPPING-UP.—See *Accumulator*.

TOROIDAL COIL.—A tuning coil having the wire arranged in a peculiar shape. The wire is first of all wound round a small-diameter cylinder, and then when the total amount of wire has been wound on, the cylinder is removed. The coil of wire is then bent round until the first and last turns touch, which results in a coil having the appearance of a large curtain ring. The advantages claimed for this type of coil are larger inductance and small external field.

TRANSFORMER.—A combination of two inductances so arranged that A.C. currents in one winding will induce currents in the other winding. There are three principal types of transformer employed in wireless receivers: high-frequency transformers, low-frequency transformers, and mains

transformers. High-frequency transformers consist simply of coils of wire, of which either the primary or the secondary may be tuned. The coupling is so tight that the effect of tuning one circuit is the same as tuning both. The relation between the windings, or in other words, the ratio, is governed by the type of valve with which it is used. The low-frequency transformer consists of a similar arrangement, with the inclusion of a core of iron to increase the inductance. The two windings may be wound one on top of the other, or side by side. The mains transformer consists of a similar arrangement, except that the primary is wound for inclusion in the A.C. mains circuit, and in place of one secondary, several secondaries are employed, to give voltage supplies for heating the heaters of indirectly heated valves. One secondary winding is provided for the purpose of giving the H.T. supply. (See also *Low-frequency Couplings*.)

TRANSFORMER COUPLING.—See *Low-frequency Couplings*.

TRANSFORMER RATIOS.—The interval transformer employs ratios of 3:1, 4:1, and 5:1. For certain purposes higher ratios, up to 7:1, are employed, but these are only employed following crystal detectors. Output transformers have ratios of 1:1, and for matching purposes some commercial types of output transformer are tapped to provide various tappings up to 60:1.

TRANSFORMER WINDINGS.—It will be understood that the primary winding of the transformer forms the "load" in the anode circuit of the valve; and that the secondary winding forms the grid circuit of the following valve. As the secondary winding has more turns than the primary winding, the voltage developed across the secondary winding will be greater than that applied

NOTES ABOUT WOODCRAFT TOOLS



FIG. 426.—Various Woodcraft Tools and points concerning their upkeep.

across the primary in the ratio of the number of turns. Thus one may have a transformer with a 3 to 1, or a $3\frac{1}{2}$ to 1, or a 4 to 1, or a 6 to 1 ratio, and so on. On what does the choice of ratios depend? Like so many other ratio problems, this is one in which the solution depends upon a great many factors. To avoid complicated mathematics and advanced technical matters, the more simple and practical points only are dealt with here. In the first place, then, it may be said that, in conjunction with a valve of the usual general-purpose class, having an amplification factor of the order of 20 to 30 and operated under good conditions, a transformer having a step-up ratio of 3 to 1 or $3\frac{1}{2}$ to 1 gives about as much amplification as can be carried with stability in the average receiver.

With a less sensitive valve, and particularly when there is only a single low-frequency stage, a higher ratio, up to 6 to 1 or 7 to 1, may under some circumstances be employed. The final factor, however, lies not in the first valve, but in the valve which follows it. In order to achieve undistorted amplification, the signal voltage applied to the grid of any valve must not exceed a certain value, sometimes called the "acceptance" of the valve. The peak value of this maximum grid input voltage is approximately half the recommended grid bias of the valve. It is clear, therefore, that if the overall gain in any stage—that is to say, the amplification due to the valve and that due to the transformer—produces a signal greater than the acceptance of the following valve, there is the risk that serious distortion will be introduced owing to overloading of the next valve.

It is particularly when two low-frequency stages are employed that it is necessary to limit the gain in

individual stages to avoid overloading the next valve. The type of output valve employed is another important factor. If the output valve is a small-power valve, or a small pentode, both of which are intended to give the greatest output reasonably possible from comparatively small grid inputs, the previous stage or stages of amplification must be kept within bounds. Generally speaking, a modern detector stage followed by a $3\frac{1}{2}$ to 1 transformer is quite adequate to load fully the average small power or pentode valve. If the detector is preceded by one or more high-frequency stages, it will probably also be able to load a super-power valve, if coupled by a $3\frac{1}{2}$ to 1 transformer. If no high-frequency stage is employed, the detector can be coupled to a super-power valve through a high-ratio transformer, or a further low-frequency stage may be interposed between the detector and the super-power valve, the coupling in each case being a low-ratio transformer.

Of course, much depends upon the working conditions, and the degree of "quality," as opposed to mere volume, which the listener desires. On a poor aerial, for instance, a greater degree of overall amplification will be necessary, while, for the sake of economy, it is sometimes decided to sacrifice tonal purity in order to obtain the required volume from the minimum number of valves.

In the case of an output valve, it is not merely a voltage drop in the anode circuit which is required, but an appreciable amount of power which can be used to operate the loudspeaker. This amount of power can be measured by multiplying the *alternating* voltage drop across the load by the *alternating* component of the anode current. The load in this case is, of course, the speaker winding, or the primary winding of

the output transformer, if one is used, or by the combined circuit provided by the output choke and the speaker winding in the case of a choke output circuit.

As the result of numerous careful calculations, confirmed by actual measurements, it has been established that, for most three-electrode output valves of the types chiefly used by amateur listeners, the optimum (or best) value of the load impedance is of the order of twice the valve resistance. The value is not very critical, and the usual range of speaker impedances covers most practical requirements. An exception must be made in the case of pentode-output valves, the optimum loads for which are usually considerably higher than those for triodes of equivalent output. For most types, loads of approximately 8,000 ohms are recommended, but some of the new low-consumption pentodes work economically with still bigger load impedances, of the order of 15,000 ohms.

Some of the larger "high-voltage" output valves, also, give their best performance with loads very much greater than twice the valve resistance. In every instance the recommendations given by the valve-maker should be followed. As already mentioned, the value of the load is not very critical, and a departure of 10 per cent. or even 20 per cent. is not likely seriously to affect either output or quality.

TRANSFORMING A.C.—See *Accumulator*.

TRANSFORMERS, LOW-FREQUENCY.—The ratio of the transformer should be chosen according to the position it occupies in the receiver. If only one stage of L.F. is employed this may conveniently be one of the high-ratio transformers, say 7 to 1. If, however, a pentode is used and you are situated near to a powerful broadcasting station, this

will result in overloading the pentode, so in this case do not use a higher ratio than 5 to 1.

If more than one L.F. stage is used, the first transformer should be of medium ratio, say 3 to 1, and the second of 4 or 5 to 1. If you place the transformers the other way round there is a danger of overloading the first L.F. valve.

The usual markings of the terminals of L.F. transformers now are P, HT, G, and GB. These should be connected respectively to the plate, high tension, grid, and grid bias. If one of the older types of transformer is used this will be marked IP, OP, IS, and OS. These correspond respectively to plate, H.T., G.B., and grid. When using a L.F. transformer after a valve working on the anode bend principle, it is preferable to shunt the primary with a condenser of .0002 or .0003 mfd. Some makes of transformer already have this condenser mounted in the moulded case.

Where it is thought desirable to avoid the direct current flowing through the primary of the transformer, it should be parallel fed. This means that the terminal marked H.T. should be joined to earth. The terminal marked P fed via a fixed condenser of up to 2 mfd. to the plate of the valve, and the high tension applied to the plate through an anode resistance of a value about four times the impedance of the valve. (See also *Low-frequency Couplings*.)

TRANSMISSION.—The act of generating high-frequency oscillations and feeding them into an aerial circuit so that the currents flowing in the aerial will set up similar impulses in the ether. The method of generating oscillations is exactly the same as tightening up the reaction control, and Fig. 427 illustrates a simple one-valve set employing two coils for

aerial tuning and reaction. When the two coils are brought close together oscillation occurs due to the feeding back of the energy from the anode circuit to the grid circuit. To employ this energy for transmitting purposes it is necessary to ensure that it shall be passed into the aerial, and therefore the aerial and earth connections are changed round.

Fig. 427 shows practically the same circuit arrangements, with the exception that the aerial is now joined to the anode instead of to the grid, and the earth connection is taken from the other end of the reaction coil. (The phones are naturally removed.) This method of connection ensures that the maximum current which the valve is capable of generating is fed into the aerial circuit, and if a milliammeter is inserted in series with the anode coil a reading of the anode current is obtained. If this current (expressed as a decimal fraction of an amp.) is multiplied by the voltage of the high-tension battery, the figure obtained will express the power of the transmitter in watts.

This circuit is the basic arrangement of *all* transmitters, and it is only necessary now to insert a key for the transmission of Morse signals, or a microphone for the transmission of speech or music. The most efficient way of breaking the circuit is to disconnect the wire linking the batteries, and therefore a tapping key should be inserted at the point marked X. When the key is depressed the circuit is completed and oscillations will be present in the aerial circuit. As soon as the key is released the oscillations will cease. The signals of the Morse code may therefore be easily transmitted. For speech, the oscillations must be continuous in the aerial circuit, and the speech currents superimposed upon those oscillations. A microphone and

a microphone transformer are the essentials required, and the secondary of the transformer (which should have a step-up ratio) is joined in the grid circuit at the point marked Y. The microphone is joined in series with the primary of the transformer, and to complete this part of the circuit a battery is necessary.

Fig. 427 shows how this microphone circuit may be completed by using the accumulator which supplies the filament of the valve, and also the method of including the secondary in the grid circuit. The value of the condenser across the secondary must be fairly carefully chosen in conjunction with the secondary winding and the frequencies which it is desired to transmit. It is also advisable to shunt the H.T. supply with a large condenser. This method of employing a microphone is not efficient, although it is the simplest method, and in actual modern practice a separate valve is used for the microphone, and this is wired up to form what is known as the "Modulator" circuit. It is arranged so that part of the aerial energy is absorbed according to the speech currents in the grid circuit of the modulator valve. The first valve generates the oscillations (known as the "Carrier Wave"), and the second valve modulates these oscillations.

It should be pointed out here that on no account must any experiments in transmission be carried out without the sanction of the Postmaster-General, and a transmitting licence must be obtained before any attempts at transmission are undertaken.

TRANSMISSION UNIT.—A measure of strength of sound evolved by telephone engineers. The unit is now used in radio and talkie work to indicate the strength of loudspeaker outputs. The transmission unit is usually expressed as T.U. or Db, which is the abbreviation of Decibel,

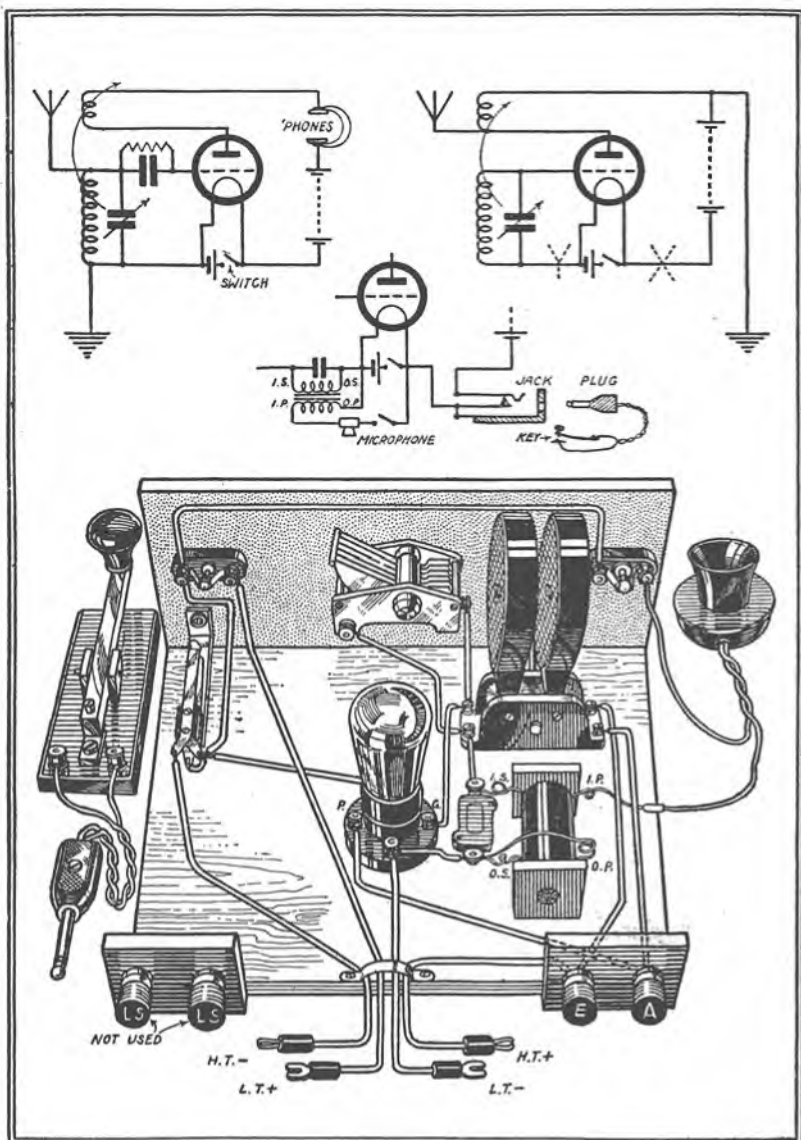


FIG. 427.—A 1-Valve Transmitter, with circuit showing how it differs from a 1-valve Receiver.

TRANSMITTER — TRICKLE CHARGER

another name for it. (See also *Decibel*.)

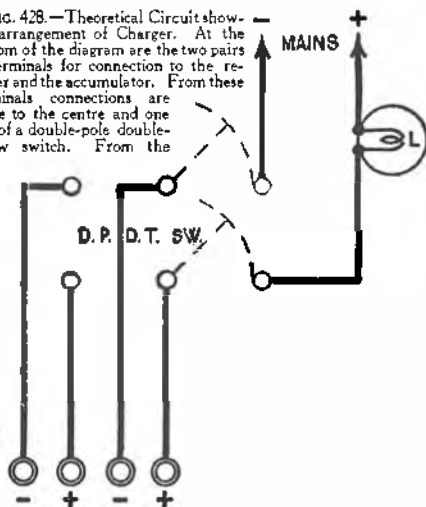
TRANSMITTER.—The sending station. This may employ spark, tonic train, or speech as the method of communication. Whatever method of communication is used, the principle is the same, namely, oscillating currents are introduced into the aerial circuit of the transmitter.

PORTABLE SETS.—This term is applied to receivers which

country many localities where electrical energy from the mains is available only in the form of direct current, and quite a large number of listeners therefore will be interested in the details given here for a useful home-charging station for low-tension accumulators. Remember, the trickle charger described in this section is suitable for use on direct-current mains only. Now, anyone using an accumulator knows, or should know,

that to attain the maximum useful life an accumulator should never be fully discharged (or run "right down"), and that recharging must be carried out regularly and at the correct rate. These, then, being the essentials to the attainment of a healthy old age in an accumulator, those contemplating recharging at home should consider the advantages of the trickle charger herein described, namely: (a) the accumulator is never "run down," but is always in a fully charged condition; (b) the recharging process is carried out regularly and automatically; (c) the charging rate is adjustable to suit the conditions under which the accumulator is being operated.

FIG. 428.—Theoretical Circuit showing arrangement of Charger. At the bottom of the diagram are the two pairs of terminals for connection to the receiver and the accumulator. From these terminals connections are made to the centre and one side of a double-pole double-throw switch. From the



RECEIVER ACCUMULATOR

other side of the switch connection is made with the mains plug by means of a flex lead, in the positive leg of which the lamp L is inserted.

are self-contained, but which are too large to be really "portable." They usually contain all batteries, or mains apparatus, in addition to the loud-speaker and aerial. They are very convenient for carrying from room to room, or, in the case of battery-operated receivers, for taking out in the country in a car.

TREMBLER.—The vibrating reed of a sounder (which see).

TRICKLE CHARGER FOR D.C. MAINS.—There still remain in this

Further, the actual constructional cost is negligible. Now, look at the theoretical diagram (Fig. 428), and it will be seen how extremely simple the device actually is. It is, moreover, absolutely foolproof in use.

A Lamp Resistance.—Current is taken from the mains, a resistance being inserted in the positive lead which regulates the rate of the charge. This resistance is conveniently obtainable by the use of a suitably sized electric lamp. (The actual

TRICKLE CHARGER FOR D.C. MAINS

size of lamp required will be dealt with later.) The charging current is applied through a double-pole change-over switch to a pair of terminals marked "accumulator," and these are capable of connection via the opposite side of the switch to another pair of terminals marked "receiver." The "accumulator" terminals are for connection to the accumulator, and the "receiver" terminals are joined to the L.T. terminals on the set.

It is quite clear then that with the change-over switch in one position the accumulator is receiving the charging current, and with the switch in the reverse position the accumulator is connected to your set for ordinary service. Once these connections have been made nothing has to be disconnected again in use, all that it is necessary to do being to operate the switch before retiring at night and reversing it again in the morning, the charging of the accumulator having been properly carried out during the night.

Finding the Resistance. Now one will want to know what resistance—in this case the actual size of electric lamp—will be necessary to obtain the correct rate of charge to suit the conditions under which one's own accumulator is used.

This is quite easily arrived at in the following way: (1) make sure of the total filament current consumed by the valves in the set; (2) decide approximately how many hours each day the set is in use;

(3) decide how many hours each night the charger shall have in which to do its work. Now multiply the first figure by the second figure, and the result is the number of ampere-hours taken from the accumulator in one day. Divide this result by the third figure, and it will give the amount of current needed to replace the full charge in the accumulator in one night. This last figure is now multi-

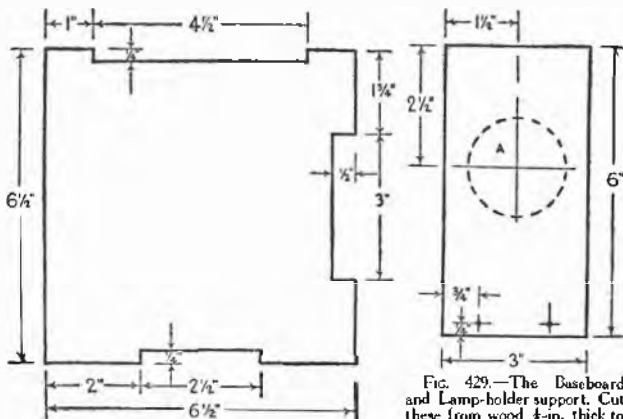


FIG. 429.—The Baseboard and Lamp-holder support. Cut these from wood $\frac{1}{4}$ -in. thick to the dimensions given in the diagram. The position of the lamp-holder is shown at A.

plied by the voltage of the mains, and a figure representing the size of the lamp in watts is obtained.

Example:

- (1) Total current consumed by valves = 3 amp.
- (2) Number of hours set is used per day = 6.
 $3 \times 6 = 1.8$ amp. hr.
- (3) Number of hours charger is used in one night = 9.
 $1.8 \div 9 = .2$ amp.

Voltage of supply mains = 200.
 $.2 \times 200 = 40$ watts.

If the figures applicable to a listener's own case give a result of an odd nature, such as 28 watts for example, a lamp of the next larger size available (30 watts) should be used.

The Components Required. One

TRICKLE CHARGER FOR D.C. MAINS

double-pole double-throw mains switch, 4 terminals (2 marked —, 2 marked +), 1 batten-type electric lamp holder.

It is essential that the switch be a good one suitable for mains use, and as the cost of the charger is so moderate a good quality lamp holder and terminals of the standard insulated type should be used.

In addition two small pieces of ebonite, some plywood or hardwood $\frac{1}{2}$ in. thick, and sufficient sheet metal to make a cover for the unit will be

support as at B in Fig. 430, to allow clearance for the connecting wires to go behind the holder.

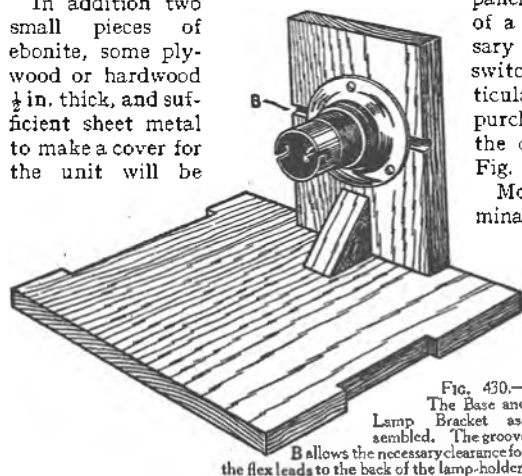
The lamp holder can now be fixed, so screw the support firmly to the base in the recess allowed for it. Extra rigidity is ensured by fixing in a small angle block, when the assembly will appear as in Fig. 430.

Next prepare the two ebonite panels. They can be cut out of a panel 7×6 in. The necessary holes for mounting the switch will depend upon the particular make of component purchased. Apart from this, all the dimensions will be found in Fig. 429.

Mount the switch and terminals on their panel, and screw both pieces of ebonite into their recesses in the base. Proceed with the wiring by reference to Fig. 431. Connections from the terminals to the switch are easily made with the usual kind of insulated connecting wire, soldered joints being the best if one is

“happy” with the soldering iron. Now make the connection from one contact of the lamp holder to the appropriate point on the switch. This is more easily done with a single piece of well-insulated flex. Now join up the long length of flex, one lead to the remaining point on the switch and the other lead to the unused contact of the lamp holder. The other end of the flex is passed through the hole in the middle of the smaller ebonite panel and connected with the mains plug or adapter.

There now remains to be made the metal cover, which is a protection and gives the unit that well-finished appearance the majority desire these days. The material used to



required. Some insulated connecting wire and a length of flex to connect with the mains plug one probably has already. Proceed with the construction by cutting the base and lamp-holder support from $\frac{1}{2}$ -in. thick wood to the dimensions given in Fig. 429. If desired, there is no reason why one should not depart from these dimensions, but be sure to allow sufficient room for the lamp being used. The sizes given in the diagram allow for any size lamp up to 60 watts, and, although one may not have to use such a big lamp, it is wise to allow for it. One may have a larger receiver later, and would then need to use a bigger lamp.

Cut a groove across the lamp-holder

TRICKLE CHARGER FOR D.C. MAINS

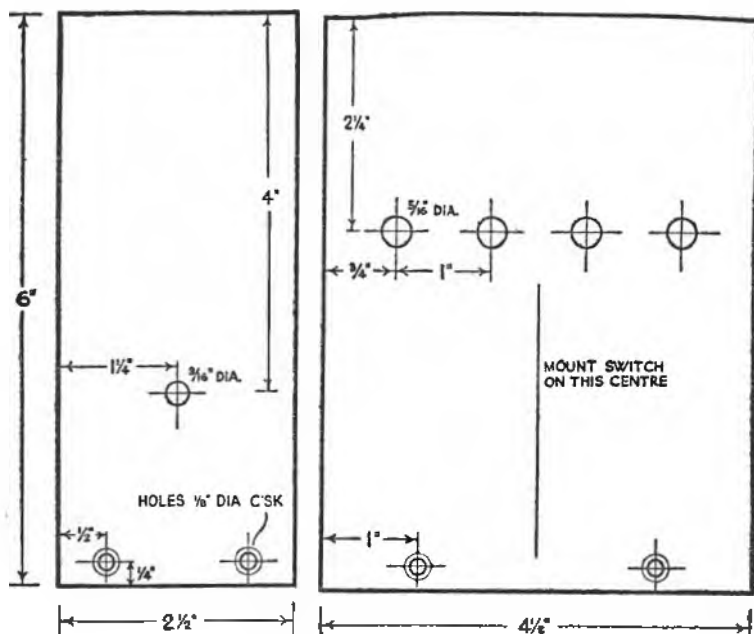


FIG. 431.—The two small Ebonite Panels. Cut from a 7 × 6-in. panel and drill as shown, the four holes in the larger piece being of suitable size for large insulated terminals. In addition the necessary mounting holes for the switch must be made on the centre line shown on the panel.

construct the cover can be of one's own choice, tinned iron sheet being about the least expensive.

If the given dimensions have been followed up to this point, do so again for the cover as shown in Fig. 433. Mark out on the metal sheet very carefully as shown and drill all the holes. The large holes are for the purpose of cooling and are therefore essential.

After cutting out with shears and trimming up as neatly as possible, the bends, indicated by dotted lines in Fig. 433, are made, and the joints

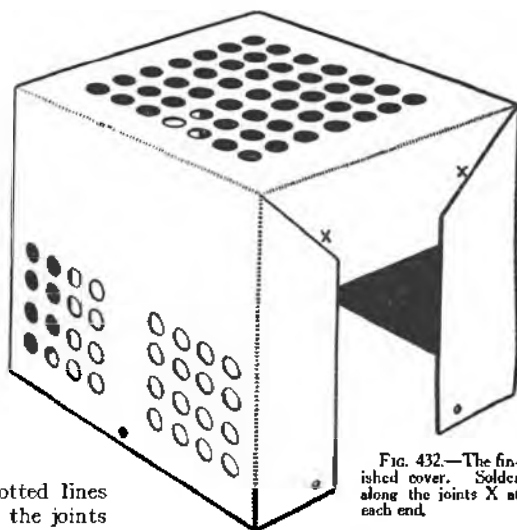


FIG. 432.—The finished cover. Solder along the joints X at each end.

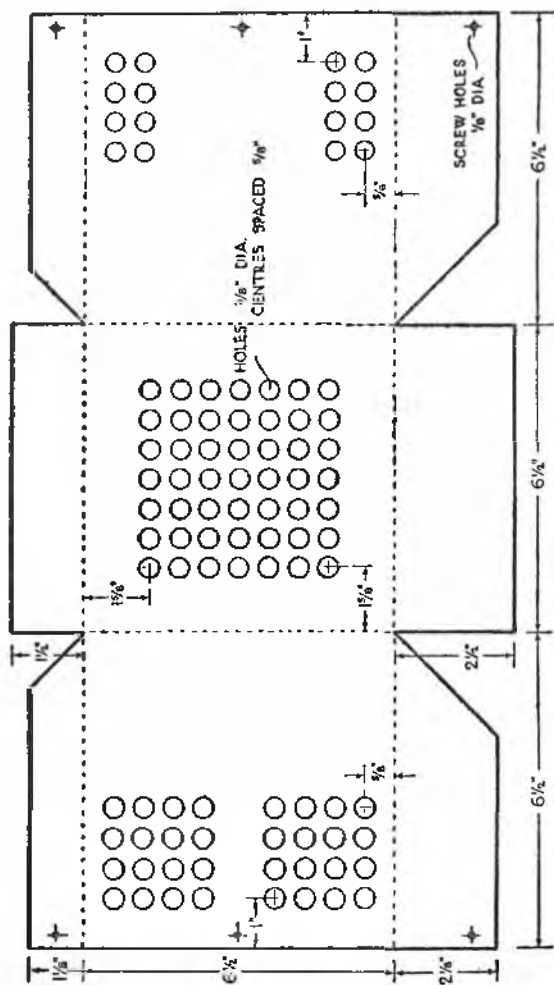


Fig. 433.—The Sheet-metal Cover. Cut out and drill as shown, then bend along the dotted lines.

of the three flaps forming the opposite sides of the cover soldered. These joints are marked "X" in Fig. 432, which shows the finished cover. Slip the cover over the unit and see that it fits properly, then insert the correct-size lamp in the lamp holder and refit the cover, fixing it with six small screws through the holes provided.

Do not connect up the accumulator yet, as the charger is not ready for use until the polarity of the mains has been arranged to correspond with that given in Fig. 428.

To do this put the charger switch in the "charge" position and plug into the mains and switch the current on. The pair of terminals marked "accumulator" must now be tested with pole-finding paper, taking the necessary precautions not to make contact with bared wires, etc., or one will be subjected to a nasty shock.

Having discovered the polarity of these terminals, if it happens to correspond with the markings on them all is well and good. If the polarity differs, however, the matter must be put right by reversing the mains plug or adapter in its socket. In either case the correct position should be marked permanently on both plug and socket for future reference, as it is essential that the plug be always inserted the correct way.

This having been done, switch off the mains and connect up the accumulator and receiver to their respective terminals on the unit.

TRIODE.—The three - electrode valve.

T.S.F.—The French abbreviation for wireless. The three words are "Télégraphie sans Fils."

TUNED ANODE COUPLING.—A method of coupling high-frequency valves characterised by including in the anode circuit of the valve a coil with a tuning condenser joined in

parallel. This method gives the greatest amplification, but unfortunately usually results in instability. To overcome this, the coil is usually tapped at the electrical centre, and this tapping is joined to the H.T. source, whilst the low potential end of the coil is connected back to the grid of the valve via a small condenser. This is known as a Neutralised, or Centre-tapped, Tuned Anode arrangement. (See also *Neutrodyne*.)

TUNED-GRID COUPLING.—A method of H.F. coupling characterised by including a H.F. choke in the anode of the valve, and feeding the anode via a small fixed condenser to one side of a tuned circuit. This side of the circuit is also joined, through the appropriate condenser, to the grid of the following valve. The other end of the tuned circuit is joined to earth. This is sometimes also called "Parallel Tuned Anode."

TUNED-PLATE CIRCUIT.—The same as tuned anode circuit, anode and plate being the same thing.

TUNER.—The term applied to a closed oscillatory circuit. The coil with its parallel condenser which is included in a receiver for tuning to the frequency of the station it is desired to receive.

TUNGAR RECTIFIER.—See *Accumulator*.

TUNING COIL.—An inductance coil used in conjunction with a variable condenser for bringing a circuit in resonance with a frequency which it is desired to receive. (See also *Coil*.)

TUNING COILS.—When the honeycomb or basket type of plug-in coil was in popular use, practically every experimenter made his own set of coils. Such coils often required special formers for their construction, and not a little patience was required in winding them. These facts are mentioned to show a contrast with present practice, for now almost every

TUNING COILS

constructor buys a ready-made tuner without thinking twice about it. Good tuners can now be purchased very cheaply, but even so it costs still less to make them. Besides, the making of a tuner provides a fascinating addition to the usual process of mere component assembly, and gives a deeper insight into the working of the set. It is true that anything which tends to drive home in a practical manner the principles upon which one's receiver works is particularly stimulating to

factors as the number of turns, gauge of wire required, and so on, let us consider the primary requirements of tuners for different purposes. In designing a tuner for a simple non-S.G. receiver of the Det.-L.F. class, the size of the complete unit is not of great consequence, but in a set having one or more screened-grid stages, it is very desirable to keep each tuning unit to the smallest dimensions compatible with efficiency. The reason for keeping down dimensions is not merely to obtain compactness in the receiver, but to avoid inter-

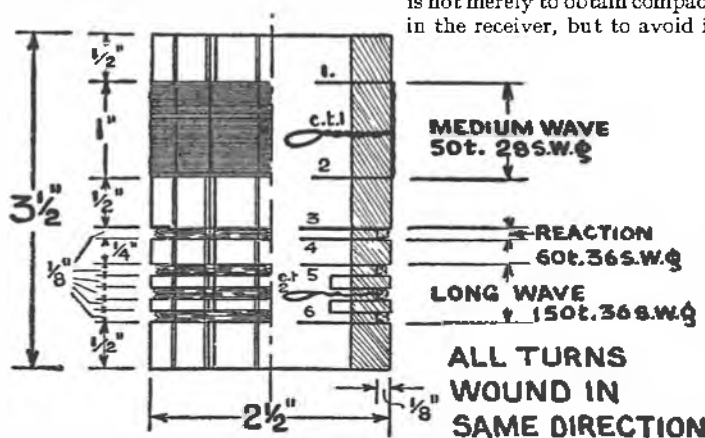


FIG. 434.—Constructional details of a Tuner made on an eight-ribbed 2 1/2-in. diameter Ebonite Former.

one's interest in radio, the finest of all hobbies. But that is not all, for after making one tuner one is sure to make another; comparison is the next step, and the reason for the superiority of one leads on to a spirit of inquiry. That soon causes the active mind to draw conclusions and to develop ideas, and no one can say to what goal those ideas will eventually lead. They cannot do other than achieve some successful results, and it may be that an entirely original system of tuning might be the outcome.

The First Essentials of Coil Design.
Before deciding upon such vital

action and feed-back between the various tuning circuits. As many constructors are aware, the magnetic field created by a coil can easily extend to six times the size of the coil itself. And it will be clear that when the "fields" of two coils overlap each other there will be a feed-back or reaction effect between the coils concerned. The reaction might not in all cases be harmful, but in many it will cause uncontrollable oscillation; at any rate, it will not be under direct control, and should therefore be avoided. Of course, we can prevent the magnetic field from "running wild," as it were, by enclosing

TUNING COILS

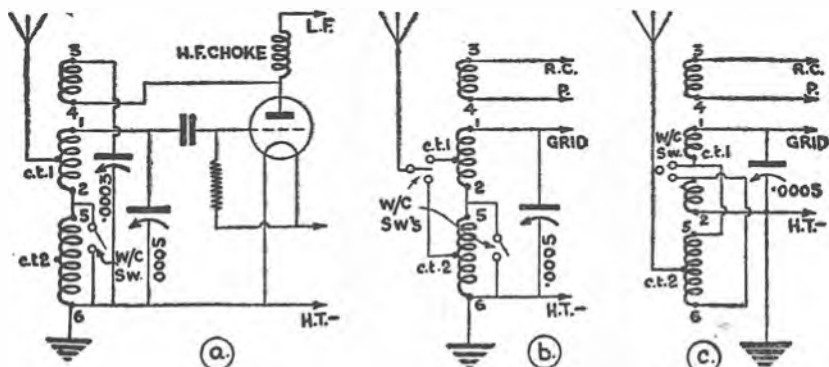


FIG. 435.—Three methods of connecting the Tuner shown in Fig. 434 into a Detector Circuit.

the coil within a metal screening compartment, but even then the small coil has the advantage of enabling the receiver to be made more compact. It might be argued that a larger coil is more efficient, since it can be wound with heavier gauge wire having a low resistance. Whilst this is true of a coil to be used in, say, a crystal set where reaction cannot be applied, it is not so in any other case.

The application of reaction (by which is meant legitimate reaction which is fully under control) gives to a coil a result equivalent to "negative resistance," and so when reaction is employed a comparatively high initial resistance is of little consequence. When a coil is screened its measured efficiency is reduced, but, as has been already seen, screening is often a practical essential. Even this factor does not cause one to experience any qualms, because the loss can again be restored by the use of reaction if necessary. This is not always necessary, however, because one does not generally want a coil which is "too" efficient, paradoxical as this may seem. One which is too efficient, if used in a highly efficient S.G. circuit, will provide too great an amplifica-

tion, which will result in instability.

A Tuner for Det.-L.F. Sets. As explained above, there is no need to restrict the dimensions of a tuner required for a non-S.G. receiver. In general, it will be found most convenient to employ a former from 2 in. to 3 in. in diameter by some 4 in. long. The former may consist of well-shellacked cardboard, paxolin, or ebonite, but the latter is usually to be preferred. Fig. 434 gives all constructional details of an excellent tuner made on an eight-ribbed ebonite former $2\frac{1}{2}$ in. in diameter by $3\frac{1}{2}$ in. long; a number of $\frac{1}{8}$ -in. deep slots are made in it, as can be seen. The slots are most easily made in a lathe, but where such a machine is not available a small warding file can be used. In the latter case it will be found very helpful to bind a piece of wire round the former to act as a guide in keeping all slots in line. The winding process is not difficult, but care should be taken in putting on the single-layer winding to keep a good tension on the wire. To anchor the ends of the winding, a pair of $\frac{1}{16}$ -in. holes should be drilled, and the wire threaded through.

The numbers of turns indicated in the drawing assume the use of

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enamelled or single silk-covered wire, which is thinner than other kinds. It will be noticed that both long-wave and medium-wave windings are centre tapped by making a loop in the wire and passing it through a hole in the former. Connections from the various tapping points can be made in two or three ways. One way is to attach terminals round one end of the former and another is to bring them out to valve pins on a six-pin base. Yet another is to bring some of the connections out to terminals and take the others to the terminals of a suitable wave-change switch mounted on an ebonite end-plate secured to the former by means

(the medium-wave centre tap), and a simple on-off switch serves for wave changing by short circuiting the long-wave winding. The other centre tapping, c.t.2, is not used at all, being left disconnected. Reaction is obtained by means of a $\cdot 0003$ -mfd. reaction condenser wired between one end of the reaction coil and earth. A I.F. choke of sound design is necessary in the detector anode circuit. This particular circuit gives good selectivity on the lower waveband, but only moderate selectivity on long waves. The latter is compensated for by slightly higher long-wave efficiency, and the arrangement is thus most suitable when extra volume is

required from a long-wave station.

The circuit given at (b) provides equal selectivity on either waveband, because the aerial is transferred from one centre tap to the other by the wave-change switch, which must be of the double-pole double-throw variety. Reaction connections

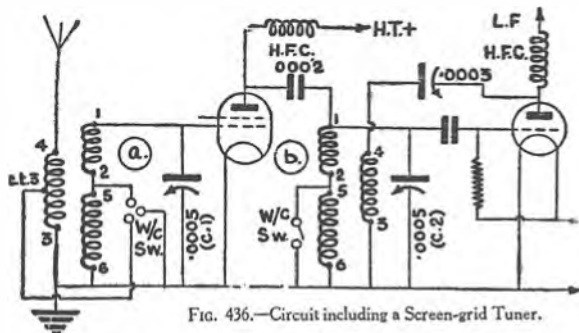


FIG. 436.—Circuit including a Screen-grid Tuner.

of small angle brackets. The latter method makes the tuner suitable for single-hole panel mounting, the switch bush being used for mounting purposes. Where it is preferred to use a cardboard or paxolin former, the same numbers of turns will be approximately correct and the same spacing between the ends of separate windings should be allowed. As, however, all three windings will have to be wound as single layers, the length of former must be increased.

Alternative Tuning Circuits. Fig. 435 shows three entirely different methods of connecting the tuner just described in a detector circuit. At (a) the aerial lead is joined to c.t.1

are not shown, but are exactly as for circuit (a). Circuit (c) gives exactly the same effect as (b), but requires only an ordinary three-point wave-change switch. The looped centre tap of the medium-wave winding (c.t.1) is broken to provide the same effect as two separate windings. The long-wave winding is connected between the two portions of the medium-wave one, and is short circuited by the switch when medium-wave reception is wanted. On long waves the aerial goes to c.t.2.

A Tuner for S.G. Receivers. It has been pointed out that it is desirable to employ a smaller tuner (physically smaller, that is) for a set having two

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or more tuning stages, and a $1\frac{1}{2}$ -in. diameter six-ribbed ebonite tube will be found to make an excellent former. The former should be the same length as that shown diagrammatically in Fig. 434, and should have similarly placed slots. All windings should consist of 36-gauge enamelled wire, the correct number of turns being as follows:

Medium wave : 80 turns.

Reaction : 84 turns, with centre tap.

Long wave : 220 turns.

In this case it will be seen that the tuned windings are not centre tapped, although the reaction is. The reason will be made clear later in this section. This tuner, which is very similar to that which has just been described, will cover the same tuning ranges as the larger one described above.

Tuner Connections for S.G. Sets.

Fig. 436 (a) shows a tuner of the latter type connected in the aerial circuit of a S.G. valve. The numbered connections correspond with those of Fig. 435, and c.t.3 is the centre tapping of the "reaction" winding. Actually this winding is not used for reaction in this instance, but acts as an aperiodic aerial coil. A three-point wave-change switch short circuits the long-wave winding and half the aperiodic winding for medium-wave reception. The circuit of Fig. 436 (a) provides a very selective arrangement, and may be followed by another similar tuner used for tuned-grid coupling as at (b) in the same diagram. The centre tapping is not used at (b), and the reaction winding is employed for its legitimate purpose. Provided care is exercised in making both tuners identical, condensers C.1 and C.2 may be ganged together with every satisfaction. In making a set to the circuit of Fig. 436 care should be taken to arrange both tuners with their axes at right angles to each other and to erect an

aluminium screen somewhere between them.

Band-pass Circuits. Either of the tuners described may be used in matched pairs for band-pass tuning. The circuit of Fig. 437(a) employs two

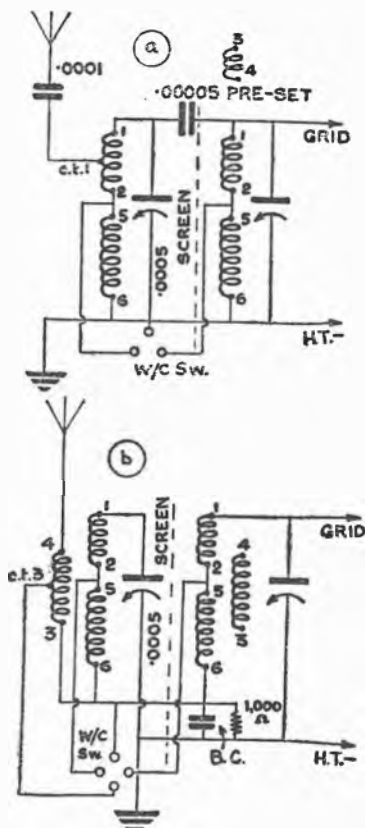


FIG. 437.—Band-pass-tuned Circuit, including a pair of small Tuners.

of the larger coils for B.P. tuning in a Det.-L.F. receiver. The two coils are coupled together by a small-capacity pre-set condenser, which can be adjusted to provide an optimum band width. A screen should be erected between the coils, and it is preferable to include a small con-

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denser in series with the aerial lead to prevent the aerial capacity influencing the first tuner unduly. Reaction is applied to the second tuner as in Fig. 436 (a), but the reaction winding of the first tuner is not used at all. A three-point wave-change switch acts on both tuners. Tuning may be accomplished by means of two separate 0005-mfd. condensers or by a two-gang condenser; the former method is safer, because this circuit does not always tune too accurately.

Fig. 437 (b) shows a band-pass circuit consisting of a pair of the smaller tuners. The arrangement is suitable for either S.G. or non-S.G. receivers; the reaction coil in the second tuner will only be used in sets of the latter

any circuit in current practice. As a guide to those constructors who wish to employ formers of other diameters than those dealt with, the table below is given.

The fundamental purpose of the tuning circuit is to separate one wavelength from another without affecting quality or permitting jamming from a station working on a nearby wavelength. This perfect state is impossible, as to-day stations are working so close together that their top notes overlap. When a station is said to be on some particular wavelength—say, 300 metres—it does not imply that it is entirely confined to this band, as if a really razor-sharp tuned circuit is used, there is a most noticeable

COIL-WINDING DATA

<i>Diameter of Former.</i>	<i>Medium-wave Winding.</i>		<i>Long-wave Winding. Number of Turns 36's gauge Enamelled Wire.</i>	<i>Reaction 36's gauge Enamelled Wire.</i>
	<i>Gauge of Enamelled Wire.</i>	<i>Number of Turns.</i>		
3 in.	28	40	130	45
2½ "	28	50	150	60
2 "	30	58	174	75
1½ "	36	80	220	84
1½ "	36	86	240	90

type. The band-pass coupling condenser B.C. should be a non-inductive one of .05 mfd. Here again a screening plate should be fitted between the two tuners. This circuit gives very accurate tuning, and it is quite safe to employ a ganged condenser for tuning simultaneously the two circuits. When used in a S.G. receiver, this band-pass arrangement might well be followed by a tuned-grid coupling as in Fig. 436 (b). In that case tuning could be controlled by a three-gang condenser.

Other Circuits. It is not possible here to give particulars of every circuit for which the tuners described may be used, but the circuits that have been suggested will give sufficient information to enable any experimenter to adapt them to almost

absence of top notes; the reason for this is that the imposed signal will slightly vary the carrier wave, the higher the note imposed by the performance being broadcast the greater will be the deviation. Obviously, then, it is possible for the top notes of two stations to overlap while the quoted wavelengths do not. If such a state exists they can only be separated if the top notes are cut off.

In the earliest days of broadcasting (some ten years ago), selectivity was not an urgent problem, as stations were few and low in power; in addition, nobody expected really good quality and consequently no one was disappointed. In any case, it is doubtful if the loss of quality caused by the tuning would be apparent above the general distortion of the

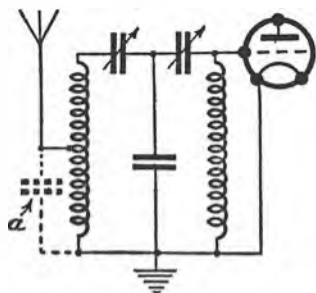


FIG. 438.—The Circuit arrangement of the Band-pass Scheme.

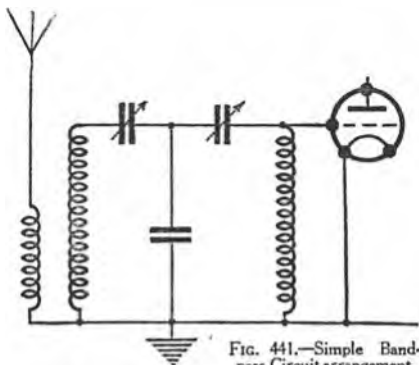


FIG. 441.—Simple Band-pass Circuit arrangement.

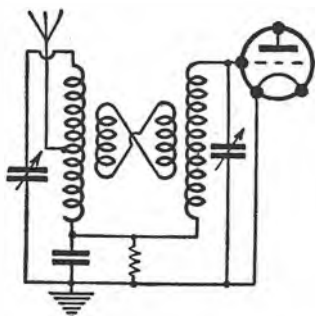


FIG. 439.—The Circuit of the "Link" Coupled Band-pass Tuner.

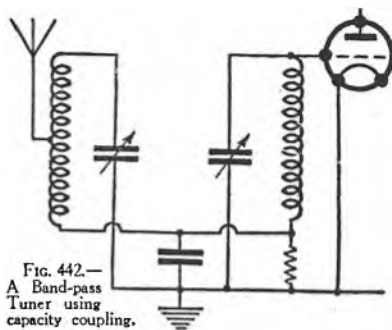


FIG. 442.—A Band-pass Tuner using capacity coupling.

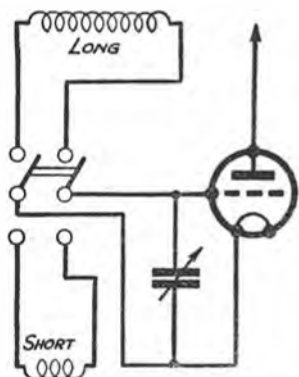


FIG. 440.—A simple method of fitting a Switch for wave-changing.

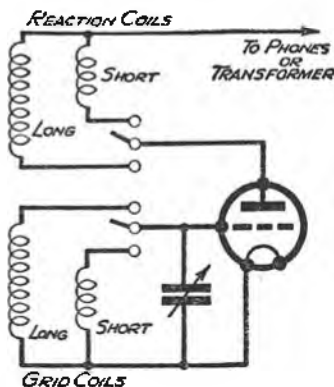


FIG. 443.—A simplified method of Switching without loss of efficiency.

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1922 loudspeakers and transformers.

Looking backwards during the last seven years, it seems probable that the tuning coil has gone through more evolution of shape than any other component. For many years the two-pin coil with standard base held sway. At the beginning of broadcasting, the only characteristic possessed by a coil was its ability to tune to the wavelength required, and the question of heavy losses was entirely forgotten; but this was to some extent beneficial, as it compensated for the unsuitability of the ordinary 3-electrode valve as a H.F. amplifier. A little later several types of tuning coils made their appearance that were definitely designed to overcome some of the disadvantages of the previous models, among which was the honeycomb coil, which possessed extremely low self-capacity, but had the disadvantage of an increased high-frequency resistance and consequent flattening of tuning. The first real efficiency coil consisted of an ingenious structure so arranged that every turn was air-spaced from its neighbour by slotted ebonite pegs and in addition each turn was practically a circle, and almost in a true plane.

About the same time several other good coils made their appearance, notable among which was the familiar yellow bound type.

The old plug-in coil is still in use to some extent to-day, and whatever may be said against it, it possesses the advantage of extreme flexibility and gives the user a possible range of, say, 20 to 25,000 metres, should he for any reason require it.

The idea that a plug-in coil is hopelessly inefficient is quite erroneous, as the coil referred to above possesses at least 70 per cent. of the efficiency of many modern screened coils.

The successor to the plug-in coil was the 6-pin type, which for many

years was considered to be the last word in design, but these coils still had the disadvantage that they had to be changed for long and short wavelengths and the multiplicity of pins often resulted in a momentary wrong connection, with occasional disastrous results. This juncture marked the beginning of the dual-range coil, which, although used almost exclusively to-day, was far from popular, as the small permissible amplification of an ordinary 3-electrode valve was such that the losses thus introduced by the dual-range switch and unused winding could not be tolerated. The neutrodyne circuit became very popular and necessitated a special type of coil. The reason for the introduction of this circuit was that valves had reached the stage of efficiency where the condenser effect between grid and anode caused terrific instability and oscillation unless some means were introduced to stop it. This could take the form of an inefficient coil, or a potentiometer to apply a small positive bias to the valve grid, but both those methods were unsatisfactory, as they either ruined selectivity or range, or both. The function of the neutrodyne was to balance out the troublesome grid anode capacity by means of a small condenser adjusted so that an equal amount of energy was fed from anode to grid in reverse to that fed through the capacity of the valve itself (see Fig. 444).

Screening. Following immediately on the problem of efficient coil design came the question of adequate screening one from the other. A common form was the 6-pin coil in a copper can, but such an arrangement was unsatisfactory, as the proximity of the metal to the coil greatly reduced the efficiency of the latter, and to overcome this difficulty, two special forms of coil were introduced. One was the binocular coil, which con-

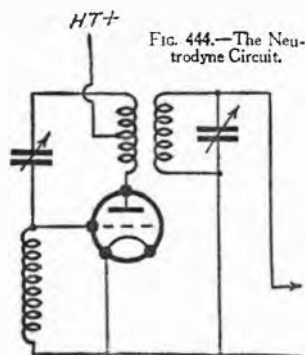


FIG. 444.—The Neu-trodyne Circuit.

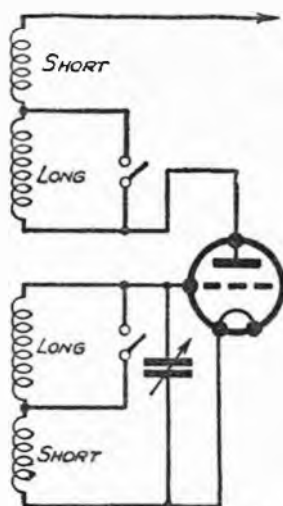


FIG. 445.—A Single-pole Single-throw Switch for wave-changing.

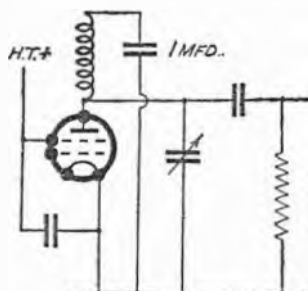


FIG. 446.—Another form of Tuned Anode Coupling.

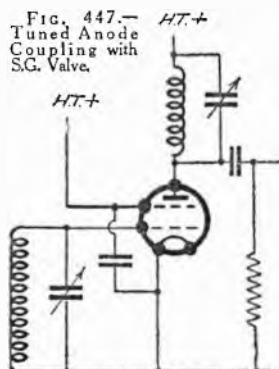


FIG. 447.—Tuned Anode Coupling with S.G. Valve.

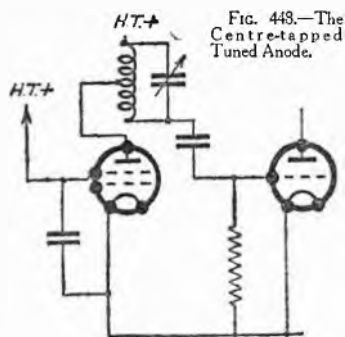


FIG. 448.—The Centre-tapped Tuned Anode.

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sisted of two coils, usually small, placed side by side so that the field was limited, and the other was the toroidal coil, which was wound on a small mandrel like a spring and then curved round until it resembled an unduly bulky curtain ring. Both these arrangements had the great disadvantage that far more wire was necessary to reach the tuning range, which resulted in an increase of H.F. resistance and impaired selectivity. Just before the advent of the screen-grid valve, super-high efficiency low-loss coils appeared. Whatever may have been the merits of this type of coil when used in some form of neutrodyne circuit, there is much to be said against it when used in conjunction with a screen-grid valve.

The position to-day is that the screen-grid valves are of very high efficiency indeed, and when associated with a really efficient coil, it becomes almost impossible to make the set stable. In fact, with a modern type of mains screen-grid valve and a 4-in. low-loss coil, nothing less than $\frac{3}{4}$ -in. sheet copper with soldered joints is adequate for screening. Therefore, for practical purposes, two combinations suggest themselves. A high-efficiency valve with a medium efficiency coil, or *vice versa*; as the efficiency of the coil will be impaired by the presence of the necessary screening, anyway, it is obvious that the first arrangement is preferable.

There are many tuning systems in use to-day that are new, but some of the old ones are firm favourites. Fig. 456 shows a straight circuit with capacity-controlled reaction, that is thought by thousands of constructors to be the true Reinartz. The latter circuit is in more or less general use with receivers that do not employ a high-frequency valve. The Reinartz can be remarkably selective and well deserves to be in much wider use. It is possible that the lack of popu-

larity is due to some extent to the fact that the necessary coil is very hard to obtain ready-made.

Another circuit that is capable of wonderful things is the Hartley, which is shown in Fig. 455, but this circuit has the disadvantage that a powerful short-wave station has the unfortunate habit of butting in on the long-wave band in the most alarming manner. This caused the circuit to die a natural death with the introduction of Brookman's Park. The circuit shown is the popular variation of the original known as the Throttle Control Hartley.

When it is desired to gang three or more tuned circuits, a condenser should be chosen where one rotating section can be advanced or retarded on the main spindle quite independently of the others, and the shape of the vanes must be logarithmic: the reason for this is that only vanes of this type can balance up discrepancy in coil inductance. If, say, a straight-line frequency condenser were used in this manner, it would gang up at one point and come out of step at another. This type of condenser can, of course, be used if the coils are a perfect match, but if they are not, which is more probable, a logarithmic is essential. The trimming condensers usually attached are to balance out the stray capacity of the wiring, and should never be used to trim badly matched coils, as they will only do so at one point of the dial. When ganging a set, always adjust the trimmer at a station that comes in as near as possible to the minimum setting of the main condensers, and adjust the relative positions of the moving sections on a station right at the top of the dial.

The use of the two coils necessary for band-pass tuning drops a considerable amount of efficiency, while the usual close "canning" also throws away some of the range.

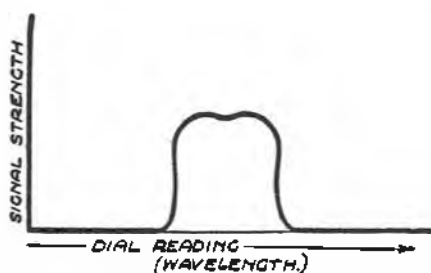


FIG. 449.—Band-pass Wave Form.

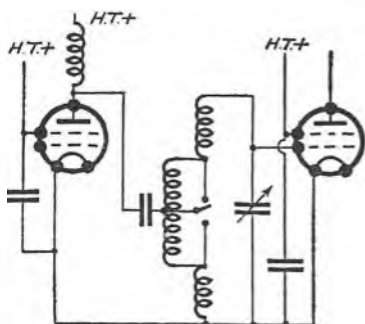


FIG. 452.—Wave-change Switching or Parallel-fed Tuned Grid Circuit.

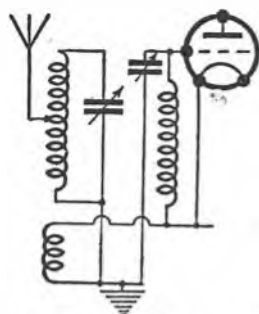


FIG. 450.—Inductive Band-pass Coupling.

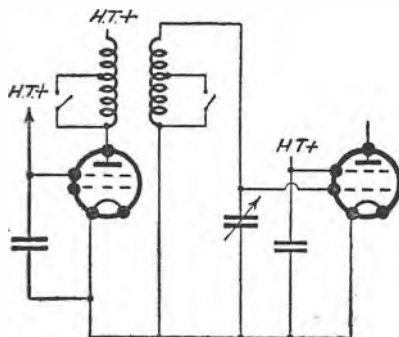


FIG. 453.—A H.F. Transformer with wave-switching.

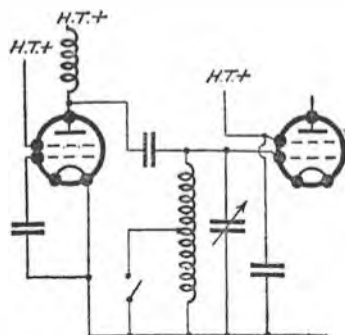


FIG. 451.—The Parallel-tuned Anode system.

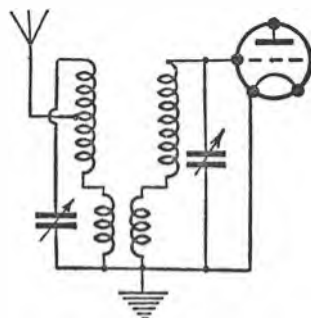


FIG. 454.—A Band-pass Tuner with common Coupling Coil.

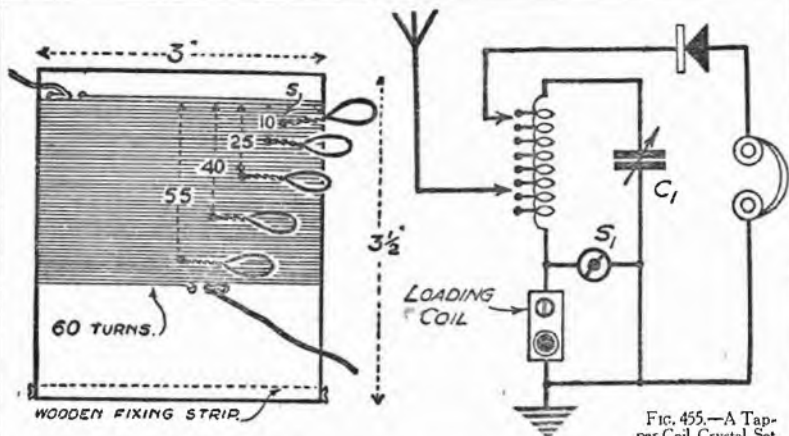


FIG. 455.—A Taper Coil Crystal Set showing (left) details of the coil winding with 26 gauge D.C.C. wire.

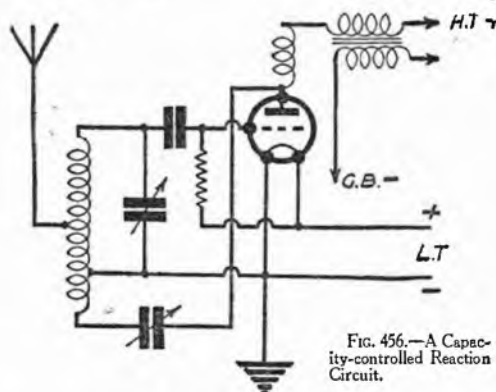


FIG. 456.—A Capacity-controlled Reaction Circuit.

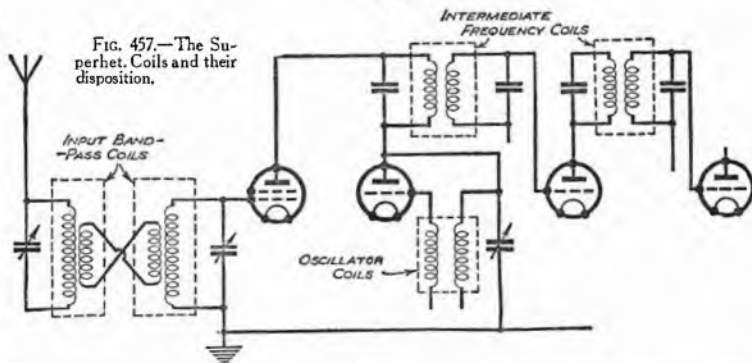


FIG. 457.—The Superhet. Coils and their disposition.

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Some form of screening is essential in the interests of stability, but with band-pass tuning the gain is much more than the loss.

The variable mu valve opens up an entirely new field for design of tuning systems, as it possesses many advantages over the original form of screen-grid valve, most important of which is the fact that it is almost incapable of cross modulation and therefore "pre-selection" is not of special importance. Another advantage that is claimed for the band-pass system is that there is no top cut.

A receiver consisting of two stages of variable mu valves preceded by a very well-designed but single coil tuner will put up a performance of combined selectivity and range coupled with good quality, but it does not equal band-pass tuning.

Screened Aerial Coil. The idea of screening is to prevent one or more components or stages from being coupled together by stray fields. If two coils are to be screened from each other, it will be sufficient to screen only one, provided that it is done thoroughly, as if coil "A" is screened from coil "B" obviously coil "B" must be screened from coil "A." To relieve the aerial coil of the damping effects of the adjacent "can" is to materially increase its efficiency.

A three-valve battery set employing a variable mu valve with a well-designed aerial coil entirely unscreened and a tuned grid coil for intervalve coupling heavily screened in a copper or brass "can" is a rival that even a band-pass set using the same number of valves will find very hard to beat indeed.

Super-Het. Coils. The type of receiver which is now becoming increasingly popular is the super-heterodyne (super-het.). For this special circuit the ordinary types of coil are entirely unsuitable, except, perhaps,

in so far as the input coils are concerned. These may be the ordinary screened band-pass coils. The principal feature of the super-het. is the high degree of selectivity obtainable, and this is carried out by changing the frequency of the received station into some pre-determined frequency and then carrying out the amplification of the signal at this new frequency. These "intermediate frequency amplifier" coils, as they are called, must be very accurately made, as no tuning condensers are fitted in these stages, and they must be designed and adjusted to cover the smallest possible band of frequencies, in order to give the selectivity. It is possible to design these coils to cover such a narrow band that definite side-band cut-off results, and tone compensators have to be inserted on the L.F. side to get a loudspeaker signal of good quality.

A further important coil in the super-het. is the oscillator coil—an arrangement which is employed after the first valve to change the frequency of the received signal. This particular coil works in conjunction with the tuned circuit of the first detector, and in order to enable one-knob control to be carried out (that is, a ganged condenser to tune input coils and first detector coils), the oscillator coil requires to be wound to a certain value, and disposed in a certain position relative to the first detector coil, so that to whatever frequency this latter coil is tuned, the oscillator coil will have the same effect from the shortest to the highest wavelength which the set is designed to cover.

A glance at a modern super-het. receiver will reveal the fact that all coils are "canned," and in order to use a "ganged" condenser, specially shaped vanes have to be used for the section included for the oscillator coil. (See also *Band-pass Tuning*,

TWIN WIRE — UNIT OF CURRENT

Circuit, Condenser, and Variable Condenser.)

TWIN WIRE.—A wire which consists of two wires twisted together, but not electrically connected. A good example is the flex used for house wiring. This is known as twin flex, and consists of two lengths of flexible wire, each enclosed in a cotton covering, the two wires being twisted for the whole of their length.

TWO-ELECTRODE VALVE.—A valve consisting of a cathode and an anode only. This valve is also known as a diode, and is used for high quality rectification purposes, or for half-wave rectification in mains receivers. An ordinary three-electrode valve may be used as a diode by ignoring the grid.

TWO-STAGE AMPLIFIER.—An amplifier having two distinct circuits. It does not, therefore, necessarily consist of two valves. For instance, one valve may be used with transformer coupling to two valves in parallel, or two valves in push pull. A "stage," therefore, is a valve (or valves) and its associated coupling.

U

ULTRA-SHORT WAVES.—The term given to those wavelengths below 10 metres.

UMBRELLA AERIAL.—An aerial having a mast with the wires for the aerial attached to the top of the mast, and then brought down to the ground in radial fashion. The name is given to the aerial on account of the fact that the arrangement is very similar to an umbrella stick and its ribs. This type of aerial is only employed in confined spaces.

UNDAMPED.—Remaining constant. A train of oscillations of constant amplitude.

UNDISTORTED OUTPUT.—A term applied to signal impulses at the anode of the output valve which are

a true replica of the signals received at the aerial. This term is also used to denote the strength of signals which may be given by a specific valve, bearing in mind its working potentials, and the amount of second harmonic distortion which is permissible. This strength, which is measured in watts, may be ascertained from the dynamic curves of the valve, and is rather difficult to work out. A very rough formula, which, although not correct, gives a proportionate result (that is, if applied to any number of valves will give the relation between the respective outputs) is as follows: grid bias squared, multiplied by amplification factor squared, divided by eight times the normal impedance. The answer is in watts.

UNIDIRECTIONAL.—In one direction. An example is direct current.

UNILATERAL.—In single layers, or in one direction.

UNILATERAL CONDUCTIVITY.—Conducting in one direction only. A crystal detector is a good example of unilateral conductivity.

UNIT B.O.T.—The Board of Trade Unit is 1,000 watt-hours.

UNIT CHARGE.—Any charge which repels an equal and like charge with a force of 1 dyne when they are 1 centimetre apart.

UNIT OF CAPACITY.—The unit of capacity is the farad. A conductor has a capacity of 1 farad when a charge of 1 coulomb raises the potential 1 volt. In wireless practice the practical unit is the micro-farad.

UNIT OF CONDUCTANCE.—The unit of conductance is the mho, which is the reciprocal of the ohm.

UNIT OF CURRENT.—The unit of current is the ampere. It is a flow of 1 coulomb per second. A pressure of 1 volt will pass a current of 1 ampere through a resistance of 1 ohm.

UNIT OF INDUCTANCE — VALVE LEG SPACING

UNIT OF INDUCTANCE.—The unit of inductance is the henry. It is the amount of inductance in a circuit which will produce a difference in potential of 1 volt when the amperage is changing at the rate of 1 ampere per second.

UNIT OF POTENTIAL.—The unit of potential is the volt. It is the pressure required to pass a current of 1 amp. through a resistance of 1 ohm.

UNIT OF POWER.—The unit of power is the power required to perform 1 foot-pound of work per second. It is referred to as F.P.S.

UNIT OF RESISTANCE.—The unit of resistance is the ohm. It is the resistance which will permit the flow of 1 amp. when a pressure of 1 volt is applied.

UNLOADED AERIAL.—An aerial having no added capacity or inductance.

V

VACUUM.—A space which is theoretically devoid of all matter. When a glass bulb as used in a valve is evacuated, it is said to be a vacuum. Theoretically it is impossible to completely evacuate a bulb; there is always a slight residual amount of air left.

VACUUM TUBE.—The tube used in X-ray work. It consists of a glass vessel which is evacuated, and has two electrodes.

VALVE.—The name given to the glass vessels containing electrodes used in wireless receivers. The ordinary valve is a device consisting of a glass stem upon which are mounted supports for holding the filament, grid, and anode.

VALVE AMPLIFIER.—A valve acts as an amplifier owing to the fact that the anode current produced by

the application of a potential to the cathode and anode is much greater than that which is passed to the grid. The signal oscillations on the grid vary the anode current, and as this is of greater magnitude than the signal oscillations amplification takes place. The term is also applied to a valve and its associated couplings in high- or low-frequency stages.

VALVE DETECTOR.—The valve may be made to rectify the received signal oscillations by applying a negative potential to the grid so that a unidirectional current is produced in the anode circuit. Rectification may also be carried out by including in the grid circuit a fixed condenser, with a high resistance joined to the cathode. The inclusion of this condenser and resistance has the same effect, namely, the production of a unidirectional current in the anode circuit. (See also *Grid Leak, Power Grid Detection, Anode Bend Rectification.*)

VALVE LEG SPACING.—The spacing of the valve legs is so ar-

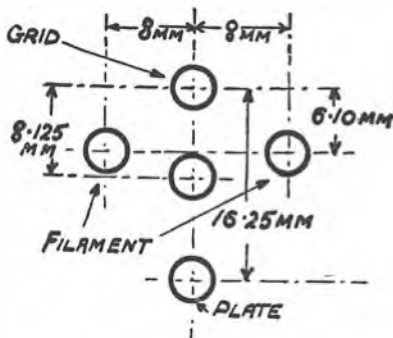


FIG. 458.—Diagram showing Valve Leg Spacing.

ranged that it is impossible to plug a valve into its holder in the wrong way. The actual disposition of the legs has been chosen so that one pin stands out apart from the rest, as shown in the attached diagram. This illustration also gives the actual meas-

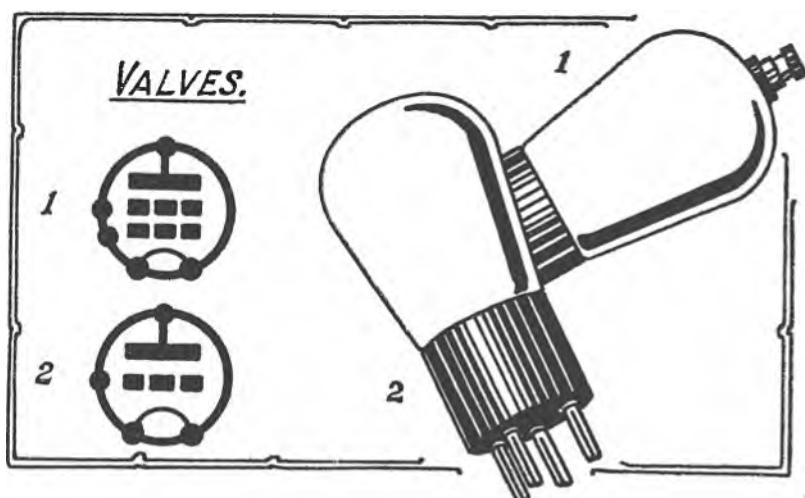


FIG. 459.—Theoretical and actual diagrams of Valves.

urements between the pins. In the early days of broadcasting the sockets of the valve holders were of solid construction, and the pins had spring legs, provided by slotting the pins or attaching thin leaf springs outside the legs. Nowadays, it has been found more satisfactory to use spring sockets and solid pins to the valves.

VALVES EXPLAINED.—If the glass bulb of a valve, the filament of which has burnt out, is carefully broken by first wrapping it in a piece of cloth and lightly tapping with a hammer, the result will reveal the electrodes. For the interior construction may be examined and, in conjunction with the following description, the various parts understood. In a modern valve of the type illustrated in Fig. 460, there are three distinct parts; these, as shown in the diagrams, are the filament at the centre, surrounded by the grid, which in its turn is surrounded by the anode; these three parts are known as electrodes. Inside the bakelite base from which the valve pins pro-

ject is cemented a glass pinch; embedded in this are five stout supporting wires, four of which run from the electrodes right through to the valve pins, two of these four to the filament pins, and one each to the anode and grid pins respectively; the fifth wire acts as a support for the filament, and helps to hold it in its correct position between the spirals of the grid.

The filament may well be dealt with first, since it plays one of the most important parts in the operation of the electrodes, although it is only a fine thread of wire upon which generally the life of the valve depends. The functioning of the valve is commenced by passing a low-tension current from an accumulator through the filament; this has the effect of heating it. When the filament has reached the correct temperature it throws off minute electrical negative charges which are known as electrons. The electrons pass through the grid, and are attracted to the anode; they flow thence back to the low-tension

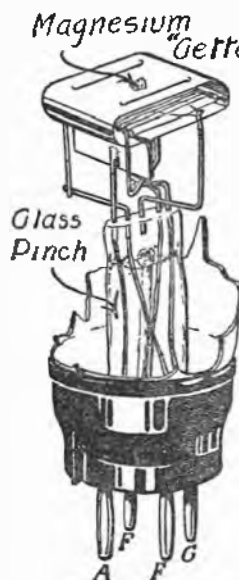


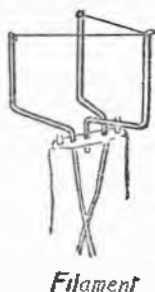
FIG. 460.—Internal parts of a modern Valve.

positive side of a high-tension battery, the negative side of the battery being connected to low-tension negative. In this way the voltage to the filament is unaltered, but the voltage of the anode with respect to the filament is greatly increased and with it the electron flow.

The grid is a spirally-wound length of wire (see Fig. 462), and, as before stated, is between the filament and the anode. To this the incoming

battery. To attract these negative electrons to the anode from the filament, the anode is kept positively charged, for it is a well-known fact that in electricity a positive charge attracts a negative charge. To positively charge the anode, it is connected to the

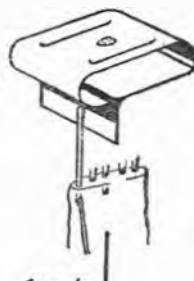
wireless signals are applied. These signals are alternately negative and positive; this changing of polarity tends to control the electron flow from the filament to the anode, for when the grid is positive it acts like a small anode, and because it is nearer to the filament its attraction for the electrons is much greater; but this also means an increase in anode current. The grid, however, is just as often negative, and has the effect of repelling electrons leaving the filament, for like repels like. A negative grid will therefore mean a decrease in anode current. It may be seen, then, that if the grid is biased negatively with a grid-bias battery as much as possible, it will tend to



Filament



Grid



Anode

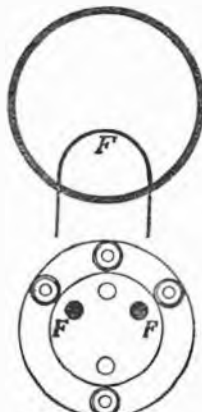


FIG. 461.—The Filament.

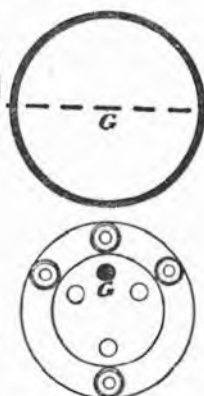


FIG. 462. The Grid.

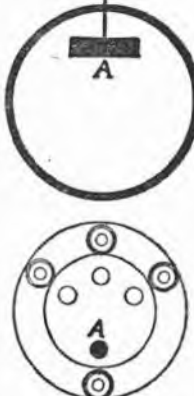


FIG. 463.—The Plate.

VALVES EXPLAINED

stop any positive signal voltages from making the grid positive; grid current is thus prevented, although the controlling action of the grid is maintained. If over- or underbiased, however, the grid will not be able to deal with the applied signal voltages, and distortion will be noticeable. Now it is possible to understand why with the correct amount of grid bias the anode current consumption of the valve is cut down and the H.T. battery is therefore being used as econo-

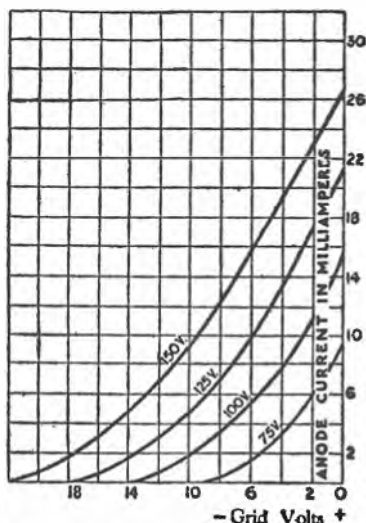


FIG. 464.—Characteristic Curve of a Low Impedance Medium Slope Valve.

mically as possible. The grid serves to interpret the wireless signals, the periodicity of which varies with the different wavelengths of the broadcasting stations into which the set is tuned; this is called the carrier wave. In a wireless wave of 300 metres the frequency of this carrier wave is in the neighbourhood of 1,000,000 cycles per second, which is far above the frequency audible to the human ear. A microphone current is modulated into this carrier wave at the broad-

casting station, and this produces the sound waves of speech and music; this current has, of course, a much lower frequency. The action of the detector valve in a set is to demodulate these two variations of current—i.e. separate them, retaining the sound waves (low frequency) and dispersing the carrier waves (high-frequency current). These low-frequency currents are the variations which, when amplified by a power valve, go to actuate the loudspeaker.

The electrodes which constitute the valve would not be able to operate if it were not for the fact that they do so in a vacuum—that is to say, the air is exhausted from the valve. Valves in which a trace of gas is allowed to remain are classified as "gassy" or "soft," and are apt to become unstable, besides having a very short life. In the process of manufacture the valve is connected to pumps and as nearly as possible evacuated and hermetically sealed. It is then brought into close proximity to a high-frequency coil, the high-frequency currents of which tend to heat the electrodes; this has the effect of releasing any gases remaining in the metal of the electrodes, and when the temperature becomes sufficiently high a small piece of magnesium, previously fixed inside the valve, is ignited and burnt. The combustion of the magnesium absorbs the remaining traces of gas in the valve. The process of combustion causes a portion of the metal to be deposited upon the inside of the glass bulb in the form of oxide of magnesium, which gives that silvered effect which may be seen in the upper parts of all valves. The operation of final exhaustion by magnesium is called "gettering," and the magnesium is known as the "getter."

The latest development in modern valves of the screened-grid and detector types is the coating of the

VALVES EXPLAINED

outer surface of the glass bulbs with a finely divided metal powder. This appears to be applied in a dry state to the tacky surface of a coat of varnish. Its effect is to eliminate the usual aluminium shield, and must be earthed in the same way as such shield. This earthing is already arranged in the valve by the manufacturers. The effect of the metal coating is to isolate the valve electrically and prevent stray currents from interfering with other surrounding components.

The screening provided by this metallic coating is quite as efficient as is obtained by enclosing the valve in a metal box, so long as the valve holder is correctly wired up. If you examine one of these metallised valves you will find, attached to the coating just above the base of the valve, a small disc or ring. This sometimes bears the letter E. From this disc or ring a thin wire can be seen passing into the holder, and the metallic coating covers both disc and wire. The filament leg beneath this disc *must* be joined to the earth terminal of the set to enable the screening to be effective.

Impedance. Impedance indicates the capability of a valve to handle large or small volume: the lower the figure of impedance the more undistorted output—i.e. the volume of pure signals that the valve will give. Impedance is arrived at by measuring the corresponding change of high-tension current that will result from changing the high-tension voltage; for example, suppose that a valve has the anode, or plate, connected to 110 volts and that the current drawn from the battery is 11 m/A, also if the anode voltage is reduced to 90 there is a reduction in the amount of H.T. current used to the extent of 4 m/A. From this it will be seen that a change of 20 volts on the anode has reduced the amount

of current drawn through the valve by 4 m/A. Such results would be obtained from a valve having an impedance of 5,000 ohms. If the same experiment was tried with a high-impedance valve, the change resulting would be very much smaller; in the case of a screened-grid valve, only a fraction of a milliamp.

Low-impedance Valves. The job that a valve is required to do is to

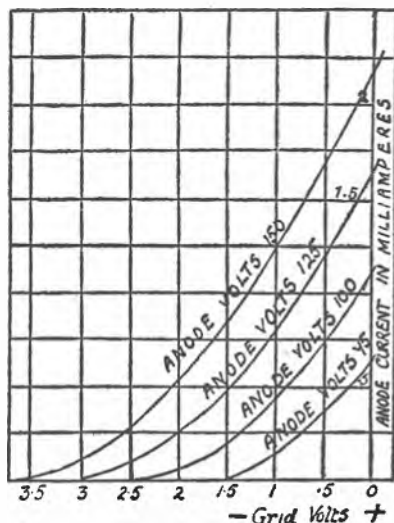


FIG. 465.—Characteristic Curve of a very High Impedance Valve.

change its high-tension current when a signal is applied to its grid, but it must not alter the nature of the signal so applied by becoming overloaded, which would cause distortion. Fig. 464 shows a valve of low impedance. A glance at the "150" curve will show that it is practically straight from 8 m/A to just over 26 m/A, or, in other words, the incoming signal can swing up and down over a nominally straight line that is 18 m/A long without touching the curve portion which causes the valve to distort very badly.

VALVES EXPLAINED

This long, straight portion indicates that it is a low-impedance valve capable of handling large signals. Reference to Fig. 465 shows that this valve is entirely different, and that the "150" line is only straight between $\frac{3}{4}$ and $2\frac{1}{4}$ m/A. From this it will be seen that the total swing is only $1\frac{1}{2}$ m/A, and that therefore the valve will handle very little volume before distortion sets in.

A low-impedance valve has a small amplification factor and a high-impedance valve a large am-

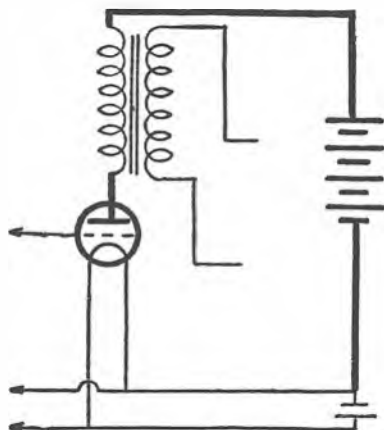


FIG. 466.—Matching is making the impedance of the anode roughly equal to the valve impedance. The Anode Circuit is shown by the heavy black line.

plification factor. The amplification factor (sometimes called "magnification factor") of a valve is the influence that a signal applied to the grid has over the H.T. current. Take the original case of the 5,000-ohm. valve referred to above. It will be remembered that it took a variation of 20 volts high tension to vary the high-tension current 4 m/A. If the anode voltage is left alone and 2 volts grid bias applied to the grid, it will be found that the same charge of 4 m/A takes place. Therefore, 2 volts applied to the grid has as

much influence as 20 volts applied to the anode; if 20 is divided by 2 the answer is 10, which is the amplification factor of the valve, or the amount of influence that the grid has over the anode. The valve shown in Fig. 465 has an amplification factor of 40, and will therefore amplify a signal four times as much as the valve shown in Fig. 464 with amplification factor of 10; but with the high amplification factor there is a corresponding rise in impedance, and consequently the valve will not handle as much volume as the valve with the lower factor.

To summarise briefly, a high-impedance valve may be used to amplify weak signals, but a low-impedance valve must be used to prevent distortion when handling loud signals. Take for example a 2-valve set employing detector and output valves. The first valve will be called upon to handle a very small input, thus a valve of high impedance can be used, and its amplifying properties employed to advantage. The signals, now strengthened by the first valve, are passed on to the second valve, which must be capable of handling the larger input, and therefore a valve of low impedance must be used. This rule of valve graduation holds good if resistance capacity coupling is used, but if a transformer is employed it is equally essential that the valve and transformer must suit each other. Let it be quite clear that it is the valve and transformer that *follows* it that are the pair, and definitely not the transformer which goes in front of the valve.

Matching is making the impedance of the anode circuit roughly equal to the valve impedance (see Fig. 466). A transformer is like a valve in some respects, as it possesses primary impedance and amplification factor in the form of the ratio; the transformer

VALVES EXPLAINED

with a high primary impedance has a low ratio, and one with a low primary impedance has a high ratio. If a high-impedance valve is used, a transformer with high primary impedance must also be used which has a small ratio, and *vice versa*. As a rough guide, the ratio of a transformer less 1, multiplied by the impedance of a valve should not exceed 60,000. For example, a transformer having a ratio of 3:1 take 1 away, which gives 2; multiply by the impedance of the valve to be used—say 30,000—the answer is 60,000, which is quite in order. On the other hand, if a 3:1 transformer is to be used with a valve having an impedance of 50,000 ohms, this simple sum will come out at 100,000, which is too high.

Mutual Conductance. The characteristic which has not been dealt with is mutual conductance, or slope as it is sometimes called. This is a combination of impedance and amplification factor, and may be described as indicating the goodness of the valve. It has many influences on the valve's performance, but a marked influence on the value of the grid bias necessary. Reference to Figs. 464 and 467 will show that there is a marked resemblance between these curves, inasmuch as the straight portion of their curves measured in m/A is almost the same, but, on the other hand, they differ greatly in the angle at which this line is set. Fig. 464 is the curve of a valve with a slope of 2. Fig. 467 is a similar curve of a valve with a slope of 4. The latter is steeper than the former, and is said to be a steep-slope valve.

Grid Bias Values for Valves. Refer to Fig. 464, and look along the grid bias figures at the bottom, and follow the 6-volt line upwards until it strikes the 125-volt line, turn to the right, and it will be found that the valve takes 10 m/A under these conditions—i.e. 125 volts H.T. and

6 volts grid bias. It will also be noticed that the point struck is sensibly on the straight portion. Now turn to Fig. 467 and find the 6-volt G.B. line; follow it until it hits the 125-volt line, turn to the right, and denote the H.T. consumption, only $2\frac{1}{2}$ m/A; also particularly note that the point is right on the bend of the curve, which will result in horrible distortion. It is therefore obvious that the same grid bias is not suitable for both valves; the valve in

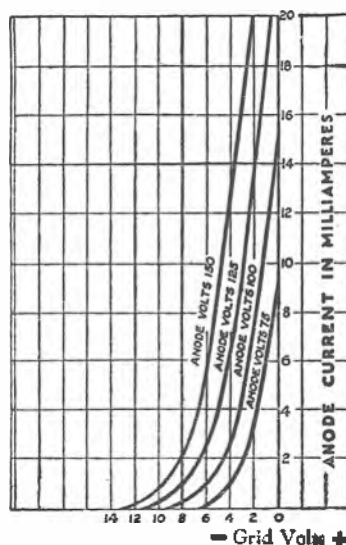


Fig. 467.—A Steep Slope Valve.

Fig. 467 has twice the slope of that in Fig. 464, consequently it only requires half the grid bias.

A valve should always be biased in the middle of the straight portion of its curve, therefore in Fig. 467 note the middle of the straight portion of the 125-volt curve. Drop the eye to the grid bias figures, and it will be seen that the figure is 3; also run along the horizontal line and note that the anode consumption is 10. The significant point is that the two

GRID-BIAS BATTERY.

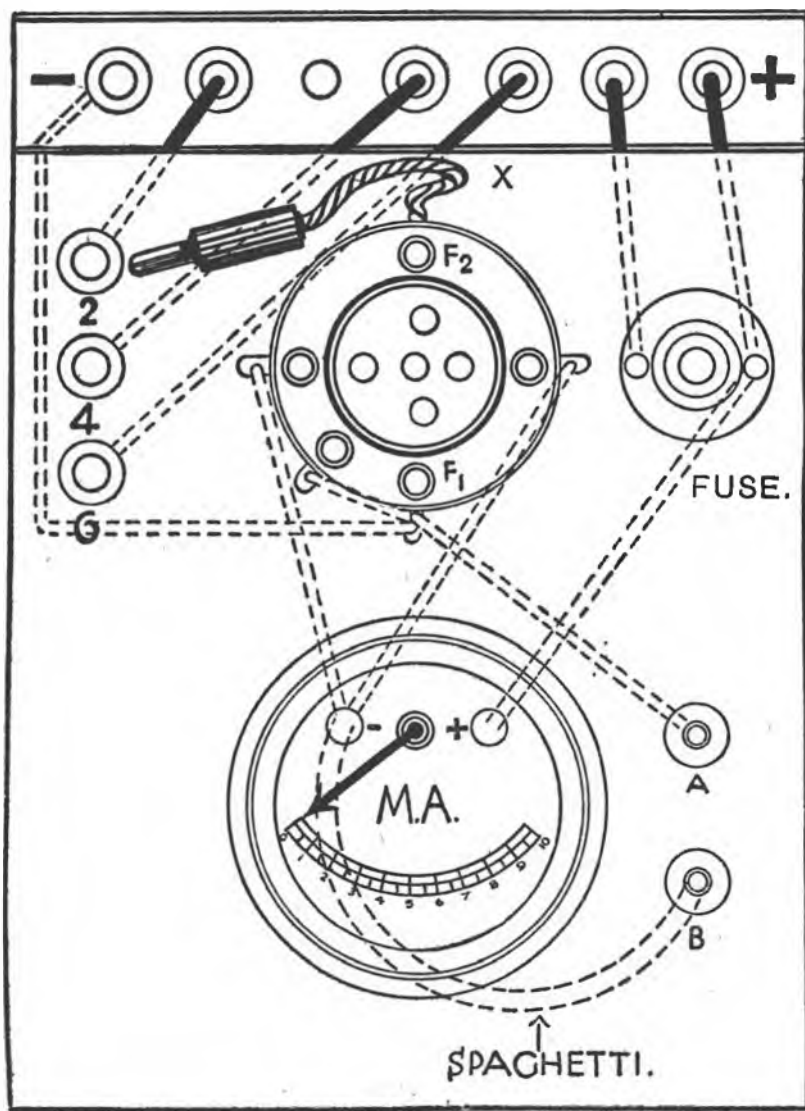


FIG. 468.—Wiring diagram of the Valve Tester.

VALVES EXPLAINED — VALVE TESTER

power valves require totally different values of grid bias to pass the same high-tension current. The one requiring 6 volts was introduced about a year ago, the one requiring 3 volts a few months ago. There is a tendency for small values of grid bias, and it is true to say that valves are as much over biased to-day as they were under biased two years ago. Over biasing causes distortion, under biasing results in an excessive drain on the high-tension battery.

It may briefly be said that impedance indicates the ability of a valve to handle powerful signals, that magnification factors show the magnification that the valve will give, and that mutual conductance is a mark of merit or efficiency.

The foregoing description of valve characteristics, if carefully read, will enable the reader to tear the glittering bulb of mystery from the valve elements and to thoroughly understand the valve.

VALVE TESTER.—The components required are:

1 Small box	6 Wander plugs
1 Panel	1 Milliammeter
2 Terminals	0-10
1 Plug	1 1,000-ohm
3 Sockets	Spaghetti
1 Fuse holder	1 9-volt bias battery
1 5-pin valve holder	1 yd. flex

The diagram shows clearly the position of the components and the wiring (see Fig. 468).

Connect

- (1) Grid bias— to filament 1, cathode, and terminal A.
- (2) Second socket to 2. (Third socket is blank.)
- (3) Fourth socket to 4.
- (4) Fifth socket to 6.
- (5) Sixth socket to fuse holder.
- (6) Seventh socket (+) to fuse holder and + terminal on milliammeter.

- (7) Filament 2 to wander plug with wire X.
- (8) Plate and grid to — terminal on milliammeter.
- (9) Spaghetti between — terminal on milliammeter and terminal B.

The valve to be tested is plugged into the valve holder, after the wander plug has been placed in the socket corresponding to its filament voltage.

S.G. valves . read approx. 2 to 3 m/a.
Det. H.F. and L.F.

read approx. 3 to 4 m/a.

Power read approx. 4 to 6 m/a.

Super power read approx. 6 to 8 m/a.

The filament can be tested by simply connecting the filament pins on terminals A and B. If the milliammeter shows current, the filament is O.K. The filament of a valve often sags and touches the grid, causing the valve to cease functioning. If such a valve is placed in the tester the needle bangs over to 10.

To test fuse bulbs and pilot lamps simply screw into the fuse holder.

To test transformers, resistances, etc., a pair of test prods on flex should be connected to A and B. Connect the prods to each end of the winding or resistance to be tested, when a reading will be obtained if O.K. Resistances above 100,000 ohms will not show any appreciable reading, therefore the test is not suitable for grid leaks.

To adapt the tester for A.C. valves the plug and connection X should be taken off entirely and a twin flex connected to terminals F1 and F2 on the valve holders. The other end of the flex should be connected to the filament terminals of a valve adaptor, and this plugged into a convenient valve holder in the receiver. The valve would be inserted in tester and the set switched on. After allowing a minute for the valve to heat up a reading should be obtained if O.K.

VALVE TESTER — VARIABLE CONDENSER

D.C. valves can also be tested with this adaptor, in a similar way to A.C. valves, with the exception that the adaptor should be inserted in the

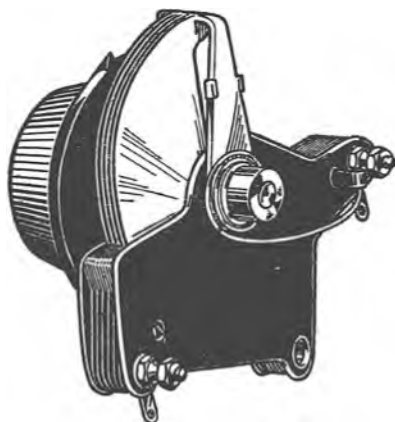


FIG. 469.—A solid dielectric type of Variable Condenser.

valve holder out of which the valve to be tested was taken.

VALVE OSCILLATOR.—A valve having some form of coupling between anode and grid circuits to maintain continuous interaction.

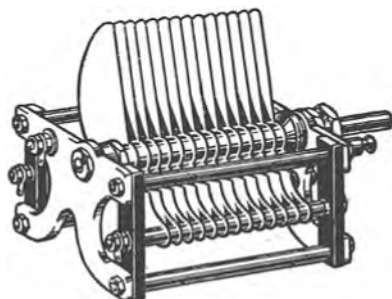


FIG. 470.—A square-law type of Variable Condenser.

This usually takes the form of a coil in each circuit, closely coupled. The frequency of the oscillations depends upon the electrical time period of the circuits in question. The valve os-

cillator is used for transmission and for super-heterodyne receivers.

VARIABLE CONDENSER. — A device consisting of a moving and fixed electrode, with a dielectric separating the electrodes.

There are four separate types of variable condenser, each of which has certain definite characteristics. The first to be introduced was the straight-line capacity type, which had a metal vane shaped in a half-circle, with the spindle in the exact centre. The result of this pattern is that the actual capacity changes in

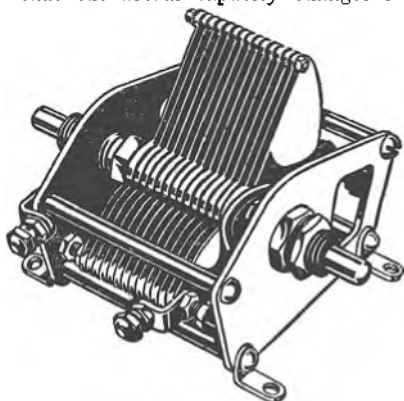


FIG. 471.—Another style of square-law Variable Condenser.

proportion to the degrees of the knob. In other words, if the dial is moved from, say, 20° to 30° , it will vary the capacity exactly the same amount as turning it, say, from 70 to 80. As the wavelength of the coil is not directly proportional to the capacity of the variable condenser, the use of this type causes all the stations to be bunched at one end and widely separated at the other.

The square-law type has vanes specially shaped to give a definite result, and when associated with a coil, the dial reading gives a definite indication of the wavelength; thus, if 30 on the dial is 300 metres and 90

VARIABLE CONDENSER

on the dial is 400 metres, then with a square-law condenser 60 must be 350 metres and so on. For station identification this is admittedly ex-

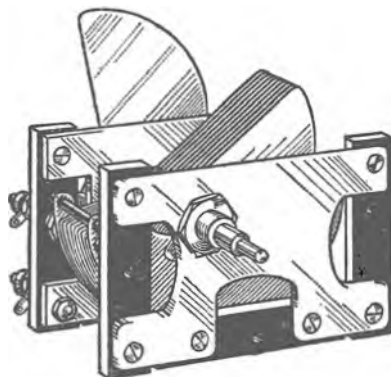


FIG. 474.—Square-law Variable Condenser with Single-plate Vernier or Trimmer.

remely useful, but it does not overcome entirely the tendency for stations to be more bunched at one end than the other; the reason for this is not generally appreciated. As the wavelength is increased, the station separation in terms of metres becomes less. For example, it is far easier to separate two stations at 300 and 310 metres respectively, than it is to separate two stations of exactly the same power working on a wavelength of 500 metres and 510 metres respectively. It will be observed that in both cases the stations differ by 10 metres, but actually, the second pair are closer together than the first pair. The reason for this is that the relative distance between the wavelengths of stations cannot be measured in metres, but must be measured in kilocycles (kcs.).

Square-law Condensers. A brief consideration of the square-law condenser will show that if it arranges for the various wavelengths to be separated by an appropriate number of metres, and that the metre is not

a true indication of separation, it follows that the square-law condenser will tend to bunch stations. To take another example, Kaunas works on a wavelength of 1,935 metres, and Lahti works on a wavelength of 1,796 metres; thus the difference in wavelengths is 139 metres; the frequency of the first-named station is 155 kcs., and the frequency of the latter 167 kcs., being a difference of 12 kcs. Thus at the very top of the long-wave dial 139 metres separation is equal to 12 kcs. separation. Belfast has a wavelength of 242 metres, and Beziers a wavelength of 240 metres, the difference being 2 metres. The frequency of the former station is 1,238 kcs., and the latter station 1,250 kcs., a difference of 12 kcs. It will be remembered that at the top of the dial 139 metres was equal to 12 kcs., but it will be observed that at the lower end of the short-wave dial the same number of kilocycles is only worth 2 metres. Before leaving this subject, the reader



FIG. 473.—A Triple Gang-screened Variable Condenser.

will doubtless be surprised to hear that the separation between London National and Toulouse is twice as great as that between Daventry 5XX and Radio Paris.

VARIABLE CONDENSER

The straight-line frequency type is arranged so that each degree on the dial is equivalent to a definite frequency difference, and, therefore, a

or more correctly the logarithmic condenser, has a special function to fulfil. From a point of view of station separation, it is midway between

the square-law and the straight-line frequency, but has a special advantage for ganging, as the shape of the vanes permits discrepancies of the coil matching to be overcome. It is incorrect to imagine that a trim-

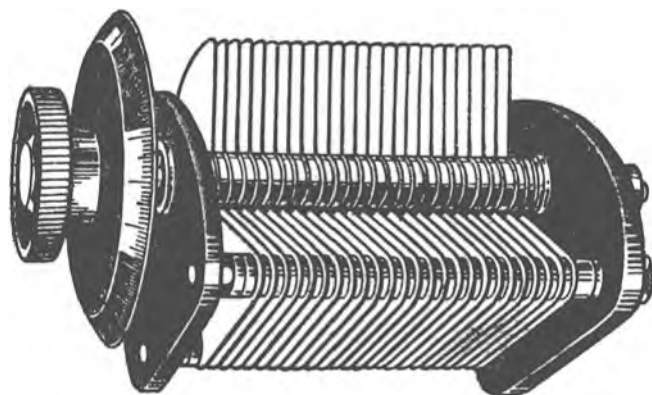


FIG. 474.—An old semi-circular-vane type of Variable Condenser—now obsolete.

movement at one end of the dial will affect the tuning of the circuit exactly the same as a similar movement at another portion of the dial. Therefore, every station is spaced along the dial in the position that it is allotted by its true frequency, and this condenser is, consequently, the best possible type to use when convenience and ease of manipulation is desired.

It should be borne in mind that of all the types of condensers available, the straight-line frequency is the least suitable for ganging, unless the user is absolutely certain that the coils associated are accurately matched.

Special Function of the Log-law Condenser. The log-law condenser,

ganging condenser will gang up a set if the coils are not properly matched, as an adjustment of the trimmers at one part of the dial will result in throw-

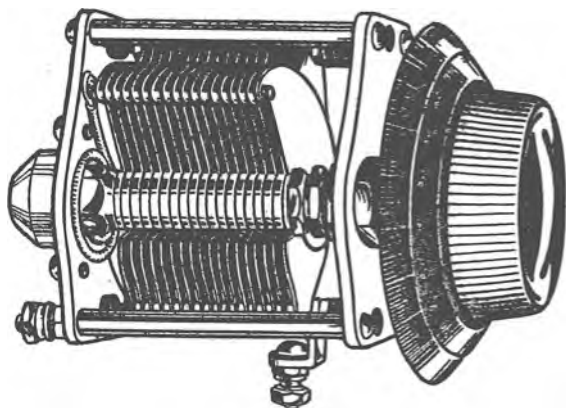


FIG. 475.—A Mid-log-line Variable Condenser.

ing out other sections. With the logarithmic condenser, where each set of moving vanes can be moved separately, it is simply a matter of advancing one set in front of the

other, so that ganging is accomplished at the top of the dial, when the special shape of the vane will result in ganging being preserved throughout the whole length, provided, of course, the trimmers have been adjusted to equalise odd capacities brought about by wiring screens, etc., which is the proper use of these adjustments. Most modern ganged condensers have logarithmic-shaped vanes, but unfortunately, they are not all made so that one set of vanes can be moved without the others.

Mechanical Defects. The modern condenser is a very fine piece of work from the point of view of efficiency, but many types have small mechanical drawbacks that are annoying to the constructor. In particular, screens are extremely difficult to replace when they have been moved from the framework. Another point that is not satisfactory is the pigtail connection which is still used on many types. This form of connection, while being liable to break, is also inclined to scrape on the plates, and in extreme cases to short them.

When choosing a condenser which comprises several units ganged together, care should be taken to see that the main spindle is properly bushed and free from side play, and also that there is no backward and forward movement possible, as these mechanical faults result in the capacity of one section changing out of proportion to another section, thus throwing out ganging. The reaction condenser is not particularly important as long as it is well made and has good insulation. A condenser with bad insulation results in worrying scraping noises when adjusted, and also prevents fine adjustment. The reader's attention is drawn to the fact that with most types the spindle and bush are connected to the moving vanes, and care must be

exercised accordingly when it is to be mounted on a metal panel to see that a short circuit is not created.

Many listeners use a series aerial condenser for adjusting or obtaining an increase of selectivity. For this purpose, it is most desirable that a type having a very low minimum capacity should be used, also the maximum value need not be above .0002. Although no difference is noticeable on long wavelengths, it is decidedly advantageous to use a condenser with air dielectric on the lower broadcast wavelengths, as the insulating material placed between the vanes of the small type in general use causes a considerable loss of efficiency round about the 200-metre mark. It is, of course, not necessary to use the ordinary large-vaned type, as many midget condensers are now available that are free from insulating material between the vanes. (See also *Condenser*.)

VARIABLE-MU VALVES.—A screened-grid valve having variable impedance. (See also *Value*.)

VARIOCOUPLER.—A variometer.

VARIOMETER.—Two coils, one rotatable within the other.

VELOCITY OF ELECTRIC WAVES.—The velocity of electric waves is 186,000 miles per second. This is equal to 300,000,000 metres per second.

VELOCITY OF ETHER WAVES.—The same as the speed of electric waves, 186,000 miles per second.

VELOCITY OF LIGHT.—The same as the speed of electric waves, 186,000 miles per second.

VOLT, THE.—The volt is the unit of electro-motive force or pressure. It is the force which causes the electricity to flow in an electrical circuit.

Other units are the *millivolt* (which equals one-thousandth of a volt), the *microvolt* (one-millionth of a volt),

VOLTAGE DROP — VOLTMETER

and the kilovolt, which equals 1,000 volts.

VOLTAGE DROP.—The difference of potential along a resistance.

VOLTAGE DROP AND RESISTANCE.—A useful example of the value of one quantity depending upon the product of two others is the

required voltage drop divided by the current in amperes.

If the current is expressed in milliamperes, the answer must be multiplied by 1,000, because a milli-ampere is one-thousandth part of an ampere. For instance, suppose your high-tension unit gives 250 volts, and you want to apply only 100 volts to your detector, which takes an anode current of 2 milliamperes, the value of the dropping resistance should be 150 volts, multiplied by 1,000 and divided by 2 milliamperes, or 75,000 ohms. Grid-bias resistances are calculated in exactly the same way, the required bias voltage being divided by the anode current of the valve, and multiplied by 1,000.

The relationships dealt with so far are all quite simple, and result from easily understood electrical laws. There are hosts of others, however, which are not so obvious, and which cannot be explained quantitatively without going too deeply into technicalities.

VOLTAIC CELL.—A cell invented by Professor Volta, and consisting of two plates, one of zinc and one of copper, immersed in a weak solution of sulphuric acid. The acid solution should consist of about 10 parts of water to 1 of acid, and the metal plates may be kept apart by a block of wood.

As soon as the plates are immersed in the liquid, chemical action takes place, and bubbles of hydrogen will be noticed rising from the zinc.

VOLTMETER.—A measuring instrument used to indicate the pressure, or E.M.F., applied to a circuit. An instrument of this type consumes current, and therefore it is essential that the use to which it is to be put should be first decided upon before the type of meter is chosen. A cheap meter will have a low resistance—say, round about 200 ohms per volt, and will therefore consume 5 milliamps.

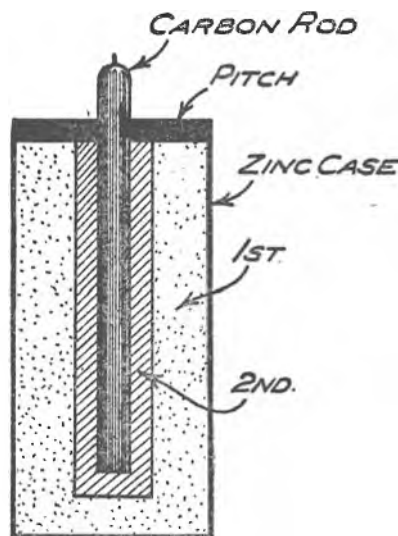


FIG. 476.—Section of a Dry Cell.

voltage drop in a resistance, which is equal to the current in amperes, multiplied by the resistance in ohms. To take a concrete case, a resistance of 4 ohms in a circuit carrying 2 amperes will cause a drop of 8 volts. The practical use of this relation can be seen when it is desired to break down the voltage of a high-tension power unit in order to apply a voltage less than the maximum to one valve, say, the detector. In order to do this, the formula must be turned round a bit, and restated to the effect that the resistance required for a given voltage drop is equal to the

VOLTMETER — VOLUME CONTROL

per volt, a quite considerable value when the meter is used to test, say, a H.T. battery of 120 volts rated to deliver 3 or 4 milliamps. This type of instrument is also useless for test-

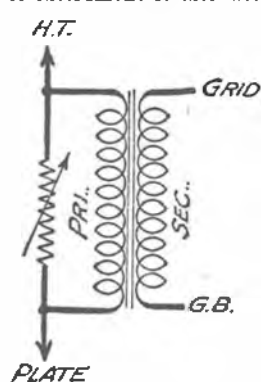


FIG. 477.—A simple form of Control in conjunction with the L.F. transformer,

type will have a resistance of about 1,000 ohms per volt, and will therefore only consume 1 of a milliamp. per volt, or 1 milliamp. for an instrument reading 100 volts. A voltmeter has to be joined in parallel (or across) the source to be measured. (See also *Meter*.)

VOLUME CONTROL. — Unless your loudspeaker gives forth the same tone on either soft or loud signals, then overloading is taking place in the receiver. There are two

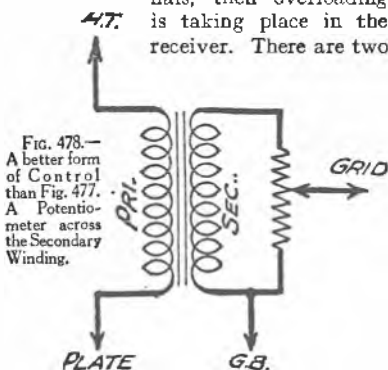


FIG. 478.—A better form of Control than Fig. 477. A Potentiometer across the Secondary Winding.

remedies for overloading—one is to increase the handling capabilities of the valve by applying more H.T., and the other is to cut down the signal strength.

A number of receivers have the reaction control labelled "Volume Control," but this is not strictly correct. A volume control should be able to cut down the strength of any signal, but the reaction control can only build up the strength of received signals, and cannot cut down below the original strength received by the detector.

There are several different forms of volume control, but there are very few which do not possess some fault. However, it should be a simple matter to decide upon which type of control will suit your particular receiver.

The Transformer. In conjunction with the ordinary type of low-frequency transformer there are two possible arrangements. These are shown in Figs. 477 and 478. In Fig. 477 is shown a variable resistance shunted across the primary of the transformer, and the value of the resistance should be chosen so that when "all in" it does not have too great an effect upon the reproduction quality. Of course, when the transformer is a high-class component the presence of an external resistance across either primary or secondary will materially affect the response curve and the reproduction will be affected. In some cases, particularly in the cheap transformer line, the reproduction may be improved owing

to the use of a potentiometer instead of the grid leak in a R.C. amplifier.

VOLUME CONTROL

to the flattening of the curve. The value of the resistance in Fig. 480 should be about 100,000 ohms—not more.

good-class component should be employed.

Where resistance capacity coupling is employed, the grid leak can conveniently be substituted by the potentiometer method of Fig. 484, and this arrangement is shown in Fig. 483. Very little, if any, distortion is introduced by this method of volume control, and the only trouble that can arise here is noisiness due to

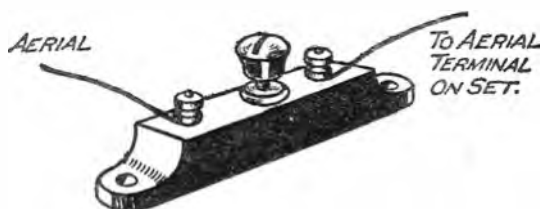


FIG. 480.—The series Aerial Condenser.

In Fig. 484 a high-resistance potentiometer is connected across the sec-

a poor contact between the resistance element and the moving arm.

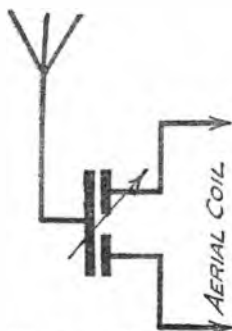


FIG. 481.—A Differential Condenser in the Aerial Circuit.

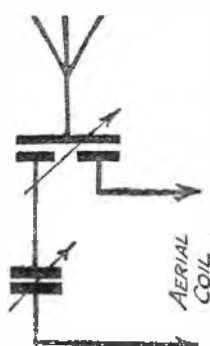


FIG. 482.—An improved form of the arrangement shown by Fig. 481.

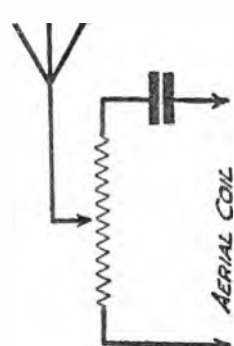


FIG. 483.—A Resistance instead of a differential Condenser in the Aerial Circuit.

ondary winding—the arm of the potentiometer being joined to the grid of the following valve. In this case the value of the resistance across the transformer is constant the whole time, and the adjustment of the arm simply taps off the required signal voltage. In Fig. 480 the adjustment of signal strength also varies the value of the resistance shunted across the primary, and therefore this method will affect the quality more than the Fig. 484 arrangement. The potentiometer should have a value of 1 or 2 megohms. To ensure noiseless adjustment a fairly

This is the best method of L.F. volume control.

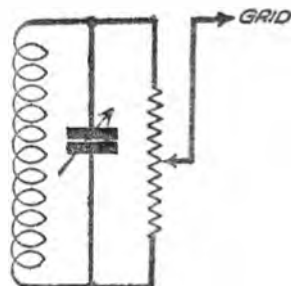


FIG. 484.—A Potentiometer across the Grid Coil.

Overloading the Detector. It is not always in the L.F. side of the receiver that overloading troubles arise. In sets fitted with one or more H.F. stages the detector valve may be overloaded, and it is therefore necessary to introduce some form of control in the aerial circuit. A very common form of control is a series aerial condenser (Fig. 480), but this will affect the tuning adjustment, and when two or more dials have to be adjusted for tuning, this alteration of the aerial tuning condenser may make it difficult to get an accurate setting. It is not therefore ideal, but will be found good enough for simple sets, and can, in fact, be used with a simple detector arrangement when situated very close to a powerful main station. The value should be .0003 mfd. maximum, and whilst the air-dielectric condenser is the best from the "loss" point of view, the simple semi-variable type of condenser is quite O.K.

A much better aerial arrangement is shown in Fig. 481—this arrangement not affecting the selectivity as does Fig. 480. A simple differential reaction condenser of .0003 mfd. is used for this, although better control is sometimes afforded by an air-dielectric condenser. The moving plates are joined to the aerial lead, and one set of fixed plates is joined to earth and the other end to the aerial terminal of the set. This gives a very smooth control of volume and does not materially alter the tuning of the set. A more elaborate version, for use in band-pass circuits and other critical tuned circuits, is shown in Fig. 482. For this, a small semi-variable condenser of .0003 mfd. is joined between the earth terminal and one set of fixed plates. The semi-variable is adjusted until a value is reached where the setting of the moving plates of the differential does not have any effect on the tuning. This is

a very good arrangement. Fig. 483 shows another form of aerial control, using this time a variable resistance. The value should be 25,000 or 50,000 ohms, and should be of the potentiometer type, having three terminals. One end of the resistance element is joined to earth and the other end is joined to the aerial terminal via a small fixed condenser, value about .001 mfd. The arm is joined to the aerial. This gives a very fine control and does not affect tuning. If the rubbing contact is poor it is inclined to be noisy.

The final method we shall deal with is shown in Fig. 484, and for this a potentiometer of 50,000 ohms is required. It is joined across the aerial coil, the arm being taken to the grid of the first valve. This is a very good arrangement, provided the tuning coil is not seriously affected by the resistance shunted across it. Some coils will be badly upset, but in most cases this will be found as good an arrangement as Fig. 482.

Practically every receiver, of two valves or more, should be fitted with one of the volume-control devices mentioned, and improved quality on the local station will be the result of the outlay necessary for the extra parts.

W

WANDER PLUGS.—Small plugs, or brass pins fitted with springs or slotted, having ebonite ends. These are attached to flexible leads, and employed for varying the voltage applied to a circuit by inserting in sockets provided on batteries of the dry-cell type.

WATT.—The Unit of Power. It is the product of volts and amps.

WATT-HOUR. — A commercial unit of electric work. It is the work done in 1 hour by a current of 1 amp. flowing between two points

having a difference of potential of 1 volt.

WAVE-CHANGE SWITCH.—A switch included in a circuit to produce a change in the range of frequencies over which that circuit will tune. The present wavelengths employed by European broadcasting stations are between 200 and 600 metres, and there is then a gap until 1,000 metres. The gap is reserved for commercial stations, ships, etc. The higher wavelengths, as they are called, extend from 1,000 to 2,000 metres. It is necessary therefore to equip a broadcast receiver with some ready means of changing from the lower wave band to the upper band, and this is done by employing a coil large enough for the upper band, and short circuiting the unwanted part when using the lower band. The switch for carrying out this process is the wave-change switch.

WAVE FREQUENCY.—See *Frequency*.

WAVELENGTH.—The distance from the crest of one oscillation to the crest of the next. This distance is measured in metres.

WAVEMETER.—A device for measuring the wavelength of a received

signal, or setting a receiver to a predetermined wavelength in order to receive a particular station. The device consists of a coil tuned by a variable condenser, the latter having a calibrated dial. Across this tuned circuit is arranged a battery and small buzzer. If desired a switch may be included in order to avoid disconnecting the battery. When the buzzer is operated oscillatory currents are set up in the tuned circuit, and these can be picked up by a receiver over quite a considerable distance. If the dial of the wavemeter is set to a given wavelength and the buzzer put in action, upon rotating the tuning dial of your receiver you will find a spot where the oscillations from the buzzer are at a maximum. At this spot the receiver is tuned to the wavelength shown by the dial of the wavemeter. In order to enable sharp tuning to be carried out it is advisable to remove the wavemeter as far away as possible from the receiver. Furthermore, once the wavemeter has been calibrated, the coils and condenser should be enclosed in boxes so that they may not be damaged and the values altered. The diagram (Fig. 485) shows the circuit arrangement.

There are three types of wavemeter in general use. First, there is the "buzzer" meter, which is in reality a miniature "spark" transmitting station which can be tuned to known wavelengths. It consists of an oscillating circuit similar to the aerial circuit of a receiver. This is excited by a buzzer like that used in an electric bell. Secondly, there is the absorption wavemeter, which works by virtue of absorbing energy

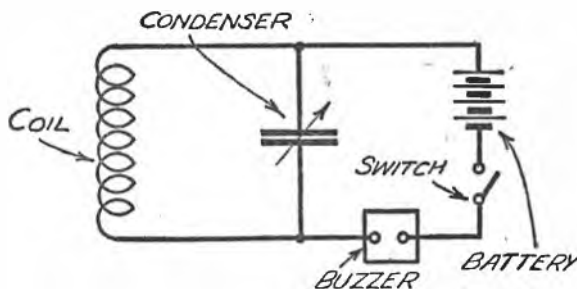


FIG. 485.—A Buzzer Wavemeter.

from the circuit of the set it is desired to calibrate. It consists essentially of a tuned circuit, comprising an inductance and a variable condenser. It is brought into close proximity to the

signal, or setting a receiver to a predetermined wavelength in order to receive a particular station. The device consists of a coil tuned by a variable condenser, the latter having

circuit to be calibrated. This latter has to be oscillating, but when the wavemeter is brought near it ceases to oscillate on the particular wavelength to which the wavemeter is tuned. This kind of wavemeter is very simple and requires no batteries, but it has the one drawback, that as it has to be brought very close to the circuit undergoing calibration it is sometimes difficult to use.

The heterodyne wavemeter is similar to the other two, in that it has a tuned circuit controlled by a variable condenser. This circuit, however, is made to oscillate by means of an ordinary valve. It might be compared to a one-valve receiver, in which the reaction is "turned on full" all the time. It is placed some little way from the set to be calibrated. The latter is then made to oscillate by advancing the reaction, and on tuning-in to the wavelength which the wavemeter is radiating, the familiar squeal one gets when passing a station with the reaction too far advanced is heard in the loud-speaker or 'phones. When this squeal is heard the wavelength of the meter is noted and the same figure marked on the dial of the receiver opposite where the pointer is.

A glance at Fig. 486 will be sufficient to show you that the little meter described here has just about the simplest circuit possible. It consists of two oscillating circuits—one for the medium and one for the long waves. Each consists of a grid coil and a reaction coil. The long-wave windings are in the form of loading coils which are brought into use by a three-point wave-change switch. An ordinary on-off switch is used to switch on the valve.

If a wavemeter is to be reasonably accurate, and what is most important, remain accurate, it must be carefully constructed, and must include only good-class components

which will not vary their characteristics in the course of time. It will be realised that any change in the value of the components will upset the readings and necessitate the re-calibration of the meter. It is for this reason that one valve must always be kept for the meter. A different valve would most likely throw the readings right out. In fact, it is best not to remove the valve at all unless you are certain of pushing it right home in its holder each time. It is the same with the other components—once they are fixed leave them alone, and try by all means to avoid the accumulation of dust, especially when accompanied with moisture.

The only part to be actually "constructed" is the coil. This is wound on a 3-in. diameter paxolin former 6 in. long. Wind the wire as evenly and tightly as possible, so that it will not shift later on and alter the wavelength. Pierce two small holes about $\frac{1}{4}$ in. from one end of the tube, and leaving a short length for connection, secure the wire through the holes. Then commence winding. Put on 55 turns, which by the way should consist of 24-gauge D.S.C. wire, and then make two more holes and finish off by threading the wire through the holes as before, leaving a short length for connections. This is the medium-wave grid coil. The reaction coil follows, and consists of 25 turns in the same direction composed of the same gauge wire. Leave a space of about $\frac{1}{4}$ in. before starting the long-wave coils. These consist of 170 and 50 turns for grid and reaction windings respectively. Fig. 486 will make the construction quite clear.

Mounting the Components. Fig. 487 gives a bird's-eye view of the layout with the panel represented as lying flat. Probably the first thing that will strike you as being somewhat unusual is the mounting of the

WAVEMETER

variable condenser. It is supported on a little ebonite panel of its own some way back from the panel. This is to reduce hand-capacity effects. If you are not familiar with heterodyne wavemeters you may not at once see the reason for this, but it is because there is no aerial or earth used with the meter. In a receiving set the moving vanes of the tuning condenser are connected to earth so that bringing one's hand, which is also at earth potential, into proxim-

tion. The original component used was intended as a reaction control, and was fitted with a small reaction condenser of the solid-dielectric type. This, of course, was removed, and an air-dielectric tuning condenser used instead as shown. If on ordering you explain to the makers that the condenser is not required, they will, no doubt, supply the dial and extension without this.

For the same reason that the condenser is placed some distance from

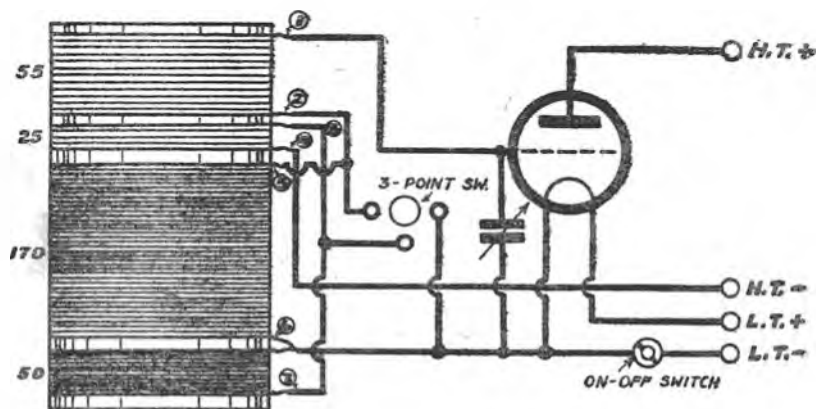


FIG. 486.—Diagram of coil connections for the Heterodyne Wavemeter shown in Fig. 487.

ity with them when tuning has no effect. The fixed vanes which are at high potential are screened by the moving vanes. Here, however, both the fixed and the moving vanes are at high potential, hence the need for placing the condenser some way back from the front panel. This is actually done by mounting it on a separate panel of its own and controlling it by an extension handle. The panel used is simply a piece of ebonite $2\frac{1}{2} \times 4$ in. held upright with two small panel brackets, and having a hole near the top for the condenser spindle to pass through. The control of the condenser is by means of a really good slow-motion dial with an ex-

the front panel, so also is the coil mounted well back. A piece of wood is fixed across the lower end of the coil with the aid of glue or one or two small brads, and then the wood is secured to the baseboard with screws. The rest of the arrangements are quite straightforward, and comprise the mounting of the two switches on the panel, the valve holder and the two terminal mounts with their four terminals.

Precautions in Wiring. Although the wiring is so simple it should not be carried out carelessly. Every wire should be as straight as possible and no fancy work indulged in, in the form of square corners or angles.

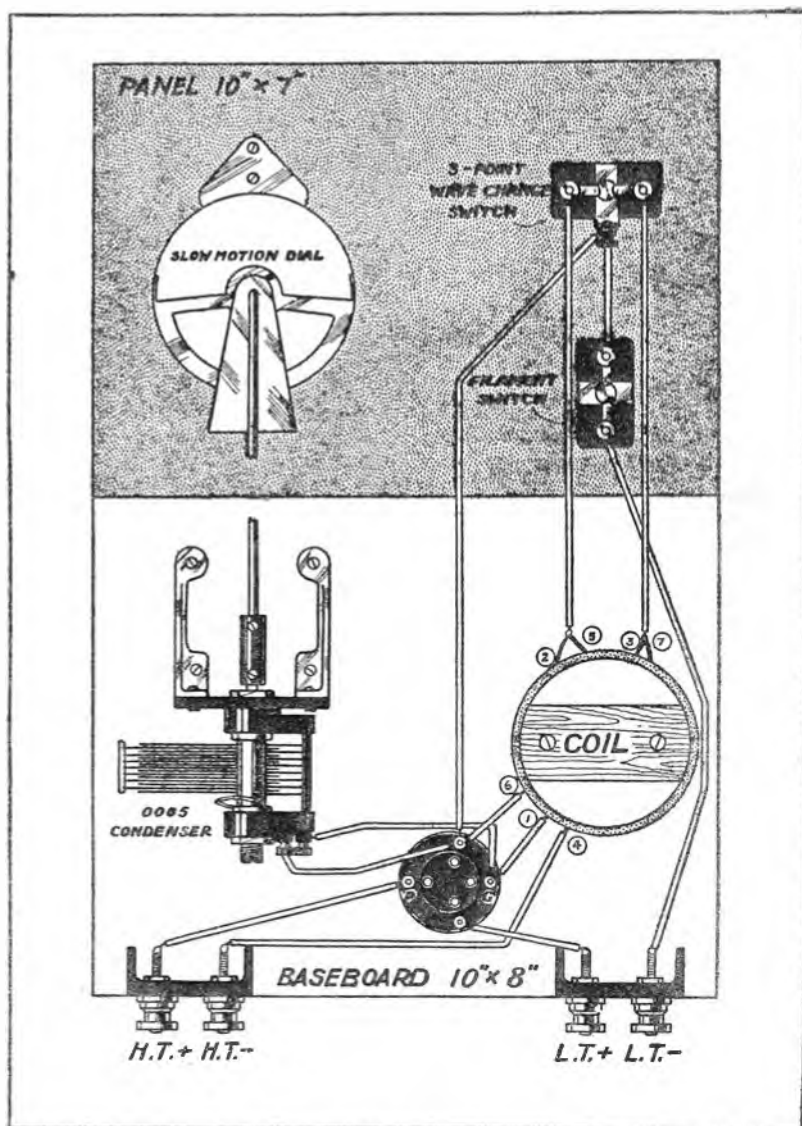


FIG. 487.—Wiring diagram for the Heterodyne Wavemeter.

WAVEMETER

Stiff wire is better than limp, as it is less likely to vary its position and so cause any slight inaccuracies in wavelength after the meter is calibrated. The same remarks apply to some extent to the wires from the set to the batteries, especially the H.T. battery. The best way is to build a cabinet to house both set and batteries and so do away with any trailing leads. It is advisable to solder all connections where possible. Where two wires from the coil are connected to the same terminal on the wave-change switch, it is best to solder them together as near to the coil as practicable, and take a single stiff connecting wire from this union to the switch terminal.

Calibrating and using the Meter. Calibration is carried out in the usual way with squared paper. Draw a line and mark it in the dial readings of the wavemeter condenser and another at right angles to it and mark it in wavelengths. Tune in a known station on a selective receiver, and tune the wavemeter to the same wavelength by turning its dial until it causes a howl right on top of the transmission being received. Mark the known wavelength of the station on the graph and also the dial reading of the wavemeter. In each case draw a pencil line in the usual way, from the point marked, so that the two lines follow the square lines of the paper, and where they cross mark the spot with a point. Repeat this procedure with as many known stations as possible. The graph is completed by joining up each of the points thus plotted with a line. This will not be straight but slightly curved. This plotting must be carried out for both wavelengths. Either make two graphs, or plot both curves on the same graph using, say, red ink for the medium-wave curve and blue ink for the long-wave one.

The meter is now calibrated, and to use it adopt the procedure mentioned in the first part of this section. Any set to be calibrated is set oscillating. Then rotate the knobs until the heterodyne whistle or squeal of the meter is picked up. It is already known to what wavelength one has previously set the meter, this having been done by means of the graph. Say it was 350 metres, perhaps 120° on the wavemeter dial. Well, then, since the set under test is tuned to the same wavelength as the meter it must be tuned to 350 metres. The meter is then set to another wavelength and the procedure repeated.

There are one or two points to be observed in calibrating and using the meter. One is always endeavour to keep the operating conditions the same. Do not, for instance, stand the meter on a wooden table one day and another time place it on an iron mantelshelf. Always keep the batteries at the same voltage. Here it may be mentioned that there is no need to use a higher value of H.T. than is necessary to keep the meter oscillating. Of course, it *must* oscillate, otherwise one won't get any note from it. If there is any difficulty in getting it to do so it means that one is not using enough H.T. or has an unsuitable valve. If one wishes one can, of course, use an earth connection to the meter, but then one must *always* use an earth, and if possible the same one, otherwise if an earth is used at one time and no earth at another the readings will be entirely different.

When calibrating a set one may, if the meter is too near, get a double hump to the heterodyne note as one does from a powerful broadcasting station. The true wavelength is at the silent point between the humps, but if the meter is placed farther away

WAVEMETER — WHEATSTONE BRIDGE

one will get just a single howl which is, perhaps, more satisfactory.

Another point to look out for is harmonics. A heterodyne meter gives out, besides the fundamental, several harmonics some distance on either side of the fundamental. These, although not nearly so strong, might possibly be mistaken for the real note where the wavelength of the set under calibration is entirely unknown. This trouble is not likely to arise with an ordinary broadcast receiver, however.

Components

- 1 '0005 mfd. low loss log condenser.
- 1 extended anti-capacity slow-motion reaction.
- 1 pair of $2\frac{1}{2}$ in. panel brackets.
- 4 terminals—H.T. +, H.T. -, L.T. +, L.T. -.
- 2 terminal mounts.
- 1 on-off filament switch.
- 1 three-point wave-change switch.
- 1 valve holder.
- Panels—one 10×7 in. and one $2\frac{1}{2} \times 4$ in.
- Baseboard, 10×8 in.
- 1 coil former 3×6 in.
- Wire for coil—about 2 oz. 24 D.S.C. and 2 oz. 30 D.S.C.
- 1 hank of connecting wire, 18 gauge.

WAVE TRAP.—A device inserted in the aerial lead for preventing interference. There are two forms of wave trap, an acceptor and a rejector. The former accepts the unwanted signal, whilst the latter rejects all but the wanted signal. The device in both cases consists of an oscillatory circuit, i.e. a coil and variable condenser. The acceptor circuit is connected in series with the aerial and the receiver, whilst the rejector is connected in parallel.

WET BATTERY.—A battery in which the electrolyte is in liquid form.

WHEATSTONE BRIDGE.—A device for measuring the value of a resistance by balancing it against other and known resistances.

Making a Wheatstone Bridge. This instrument is to the electrician as important as the balance to the

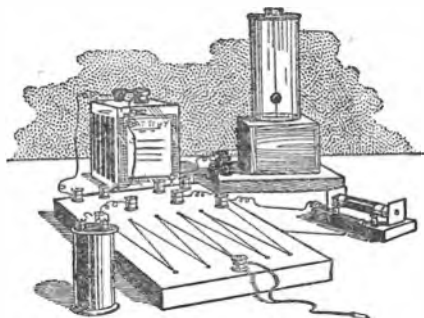


FIG. 488.—The Wheatstone Bridge and its associated apparatus.

chemist, and therefore is very useful to have.

It consists of a board 12×8 in. of very dry oak. If one cares to go to a little more expense, one can use ebonite.

Mount nine brass terminals upon it in the positions shown in Fig. 489. At 20, 40, 60, 80, are brass pins driven into the base $1\frac{1}{2}$ in. apart. At a distance of 7 in. from this row of pins is a row of five more, 10, 30, 50, 70, 90, the same distance apart, and arranged alternatively with the top row as shown.

The zigzag line is a length of bare Eureka resistance wire of 22 gauge—the same kind of wire that was used for the resistance box (which see) if it is bared, but Eureka resistance wire can also be bought bare.

Fasten one end under terminal R, and stretch it lightly in a zigzag manner round the brass pins as shown, finishing off under terminal X¹.

Rule eleven horizontal lines across

WHEATSTONE BRIDGE — WIMSHURST MACHINE

the board as shown, $\frac{1}{16}$ in. apart, and number the intersections of these lines with the resistance wire.

Board Connections. The dotted lines represent connections at the back of the board with thick copper wire. Be careful to join up the correct terminals—R to B, B' to X', R' to X, G' to Z, G to the middle of the R'X wire. Solder all connections if possible, but remember that a good screwed-up connection is

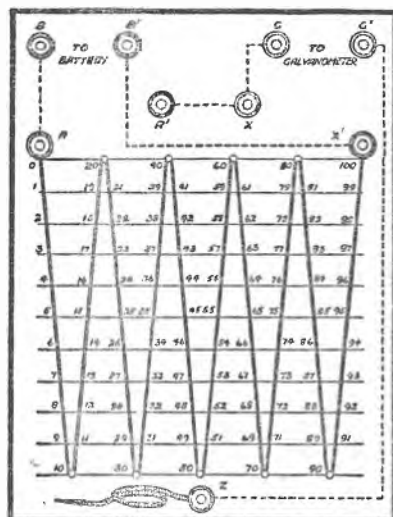


FIG. 489.—A detailed sketch of the Wheatstone Bridge, showing its construction.

better than a badly soldered one. A battery is joined up between B and B', and the galvanometer between G and G'.

The instrument is used commonly to find the resistance of a wire or given circuit.

Suppose one wants to find the resistance of a certain piece of wire. Connect it up between X and X'. Between R and R' connect up a standard resistance coil, say 5 ohms.

To the terminal Z is connected a length of flexible wire, with a short

tag of stiff copper wire soldered to the end of it.

When everything is connected up, touch the zigzag wire with this flexible lead. The galvo needle moves violently. Try different spots on the zigzag wire, and one will eventually find the one where the galvo needle is unaffected.

The Formula. Note the number of this spot by means of the parallel lines and figures. Suppose the spot is 25.

By using the following formula find the resistance of the wire :

$$\frac{100 - N}{N} XR = X,$$

where N = the number on the board,
R = the standard resistance,
X = the unknown resistance.

$$\text{Then } \frac{100 - 25}{25} X_5 = X$$

$$\frac{75}{25} X_5 = X,$$

whence the resistance of the wire is 15 ohms.

If the unknown quantity is suspected of being high resistance, a high standard resistance should be used. One can easily make the standard resistances, remembering that the Eureka 22 gauge is 1 ohm per 33 in. For 5 ohms, cut off 165 in., plus 1 in. for connections. Coil this round a small cardboard cylinder, leaving 2 in. free at either end for connections. When placed in the bridge, $\frac{1}{2}$ in. of the wire should go under each terminal to give the correct resistance between the terminals.

WIMSHURST MACHINE. — A machine for producing static charges. It consists of two glass or similar insulating discs having a number of strips of tinfoil attached to one side. These are rotated close to each other, but in opposite directions. Small tinsel brushes touch the tinfoil strips,

WIRE GAUGES — WOOD SCREW PROPORTIONS

and collecting combs are also arranged close to the brushes. Charges are produced by induction, and are conveyed to a Leyden jar. Perfect dryness is essential for the apparatus to work satisfactorily.

WIRE GAUGES.—Instrument wires are numbered according to their thickness, and this numbering is standard. Consequently it is known as Standard Wire Gauge, abbreviated to S.W.G.

INSTRUMENT WIRE GAUGES

No.	Dia.	No.	Dia.
4/0	.409	24	.022
3/0	.372	25	.020
2/0	.348	26	.018
0	.324	27	.0164
1	.300	28	.0148
2	.276	29	.0136
3	.252	30	.0124
4	.232	31	.0116
5	.212	32	.0108
6	.192	33	.0100
7	.176	34	.0092
8	.160	35	.0084
9	.144	36	.0076
10	.128	37	.0068
11	.116	38	.0060
12	.104	39	.0052
13	.092	40	.0048
14	.080	41	.0044
15	.072	42	.0040
16	.064	43	.0036
17	.056	44	.0032
18	.048	45	.0028
19	.040	46	.0024
20	.036	47	.0020
21	.032	48	.0016
22	.028	49	.0012
23	.028	50	.0010

The first column in the above table is the S.W.G. number and the second column gives the diameter in inches. (See also *Coil*.)

WIRE RESISTANCE.—See *Resistance Wire* on page 13.

WIRED WIRELESS.—A process of sending wireless signals along a wire, using the wire to conduct the high-frequency currents. This method permits of a telephone line being used for its legitimate purpose of carrying telephonic communications, whilst at

the same time carrying the wireless signals. They do not interact.

WOLLASTON WIRE.—A very fine platinum wire which is coated with silver.

WOOD SCREWS.—The diameter of the fixing screws used to secure components to the baseboard should be such that they comfortably fit the holes, and for reference the following list of small-hole diameters and corresponding sizes of wood screws that will fit them with reasonable accuracy will be found handy from time to time: $\frac{1}{8}$ -in. diam., No. 00; $\frac{1}{16}$ -in. diam., No. 2; $\frac{1}{8}$ -in. diam., No. 5; $\frac{3}{16}$ -in. diam., No. 7; and $\frac{1}{4}$ -in. diam., No. 9.

WOOD SCREW PROPORTIONS

TWIST DRILLS FOR WOOD SCREWS

No. (or size) of Screw.	Dia- meter of Neck or Shank.	For Wood or Metal.		With Side Lips and Centre for Wood only.	
		No., etc.	Dia- meter.	Size.	Dia- meter.
1	.066	51	.067	—	—
2	.080	46	.081	—	—
3	.094	41	.096	—	—
4	.108	35	.110	—	—
5	.122	30	.128	$\frac{1}{8}$	.125
6	.136	28	.140	$\frac{1}{4}$	.136
7	.150	23	.154	$\frac{3}{8}$	.150
8	.164	18	.169	$\frac{1}{2}$	.167
9	.178	14	.182	$\frac{3}{4}$	.187
10	.192	9	.196	$\frac{7}{8}$	.198
11	.206	4	.209	$\frac{1}{2}$	.218
12	.220	1	.228	—	—
13	.234	E	.238	—	—
14	.248	H	.250	$\frac{1}{2}$	.250
15	.262	K	.266	—	—
16	.276	M	.281	$\frac{3}{8}$	.281
17	.290	O	.295	$\frac{1}{2}$	.295
18	.304	P	.316	$\frac{3}{4}$	.312
19	.318	R	.323	$\frac{1}{2}$	.323
20	.332	S	.339	—	—
21	.346	T	.348	—	—
22	.360	U	.368	$\frac{1}{2}$	.375
23	.374	V	.377	$\frac{3}{8}$	.375
24	.388	X	.397	—	—
25	.402	Z	.413	$\frac{1}{2}$	.406
26	.416		.421	—	—
27	.430		.437	$\frac{1}{2}$	.437
28	.444		.453	—	—
29	.458		.465	$\frac{3}{8}$	.468
30	.472		.484	$\frac{1}{2}$	.480
31	.486		.500	$\frac{1}{2}$	.500
32	.500		.513	$\frac{1}{2}$	.500

All dimensions in parts of an inch.

WOOD SCREW PROPORTIONS — ZINCITE

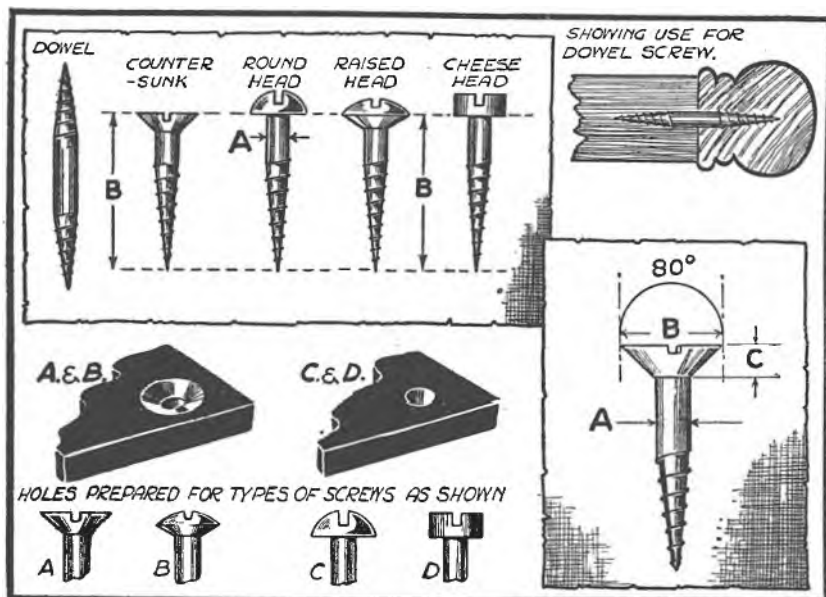


FIG. 490.—Wood Screw proportions and types.

STANDARD WOOD SCREWS

No. of Screw. Gauge	Dia- meter. Dec.	A In. Approx. Fraction.	B In.	C In.	Slot.	
					Width.	Depth.
0	·05784	★	★	★	★	★
1	·07100	★	★	★	★	★
2	·08416	★	★	★	★	★
3	·09732	★	★	★	★	★
4	·11048	★	★	★	★	★
5	·12364	★	★	★	★	★
6	·13680	★	★	★	★	★
7	·14996	★	★	★	★	★
8	·16312	★	★	★	★	★
9	·17628	★	★	★	★	★
10	·18944	★	★	★	★	★
11	·20260	★	★	★	★	★
12	·21576	★	★	★	★	★
13	·22892	★	★	★	★	★
14	·24208	★	★	★	★	★
15	·25524	★	★	★	★	★
16	·26840	★	★	★	★	★
17	·28156	★	★	★	★	★
18	·29472	★	★	★	★	★
19	·30788	★	★	★	★	★
20	·32104	★	★	★	★	★
21	·33420	★	★	★	★	★
22	·34736	★	★	★	★	★
23	·36052	★	★	★	★	★
24	·37368	★	★	★	★	★

WOOD'S METAL.—A special soft solder employed to fix crystals in the holder. It consists of 1 part of tin, 4 parts of bismuth, and 1 part of cadmium. It melts at about 60° Centigrade. (See also *Crystals*.)

X

X-RAYS.—The name given to the rays of light which are produced by passing a current through a vacuum tube. These rays possess the property of passing through opaque bodies. Another term for them is Röntgen rays.

X's.—The term given to static or atmospheric disturbances. (See also *Static*.)

Z

ZINCITE.—A crystal formed from oxide or zinc. Used in conjunction with bornite or copper pyrites. (See also *Crystals*.)