

1929

THE
PRACTICAL
WIRELESS
ENCYCLOPÆDIA

By
F. J. CAMM

The Only Work of its Type

Compiled by an acknowledged expert, this volume forms a complete guide, in alphabetical order, to the construction, operation, repair and principles, of every type of wireless receiver, including definitions, explanations, formulæ and complete instructions on the making and testing of various wireless components.

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THE PRACTICAL WIRELESS ENCYCLOPÆDIA

A Complete Guide to the Principles, Construction,
Operation, Repair, and Overhaul of all types of Wireless
Receivers and Components, including Definitions of all
Terms and Units

By

F. J. CAMM

(Fellow, Royal Society of Arts)

Editor of

*“Practical Wireless,” “Practical Motorist,” “Practical
Mechanics,” “Practical Engineering,” “Cyclist,” and
“Bicycling News”*

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THE
PRACTICAL WIRELESS ENCYCLOPÆDIA

By the same Author

Newnes' Television and Short-wave Handbook
Everyman's Wireless Book
Home Mechanic Encyclopædia
Practical Motorist's Encyclopædia
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Sixty Tested Wireless Circuits
Flying Reference Book
Watches : Adjustment and Repair
Practical Wireless Short-wave Manual
Dictionary of Metals and Alloys, etc., etc.
More Miles Per Gallon

PREFACE TO THE SEVENTH EDITION

IN this Seventh Edition I have included new terms and definitions and considerably amended the text throughout; a great amount of new matter has also been added. The practical information on the making of various components has been retained, particularly that relating to intermediate-frequency transformers, oscillator coils, mains transformers, and chokes. Additionally, the title of the work has been changed from the *WIRELESS CONSTRUCTOR'S ENCYCLOPÆDIA* to the *PRACTICAL WIRELESS ENCYCLOPÆDIA*. There have been no radical changes in design since the last edition went to press in March 1938, and the present edition, therefore, reflects the latest position of the science and its kindred subjects.

Well over 200,000 copies of this book have been sold since it was introduced, and it has circulated in every country. It remains the only work of its type, and represents the only effort to present in encyclopædic form an easily referred to, practical work, incorporating the accumulated knowledge of radio scientists. It is a work which indexes itself and is presented in a form which beginner and expert will appreciate. I am gratified to note that it has become the standard work of reference for radio designers, students, and teachers. Once again I express my thanks to readers all over the world who have made suggestions for subjects to be treated in future editions.

F. J. CAMM
(Editor, *Practical Wireless*).

ABBREVIATIONS

- A.—Anode, or plate.
 A.A.—Artificial aerial.
 A.C.—Alternating current.
 A.E.—Aerial.
 A.F.—Audio frequency.
 A.F.C.—Automatic frequency control.
 A.G.C.—Automatic gain control.
 A.T.C.—Aerial tuning condenser.
 A.T.I.—Aerial tuning inductance.
 A.V.C.—Automatic volume control.
 A.V.E.—Automatic volume expansion.
 B.A.—British Association.
 B.C.L.—Broadcast listener.
 B.F.O.—Beat frequency oscillator.
 B.O.T. Unit—Board of Trade unit = 1,000 watt-hours, or 1 kilowatt-hour.
 C.C.C.—Closed circuit or secondary condenser or S.T.C.
 C.C.I.—Closed circuit or secondary tuning inductance or S.T.I.
 cm.—centimetre.
 C.P.—Candle power.
 C.W.—Continuous waves.
 D.A.V.C.—Delayed A.V.C.
 db.—decibel.
 D.C.—Direct current.
 D.C.C.—Double cotton covered.
 D.E.—Dull emitter.
 D.F.—Direction finding, or direction finder.
 D.P.—Difference of potential.
 D.P.D.T.—Double pole double throw.
 D.P.S.T.—Double pole single throw.
 D.S.C.—Double silk covered.
 D.X.—Long distance.
 E.—Earth.
 E.M.F.—Electro-motive force.
 F.—Filament.
 G.—Grid.
 G.B.—Grid battery or grid bias.
 G.C.—Grid condenser.
 G.L.—Grid leak.
 H.F.—High frequency (same as radio frequency).
 H.F.C.—High-frequency choke.
 H.P.—Horse power.
 H.R.—High resistance.
 H.T.—High tension.
 I.C.—Intermittent current.
 I.C.W.—Interrupted continuous waves.
 I.F.—Intermediate frequency.
 I.P.—In primary (of transformer); start of primary.
 I.S.—In secondary (of transformer); start of secondary.
 kw.—Kilowatt = 1,000 watts.
 L.F.—Low frequency.
 L.F.C.—Low-frequency choke.
 L.R.—Low resistance.
 L.S.—Loudspeaker.
 L.T.—Low tension.
 mfd.—micro-farad.
 mhy.—microhenry.
 mm.—millimetre.
 mmfd.—micro-micro-farad.
 O.L.—Output load.
 O.P.—Out primary (of transformer); end of primary. Also output.
 O.S.—Out secondary (of transformer); end of secondary.
 P.—Plate, or anode.
 P.A.—Public address.
 P.D.—Potential difference, same as D.P.
 P.M.—Permanent magnet.
 Pot.—Potentiometer.
 P.V.—Power valve.
 Q.A.V.C.—Quiet automatic volume control.
 Q Code.—See p. vii.
 Q.M.B.—Quick make and break.
 Q. P.-P.—Quiescent Push-pull.
 R.F.—Radio frequency (same as high frequency).
 R.M.S. Value—Root-mean-square value.
 Rx.—Receiver.
 S.C.C.—Single cotton covered.
 S.I.C.—Specific inductive capacity.
 S.P.—Series parallel.
 S.P.D.T.—Single pole double throw.
 S.P.S.T.—Single pole single throw.
 S.S.C.—Single silk covered.
 S.T.C.—Secondary tuning condenser.
 S.T.I.—Secondary tuning inductance.
 S.W.G.—Standard wire gauge.
 S.W.L.—Short-wave listener.
 T.R.F.—Tuned radio frequency.
 T.T.—Tonic train.
 Tx.—Transmitter.

SYMBOLS

Admittance	Y	Resistivity	ρ
Amplification Factor	μ	Self-inductance	L
Capacity	C	UNITS	
Current	I	Ampere	A
Conductance	G	Ampere-hour	Ah
Dielectric Constant	ϵ	B.O.T. Unit = 1,000 watt-hours, or 1 kilowatt-hour	
Efficiency	η	Coulomb	C
Electrostatic Flux Density	D	Farad	F
E.M.F. (voltage)	E	Henry	H
Energy	W	Joule	J
Frequency	f	Kilovolt-ampere	kVA
Impedance	Z	Ohm	Ω
Magnetic Field	H	Volt	V
Magnetic Flux	Φ	Volt-ampere	VA
Magnetic Flux Density	B	Watt	W
Period Time	T	Watt-hour	Wh
Permittivity	κ	PREFIXES	
Phase Angle	ϕ	Kilo	k
Power	P	Mega	M
Quantity	Q	Micro	μ
Reactance	X	Milli	m
Reluctance	S		
Resistance	R		

THE INTERNATIONAL CODE OF ABBREVIATIONS

The chief Abbreviations used by Amateurs to form a rapid means of communicating information in code.

Q CODE

- | | |
|--|---|
| QRA—The address of the station is . . . | QRO—Increase power. |
| QRB—The approximate distance between our stations is . . . | QRP—Decrease power. |
| QRG—Your frequency is . . . kilocycles. | QRT—Stop transmitting. |
| QRH—Your frequency varies. | QRU—I have nothing more for you. |
| QRJ—I cannot receive you. | QSA—Signal strength (see QSA code below). |
| QRK—Your signals are good. | QSL—An acknowledgment of reception (i.e. QSL card). |
| QRM—Interference. | QSO—A communication or contact. |
| QRN—Atmospherics. | |

THE QSA CODE

- | | |
|---|--|
| QSA1—Hardly perceptible. | XX—Strong static. |
| QSA2—Weak signals, readable only now and then. | XXX—Very strong static. |
| QSA3—Fairly good reception, readable with difficulty. | N—No static. |
| QSA4—Good, readable signals. | F—Slight fading. |
| QSA5—Very good signals, perfectly readable. | FF—Fairly strong fading, but the transmission still intelligible. |
| | FFF—Very strong fading, with complete loss of transmission at times. |
| X—Slight static. | |

R CODE

- | | |
|---|---|
| R1—Very faint signals, unintelligible. | R7—Good, clear reception that comes through interference. |
| R2—Weak reception, unintelligible. | R8—Very strong signals heard several feet from the 'phones. |
| R3—Weak reception, but partly intelligible. | R9—Extremely strong signals. |
| R4—Fair signals, just intelligible. | |
| R5—Moderately strong signals. | |
| R6—Good reception. | |

T CODE

- | | |
|-------------------------------------|--|
| T1—Very bad A.C. ripple. | T7—Pure D.C. note, but key clicks noticeable. |
| T2—Rough, A.C. ripple. | T8—Pure D.C. note, but not as good as T9. |
| T3—Bad ripple on note. | T9—Fine, steady, crystal-controlled D.C. note. |
| T4—Small ripple on note. | |
| T5—Nearly D.C., but bad key thumps. | |
| T6—Good note, but not quite pure. | |

THE SHORTHAND OF WIRELESS

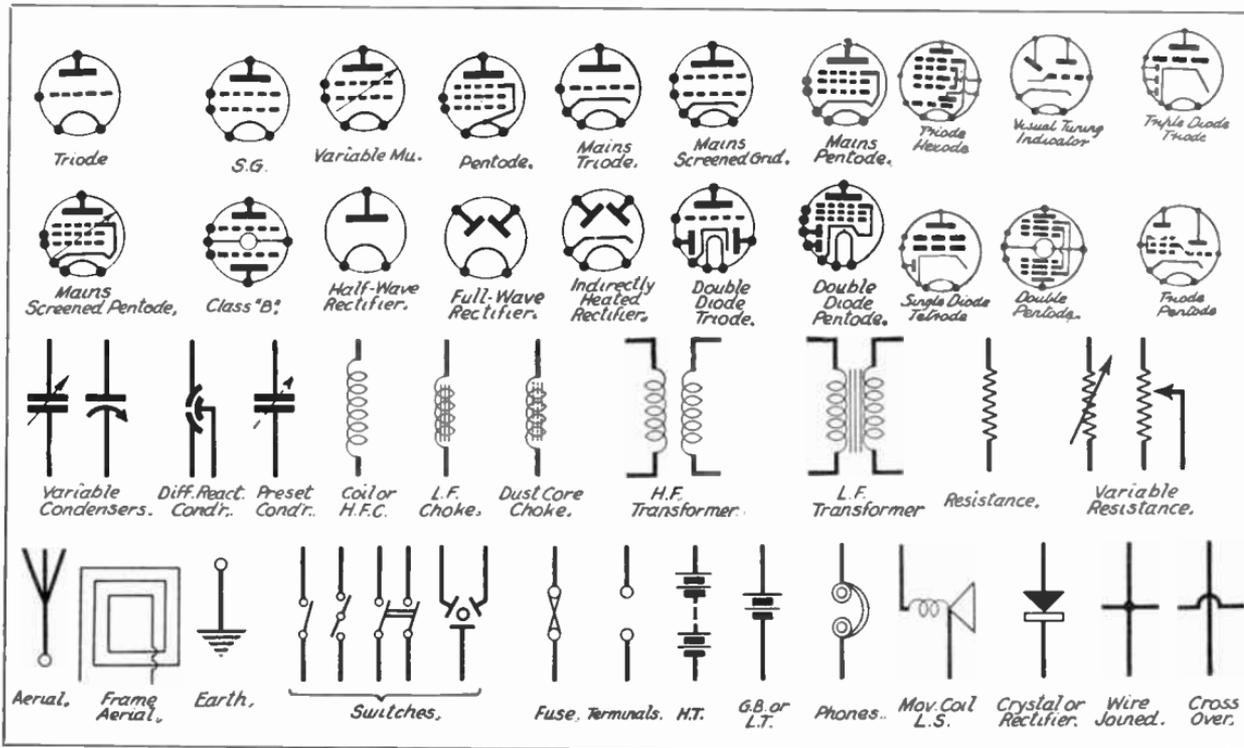


FIG. 1.—Diagram of the conventional signs used in drawing a wireless circuit, which merely consists of a number of these signs joined together. Pictorial diagrams showing the actual components represented are given in the book in their correct alphabetical order.

THE PRACTICAL WIRELESS 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. A nomogram.

ABAMP.—The absolute electromagnetic unit of current—that current which, passing along a wire of 1 cm. length, bent into an arc of 1 cm. radius, will exert a force of one dyne on a unit magnetic pole placed at the centre. One abamp equals 10 amperes; one ampere equals one-tenth of an absolute unit of current. (See *Weber.*)

ABBREVIATIONS.—See page vi.

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

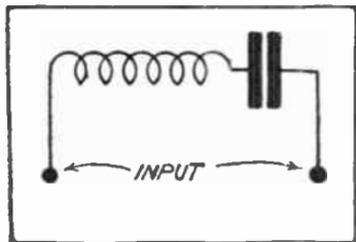


FIG. 2.—Acceptor Circuit.

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 Wave-trap, where a coil with series condenser is arranged in series with

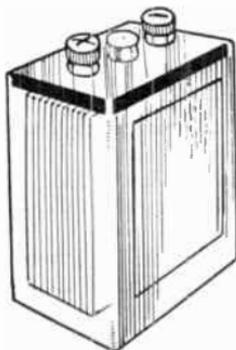


FIG. 3.—Theoretical and actual diagram of an Accumulator. Note that the thick line is always the negative in a theoretical diagram.

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. (See *Rejector Circuit.*)

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 the 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

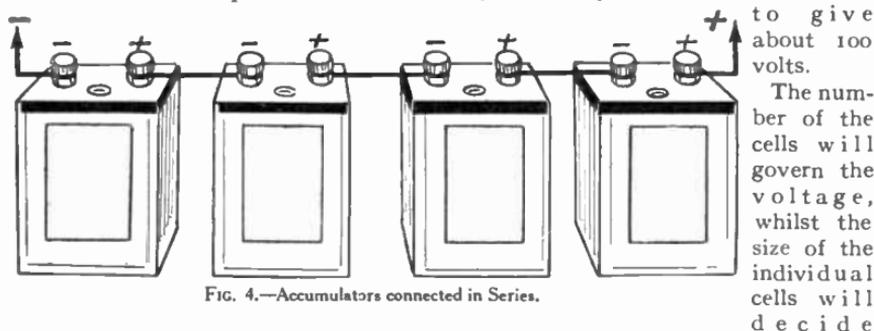


FIG. 4.—Accumulators connected in Series.

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 accumulators 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 large accumulator possesses greater storage capacity than a small one and, 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

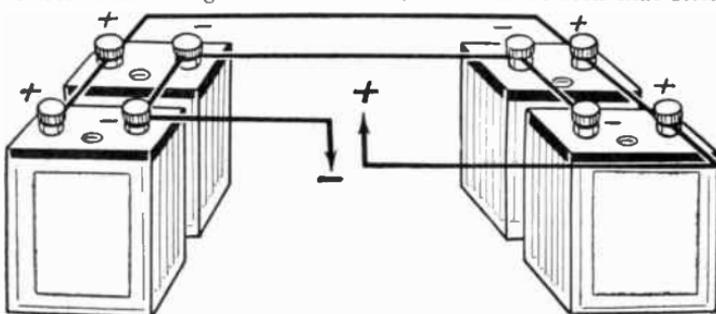


FIG. 5.—Accumulators connected in Parallel.

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 for house-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 stored in a wet condition.

How to dilute Acid. Pure brimstone sulphuric acid is supplied in carboys, and can be obtained broken down to 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.

ACCUMULATOR CHARGING FROM ALTERNATING CURRENT.

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 approximately half of 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 re-

ACCUMULATOR CHARGING

moved during the first charge to allow the gas generated to disperse. 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

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 metal rectifier is the most suitable.

The Motor Generator. There are on the market a number of motor

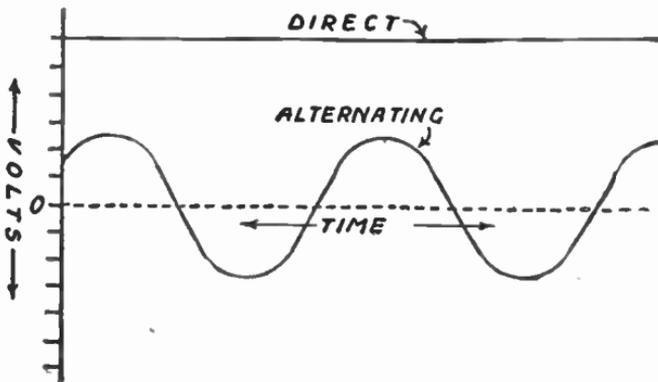


FIG. 6.—Graph illustrating difference between Direct and Alternating Current.

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

WIND-CHARGERS

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)

disaster in a gale and yet be sufficiently sensitive to develop useful power in winds of light or moderate velocity.

This brings us to the necessity for some definition as to what constitutes the difference between a breeze and a

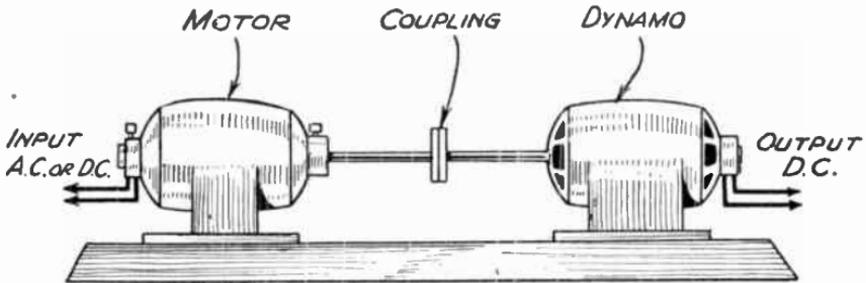


FIG. 7.—Diagram showing the principle of the Rotary Converter and Rotary Transformer. A motor, either A.C. or D.C., is driven from the mains and coupled to a D.C. generator which charges the accumulators. In practice one machine acts both as motor and dynamo.

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 sparking at the commutator, necessitating frequent renewal.

WIND-CHARGERS. — Another method of charging, which has much to recommend it, consists of driving a dynamo or generator by means of wind sails. Although wind power in this country is apt to be rather erratic, far too much of it at times and not enough of it at others to provide any useful results, it is a notable fact that, taken over a long period, careful observations have proved that serviceable wind power is available for an average of eight hours per day in the majority of localities, if the site is carefully chosen.

The problem with wind motors is, of course, to control the variations in speed arising from extreme weather conditions, such as periods of calm, on the one hand, and tempests on the other. A wind motor to be successful must be so constructed as to resist

hurricane. The Meteorological Office has compiled a table known as "Beaufort Scale Numbers" which are attributed to winds of varying force according to their characteristics as below :

Beaufort Scale	Corresponding Wind	Velocities in Miles per Hour
0	Calm	Under 2
1 to 3	Light Breeze	2 to 12
4 to 5	Moderate Wind	13 to 23
6 to 7	Strong Wind	24 to 37
8 to 9	Gale	38 to 55
10 to 11	Storm	56 to 75
12	Hurricane	Above 75

The indispensable parts in any such outfit comprise (1) the constant-voltage dynamo, (2) the propeller, (3) a tailpiece to keep the propeller in the wind, (4) the collector rings for conveying current from the movable head to fixed terminal points, and (5) the mast upon which the whole is mounted.

So far as the generator is concerned there are plenty of good secondhand car lighting dynamos to be picked up

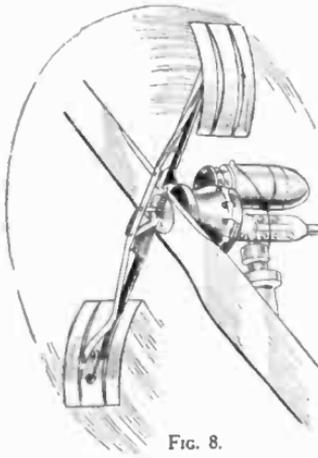


FIG. 8.

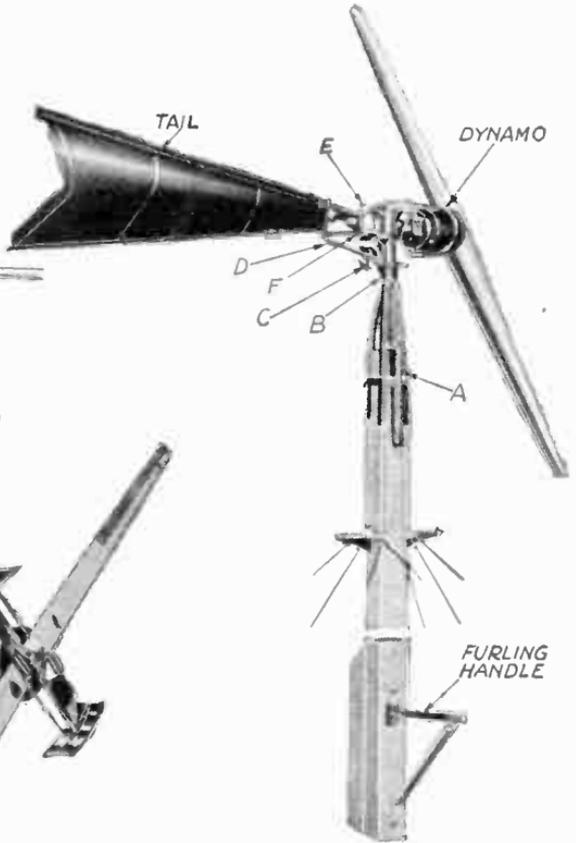


FIG. 11.—A Commercial Wind-Charger, with furling tail.

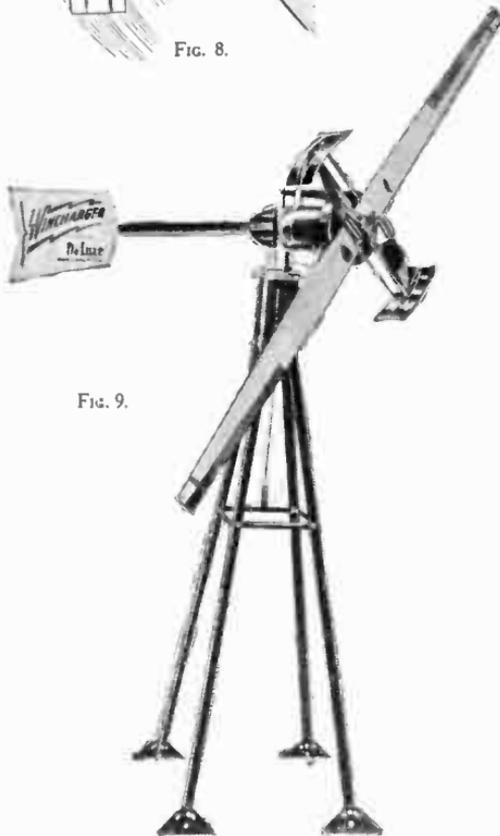


FIG. 9.

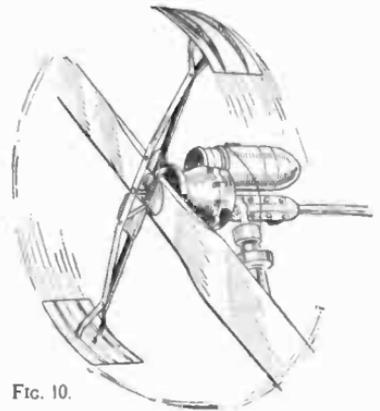


FIG. 10.

FIGS. 8 to 10.—An addition to the 2-blade main propeller in the form of small blades hinged at one end, which open out at excess speeds.

WIND-CHARGERS

cheaply, of a type illustrated in Fig. 12. This is one of the most popular models, and makes a very serviceable unit, cutting in for charging at 850 r.p.m. and giving its full output of 12 volts 13 or 14 amperes at about 1,350 r.p.m. If larger models happen to be available they can, of course, be used, and the lower the cutting-in speed the more serviceable will they be in light winds.

The Propeller. Item (2), the propeller, will no doubt demand some little patience and several modifications before a satisfactory home-made

carrying it consisting of a length of seamless steel conduit about 1 in. diameter, such as used in electric wiring, attached to the revolving head by saddles at each extremity.

The Rotatable Head. The rotatable head with the collector rings needs planning out with a view to utilising whatever material happens to be available in the workshop, and dimensions are of secondary importance, so long as the collector is not too small, say, 3 in. in diameter. The main idea is sketched out in Fig. 13, but is not to scale, for reasons stated

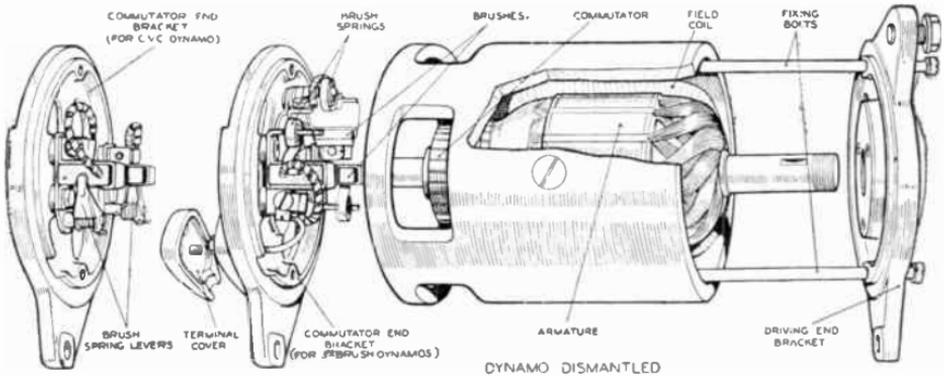


FIG. 12.—A car lighting dynamo, showing construction.

article is arrived at. Lightness and strength is, of course, essential, as the centrifugal effect and thrust will be considerable at high speeds. A well-seasoned piece of straight grained pine or cedar will be required, in one piece 6 ft. long and $1\frac{1}{2}$ in. thick, tapering from $6\frac{1}{2}$ in. wide at the hub to $3\frac{1}{2}$ in. or 4 in. at the tips, fashioned on the lines shown in Figs. 9 and 11, the pitch of the blades being about 35 degrees measured from the plane of rotation. The boss needs strengthening by a flanged double-arm casting, keyed to the dynamo shaft and retained by an end lock nut.

The design and proportions of the sheet-metal tailpiece are obtainable from Fig. 9, the extension arm

above. As shown in this figure, the wood mast A terminates in four angle pieces of $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. mild steel B, not less than 12 in. long, which are arranged to grip the mast with four straps and bolts S. These angle pieces stand up six inches beyond the end of the mast, and a flanged steel plate C is screwed to them to form a rigid metal top. Above this is the rotatable table E to which the dynamo is fixed, and from the underside of which extends a central tube G carrying the two insulated sliprings H. From these rings current can be collected, whatever may be the position in which the dynamo is pointing, by means of two insulated cartridge-type carbon brush-holders K. An outer casing L which

WIND-CHARGERS

serves for their mounting is fixed to C and forms a protection from wet or dust, and is drawn in section to expose the collector rings.

through a cross strap riveted to the angles B, with a nut P to prevent it from rising.

The design of the head is to be taken as a suggestion and subject to variation according to means and experience. It forms a workable basis for building up a practicable wind-driven lighting installation capable of providing a good light to four or five bulbs of 25-watt size, when working in conjunction with a 12-volt car accumulator.

A Mechanical Governor. Some attempts have certainly been made to steady the charging current by the addition of a mechanical governor or wind-diverter, or even a small wind vane attached to the tail to move the propeller into less effective positions with increasing force of the wind. One example is given in Fig. 10, showing an addition to the 2-blade main propeller in the form of small blades hinged at one end which open out at excess speeds by centrifugal effect and cause the wind stream to diverge before reaching the main propeller blades. This device is used in the "Wincharger" outfits manufactured by an American Company. In these

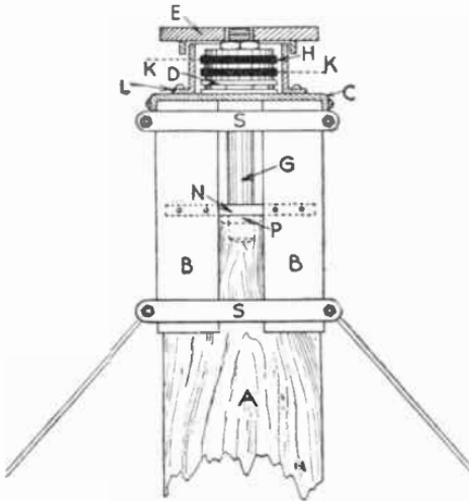


FIG. 13.—Details of the rotatable head.

Connections from the dynamo terminals are brought down through the hollow stem G, one being attached to each slipping. Between the underside of the slipping assembly and the

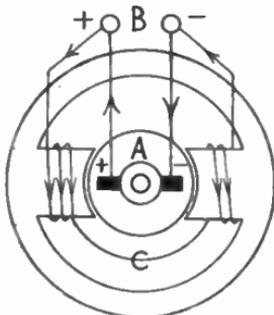


FIG. 14.—A constant voltage dynamo.

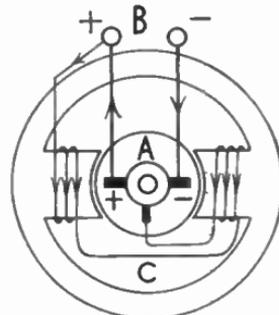


FIG. 15.—A shunt-wound 2-pole dynamo.

fixed head C may be placed a ball thrust washer D to carry the whole weight of the dynamo and propeller. The extremity of the stem at N is guided and supported by passing

the natural regulation of the constant-voltage dynamo is augmented by the action of the air-brake, seen at right angles to the propeller, when a critical speed is exceeded. An English set is

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illustrated in Fig. 11, which relies principally on the self-governing properties of the dynamo, aided by a furling action of the wind motor-tail. The operation of this device, as supplied by the makers, is as follows, the parts referred to being illustrated in Fig. 11. When the furling handle is moved downwards to bring the set into operation, a metal collar B is slid down the shaft against the tension of spring A. The whole of the head gear is free to rotate within the metal collar. A forked member C is engaged with the collar and is moved downwards about its pivot by the collar. A lever arm F attached to the forked member engages the tail bracket E, causing it to be moved outwards against the tension of spring D. When furling, the reverse takes place. Release of the furling handle relieves spring A and allows the metal collar to slide up the headgear. This lifts the forked member, the lever arm F is disengaged from the tail bracket, and the tail is thus returned to the furled position by spring D. In the event of very strong winds likely to cause excess speeds the tail is swung back and out of the wind with a consequent regulation of the dynamo speed.

The Electrical Circuit. Apart from details of design, such as are shown in the foregoing illustrations, the electrical circuit is similar in all such outfits, and in its simplest form without any switches, instruments, or other complications, consists of placing the dynamo and battery in parallel.

But there must be some automatic means of preventing current from the battery discharging back through the dynamo when the latter is not running fast enough to charge. Also, switches are required to control individual lamps, and an ammeter to measure the charge or discharge current in the accumulator circuit.

Readers who feel that the profes-

sionally made wind-electric charging sets are beyond their means, may care to consider those illustrated in the foregoing as suggestions for building up home-made outfits with such variations as they care to introduce, and making use of such material as happens to be available, modifying the general design accordingly. They will be well advised, however, to regard simplicity of design as the first essential, and bear in mind that the wind-electric outfit is not always a fine-weather equipment, and must be substantially built so as to withstand storm and tempest.

Any lighting system to be practicable must be so designed as to allow a reasonably constant voltage to be maintained at the terminals. Much the same problem confronts the automobile industry; the considerable variations of engine speed which occur during road use have to be counteracted by some means before lighting from the car dynamo can become satisfactory, and in this there is a definite resemblance between motor-car generators and wind-driven dynamos. In the car, engine speeds must of necessity vary in order to meet the conditions imposed by gear-changing, gradients, traffic conditions, etc. In the wind generator similar speed variations are unavoidable with changes in the wind velocity. The battery being charged, however, helps to "absorb" the fluctuation.

Constant Voltage Generator. The motor industry solves this problem by the development of the so-called "constant voltage" generator, which permits of a fairly constant voltage being obtained from its terminals at widely different driving speeds by a special construction, and by the use of a "floating battery" used in conjunction with it.

There are, in fact, a good many different devices for obtaining constant voltage at varying speeds, but the

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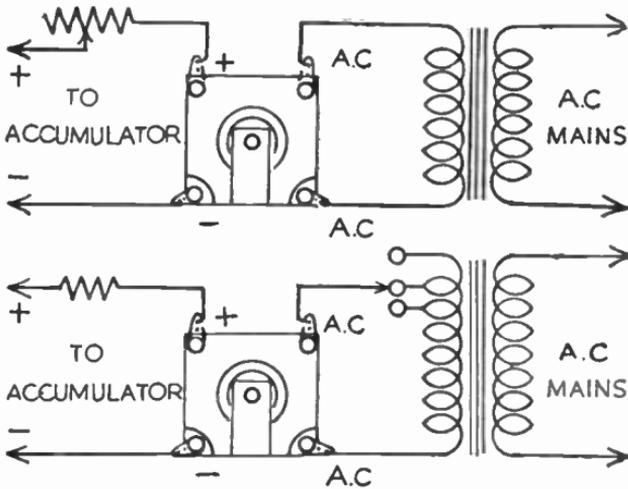


FIG. 16.—Two standard methods of employing a metal rectifier for charging accumulators.

cooling fin interspersed at frequent points to dissipate the heat and thus prevent damage.

Various methods of connection are possible, according to the use to which the rectifier is to be put. The metal rectifier is very robust in construction and has a higher efficiency than most other types of rectifier.

Fig. 16 shows the theoretical symbol for the metal rectifier, ar-

most popular is the one known as "third-brush control." In the case of the ordinary shunt-wound 2-pole dynamo, such as used for stationary lighting sets, engine-driven at a closely governed speed, there are two brushes only at opposite positions on the commutator, see Fig. 14. The windings form two distinct circuits, one through the armature A and brushes to the main terminals B and so direct to the lamps or battery; the other is an independent and separate circuit C through the fields only, a small current being "shunted" from the main terminals for the sole purpose of exciting the field magnet coils.

Metal Rectifiers. This type of rectifier has developed to such an extent that it competes favourably with the valve rectifier.

In brief, the principle upon which the metal rectifier operates is that copper in contact with a certain oxide permits of the flow of current in one direction only.

In the metal rectifier which is used in wireless, discs of copper, oxidised copper, and lead are mounted on a non-conducting tube, with a large

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 re-

rectifier in what is known as the Bridge Circuit. A smaller type of rectifier has also been developed for use in the high-frequency circuits, and this is commonly referred to as a "cold valve" (which see).

Transforming Alternating Current. Unlike direct current, alternating-current voltage can be transformed to

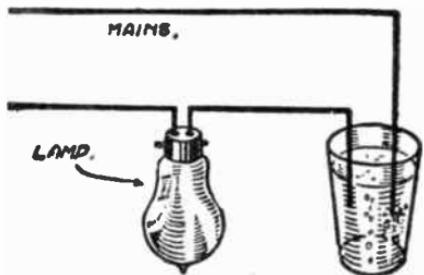


FIG. 17.—Dissolve a teaspoonful of salt in a glass of water and dip the ends of the charging wires in the solution. Bubbles of gas will form on the negative wire. (See also Figs. 26 and 27.) Take care that the two wires do not touch one another.

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sistance, the advantage being that the excess voltage need not be dissipated and, therefore, wasted.

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.

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 dried before coating with acid-proof paint.

Finding Polarity of Mains: First

Method. With D.C. mains, connect the + pole of a D.C. voltmeter to the (supposed) positive main, and allow a wire from the - 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. The meter must have a resistance of at least 200 ohms per volt.

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 necessary to connect a lamp of "mains" voltage in series with the wire to avoid the danger of short circuits (see Fig. 17).

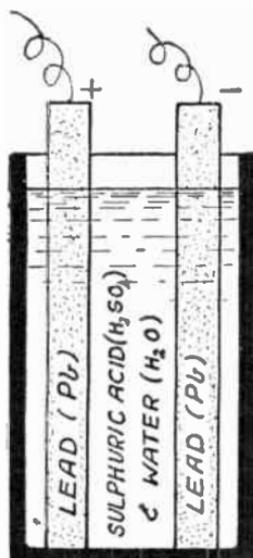


FIG. 18.—Simple cell ready for charging.

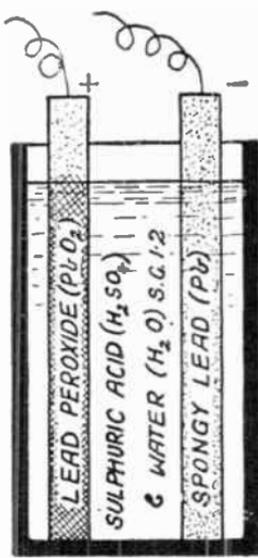


FIG. 19.—State of cell when charged.

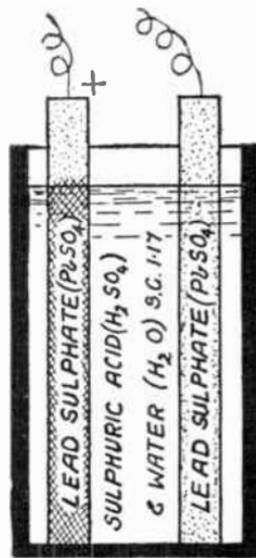


FIG. 20.—State of cell when discharged. Note the acid becomes weaker, having been used up in forming lead sulphate.

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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

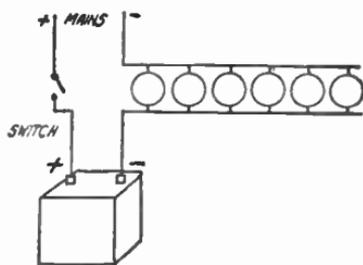


FIG. 20A.—A typical arrangement of Lamp Resistances.

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.
$\frac{1}{4}$	—	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.

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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.).						
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	.181.2	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	0.4703	34	.0998	43	.0153
17	3.6945	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,

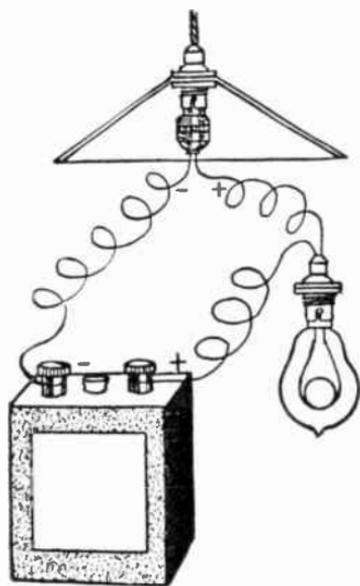


FIG. 20b.—Simple Charging Arrangement from D.C. Mains.

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 pendant 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	.209
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

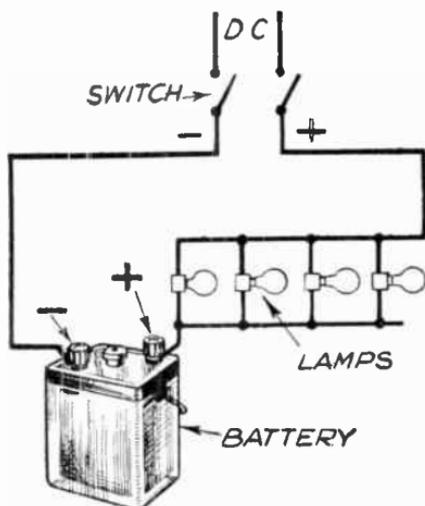


FIG. 20c.—The complete Charging Circuit.

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,

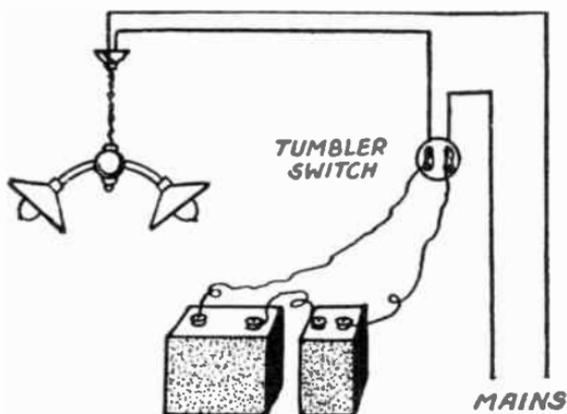


FIG. 20D.—Charging from House-lighting Switch.

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-

nect 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 resistances

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.

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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-

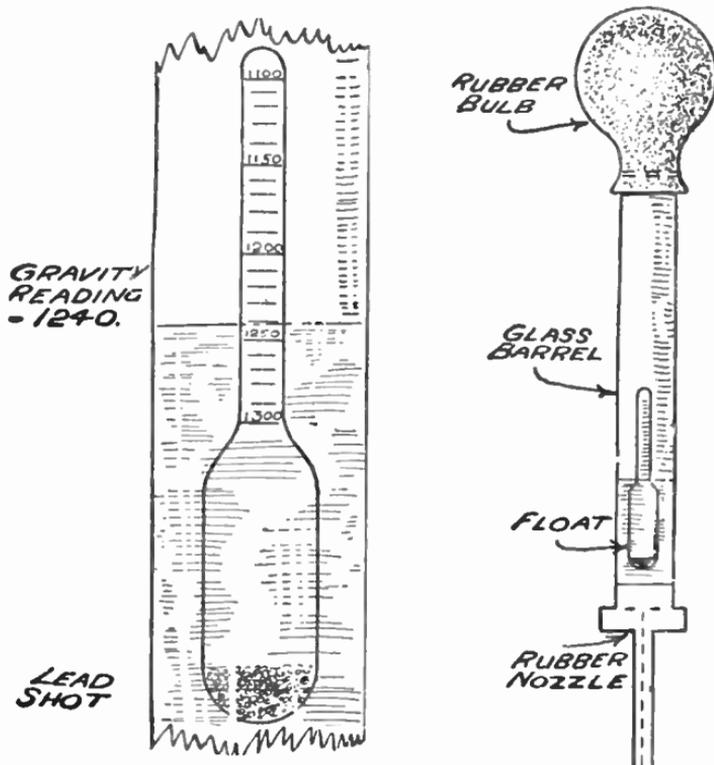


FIG. 21.—Hydrometer.

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

trollyte 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_4 . The H_2 combines with some of the oxygen in the lead peroxide and forms H_2O , while the SO_4 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.

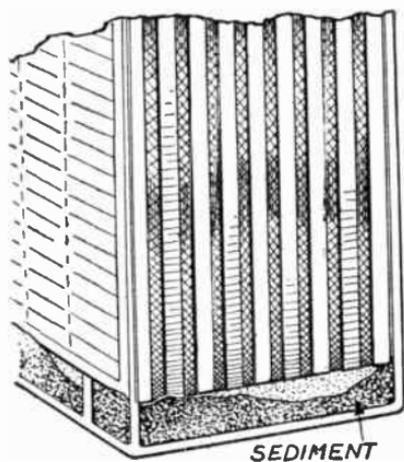


FIG. 22.—Sediment should be removed periodically, to prevent short-circuiting of plates.

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

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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-

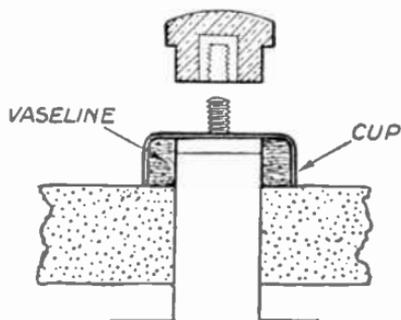


FIG. 23.—Method of preventing corrosion of terminals by means of a vaseline gland.

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

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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 $\frac{1}{2}$ 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

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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 discharged	1.207	1.204	1.200	1.196	1.193	1.189	1.186
Fully discharged	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.

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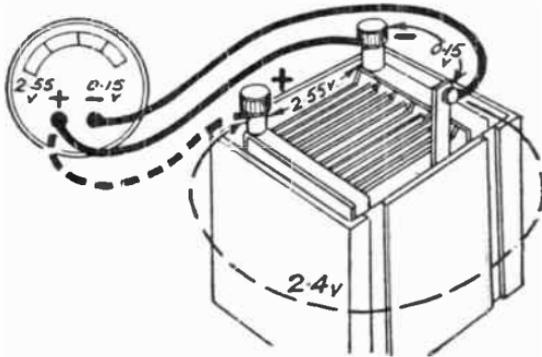


FIG. 24.—Testing a fully charged Accumulator with a Cadmium Tester.

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 $\frac{3}{8}$ 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-

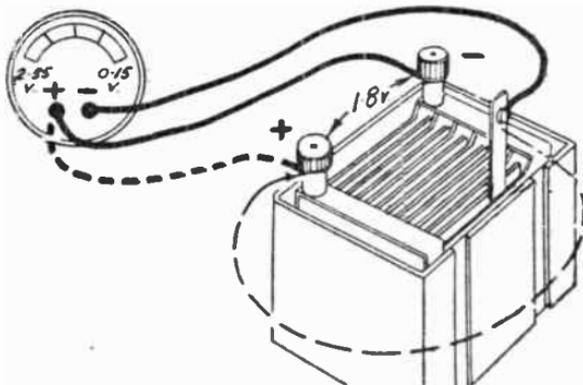


FIG. 25.—Testing a discharged Accumulator with the Cadmium Tester.

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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

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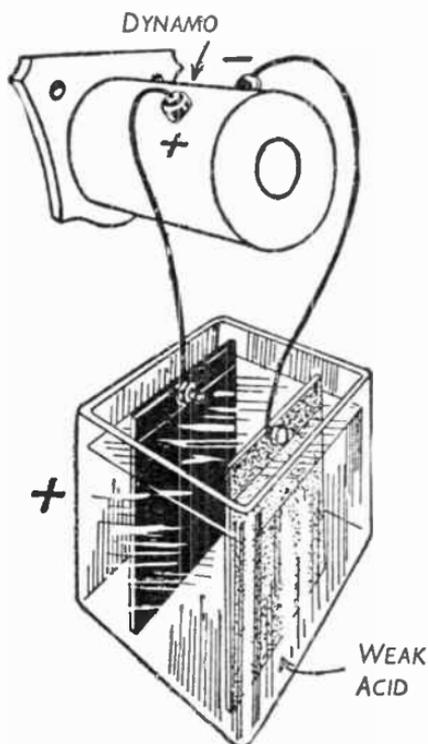


FIG. 26.—Method of testing a Dynamo for Polarity.
(See also Fig. 17.)

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, trouble may ensue. 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

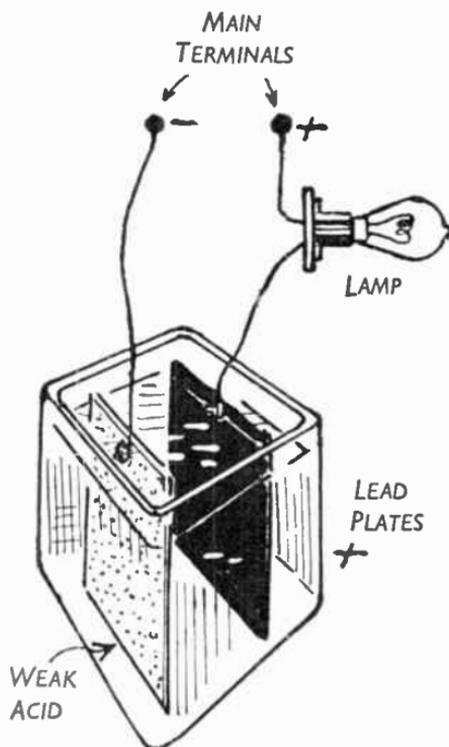


FIG. 27.—Method of testing Mains for Polarity.
(See also Fig. 17.)

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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!

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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-

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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 $\frac{1}{2}$ 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

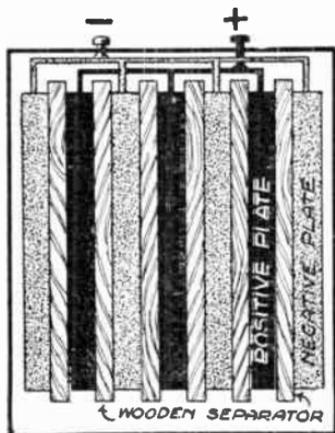


FIG. 28.—Section of a Heavy-duty type of Accumulator.

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

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

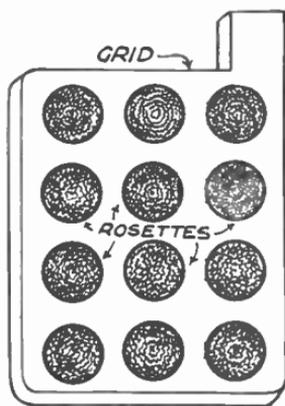


FIG. 29.—A Positive Accumulator Plate of the Rosette type.

ACCUMULATOR TYPES

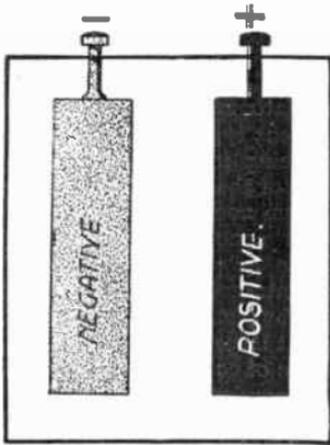


FIG. 30.—Section of a Slow Discharge type of Accumulator.

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

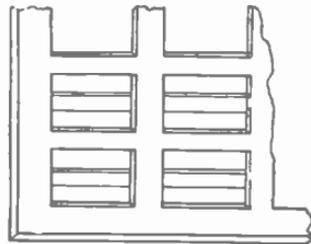


FIG. 31.—The Grid ready for pasting.

ACCUMULATOR TYPES

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

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 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

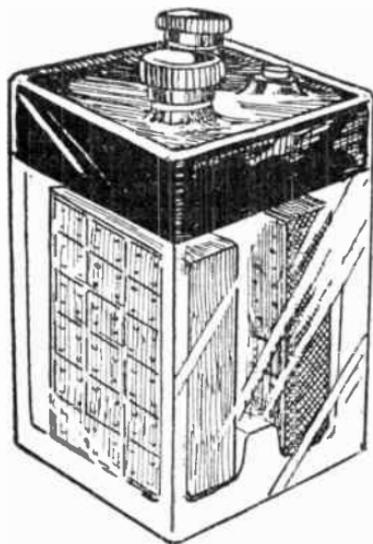


FIG. 32.—2-volt Cell for Radio purposes. The moulded glass container obviates the use of separators.

important 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

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 related to acetic acid; pyro-acetic acid, sometimes 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. (See *Amyl Acetate*.)

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 FEED-BACK.—The effect produced when the sound from loudspeakers feeds back to the microphone.

ACOUSTIC WATT.—The unit of sound energy, based on a reference level of 10^{-16} watt per sq. centimetre. (See *Bel, Decibel, Neper, and Phon.*)

ACOUSTIC WAVES.—Sound waves.

ACTINOMETER.—A apparatus which measures the actinic value of light.

ADAPTOR, SHORT-WAVE.—See *Circuit and Short-wave Adaptor*.

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

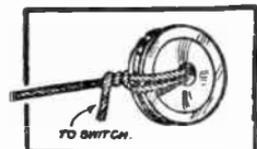


FIG. 33.—The wire passed through the insulator to form a double bight.

Anything which aids current flow in a circuit. May be calculated by dividing I by the impedance. The unit is the Mho (ohm reversed).

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

films, and yielding a glow which has greater actinic value than a neon lamp. A microphone is employed to convert 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

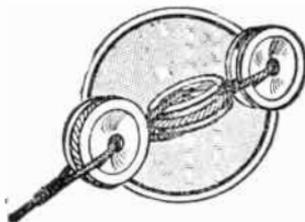


FIG. 34.—For a Single-wire Aerial three Insulators should be fitted at each end.

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 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.

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

AERIALS

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,

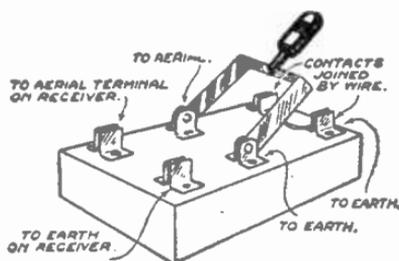


FIG. 35.—The method of connecting up the Lightning Switch.

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 saturate with water. Remember that the earth connection

INDOOR AERIALS and EARTHS

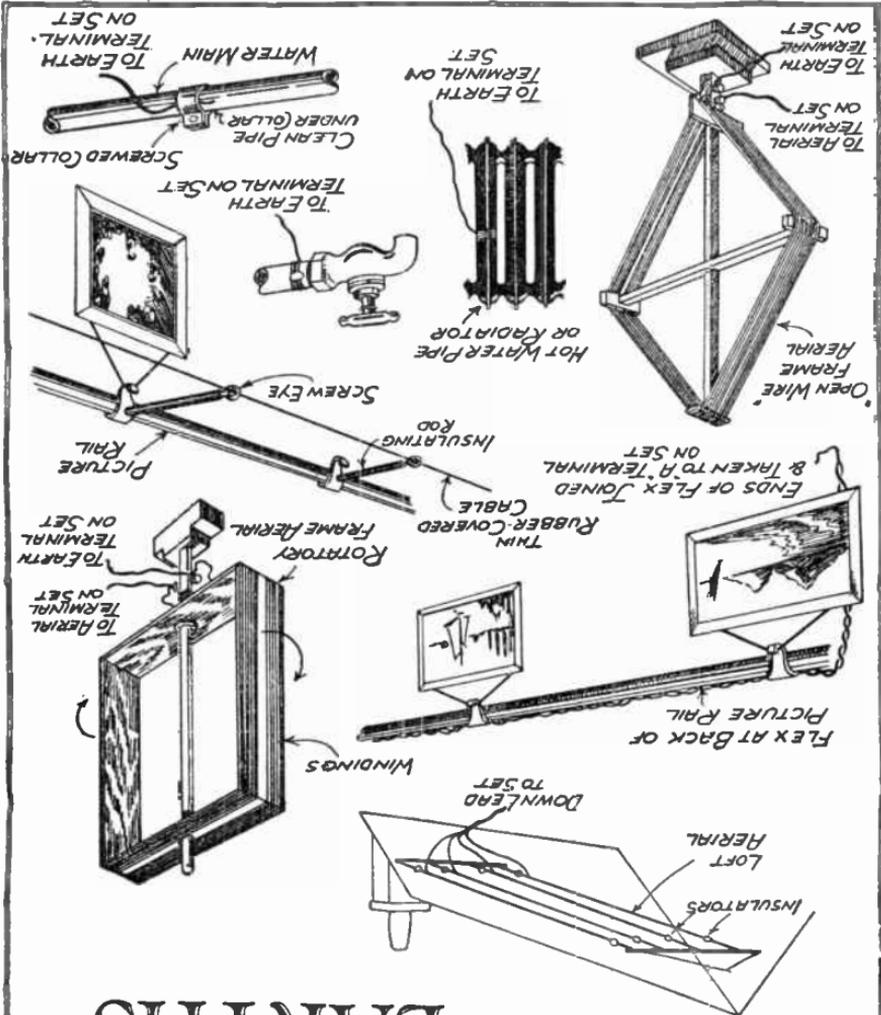


FIG. 36.
37

OUTDOOR AERIALS

and

EARTHS

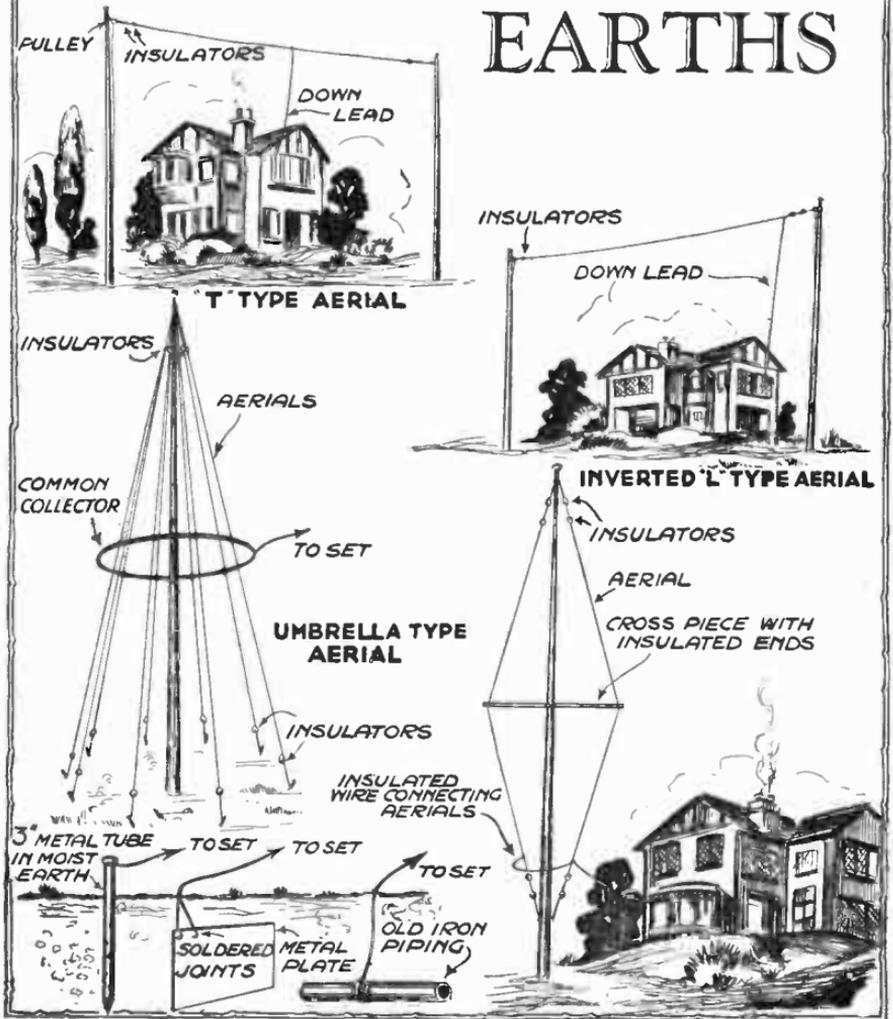


FIG. 37.

AERIAL HINTS

SOME ALTERNATIVE METHODS

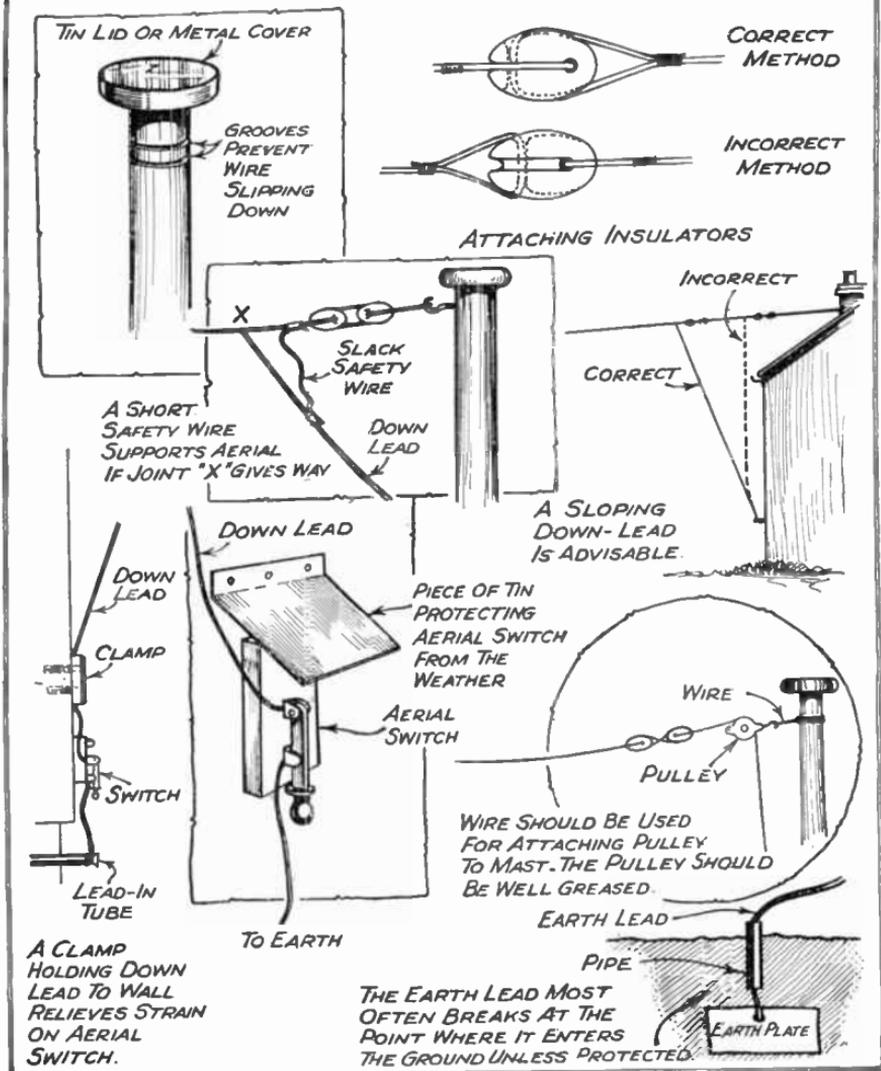
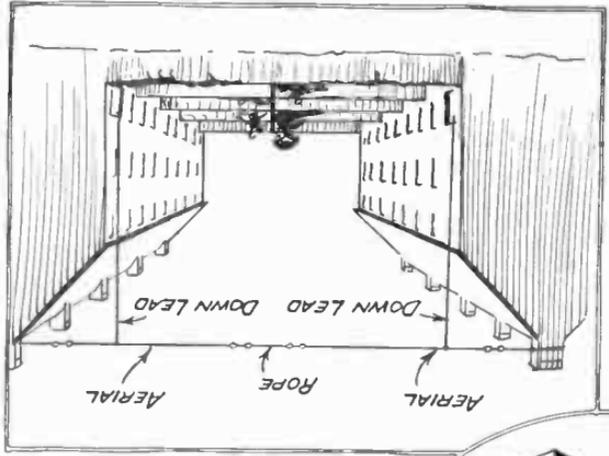
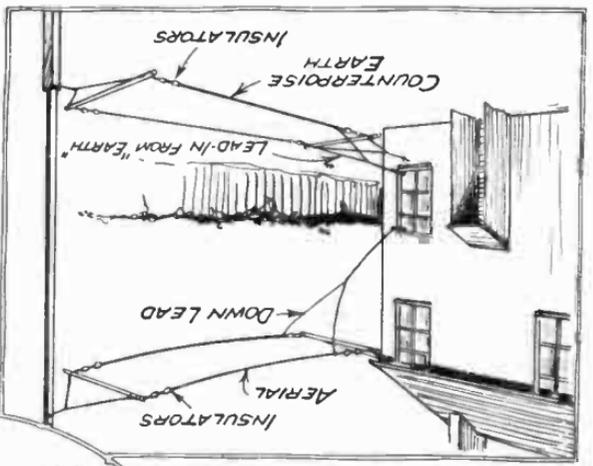


FIG. 38.

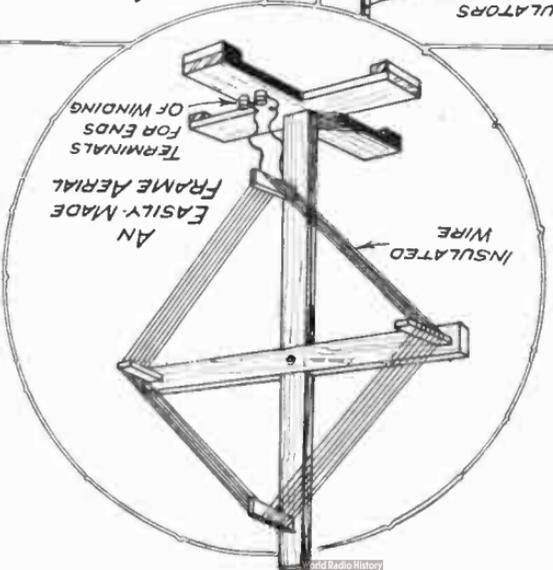
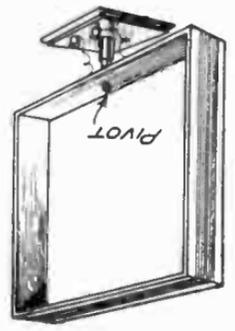
TWO AERIALS ERECTED AS SHOWN ABOVE.



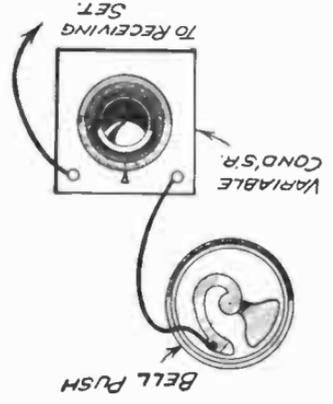
AN "L" TYPE AERIAL WITH A COUNTER-POISE PART



DIRECTION-FINDING TYPE OF FRAME AERIAL.



UTILISING A BELL CIRCUIT AS AN AERIAL.



AERIALS

should be kept 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. 42 to 46. The materials required to make it consist of a piece of $\frac{3}{8}$ -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 hobbin.

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.

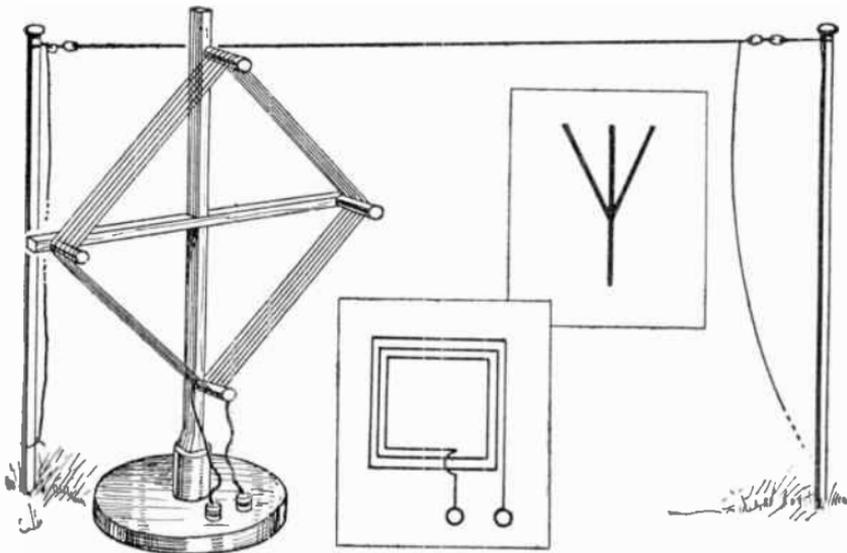
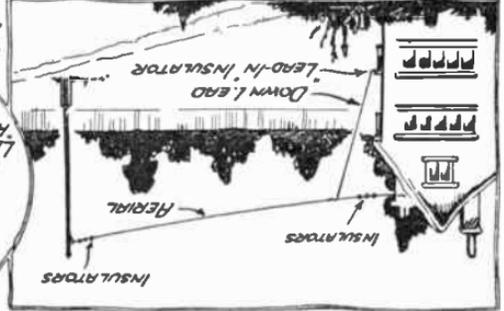
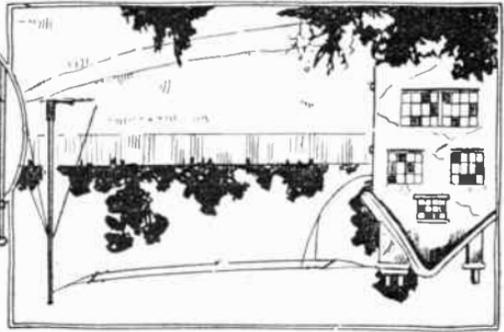


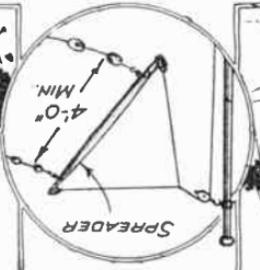
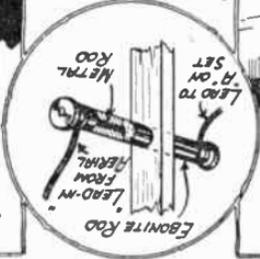
FIG. 40.—Conventional signs for outdoor and frame aerials, shown also pictorially.



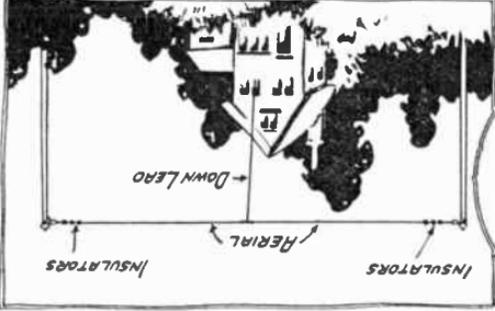
T Type Aerial. Keep free of trees, etc. Down lead is clear of gutters, etc.



TWIN "T" TYPE AERIAL WITH WOODEN SPREADERS.



TWIN "T" TYPE AERIAL.



T Type Aerial. Down lead taken from centre of aerial wire, clear of roof, to lead-in.

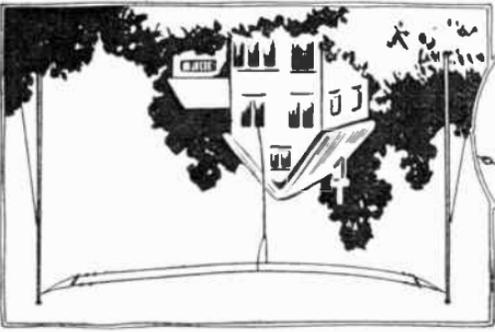


FIG. 41.—Various Aerial Systems.

AERIALS

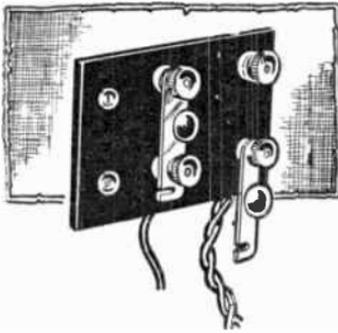


FIG. 42.—The Switch in earthed position.

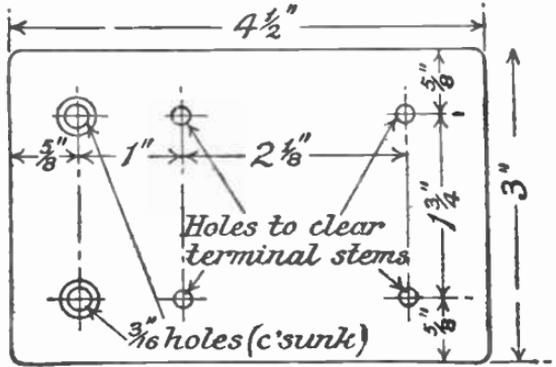


FIG. 45.—How to mark out the Ebonite Base.

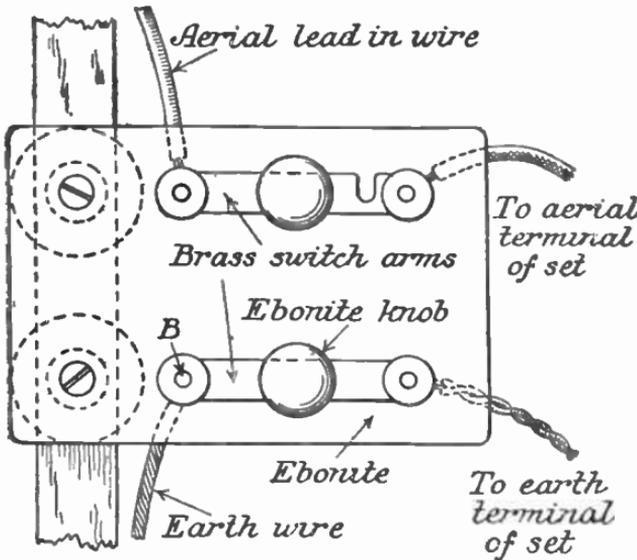


FIG. 43.—A front elevation.

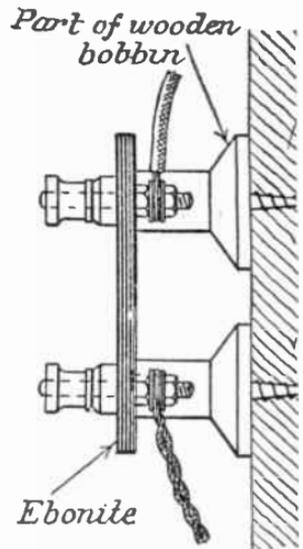


FIG. 44.—A side elevation.

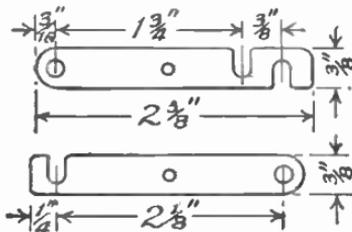


FIG. 46.—Details of the Switch Arms.

All-wave Anti-interference Aerial Systems. The aerial system (which

includes the aerial, lead-in wire, earth wire, and the coil connected between aerial and earth terminals) will resonate at a particular frequency dependent upon its inductance and capacity. When the grid circuit to which this is coupled is tuned, the aerial is also tuned, due to the coupling between the aerial and grid coils, but the resonance is most pronounced at the natural frequency of the aerial system. At harmonics of that frequency it will also provide strong

AERIALS

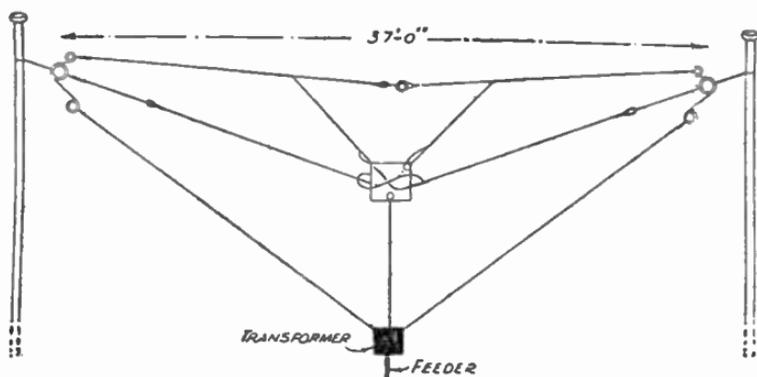


FIG. 47.—The Spider-web anti-interference aerial.

resonance, and therefore it should be possible to find a length which will give maximum response at two or three different frequencies or wavelengths. In practice this is not easy

to attain, and it is preferable to use separate aerials, each chosen to resonate at a frequency roughly in the centre of the waveband covered by the tuning coil being used. Thus for a three-band receiver three separate aerials are desirable, a short wire, say

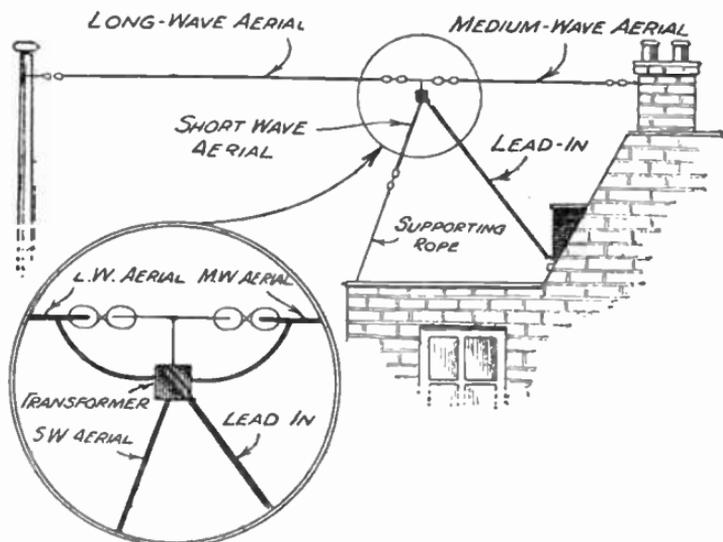


FIG. 48.—All-wave anti-interference aerial.

10 feet or so in length, being included in addition to the normal aerials. These may be arranged in many ways, and one of the most convenient is depicted in Fig. 48. Here the two

broadcast aerials are joined end to end (insulated at the junction), and the short-wave aerial is suspended from the point at which they are joined.

In some cases it may be necessary to use even more than these three

AERIALS

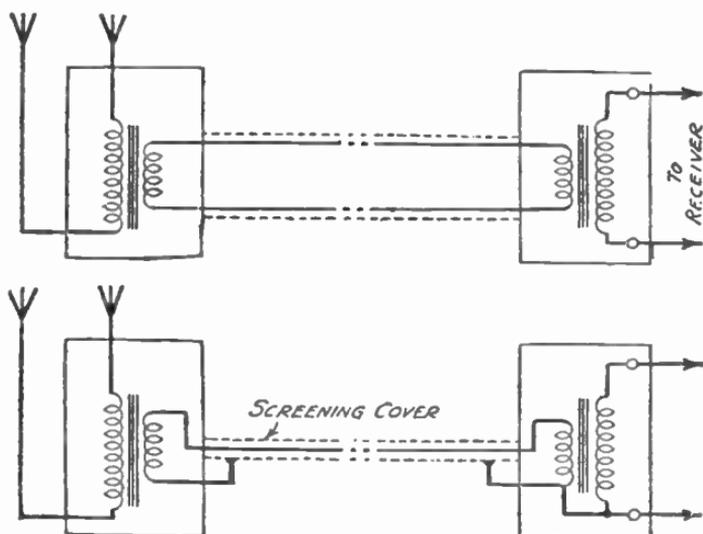


FIG. 49.—Connections for two types of impedance-matching transformer for anti-interference aerials.

aerials, including other lengths, to resonate at some other part of the wavebands covered. Such an aerial is known as the spider-web aerial, a diagram of it being given at Fig. 47. It will be seen here, however, that the

aerials each consist of a dipole, or half-wave aerial, each built up from two quarter-wave aerials, and this necessitates twin feeder wires from the centre point. The advantage of an aerial of this type is that the

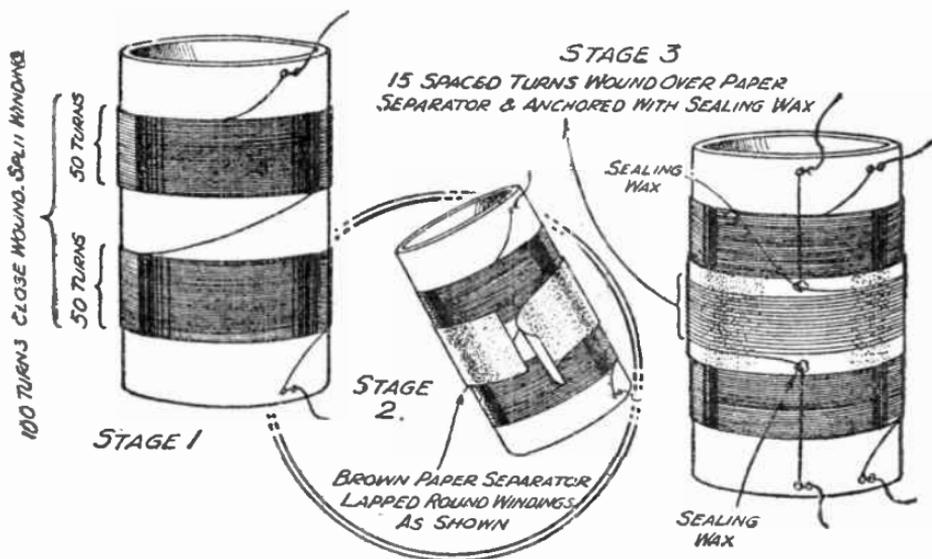


FIG. 49A.—Constructional details of the transformers for anti-interference aerials.

AERIALS

feeder wire (or lead-in) will not pick up any energy, as it is either screened or transposed throughout its length. This is the arrangement which has to be adopted if local interference is experienced, as the aerial array may be placed well away from the building (out of the area of interference) and the lead-in will play no active part in picking up the signals. If a very long feeder is needed it will be necessary to include two transformers in the aerial system, one at each end of the lead-in, to balance out losses. This is carried out by using a step-down transformer at the aerial end and a step-up transformer at the receiver. The two sections of the transformers which are connected together form a low-impedance circuit, and consequently the capacity between the feeders will not have such a marked effect upon the signals, which would otherwise be seriously interfered with. The usual way of arranging such a feeder is to use parallel-laid insulated wires in a heavy rubber cable. An alternative scheme is to use a single wire laid inside an insulated cable with a braided metal screen surrounding it, and this screen may form one of the feeder wires by being connected to one side of both transformers. The separate schemes are shown in Fig. 49. The majority of modern impedance-matching transformers employ iron-cored coils providing a high inductance-capacity ratio, and are accordingly beyond the scope of the average amateur to build. A design which has been found to offer good results from an all-round point of view is to wind the aerial transformer (that is the one joined direct to the multi-aerial system) with a primary of 100 turns of 28 D.C.C. wire on a 1-in. diameter former, and to split this into two equal sections, separated by $\frac{1}{2}$ in. Over the centre space three or four layers of thick brown paper are

wound, and in the centre of this 15 turns of a similar gauge of wire are wound for the secondary. The ends of this winding should be anchored with sealing wax or Chatterton's compound, and taken straight across the primary at right angles before being led through anchoring holes in the ends of the former for connecting purposes.

This coil should be mounted inside a small aluminium screening can, and the bottom of this should be sealed with a disc of waxed wood or ebonite. Chatterton's compound or some similar wax will make it waterproof, and the holes through which the ends of the aerial and lead-in are passed should also be sealed. The receiver transformer will be wound in exactly the same manner, but the larger winding (which is in this case the secondary) must be tapped to provide the necessary wave-change selection points. The ideal system is to use a two-point switch so that equal tapings are selected from each end of the secondary, although in many cases it is quite sufficient simply to transfer one connection by stages down the secondary, leaving the earthed end permanently connected.

The receiver transformer should be mounted as close as possible to the aerial and earth terminals of the receiver, and the leads to these terminals should also be screened.

It must be emphasised that these details will not apply to every set, and therefore the constructor must be prepared to carry out some experiments as previously mentioned.

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

AERIALS

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 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 condition 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-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. 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,

AERIALS — ALPHABET

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 must be joined to one of the tapping loops, the particular one to use depending on the degree of selectivity required (Fig. 49A). (See also *Short-wave Aerials*, pp. 180 and 181.)

AERIAL, NATURAL WAVELENGTH OF.—The natural wavelength of an aerial is approximately four and a half times its electrical length (length between insulators plus length of lead-in). Standard aerial of 100 ft. has a natural wavelength of about 120 metres. If connected direct to the grid of the detector valve, it would receive transmissions on this wavelength.

AERIAL, P.M.G.—The maximum length of aerial, inclusive of lead-in, permitted by the Postmaster-General is 100 ft.

AERIAL, REFLECTOR.—An arrangement generally employing a dipole aerial, for preventing a signal from being radiated in all directions, or for ensuring maximum reception in a given direction. It consists of a vertical or horizontal aerial behind which is erected a similar aerial (not connected to anything), the spacing between these being adjusted according to the frequency of the signals. A multi-reflector system will generally have the reflectors arranged in the form of a parabola with the aerial at the focal point.

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).

A.F.C.—See *Automatic Frequency Control*.

A.G.C., also **A.V.C.**, meaning automatic volume control or automatic gain control. (See also *A.V.C.*)

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 *Condenser and Variable Condensers*.)

ALL-WAVE AERIALS.—See *Aerials*, p. 43.

ALPHABET, WIRELESS PHONETIC.—The phonetic alphabet generally 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.

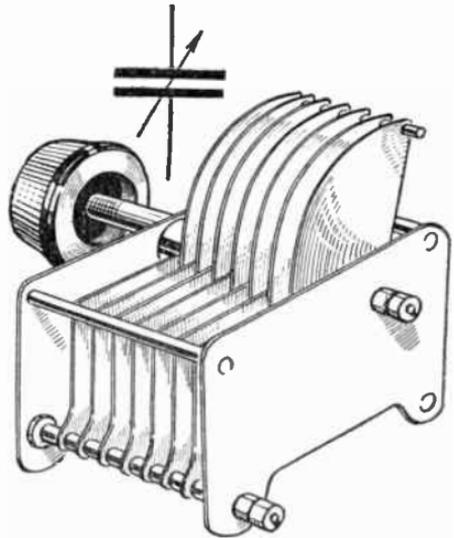


FIG. 50.—Variable condenser with air dielectric.

ALTERNATING CURRENT — AMPLIFICATION FACTOR

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 element 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*.)

ALUMINUM.—American term for aluminium.

AMATEUR WAVEBANDS.—See *Wavebands, Amateur*.

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 an H.T. battery in wireless circuits, the milampere is the unit used. This is equal to one-thousandth of an ampere. Even smaller currents are measured in microamperes. (Formerly *Weber*, which see.)

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 impedance 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:

Gain = $\frac{\text{Resistance of load} \times \text{amplification factor of valve}}{\text{Anode resistance of valve} + \text{resistance of load}}$
(See also *Stage gain, Push-pull, Quiescent push-pull, Class A, Class B, and Class AB*.)

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

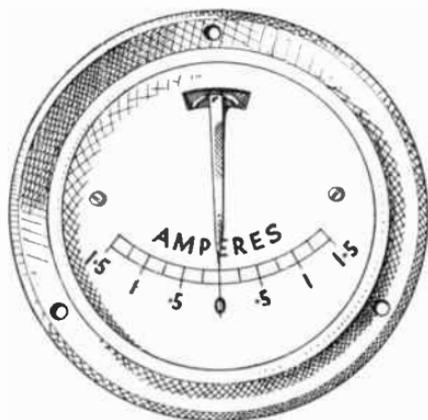


FIG. 51.—Ammeter.

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

AMYL ACETATE.—Chemical compound used for dissolving celluloid; also for making celluloid jointing cement; odour similar to pear drops.

ANELECTRIC.—Any body unaffected (*i.e.* does not become electrified) by friction. The reverse of *dielectric*.

ANGLE OF INCIDENCE.—The angle from the perpendicular at which the sound waves impinge upon a surface.

ANGSTROM UNIT.—A standard of measurement of the wavelength of light. One Angstrom unit equals one ten-millionth of a millimetre, or one ten-thousandth of a micron (which see). (See *Lux, Lumen, Foot-candle.*)

ANION.—(Obsolete term for negative ion. The electro-negative constituent of an electrically decomposed compound, appearing at the anode of a voltaic battery. (Opposer to *Cation*, which see.)

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.

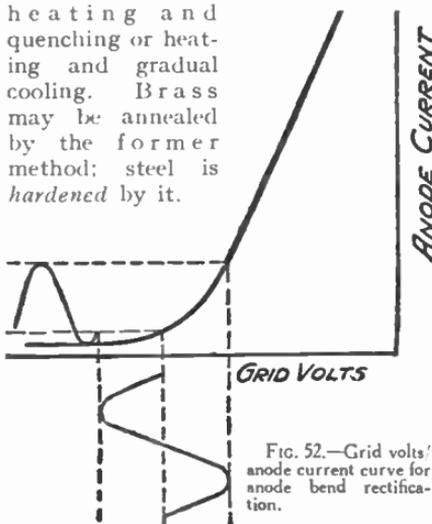


FIG. 52.—Grid volts/
anode current curve for
anode bend rectifica-
tion.

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 terminal.

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. A certain amount of amplification also takes place.

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

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

ANTI - BREAK - THROUGH CHOKE.—Coil of wire connected in the aerial lead to prevent the passage of long-wave signals when receiving medium-wave signals. (See also *Chokes, High-frequency Chokes, and Break Through.*)

ANTI - INTERFERENCE AERIALS.—See *Aerials*, p. 43.

ANTINODES.—In a series of oscillations 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"

ARMATURE — ATMOSPHERICS

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.

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 it to be fully charged.

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. (See also *Hydrometer*.)

ARMATURE.—See *Loudspeaker*.

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

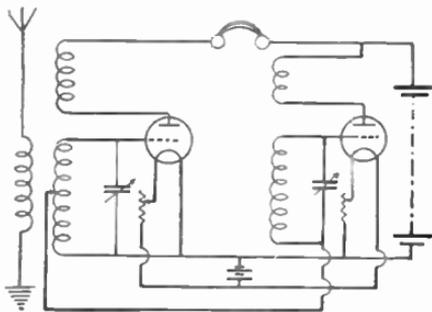


FIG. 53.—The Armstrong Circuit.

regenerative principle. The value of the circuit elements are rather critical, and the arrangement is now chiefly used for ultra - short - wave reception. (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

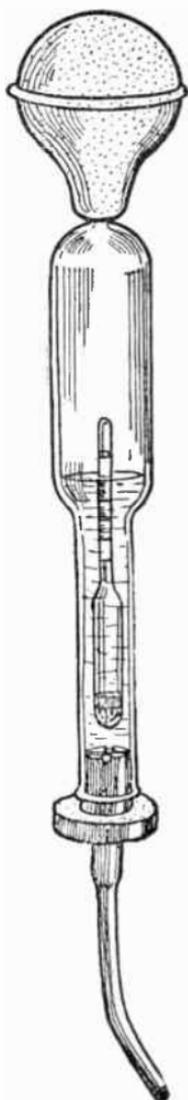


FIG. 54.—Another type of Hydrometer.

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

red we find radio frequencies, and below these alternating and audio frequencies. Above the visible band we find X-rays, gamma-rays, and others not yet named, although the cosmic rays are found in these extreme upper ranges.

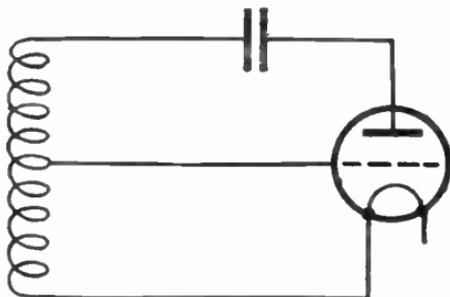


FIG. 55.—Autodyne Circuit.

are due to atmospherics. (See also *Interference and Noises*.)

ATOM.—All matter is composed of minute particles or *atoms*; elements consist of atoms of one kind—carbon, copper, gold, etc. Compounds consist of groups of atoms. Thus water consists of two atoms of hydrogen and one atom of oxygen, forming a molecule of water.

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

ATTENUATOR.—A circuit or piece of apparatus for reducing or cutting off the output from a transmitter, receiver, or amplifier.

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.

AUDIBLE SPECTRUM.—This extends above and below the visible spectrum (which see). Below infra-

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

AUDION.—The de Forest and Fleming types of valve. The main feature is the second plate, which makes it a rectifier and 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 (Fig. 55).

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 a series of four-second dashes broken by spaces of one second cause bells to sound the alarm.

AUTOMATIC FREQUENCY CONTROL.—The term applied to an arrangement which causes a circuit automatically to be tuned after the main control has been turned to approximately the correct wavelength setting. In its simplest form it consists of a double-diode valve, each diode of which is coupled to the oscillator circuit in a superhet. The out-of-balance effect of the signals on the two diodes, after rectification, is fed back to the oscillator circuit and causes a readjustment of this to bring the set into tune and thus an equal voltage across the two diodes.

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

AUTOMATIC GRID BIAS

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 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.

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.

There is one disadvantage. Any biasing voltage thus applied is subtracted from the total H.T.

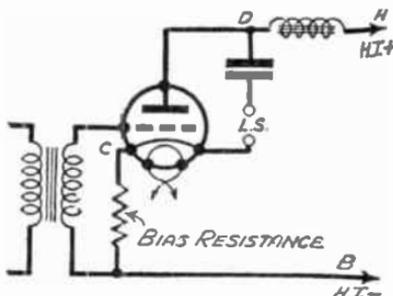


FIG. 56.—A resistance inserted in the cathode lead of an indirectly heated valve.

voltage. 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 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.

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

sistances 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

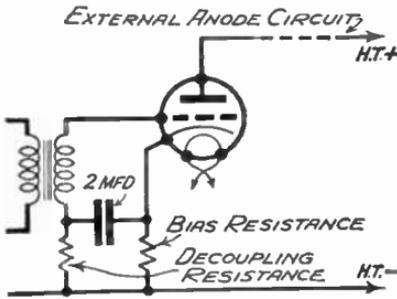


FIG. 57.—The arrangement of Fig. 56 with a Decoupling Circuit added.

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 — AUTOMATIC TONE COMPENSATION

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-

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.

For Portable Sets. It should not be forgotten that automatic bias can just as simply be applied to battery-operated receivers. 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.

AUTOMATIC TONE COMPENSATION.—The object of this scheme is to compensate for the high-note cut-off introduced when reaction is advanced to its limit. The idea is that an L.F. transformer of a type which emphasises the high-notes is used after the regenerative detector valve and the differential reaction condenser is so connected that when its capacity is reduced to a minimum it completes

detector 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

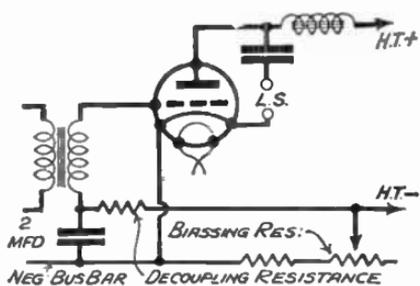


FIG. 58.—An alternative arrangement of Fig. 57, in which the cathode is maintained at the normal negative potential.

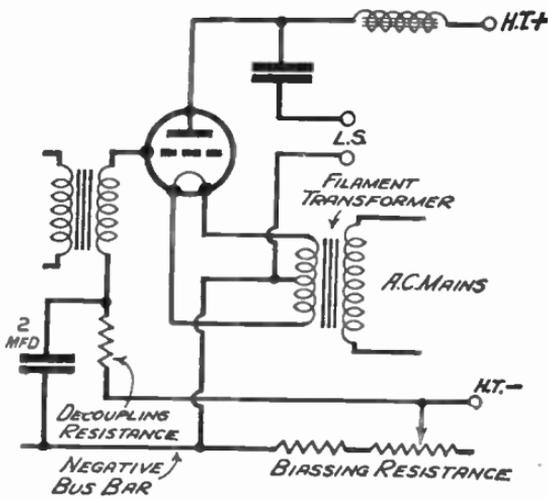


FIG. 59.—A Battery-heated Valve arranged in the same manner as Fig. 58.

AUTOMATIC TONE COMPENSATION — BALANCING CAPACITY

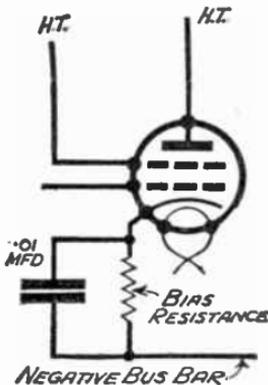


FIG. 60.—The biasing resistance arranged in the cathode lead of a S.G. valve.

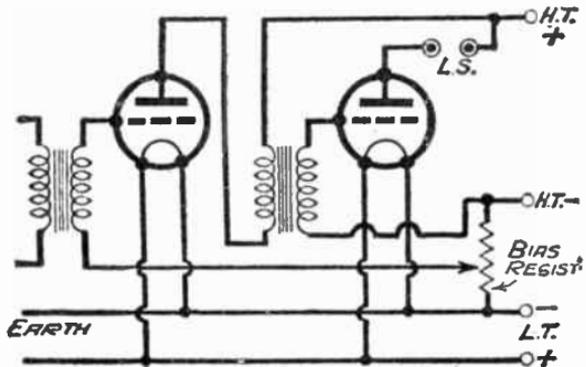


FIG. 61.—A common resistance connected up to provide bias for two battery-heated valves.

the circuit of a fixed condenser joined in parallel with the primary winding of the special L.F. transformer. The effect of the condenser is to reduce the high-note response.

AUTOMATIC TUNING. — See *Push-button Tuning*.

AUTOMATIC VOLUME CONTROL, OR A.V.C.—A system by means of which the volume of sound delivered by the loudspeaker is of constant intensity regardless of the station being received. A.V.C. thus prevents overloading of the detector valve by a powerful local transmitter and also overcomes fading on distant stations. The principle of A.V.C. is that the signal voltage fed to the detector valve is employed to produce a negative bias voltage which is applied to preceding variable- μ amplifiers. The negative voltage produced is directly proportional to the detector signal voltage, and it produces a reduction in amplification of the V.-M. valve or valves. As the reduction in amplification is proportional to the signal voltage it will be seen that the result mentioned above can be obtained. Most A.V.C. systems depend upon the use of a "Double-

Diode" detector valve or else a "Cold Valve." (See also *Quiet Automatic Volume Control* and *Delayed Automatic Volume Control*.)

AUTO TRANSFORMER.—A transformer having a single winding instead of the usual two windings. Part of it is tapped off to form the primary, the other part forming the secondary.

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

A.V.C.—Automatic Volume Control (which see).

B

B.A.—British Association, also the screw-thread system used in 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 loudspeaker. Its use is to accentuate the bass notes.

BALANCING CAPACITY.—Any artificial or capacity earth. Extra capacity inserted in the aerial circuit to replace the earth.

BALLISTIC GALVANOMETER — BARRETTTER

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

BAND-PASS TUNING.—A system of tuning which enables a very high degree of selectivity to be obtained.

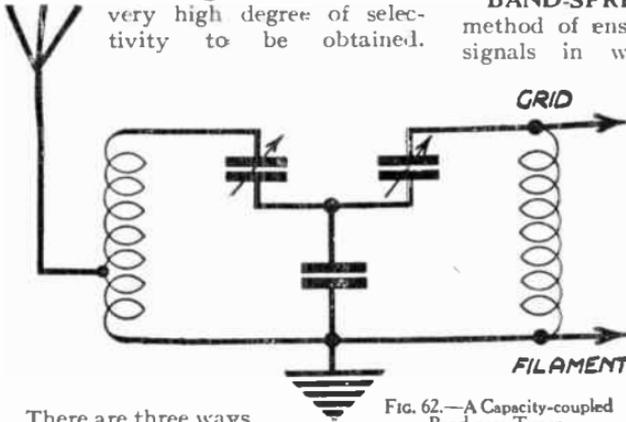


FIG. 62.—A Capacity-coupled Band-pass Tuner.

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 circuit, but connected in the grid circuit of the valve. To connect these two tuned circuits together, in some cases a fixed condenser having a value of .01 is used (Fig. 62).

In some cases an inductance or resistance is used to couple the circuits (Fig. 63). 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.) (See also *Tuning Coils*.)

BAND-SETTER.—The larger of the two condensers employed in band-spread tuning.

BAND-SPREAD TUNING.—A method of ensuring good short-wave signals in which two condensers are employed in parallel across the tuning coil. One of these is a high capacity and the other a very small capacity, and this "spreads" out the tuning and thus gives a similar effect to a very accurate reduction drive tuning dial.

BANK.—A bank of condensers. A number of condensers self-contained as one unit.

BARRETTTER.—An American term. In D.C. mains receivers, for instance, designed for a 100-volt supply and connected to a 200-volt supply, it will be necessary to include a lamp in series with the receiver to dispose of the excessive 100 volts. Such a lamp is called a Barretter or Ballast Lamp.

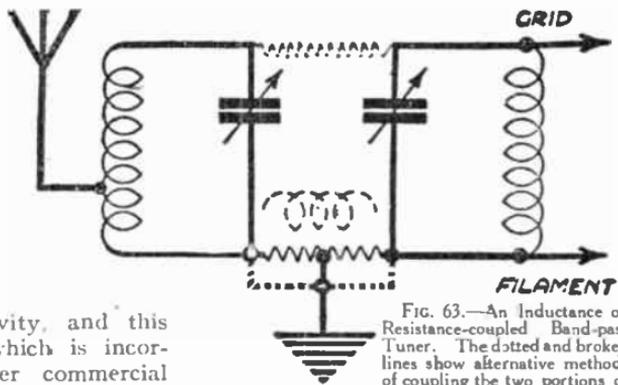


FIG. 63.—An Inductance or Resistance-coupled Band-pass Tuner. The dotted and broken lines show alternative methods of coupling the two portions of a Band-pass Tuner.

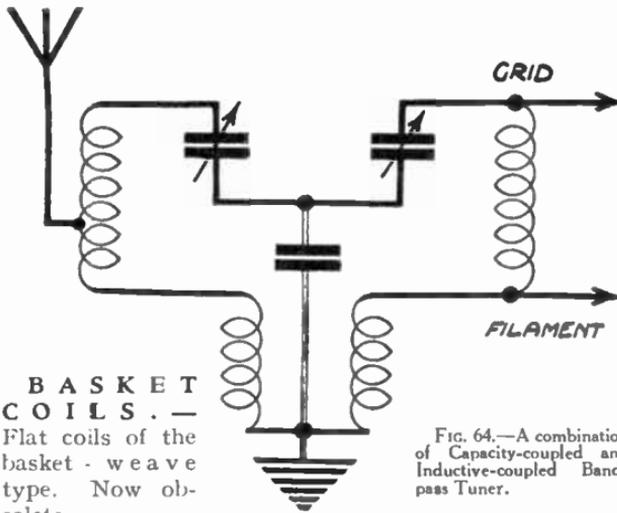


FIG. 64.—A combination of Capacity-coupled and Inductive-coupled Band-pass Tuner.

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 current, 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 POWER.—Term applied in modern valves, where electron flow is directed in beam formation to over-

come the loss resulting from secondary emission.

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.

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," the difference between the two frequencies.

BEL.—The unit of sound intensity. The bel is too large for measuring the output of wireless apparatus, and therefore one-tenth of the bel, or a decibel (which see), is employed for this purpose. (Named after Alexander Graham Bell, inventor of the telephone (1847-1922). See also *Decibel*, *Neper*, *Phon*, and *Acoustic Watt*.)

BELLINI TOSI AERIAL.—A double-frame aerial, having the two sections arranged at right angles.

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 wave-

BIAS — BLUE PRINTS

length whose frequency is closer than 10 kcs. to any other station.

BIAS.—The voltage applied to a valve to ensure its correct working as an H.F. or L.F. amplifier. A valve operating as an anode-bend detector also requires an application of bias to bring the working point to the correct portion of the curve. (See also *Grid Bias* and *Automatic Grid Bias*.)

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.

BIG BEN TIME SIGNAL.—See *Time Signal*.

BI-GRID VALVE.—A valve having two grids, an anode, and a cathode. This valve differs from a screen-grid valve, which has also two grids, in that one of the grids of the latter valve is biased to negative the results of the space charge. In the bi-grid valve the two grids are used separately for such purposes as combined oscillator and frequency changer and for one or two other special purposes in superhets.

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.

BIMORPH.—Another term for the pi-zo-crystal used in some speakers, microphones, pick-ups, etc. (See *Piezo-Electricity*.)

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. This apparatus is now known as the Marconi-Stille Recorder.

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

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

BLUE GLOW.—A valve gives rise to blue

glow when excessive current is flowing from plate to filament. Blue glow signifies that the valve is "soft"—not completely exhausted of air.

BLUE PRINTS.—A photographic copy of a drawing. Probably the quickest way of building a set exactly

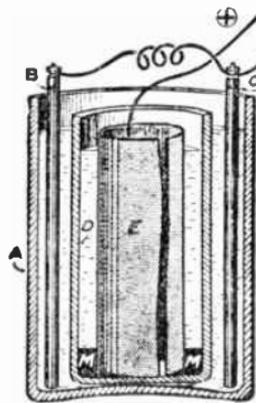


FIG. 65.—Section of the Bichromate Cell. A, glass jar; B and C, carbon rods; D, porous pot; E, zinc; M, mercury.

BLUE PRINTS—BOOSTER

to specification is to use a full-size blue 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 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 examine it very carefully. This will give you some idea of what the finished receiver 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.

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.

BOARD OF TRADE UNIT.—1,000 watt-hours. 1 kilowatt hour, or 3,415 British Thermal units.

BOLOMETER.—A particular type of Wheatstone Bridge possessing a 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

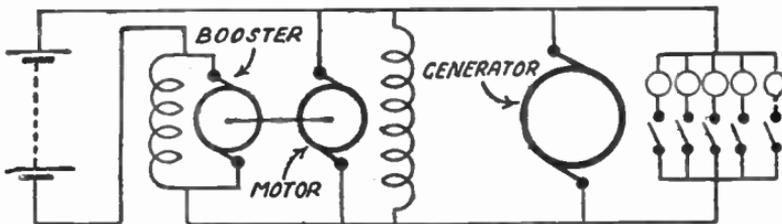


FIG. 66.—Circuit diagram showing how the Booster is connected.

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

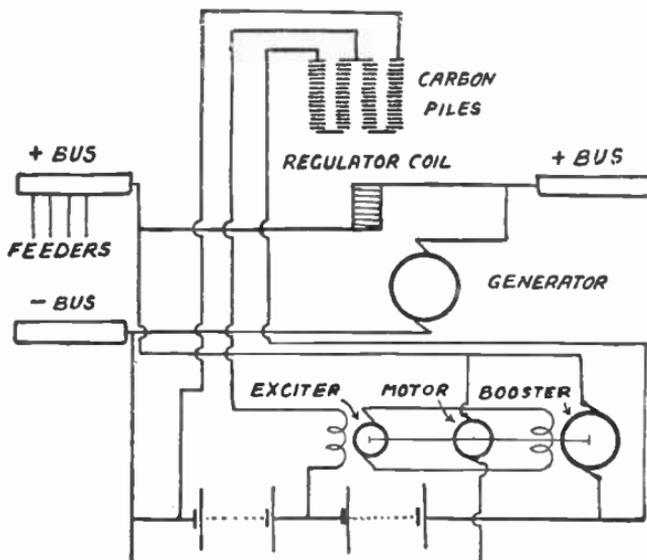


FIG. 67.—Arrangement of Automatic Reversible Booster.

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-

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

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. (See *Board of Trade Unit and Abbreviations*, page vi.)

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

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

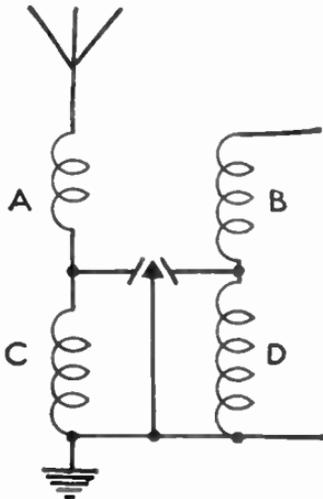


FIG. 68.—Circuit of a Dual-range Coil with which break through may occur.

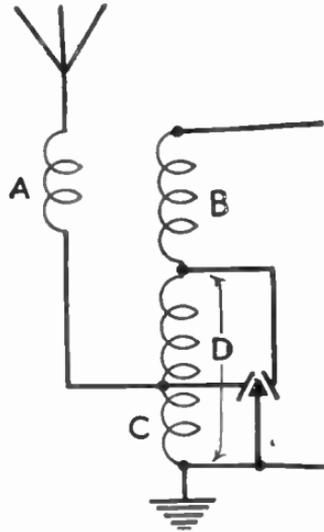


FIG. 69.—Another typical Dual-range Circuit.

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

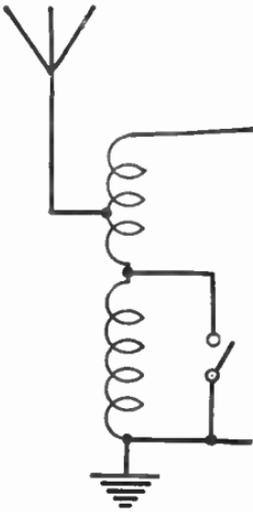


FIG. 70.—A very common circuit employed in commercial coils. Break through does not occur, but it is unselective on the long waves.

wave band. 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

tical difference is that the circuit of Fig. 68 is more tightly coupled on the long waves than that of Fig. 69.

Any attempts at a cure must be in the direction of keeping the natural wavelength of the primary coil AC well away from the medium-

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

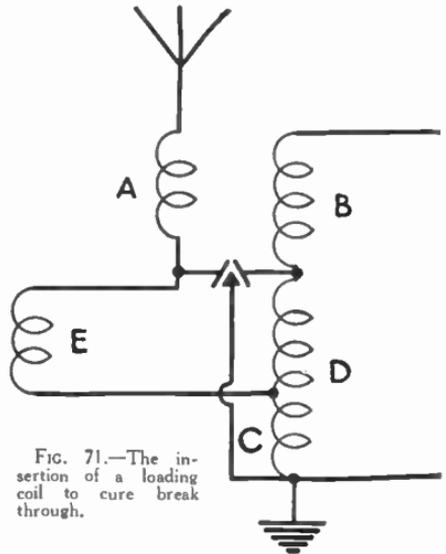


FIG. 71.—The insertion of a loading coil to cure break through.

BREAK THROUGH — BRITISH BROADCASTING STATIONS

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

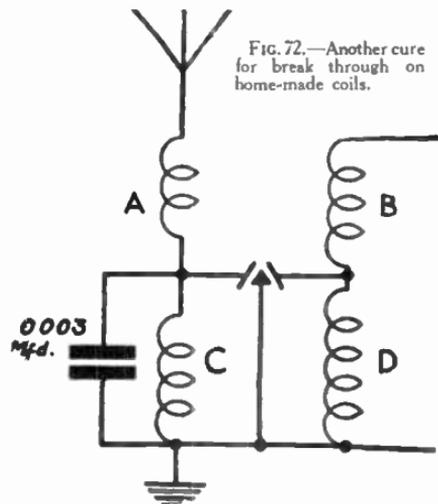


FIG. 72.—Another cure for break through on home-made coils.

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. (See also *anti-break-through chokes, Chokes, and High-frequency Chokes.*)

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)

$$\text{Formula} \begin{cases} p = \text{pitch} \\ d = \text{depth} = p \times .6 \\ r = \text{radius} = \frac{2 \times p}{11} \end{cases}$$

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	0.59	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	★
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

(See also *Short-wave Stations and European Broadcasting Stations, and International Call Signs.*)

B.B.C. Empire Call Signs

	Mcs	metres
GSA—A for Aerial	6.05	49.59
GSB—B for Broadcasting	9.51	31.54
GSC—C for Corporation	9.58	31.31
GSD—D for Daventry	11.75	25.53
GSE—E for Empire	11.86	25.28
GSF—F for Fortune	15.14	19.81
GSG—G for Greeting	17.79	16.86
GSH—H for Home	21.47	13.97
GSI—I for Island	15.26	19.66
GSJ—J for Justice	21.53	13.93
GSJ2—J for Justice	21.56	13.91
GSL—L for Liberty	6.11	49.10
GSM—M for Nation	11.82	25.38
GSO—O for Ocean	15.18	19.76
GSP—P for Progress	15.31	19.60
GST—T for Transmitter	21.55	13.92
GST2—T for Transmitter	21.64	13.86
GSU—U for Unity	7.26	41.32
GSV—V for Valour	17.81	16.84
GSW—W for Westminster	7.23	41.49

BRITISH SYSTEM OF UNITS — CABINET CONSTRUCTION

Station	Frequency kc/s.	Wave-length metres	Power kW.	Programme
Droitwich	200	1,500	150	National
Moorside Edge	668	449.2	70	North Regional
Westerglen	767	391.1	70	Scottish Regional
Westerglen	1,149	261.1	50	Scottish National
Burghead	767	391.1	60	—
Washford	804	373.1	70	Welsh Regional
Penmon	804	373.1	5	—
Brookman's Park	877	342.1	70	London Regional
Lisnagarvey	977	307.1	100	Northern Ireland Regional
Droitwich	1,013	296.2	70	Midland Regional
Stagshaw	1,122	267.4	60	—
Brookman's Park	1,149	261.1	20	National
Moorside Edge	1,149	261.1	20	National
Westerglen	1,149	261.1	50	National
Aberdeen	1,285	233.5	5	—
Start Point	1,050	285.7	100	} West Regional
Clevedon	1,474	203.5	20	
Alexandra Palace (Television)	45 41.5	6.7 7.2	17 3	} Vision / Sound

The Proposed Wavelengths of B.B.C. Stations on and after March 4th, 1940

Station	New Wavelength	Present Wavelength
Droitwich	1,511	1,500
North Regional	447.1	449.1
Burghead and Scottish Regional	360.2	391.1
Penmon and West Regional	344.4	373.1
London Regional	327.5	342.1
Northern Ireland Regional	285.4	307.1
Midland Regional	276	296.2
London Nat., Northern Nat., and Scottish Nat.	262.9	261.1
Stagshaw	253	267.4
Start Point (new station)	245.5	—
Norwich (new station)	214	—
Aberdeen	212.6	233.5
Clevedon (new station)	204.8	—

BRITISH SYSTEM OF UNITS.—

The foot-pound-second system (F.P.S.). The poundal is the Unit, consisting of the energy of one pound moving 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.

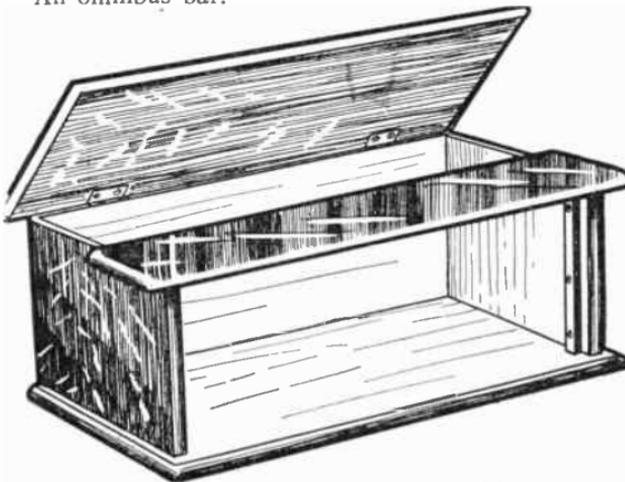


FIG. 73.—The American style of Cabinet.

CABINET CONSTRUCTION

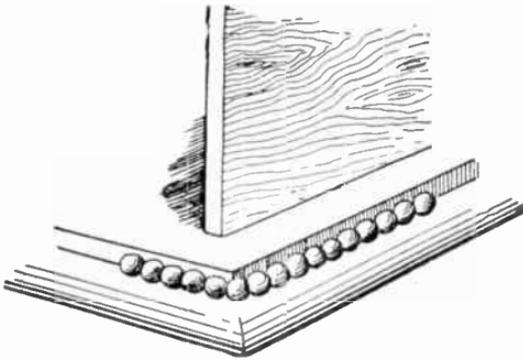
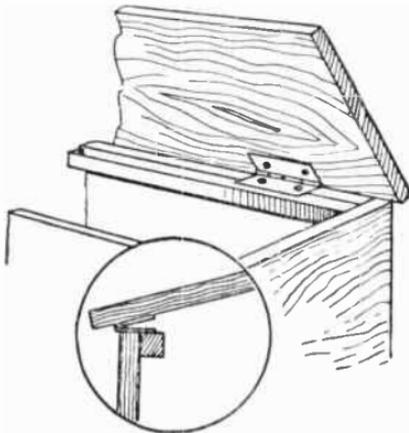


FIG. 74.—The base is improved by the addition of beading glued in the corner angle of the two parts.

The boards should be $\frac{3}{8}$ in. thick for the smaller sets—say, with a panel of 10 x 7 in.—and $\frac{1}{2}$ in. thick for the larger ones. The simplest construction is shown by the cabinet illustrated in Fig. 73.

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 back can



FIGS. 75 and 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

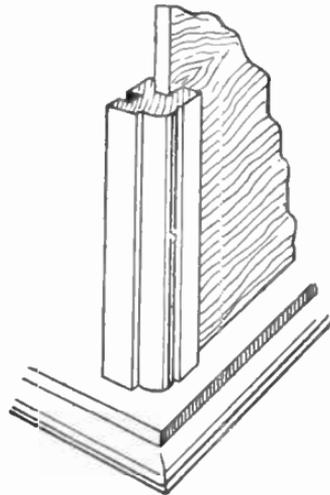


FIG. 77.—This shows plainly how corner moulding simplifies the construction.

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

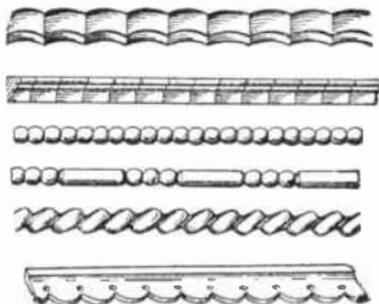


FIG. 78.—Fancy beading which is excellent for decorating the cabinet.

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 $\frac{3}{8}$ -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 $14\frac{3}{8}$ in. must be allowed between the inside surfaces of the ends of the cabinet. The shape of the moulding on the corner turns over $\frac{3}{8}$ 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 stains and Hobbies 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 obtain an 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 stations heard on a set, and at the same time to 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 130, 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 *o*. 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.

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.

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.

CALL SIGNS, INTERNATIONAL.

—See *International Call Signs*.

CALORIE.—Same as *Calory*.

CALORY.—The unit of heat. The degree of heat required to raise a gramme of water at 15° Centigrade by 1° Centigrade (C.G.S. system).

CANAL RAYS.—Diacathode Rays (which see).

CAPACITANCE.—The potential difference existing between a body and surrounding bodies when a quantity of electricity is imparted to it. Unit, the Farad.

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.

CAPACITY BRIDGE — CELLS IN SERIES

CAPACITY BRIDGE.—A device for measuring the value of an unknown condenser. It consists in principle of a device similar to a Wheatstone bridge, and the unknown condenser is "balanced" against known values in the remaining arms of the bridge. (See also *Wheatstone Bridge*.)

CAPACITY EARTH.—A counterpoise 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 compound of carbon and silicon made by heating sand and coke in an electric furnace. Also, 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 TUBE.—An electrical 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 evacuated, 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. (See also *Braun Tube* and *Television*.)

CATION.—Obsolete term for positive ion. An element which in electrolysis is evolved at the cathode. Sometimes spelt *Cathion*. Opposed to *Anion* (which see).

C.C.—Cubic centimetres.

CELLS IN 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. The voltage remains unchanged.

CELLS IN 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.

CENTI — CHARACTERISTIC CURVES

CENTI.—One-hundredth.

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

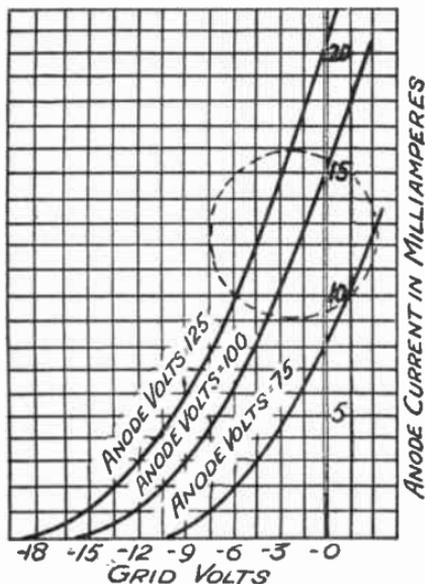


FIG. 80.—The ordinary grid-volts anode current curves.

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

Volts." Sometimes 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, 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.

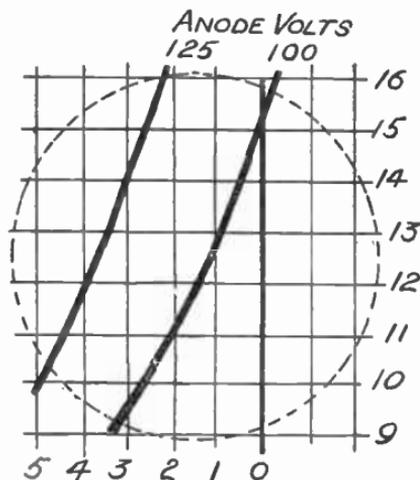


FIG. 81.—An enlarged view of the section shown in Fig. 80.

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

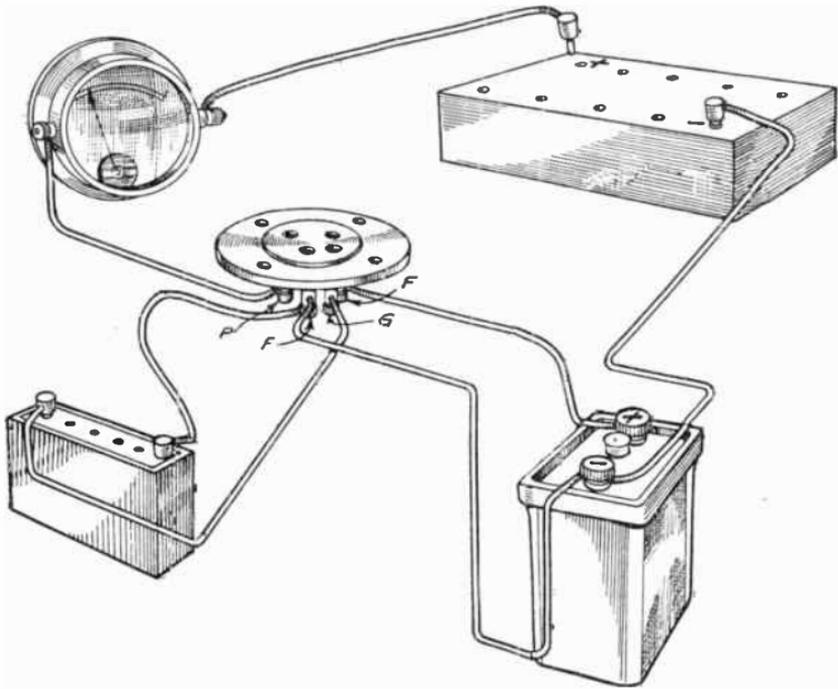


FIG. 82.—How to arrange the necessary parts in order to read a valve and prepare your own curves, or check your valves.

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

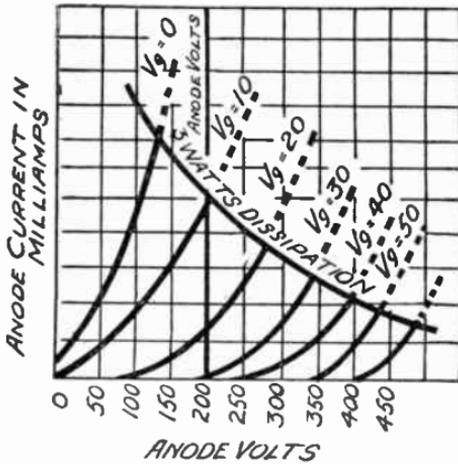


FIG. 83.—The Dynamic Valve Curves—which are the most important curves to have.

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

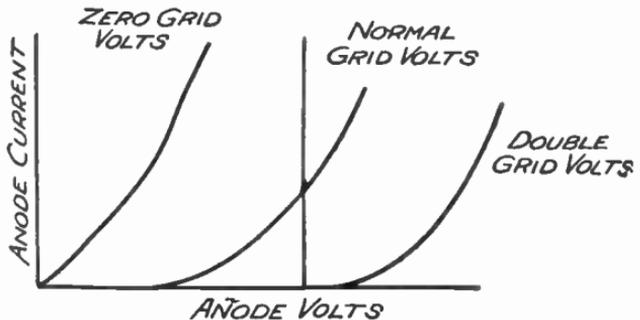


FIG. 84.—The Dynamic Curves simplified.

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

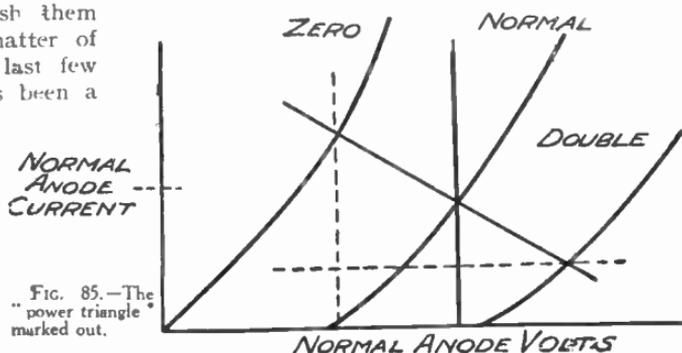


FIG. 85.—The "power triangle" marked out.

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

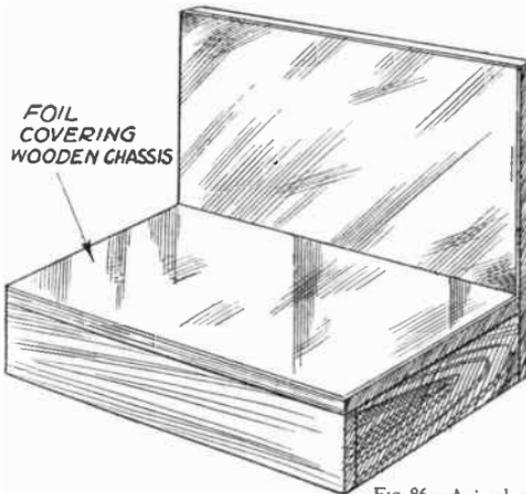


FIG. 86.—A simple way of making a "metal" Chassis. A wooden framework covered with metal foil.

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, $\frac{1}{2}$ 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

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

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. 93 would make this unnecessary.

A simpler form of chassis is now available for the home constructor, consisting of a plywood base upon which is a coating of metal, sprayed on under pressure and giving the same effect as a sheet of metal. This is easy to work, and the surface may be scraped away with a pen-knife or similar implement when it is desired to mount a component, which must now be earthed. If this type of chassis is used for short-wave apparatus, the metal surface should not be employed for earth-return purposes, as it may become damaged due to handling and thus

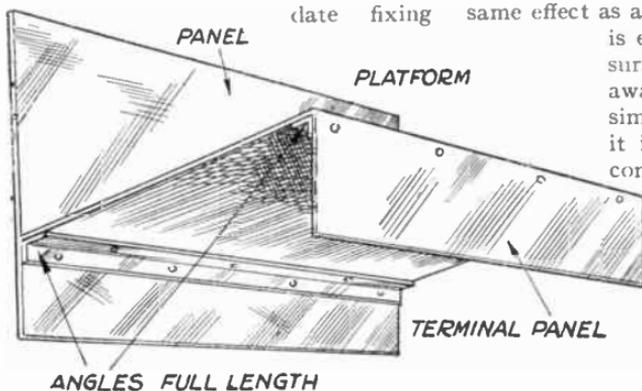


FIG. 87.—A metal Chassis using angle-irons instead of bending the aluminium.

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

give rise to a high-resistance joint. It is also possible to make a similar type of chassis, having the working facilities of the wooden structure, with the advantages of the metal arrangement, by using ordinary plywood for the foundation and covering it with a layer of good copper or aluminium foil. For short-wave

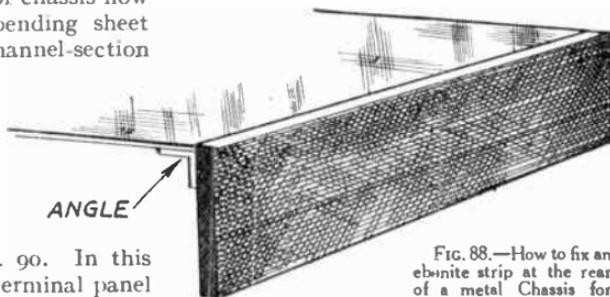


FIG. 88.—How to fix an ebonite strip at the rear of a metal Chassis for terminal connections.

CHASSIS CONSTRUCTION

apparatus the copper is preferable, and all earth-return leads may be made through the foil, using holding-down bolts or screws as the anchoring points for the earth connections. It is also possible to solder the connections at these points, but if the latter is not adopted, the point at which the wire is attached should be very carefully cleaned if H.F. currents are to be fed through the coil. A word of warning should be added here not to use the various types of

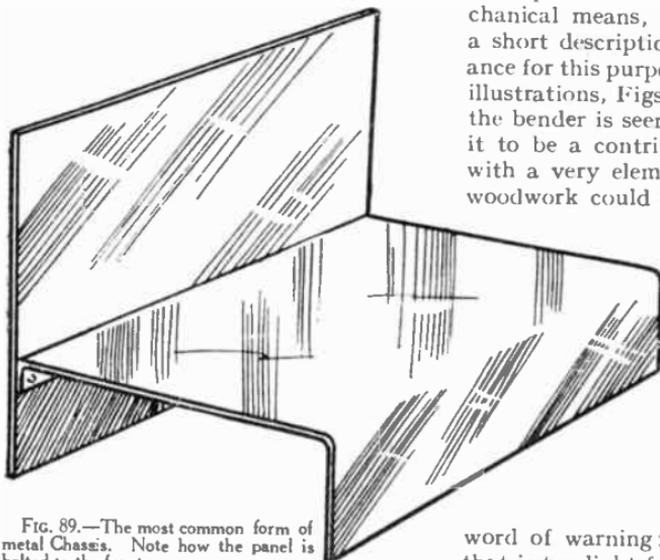


FIG. 89.—The most common form of metal Chassis. Note how the panel is bolted to the front.

metallised paper which may be obtained from various sources, such as wall-paper and similar material, which consists of fine metallic powder held in position by some adhesive material which does not provide continuity in an electrical sense, and therefore the utmost care should be taken if such material is selected. For the same reason it is not worth while attempting to use small pieces of foil-covered paper, joining them together by overlapping and sticking them down, as this will also break the continuity between adjacent pieces of foil.

Now, unfortunately these long 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, Figs. 91 and 92, 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 ⅜-in. Whit. countersunk-headed ones;

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

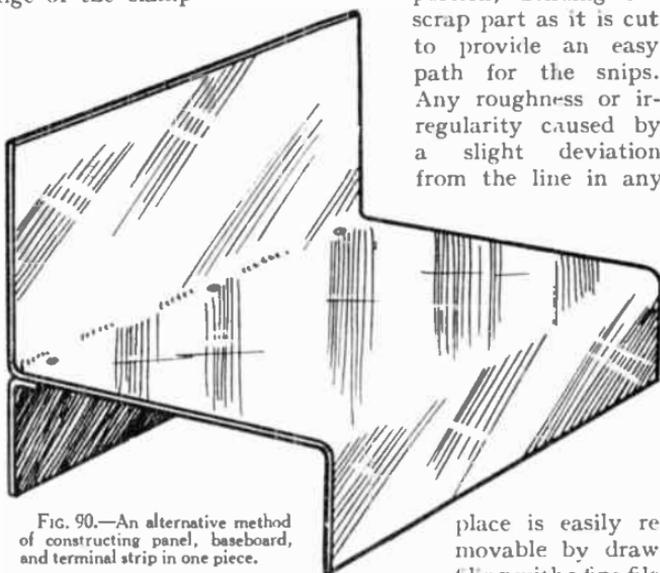


FIG. 90.—An alternative method of constructing panel, baseboard, and terminal strip in one piece.

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

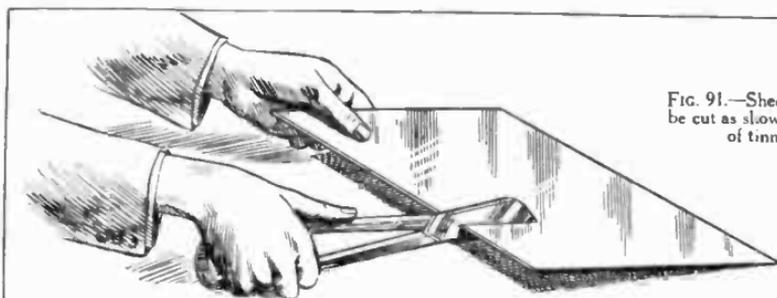


FIG. 91.—Sheet aluminium should be cut as shown here, with a pair of tinman's shears.

FIG. 91A.—Marking out should be done with a steel straight-edge and a scribe.

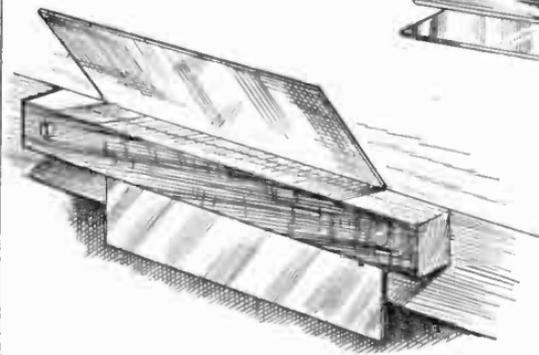
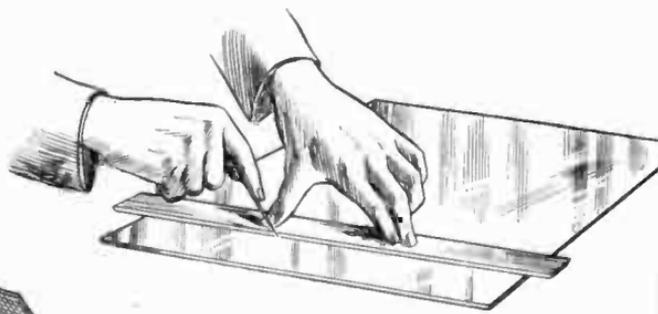
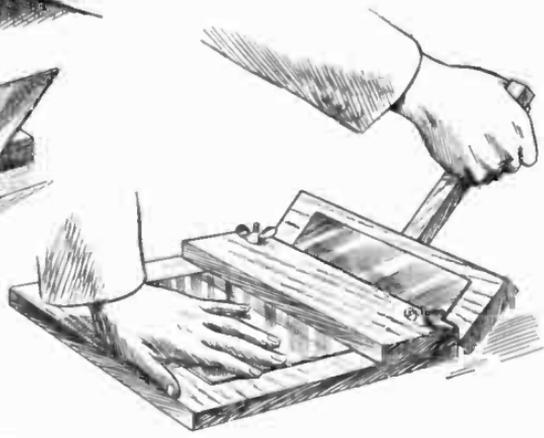
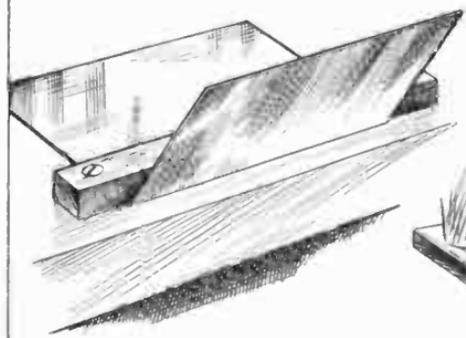


FIG. 92.—(Left) One method of bending aluminium. (Below) A simple bending or forming jig. (Left bottom) A further method of bending aluminium sheet.



CHATTERTON'S COMPOUND

bends may be completed in like manner.

the type provided with a quadrant and positive locking device, the end

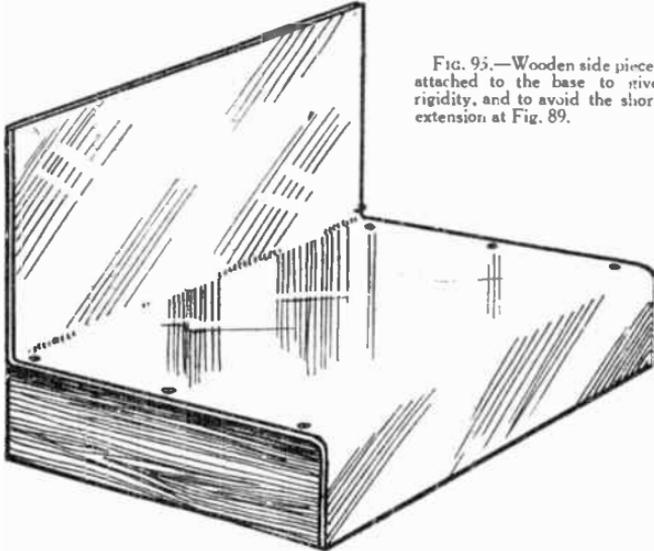


FIG. 93.—Wooden side pieces attached to the base to give rigidity, and to avoid the short extension at Fig. 89.

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

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.

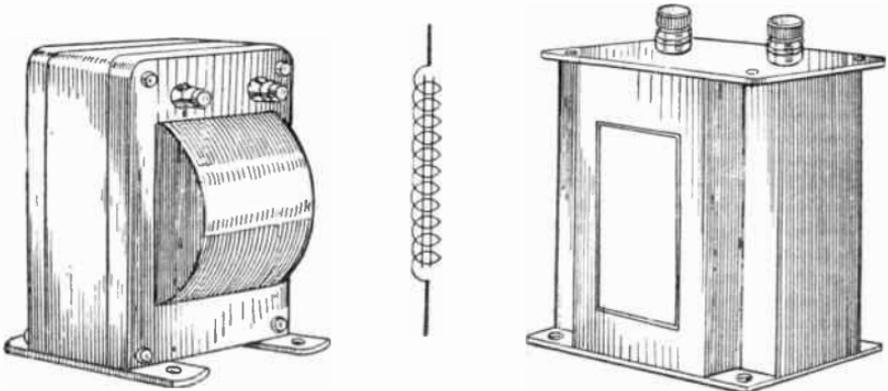


FIG. 94.—Conventional and actual diagram of two forms of L.F. Choke.

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

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

CHOKE — CIRCUIT

substance of a plastic character.

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

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

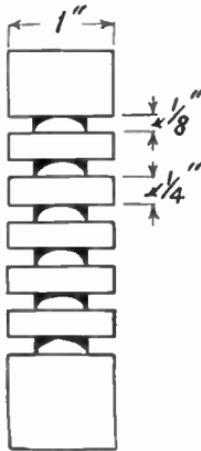


FIG. 95.—A home-made Former.

turn out slots about $\frac{1}{4}$ in. deep by just over $\frac{1}{8}$ 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 $\frac{1}{2}$ 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 Chatterton's Compound. Fig. 95 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. (See also *High-frequency Chokes*, and *Anti-break-through Choke*.)

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

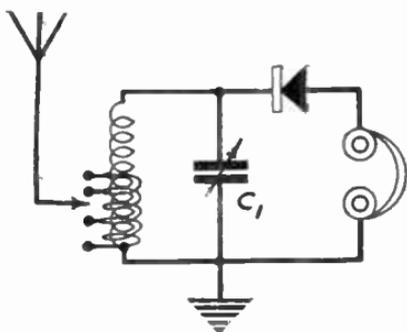


FIG. 96.—Crystal Circuit using tapped coil.

List of Components for Fig. 96

- 0005 mfd. variable condenser (C_1).
- 1 crystal detector.
- Plug-in coil holder.
- Plug-in coils.
- Terminals, connecting wire, and screws.

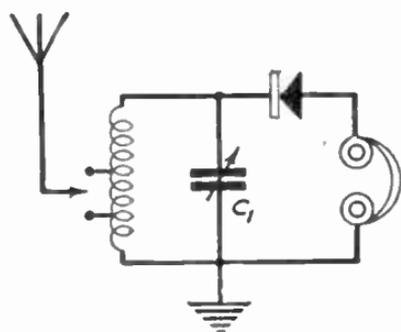


FIG. 97.—The very simplest Crystal Circuit.

List of Components for Fig. 97

- 0005 mfd. variable condenser (C_1).
- 1 crystal detector.
- Terminals, connecting wire, and screws.

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

TYPICAL CIRCUITS

Two simple crystal circuits are shown in Figs. 96 and 97.

Circuit No. 1. The simplest form of single-valve receiver is shown in Fig. 98. 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

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

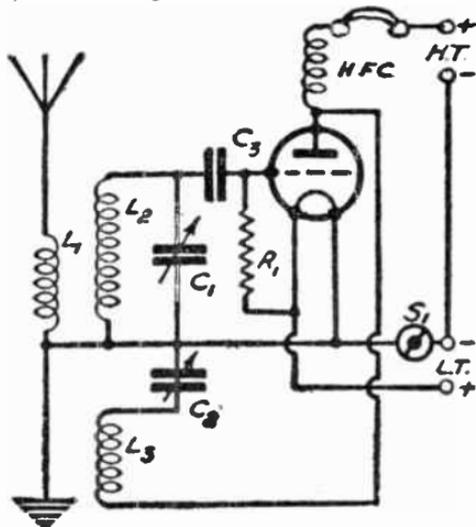


FIG. 98.—Circuit No. 1: The simplest One-valve Circuit.

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-

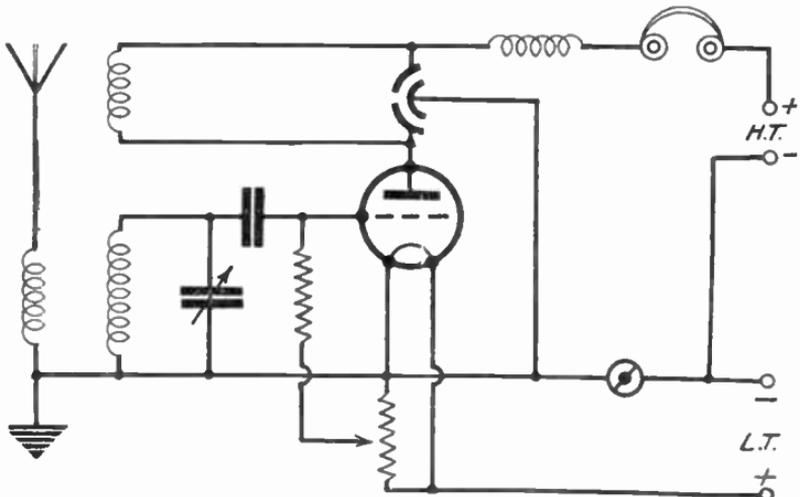


FIG. 99.—Circuit No. 2: a similar circuit to Fig. 98, employing a different system of reaction control.

Circuit No. 2. This (Fig. 99) 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 x 7 in.
- 1 baseboard, 13 x 9 in.
- 1 cabinet to fit.
- 1 .0005 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. 100 shows a simple one-valver employing home-made coils.

List of Components for Circuit No. 3

- .0005 mfd. variable condenser (C1).
- .0003 mfd. variable condenser (C2).

.0002 mfd. fixed condenser (C3).

1 H.F. choke.

1 2-megohm grid leak and holder (R1).
Valve holder.

On-and-off switch (S1).

Terminals, connecting wire, and screws.

Circuit No. 4. Fig. 101 shows a two-valve set, designed for purity of reproduction. Plug-in coils are used. Remarks in Circuit No. 1 relative to this part of the circuit will also apply. The resistance R2, the condenser C4, and the resistance R3 are all incorporated in the commercial 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.

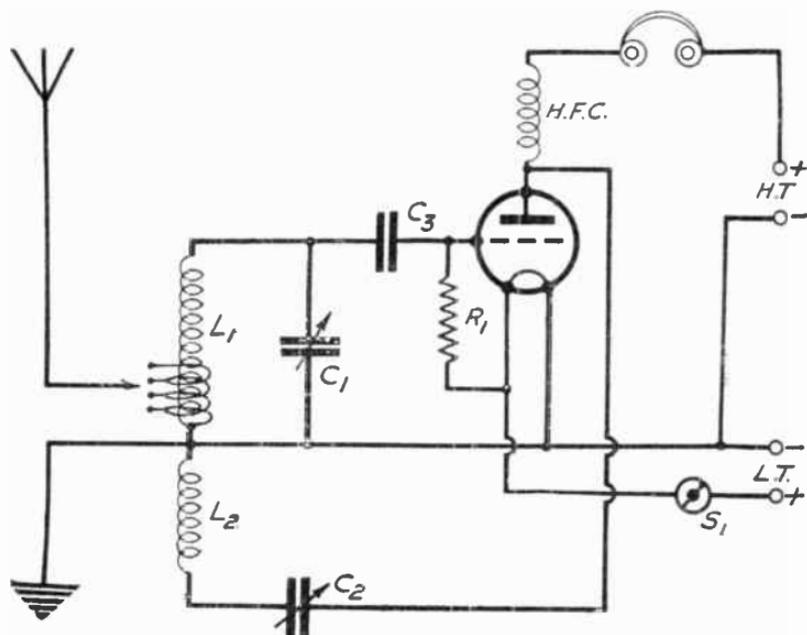


FIG. 100.—Circuit No. 3: Another simple One-valve Set.

CIRCUIT

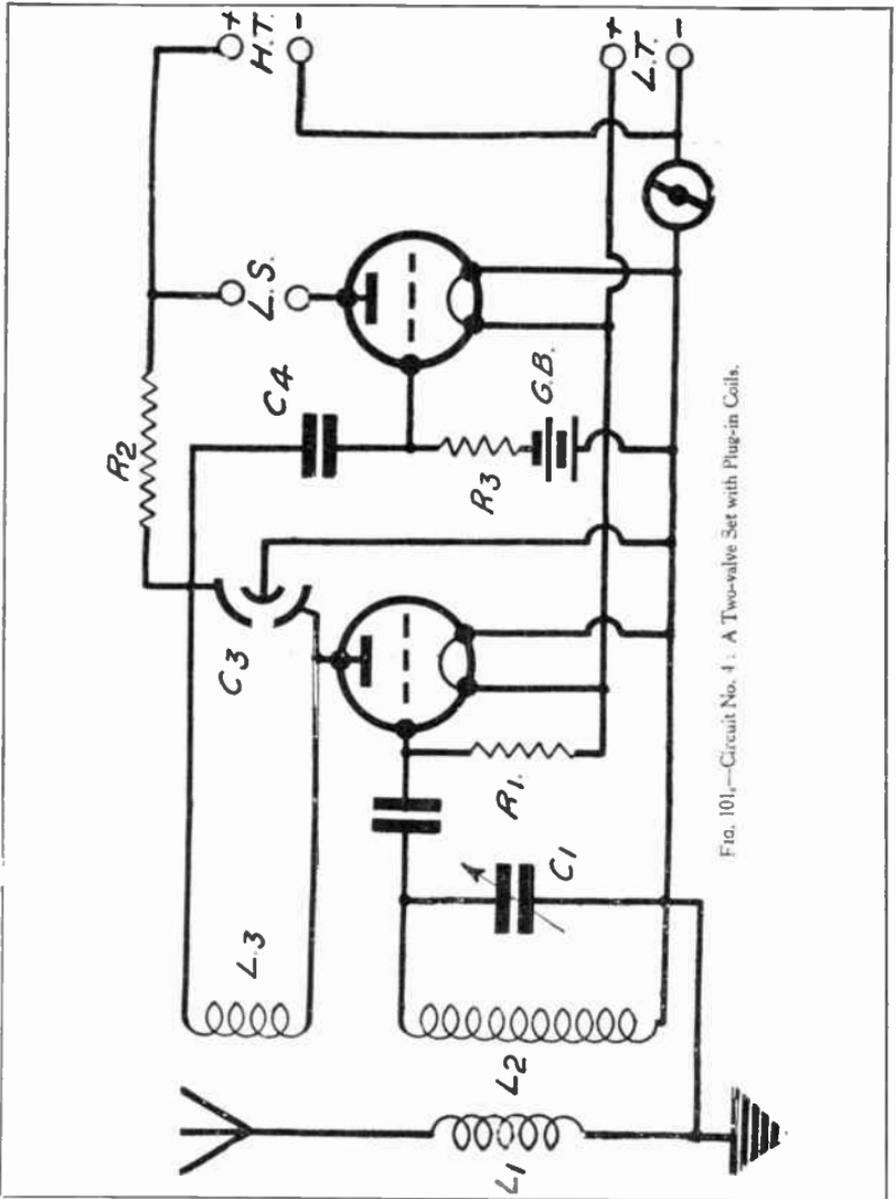


FIG. 101.—Circuit No. 4 : A Two-valve Set with Plug-in Coils.

List of Components for Circuit No. 4

- 0005 mfd. variable condenser (C₁).
- 0002 mfd. differential reaction condenser (C₃).
- 0002 mfd. fixed condenser (C₂).

- 01 mfd. fixed condenser (C₄).
- 1 2-megohm grid leak and clips (R₁).
- 1 100,000-ohm resistance and holder (R₂).
- 1 25,000-ohm resistance and holder (R₃).

CIRCUIT

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

Circuit No. 5. 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. 5*
- 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. 6. 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. 6*
- 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. 7. 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

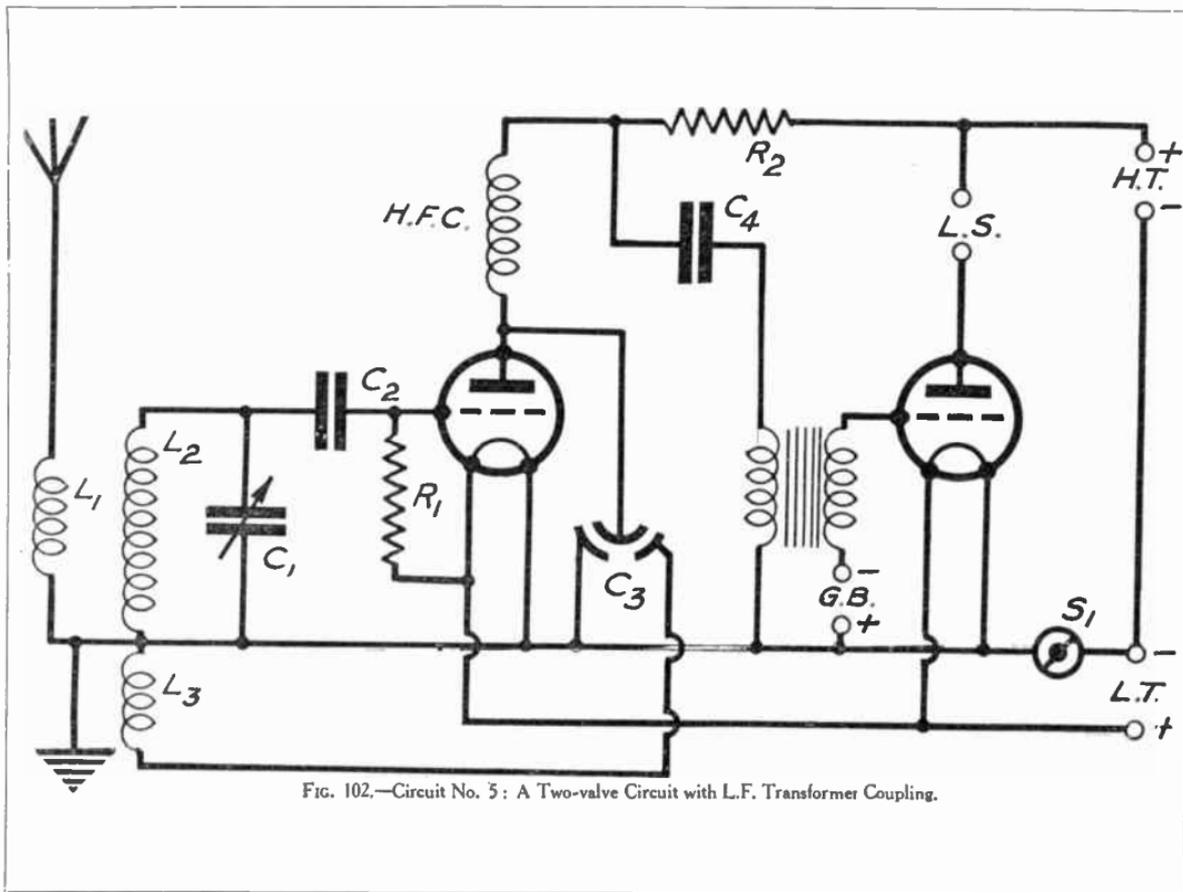
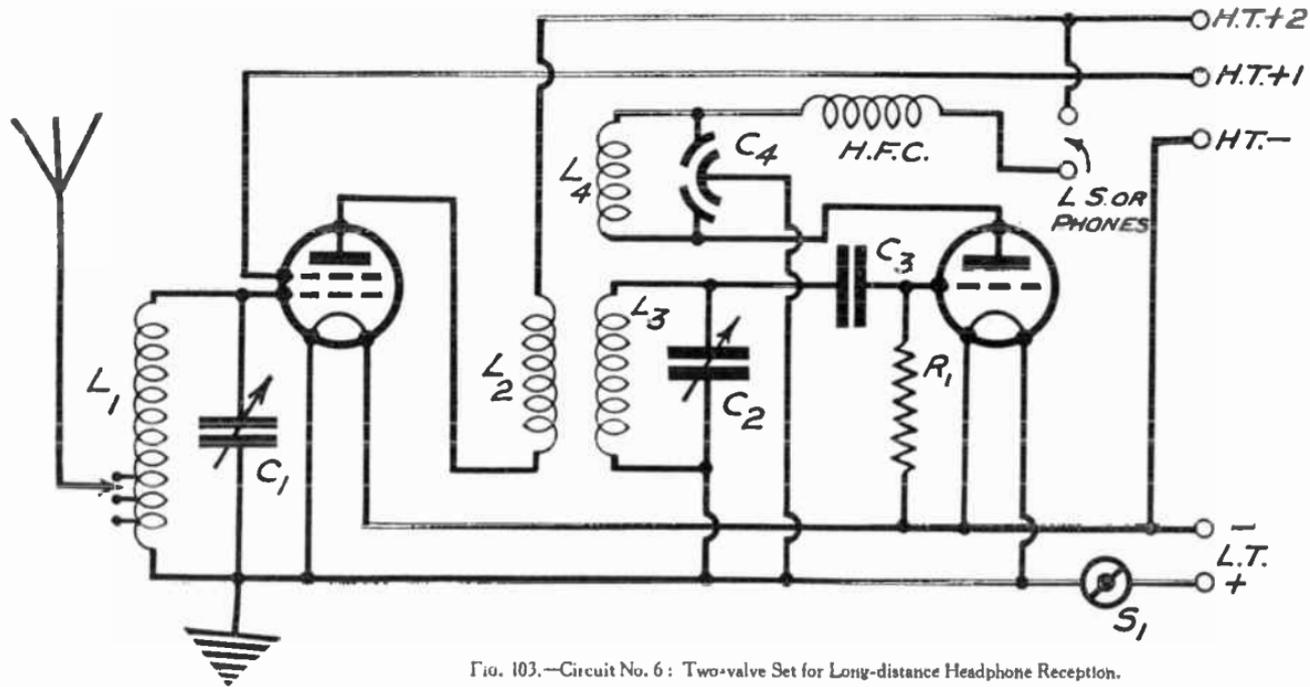


FIG. 102.—Circuit No. 5: A Two-valve Circuit with L.F. Transformer Coupling.



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

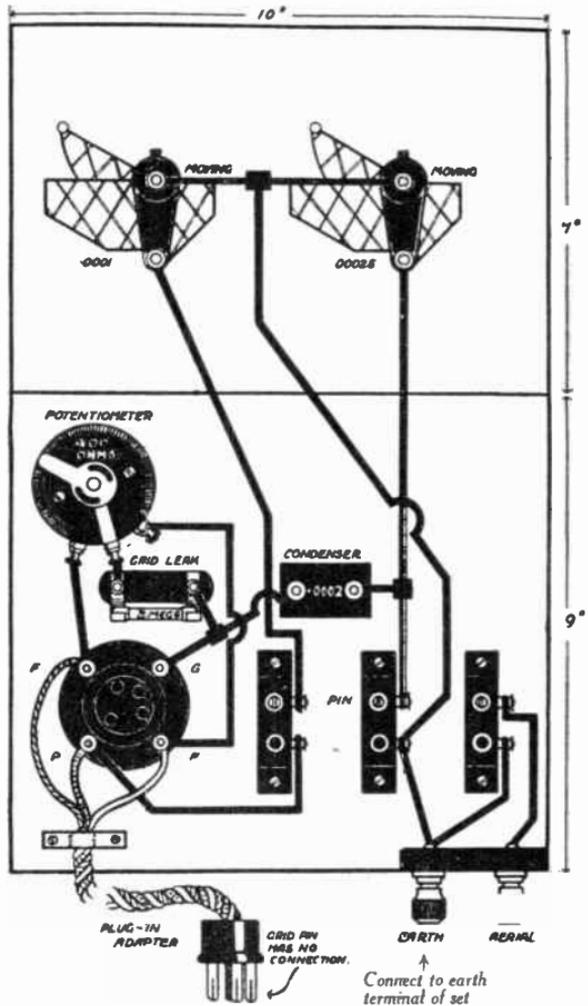


FIG. 104.—Circuit No. 7: Wiring Diagram for Short-wave Adapter Unit.

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. The earth terminals of receiver and adapter should be joined with a short length of wire. If the receiver is now 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.

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 $\frac{1}{4}$ 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

CIRCUIT

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

List of Components for Circuit No. 7
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-

List of Components for Circuit No. 8: One .0001 mfd. short-wave tuning condenser and slow-motion dial.

One .0003 mfd. reaction condenser.

One .0002 mfd. fixed condenser.

One short-wave H.F. choke.

One L.F. transformer (ratio 4 or 5 to 1).

One 1 megohm grid leak.

One 3 megohm grid leak.

One on/off switch.

One set short-wave coils.

Two 4-pin valveholders.

Seven terminals (aerial, earth,

H.T.1, H.T.2, H.T.-,

L.T.-, and L.T.+).

Ebonite panel, 12 x 8 in.

Baseboard, 12 x 9 in.

Two wander plugs (G.B.-

and G.B.+).

Flex, wire, screws, etc.

One general purpose valve

One L.F. valve.

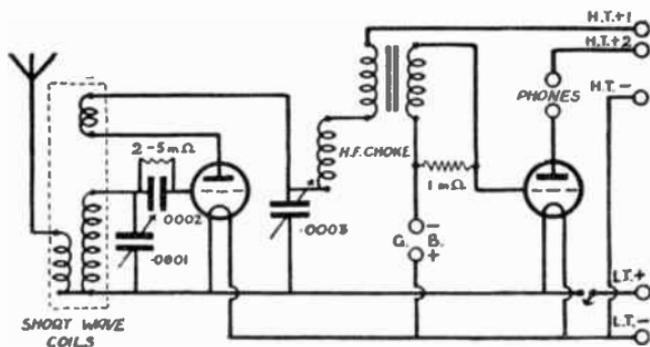


FIG. 105.—Circuit No. 8: Circuit for a Short-wave Two-valve Set.

1 anti-microphonic valve holder.

1 set of short-wave coils.

1 plug-in valve adapter.

Flex, wire, screws, etc.

2 terminals.

Circuit No. 8. 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 multi-valver 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

CIRCUIT

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. 9. 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-

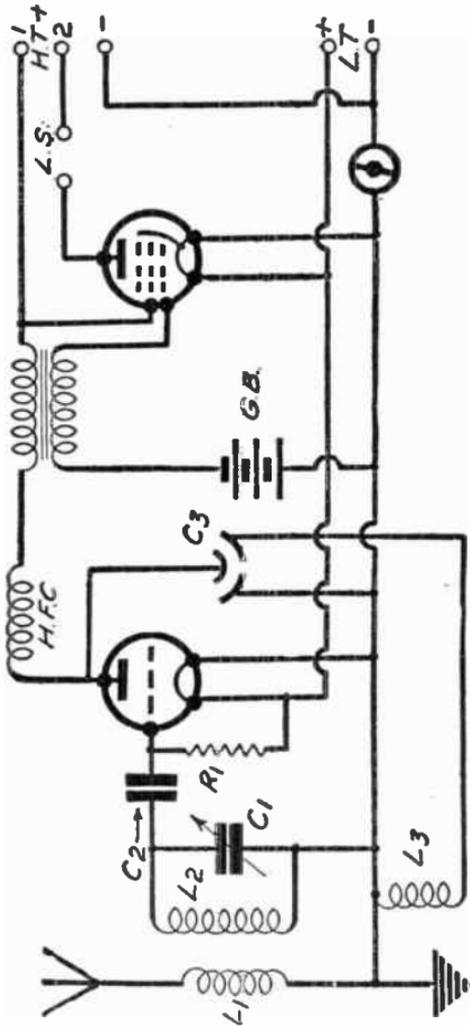


Fig. 106.—Circuit No. 9: Two-valve Set suitable for working with a battery eliminator.

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-

CIRCUIT

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. 9

- I .0005 - mfd. variable condenser (C1).
- I .0001 - mfd. fixed condenser (C2).
- I .0002 differential condenser (C3).
- I 25,000 - ohm grid leak and holder (R1).
- I 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. 10. Fig. 107 shows a

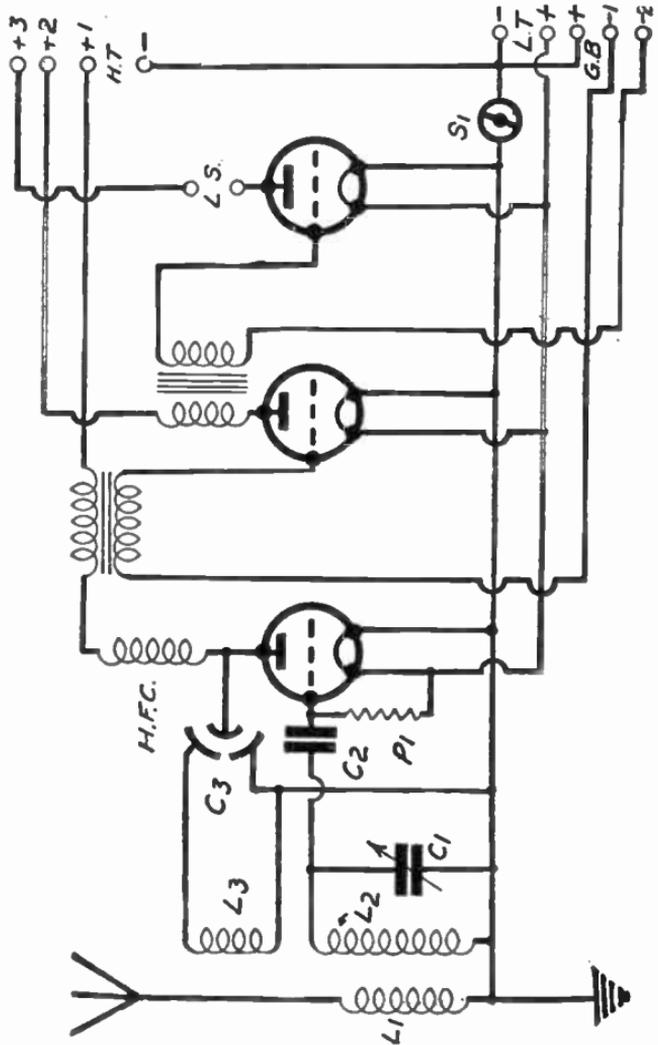


Fig. 107.—Circuit No. 10 : A Simple Three-valve Circuit.

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 recommend. 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. 10

- 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. 11. This is a three-valve receiver employing the superhet feature, and to keep the number of valves to a minimum (thus giving economy of operation) a Westector or cold valve is employed in place of the second detector. Coupling to the output valve is by means of a special high-ratio auto-transformer, and although economical to operate, this receiver may be relied upon to provide a considerable number of stations, with a very high degree of selectivity.

List of Components for Circuit No. 11

- 1 set 3-gang superhet coils.

- 1 3-gang superhet midget variable condenser and disc drive.
- 2 "Practical Wireless" I.F. transformers (110 kc/s).
- 1 .002-mfd. preset condenser.
- 1 50,000-ohm potentiometer.
- 1 1-mfd. fixed condenser.
- 2 .5-mfd. fixed condensers.
- 1 .01-mfd. tubular condenser.
- 2 .0001-mfd. fixed condensers, type 34.
- 3 resistances, 150,000, 100,000, 30,000.
- 1 L.F. transformer.
- 1 potentiometer bracket.
- 1 3-point on-off switch.
- 1 7-pin sub-baseboard valve holder, terminal type.
- 1 5-pin sub-baseboard valve holder, terminal type.
- 1 4-pin sub-baseboard valve holder, terminal type.
- 1 Westector, type W6.
- 3 wander plugs (H.T. + 1, H.T. + 2, H.T. -).
- 2 spade terminals (L.T. +, L.T. -).
- 3 G.B. plugs (G.B. +, G.B. - 1, G.B. - 2).
- 2 terminal strips (A.-E. and L.S.).
- 1 Metaplex chassis, 11 x 10 in., with 2½-in. runners.
- 3 valves, pentagrid, var.-mu H.F. pentode, and output pentode.
- 1 P.M. loudspeaker.
- 1 120-volt H.T. battery.
- 1 G.B. 16½-volt battery.
- 1 L.T. 2-volt accumulator.

Circuit No. 12. This is an all-wave receiver designed to utilise ordinary plug-in coils for the short waves, but with standard screened coils for the

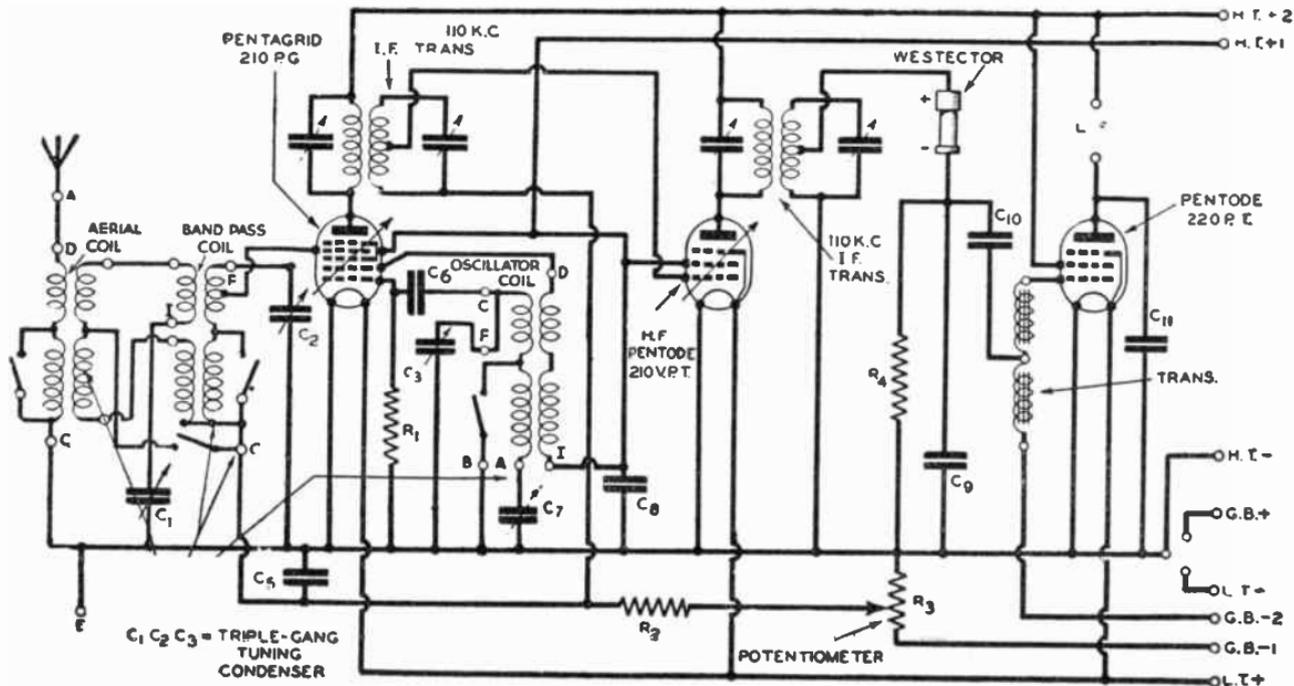


FIG. 108.—Circuit No. 11: A Three-valve Battery-operated Superhet.

CIRCUIT

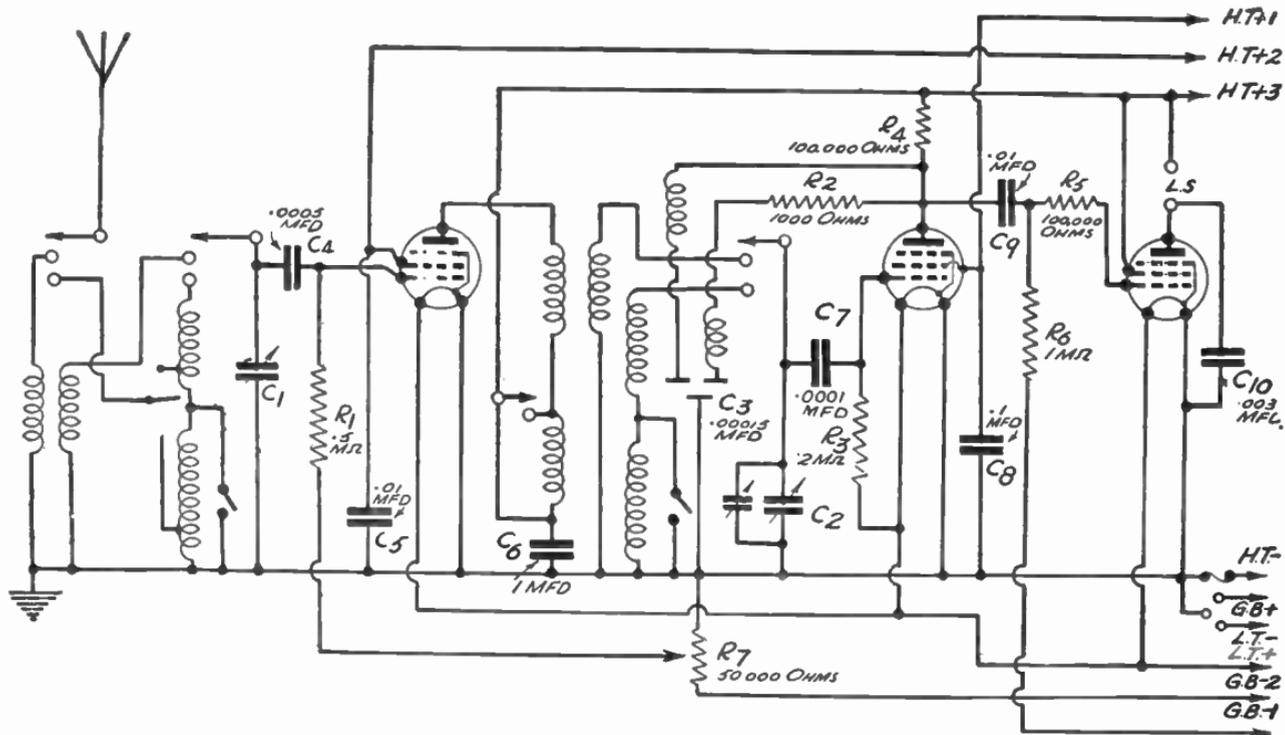
broadcast wavelengths, and the change from one band to another is carried out by means of a special multi-switch unit. Three pentodes are employed for maximum gain, and the first valve employs variable-mu control, that is, the volume may be controlled by varying the grid bias applied to the valve. Resistance-capacity coupling is employed between the detector and output pentodes, and this preserves quality as well as cheapening initial costs. The connections to the switch unit are given to enable this part of the constructional work to be followed, but for the remainder the standard type of layout should be followed. That is, the ganged tuning condenser should be mounted in the centre front of the chassis, with the two-gang broadcast coil unit on the left. The volume control should be mounted on the right of the condenser, and the second two valves (V₂ and V₃) should be placed one behind the other at the rear of this control. The four-pin short-wave coil holder should be mounted behind the two-coil unit, and V₁ and the six-pin coil holder should then be mounted in a line between the four-pin holder and V₂. The reaction condenser and the multi-switch unit should be mounted in the centre of the under side of the chassis and extension handles connected to the spindles for control purposes. This avoids using long connecting leads, and two component-mounting brackets must be mounted on the front of the chassis to hold the extension handles firm.

In the following lists of components, whilst names of makers have been omitted, it should be mentioned that kit suppliers are willing to supply complete sets of parts as used in the original receiver. In ordering mention this volume and the circuit number to enable the maker to select the right kit.

List of Components for Circuit No. 12

- 1 2-gang coil unit.
- 2 short-wave coils.
- 1 2-gang condenser (C₁, C₂).
- 1 2-bank multi-switch.
- 1 ·00015-mfd. differential reaction condenser (C₃).
- 1 horizontal drive with trimmer.
- 3 valve holders (two 4-pin, one 5-pin), V₃.
- 2 coil holders (one 4-pin, one 6-pin).
- 2 extension rods.
- 1 volume control, 50,000 ohms, with 3-point switch (R₇).
- 6 fixed resistances: ·5 megohm (R₁), 1,000 ohms (R₂), 100,000 ohms (R₄), 100,000 ohms (R₅), 2 megohms (R₃), 1 megohm (R₆).
- 7 condensers: ·1 mfd. (C₆), ·1 mfd. (C₈), ·01 mfd. (C₅), ·01 mfd. (C₉), ·0005 mfd. (C₄), ·0001 mfd. (C₇), ·003 mfd. (C₁₀).
- 5 component brackets.
- 2 terminal strips: A. E. and L.S.
- 1 100-mA. fuse and holder.
- 3 valves: Var.-mu pentode, straight pentode, and output pentode.
- 1 Metaplex chassis 10 × 9 × 3 in.
- 1 speaker.
- 1 cabinet.
- 7 plugs: H.T.1, H.T.2, H.T.3, H.T. -, G.B. +, G.B. - 1, G.B. - 2.
- 2 spades: L.T. +, L.T. -.

Circuit No. 13. The receiver now described (see Fig. 110) is entirely self-contained, although a 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-



CIRCUIT

FIG. 109.—Circuit No. 12: An All-wave All-pentode Battery Receiver.

CIRCUIT

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 ($15\frac{1}{2} \times 15\frac{1}{2} \times 5\frac{1}{2}$) should be made first, 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

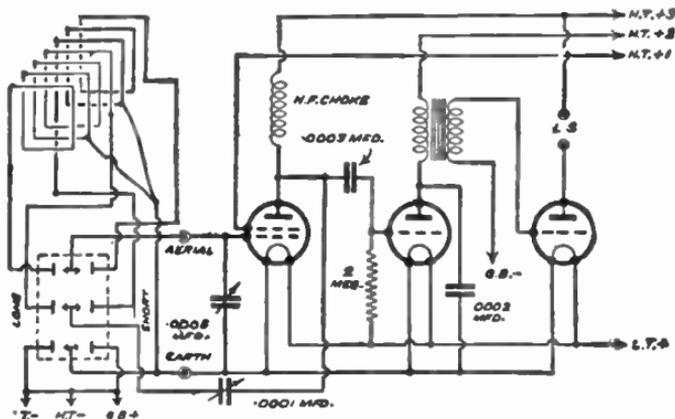


FIG. 110.—Circuit No. 13: Circuit diagram for a Three-valve Portable Set.

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. 26 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 $\frac{1}{10}$ 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

CIRCUIT

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 H.F. 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. 13

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. 26 D.C.C. wire for frame aerial.
 Wood for cabinet, silk gauze for grille.
 Screws, Glazite for terminals, wiring up, wander plugs, etc.

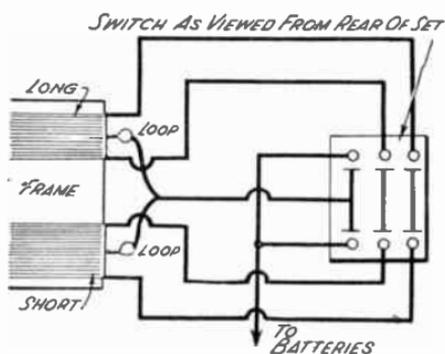


FIG. 111.—The Switch Connection to the Aerial of Circuit No. 13.

Circuit No. 14. 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 transformer coupled. This will give very good-quality loudspeaker results from a large number of stations and is really simple to handle. The aerial circuit consists of a simple screened coil of modern type, and the H.F. transformer a similar type of coil.

List of Components for Circuit No. 14

1 double-gang condenser, .0005 mfd. (C1 and C2).
 2 Screened coils.
 1 .00015-mfd. differential reaction condenser (C5).
 1 5 : 1 L.F. transformer.

CIRCUIT

- | | |
|---|---|
| <ul style="list-style-type: none"> 3 chassis-mounting valve holders. 1 H.F. choke. 1 20,000-ohm 1-watt electronic resistance (R₂). 1 2-megohm 1-watt grid leak (R₁). 1 2-mfd. tubular fixed condenser (C₆). | <ul style="list-style-type: none"> 1 on-off switch. 1 4-point switch. 1 5-way battery cord, fitted with wander plugs marked H.T. -, H.T. +2, and H.T. +, and spade terminals marked L.T. + and L.T. -. |
|---|---|

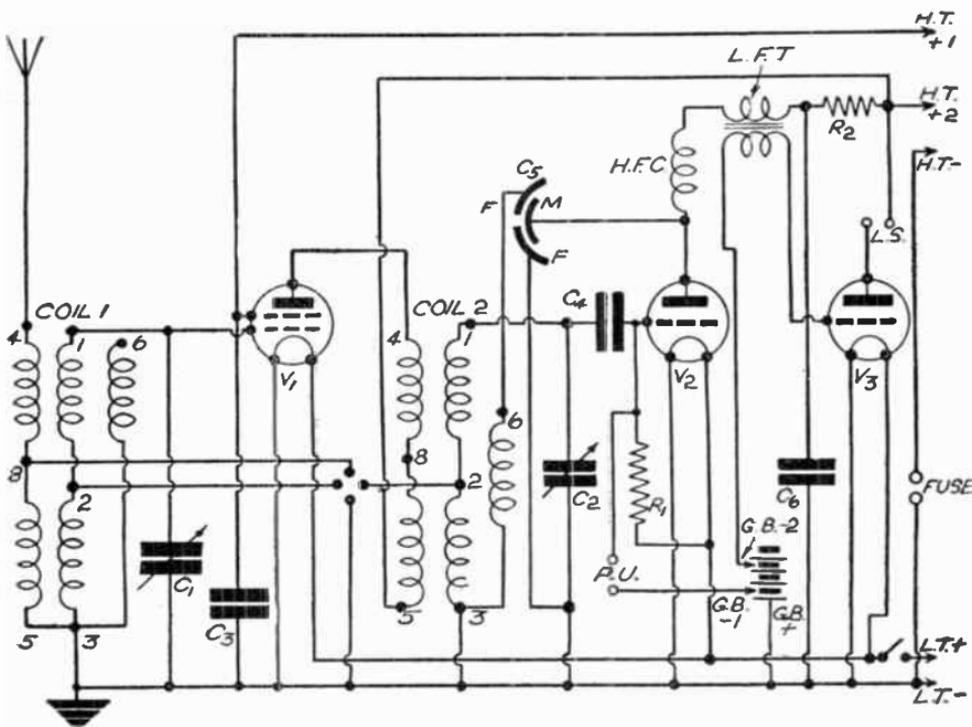


FIG. 112.—Circuit No. 14: A Beginner's Three-valve Set.

- | | |
|---|---|
| <ul style="list-style-type: none"> 1 1-mfd. fixed condenser (C₃). 1 .0002-mfd. fixed condenser (C₄). 2 terminal socket strips; one marked A and E, the other L.S. and P.U. 6 solid plugs (for use with terminal strips). 1 grid bias battery clip, type No. 2. 1 fuse holder and fuse bulb. | <ul style="list-style-type: none"> 1 Metaplex chassis, 12 × 10 in., with 1½-in. runners. 3 component brackets. 3 valves: screen-grid, detector, and power. 1 20-volt high-tension battery. 1 9-volt G.B. battery. 1 2-volt accumulator. 1 cabinet. |
|---|---|

CIRCUIT

Circuit No. 15. 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 a simple type of five-valver. The aerial circuit and H.F. transformer consist of a pair of modern coils operated by two switches actuated by a common control. All the other components have been chosen with a view to high efficiency, and therefore the list of parts should be rigidly adhered to. 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.

List of Components for Circuit No. 15

- 2 ·0005-mfd. variable condensers.
- 1 pair tuning coils.
- 1 standard screened H.F. choke.
- 1 special screened H.F. choke.
- 2 ·0001-mfd. fixed condensers.
- 1 ·01 fixed condenser.
- 1 2-mfd. fixed condenser.

- 1 1-mfd. ditto.
- 1 30,000-ohm 1-watt fixed resistor.
- 1 10,000-ohm ditto.
- 1 2-megohm grid leak.
- 2 4-pin chassis-mounting valve holders.
- 1 L.F. transformer.
- 1 16-henry 15-m/A L.F. choke.
- 2 toggle switches, and operating rod.
- 1 ·0003-mfd. reaction condenser.

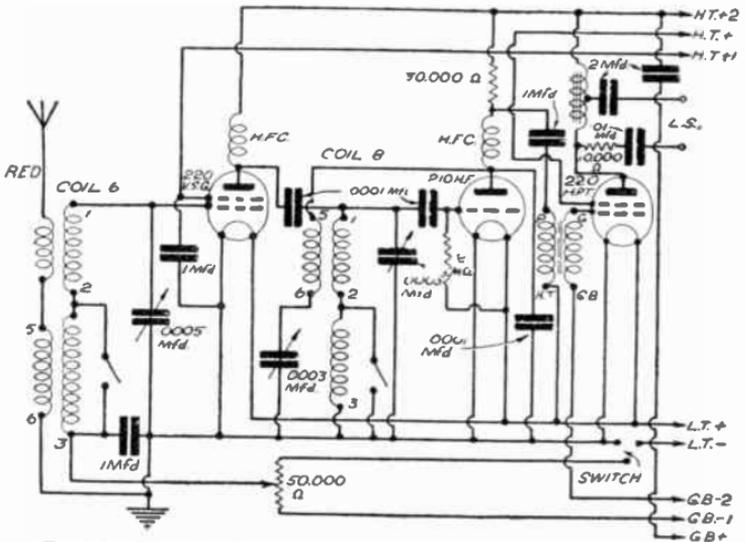


FIG. 113.—Circuit No. 15: A Three-valve Set with Variable-mu Volume Control.

- 1 3-point on-off switch.
- 1 50,000-ohm potentiometer.
- 4 terminals, aerial, earth, L.T. +, and L.T. -.
- 6 wander plugs, G.B. - 2, G.B. - 1, H.T. -, H.T. + 1, H.T. + 2, G.B. +.
- 1 16-gauge metal panel and chassis.
- 1 7-way battery cord.
- Connecting wire, bolts, and nuts.
- 1 loudspeaker.
- 1 120-volt H.T. battery.
- 1 G.B. battery.

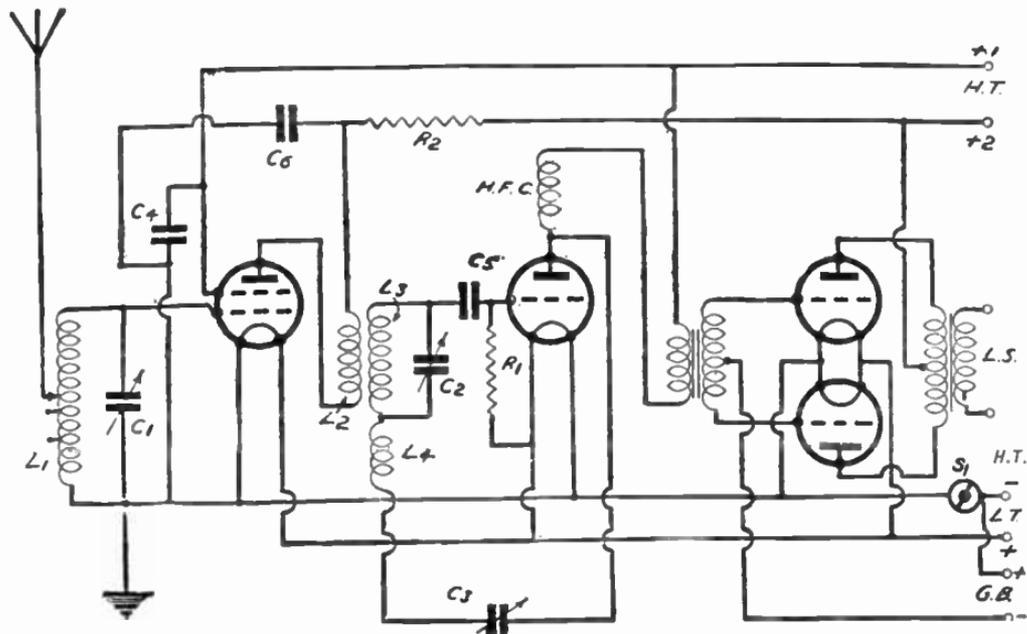


FIG. 114.—Circuit No. 16: Four-valve Circuit with two valves in Push-Pull.

*List of Components
for Circuit No. 16*

- 2 ·0005-mfd. variable condensers (C_1 and C_2).
 - 1 ·0002-mfd. variable condenser (C_3).
 - 1 ·0001-mfd. fixed condenser (C_5).
 - 2 2-mfd. fixed condensers (C_4 and C_6).
 - 1 25,000-ohm resistance and holder (R_1).
 - 1 H.F. choke.
 - 1 input push-pull transformer.
 - 1 output push-pull transformer.
 - 1 on-and-off switch (S_1).
 - 1 20,000-ohm spaghetti resistance (R_2).
 - 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

1 2-volt L.T. accumulator.

3 valves : var.-mu screen grid, H.F.,
and output pentode.

Circuit No. 16. 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 of 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. 17. This is a simple three-valve mains receiver, entirely self-contained, and possessing adequate selectivity for all normal requirements. Due to the elimination of trimming adjustments, the receiver is extremely simple to set up, and the layout may follow the circuit diagram, with the small components mounted on the under side of a chassis if this form of construction is preferred. The mains section should be built on the rear of the chassis and kept clear of the aerial side of the receiver in order to avoid hum difficulties. To simplify matters it is possible to build the receiver portion as a separate unit and to mount the loudspeaker on the mains section, erected in another part of the cabinet. A receiver of this type may be used for the construction of a radio-gramophone, and the mains section and speaker may then be mounted in the lower part of the cabinet, with the receiver about it connected through a multi-cable.

List of Components for Circuit No. 17

- 1 double-gang condenser .0005 (C1 and C2).
- 2 screened coils.

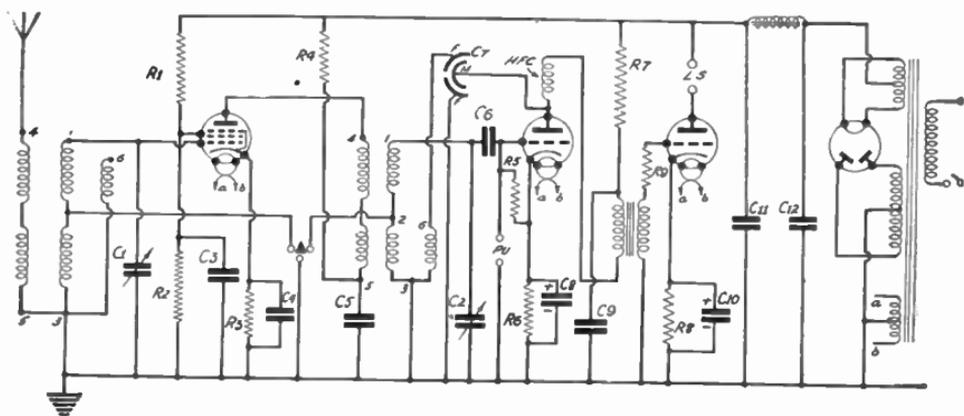


FIG. 115.—Circuit No. 17: A Simple Three-valve A.C. mains receiver.

CIRCUIT

- 1 triode valve.
- 1 power valve.
- 1 Cossor rectifier.
- Wire, screws, flex, etc.

Circuit No. 18. Many districts are at present supplied by D.C. mains, and it is proposed to change these eventually to A.C. To avoid scrapping a receiver it may be built as what is known as the Universal type, that is, suitable for use on either A.C. or D.C. mains without modification. This circuit employs three pentodes to provide maximum amplification, and is designed to tune down to the short waves in addition to the normal broadcast wavelengths. It will be noted that to simplify matters the aerial circuit is untuned, and if desired a good short-wave H.F. choke may be included in place of the .25-megohm resistance shown in this part of the circuit. The tuning is carried out by means of a special all-wave tuning unit into which five coils are inserted. This unit has its own selector switch and indicating plate, and thus enables the user instantly to select the desired wave-band without the complication of changing coils. The lower bands may be selected to suit individual requirements, a good range of coils will be found in most manufacturer's lists for use with the tuner. The coils given in the list of components will cover the following bands: 20-45, 49-80, 85-170, 200-500 and 1,000-2,000 metres. The switch and other coil units are omitted from the circuit diagram in order to avoid complication.

List of Components for Circuit No. 18

- 1 Metaplex chassis, 14 x 10 x 3 in.
- 1 ebonite or plywood panel, 14 x 8 in.
- 4 5-pin chassis-mounting valve holders.

- 1 side-contact chassis-mounting valve holder.
- 1 5-range coil chassis with switch.
- 5 coil units for above chassis, types SW.24, SW.25, SW.26, SW.28, and SW.29.
- 1 .0005-mfd. slow-motion condenser.
- 1 .0002-mfd. midget condenser (for reaction).
- 1 all-wave H.F. screened choke.
- 1 all-wave unscreened H.F. choke.
- 1 30-henry smoothing choke.
- 8 1-watt metallised resistances; one each, 40,000 ohms, 40,000 ohms, 20,000 ohms, 600 ohms, 200 ohms, .1 megohm, .25 megohm, and 5 megohm.
- 3 .0001-mfd. tubular condensers.
- 3 fixed condensers, .1 mfd., 1 mfd., and 2 mfd.
- 1 25-mfd. electrolytic condenser.
- 2 8-mfd. reversible electrolytic condensers.
- 1 1,000-ohm volume control potentiometer.
- 1 1 : 3.5 L.F. transformer.
- 4 Cossor valves, types 13VPA, 13SPA, 40PPA, and 40SUA.
- 1 Philips barretter, type C.1.

Circuit No. 19. This four-valver is designed to provide large volume with a fair selection of stations, and consequently two L.F. stages are employed with a single H.F. stage. Transformer coupling is employed in both L.F. stages, although in the case of the second stage the transformer is parallel-fed, and therefore a commercial unit designed for the purpose is used. Two screened coils are used, and thus interaction is avoided, and as the coils are carefully matched by the makers, a two-gang or two-section condenser may be

CIRCUIT

employed for tuning, giving single-knob control. The first valve is of the variable-mu type, and thus a volume control may be fitted to modify the grid bias applied to it and therefore regulate the volume obtained. The receiver may be built upon an ordinary flat wooden baseboard, and no difficulty should be experienced in wiring this simple circuit. The output filter enables an extension speaker to be employed without difficulty, and any length of lead may be used for this purpose.

List of Components for Circuit No. 19

1 coil unit.

- 1 3:1 L.F. transformer.
- 1 parallel-feed unit.
- 1 1,000-ohm 1-watt resistor.
- 1 10,000-ohm 1-watt resistor.
- 1 2-megohm grid leak.
- 1 volume control with 3-pt. switch.
- 4 4-pin valve holders, baseboard.
- 1 500,000-ohm volume control.
- 1 fuse, 100 m/A., and holder.
- 3 terminal mounts.
- 6 terminals, A, E, L.S. -, L.S. +, P.U., and P.U.
- Five-way battery cord.

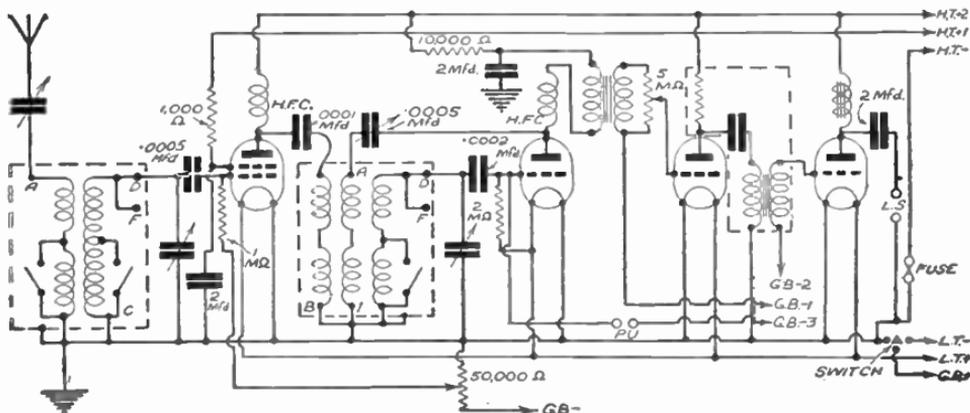


FIG. 117.—Circuit No. 19: A Simple Four-valve Battery Set.

- 1 2-gang .0005-mfd. condenser with concentric trimmer.
- 1 .0003-mfd. preset condenser.
- 1 .0003-mfd. reaction condenser.
- 3 2-mfd. fixed condensers.
- 1 .0002-mfd. condenser.
- 1 .0001-mfd. condenser.
- 1 .0005-mfd. condenser.
- 1 standard screened H.F. choke.
- 1 H.F. choke.
- 1 L.F.16 L.F. choke.
- 5 wander plugs, G.B. -, G.B. +, G.B.1, G.B.2, G.B.3.
- 1 wooden baseboard 12 x 10 in.
- 1 120-volt H.T. battery.
- 1 9-volt G.B. battery.
- 1 2-volt L.T. accumulator.
- 1 loudspeaker.
- 1 VP215 valve.
- 1 HL210 valve.
- 1 L.2 valve.
- 1 P220A valve.

CIRCUIT

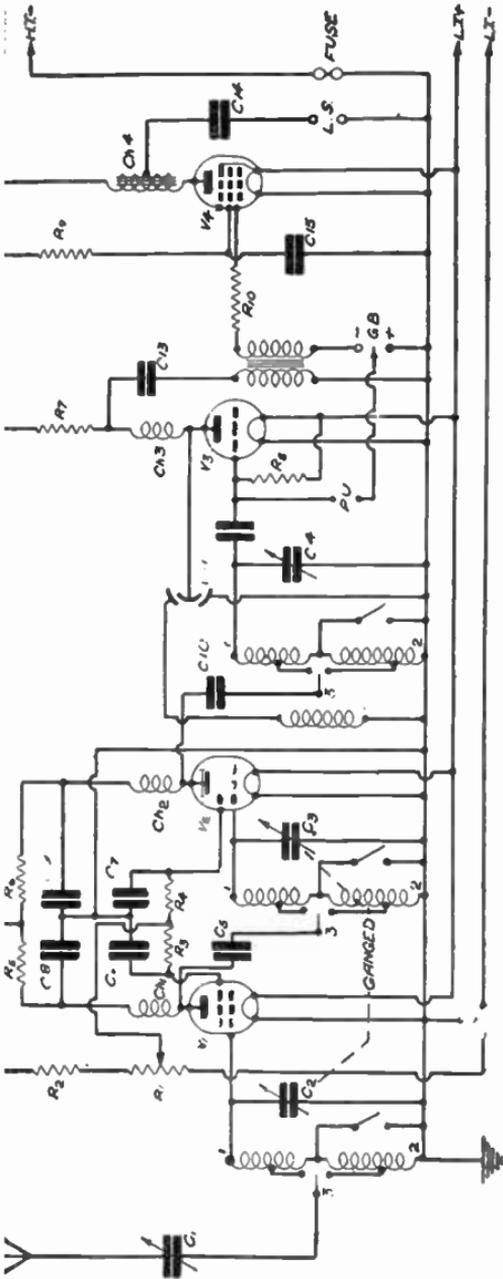


FIG. 118.—Circuit No. 20 : A Long-range Four-valve Battery Set.

Circuit No. 20. This circuit is a very powerful four-valver, designed to provide long range of reception. It will be noted that two stages of H.F. amplification are employed, both of which are screen-grid valves. A set of three-ganged coils is employed, and they are tuned by a two-gang condenser (for the first two coils), and a single condenser for the third coil. This enables the maximum performance to be obtained without tricky trimming adjustments, and avoids one of the difficulties generally met with by the beginner when endeavouring to adjust a three-circuit tuner. High quality is ensured by the employment of resistance-capacity coupling between the detector and the output valve, which in this case is a pentode. A tapped output choke is provided, so that extension leads may be used to feed the loudspeaker if desired.

List of Components for Circuit No. 20

- 1 3-gang coil assembly.
- 1 2-gang condenser with drive.
- 1 single-gang condenser with drive
- 1 $\cdot 0003$ preset condenser.
- 1 S.G. choke.
- 1 S.G. choke.
- 1 screened H.F. choke.
- 1 L.F. transformer, ratio 3 : 1.
- 1 pentode output choke.
- 3 1-mfd. fixed condensers.
- 2 $\cdot 0003$ -mfd. fixed condensers.
- 1 $\cdot 0002$ -mfd. fixed condenser.
- 2 $\cdot 1 + \cdot 1$ C-mfd. fixed condenser.
- 4 chassis-mounting valve holders, three 4-pin and one 5-pin.
- 4 1,000-ohm 1-watt type resistors.
- 1 100,000-ohm 1-watt type resistor.
- 1 5,000-ohm 1-watt resistor.

CIRCUIT

- 1 2-megohm grid leak with wire ends.
- 3 terminal mounting blocks.
- 1 4-way battery cord.
- 6 terminals: A, E, Pick-up (2), and L.S. (2).
- 1 fuse holder, with fuse.
- 1 50,000-ohm potentiometer.
- 1 .0003-mfd. differential reaction condenser.
- 1 3-point switch.
- 1 ebonite panel, 16 × 8 in.
- 1 chassis, 16 × 10 in., with 2-in. runners.
- 4 valves: type 220SG, 220SG, 210HF, and 220PT.

Circuit No. 21. This is a four-valve portable receiver, with self-contained frame aerial and a Class B output stage giving considerable volume.

The framework of the cabinet is constructed from stripwood 1 in. wide by $\frac{1}{4}$ in. thick, and this is screwed together by means of short metal

strips found in a well-known constructional toy. The speaker grille is $5\frac{1}{2}$ in. in diameter, and is covered on the inside with silk or the special fabric obtainable from any good radio dealer. The cabinet is afterwards covered with leatherette glued in position, and a carrying handle is attached to the cross-strips on the upper surface. The front of the cabinet is attached by hinges to the lower edge so that it may be lowered to insert the batteries and make tests or voltage measurements.

The frame aerial is wound on the inside of the front, spacing-strips of ebonite being screwed diagonally in the four corners. These strips are no longer on the market but may be made by obtaining a piece of $\frac{3}{8}$ -in. ebonite and cutting strips $\frac{1}{2}$ in. wide and $2\frac{1}{4}$ in. in length. Drill holes at each end so that they may be screwed to the front of the cabinet and then with a hacksaw make eight cross-cuts about $\frac{1}{4}$ in. deep, followed by two further slots, made by making two cuts and breaking out the intervening piece of ebonite so that these

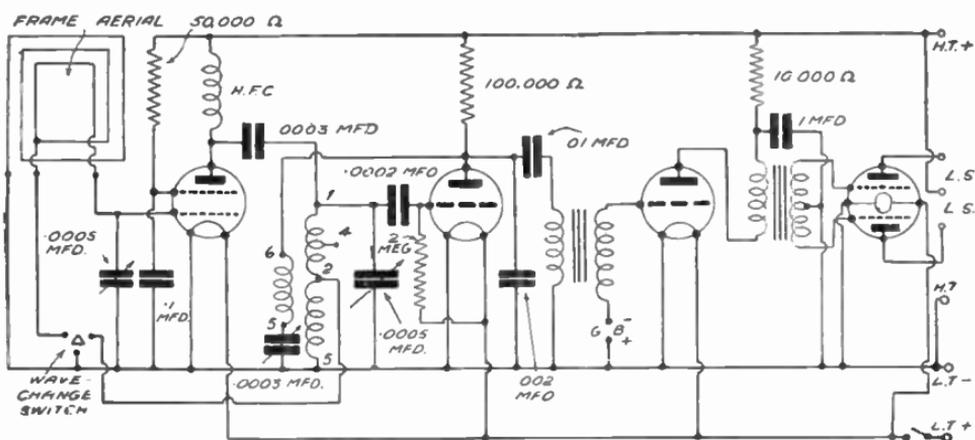


FIG. 119.—Circuit No. 21: A Four-valve Portable.

CIRCUIT

two slots are nearly $\frac{1}{4}$ in. in width. All of the slots should be cut at an angle, so that when the wire is wound in it will be prevented from falling out. One end of the 24-gauge wire is soldered to the upper right-hand contact of the tuning condenser, and the wire is then passed across to the upper slot of the nearest spacer. Run the wire across to the left, through the upper slot on the left-hand spacer and down to the lower spacer, across the lower edge, and so continue to the slot where you commenced. Carry the wire through this slot again, and make a further turn, repeating the process so that there are three turns in the first slot. Pass to the second slot, and wind three turns in this, after which two turns only are wound in each remaining slot until eight slots have been used. There now remain the two wide slots. The end of the 24-gauge wire must be cut, and it should be soldered, together with the beginning of the 34-gauge wire, to the upper terminal of the three-point switch. The long-wave winding consists of twenty-three turns in each slot, and the finish of the winding is joined to the lower terminal of the left-hand tuning condenser. Upon completion of the frame-aerial winding the slots may be sealed with sealing-wax or Chatterton's compound.

Normally, the receiver should be perfectly stable in operation, but it was originally found that, due to the compact form taken by the receiver, some constructors experienced instability. This is due to the fact that many of the wires were run too close together, and thus the first step to take if this trouble is experienced is to space out the wiring as much as possible. Initially, no screening of leads should be introduced, but if it is found impossible to obtain stable working the lead from the anode of the S.G. valve may be passed through

a length of ordinary screened sleeving and the sleeving connected by means of a short length of wire to the nearest earth terminal. The leads to the reaction condenser may also be screened in a similar manner, whilst in a very severe case of instability, the two leads to the loudspeaker may also be similarly screened. It must be emphasised, however, that such extreme screening should not be necessary unless the wiring is very badly carried out or some other difficulty arises.

List of Components for Circuit No. 21

- 2 bakelite variable condensers, .0005 mfd.
 - 1 .0003 variable condenser.
 - 1 H.F. choke.
 - 1 dual-range coil.
 - 1 10,000-ohm wire-end resistor.
 - 1 50,000-ohm wire-end resistor.
 - 1 100,000-ohm wire-end resistor.
 - 3 4-pin chassis-type valve holders.
 - 1 7-pin chassis-type valve holder.
 - 1 on-off switch.
 - 1 3-pt. switch.
 - 1 Class B driver transformer.
 - 1 2-megohm grid leak with wire ends.
 - 1 .01-mfd. fixed condenser.
 - 1 .0003-mfd. fixed condenser.
 - 1 .0002-mfd. fixed condenser.
 - 1 .002-mfd. fixed condenser.
 - 1 .1-mfd. fixed condenser.
 - 1 1-mfd. fixed condenser.
 - 1 220 S.G. valve (metallised).
 - 1 210 H.F. valve (metallised).
 - 1 215P valve.
 - 1 240B valve.
 - 1 loudspeaker, Class B.
- Quantity 24 D.C.C. and 34 D.S.C. wire.

CIRCUIT

- 1 120-volt H.T. battery.
- 1 9-volt G.B. battery.
- 1 2-volt accumulator.
- 4 wander plugs, H.T.+, H.T.-, G.B.+, and G.B.-.
- 2 spades, L.T.+ and L.T.-.

Connecting wire, flex, screws, wood for case, leatherette, carrying handle, and hinges.

Circuit No. 22. This circuit of a 12-watt amplifier is a comprehensive one capable of delivering sufficient volume for a small hall for dancing purposes, but may be coupled to a radio unit for reproducing the wireless programmes. The output stage is of the push-pull type, and the input circuit is split so that the operator may use a microphone and pick-up and fade from one to the other for announcement purposes. The components should preferably be mounted

on a rigid metal chassis and precautions should be taken to avoid shocks from the high voltages which are present.

List of Components for Circuit No. 22

- 1-push-pull input transformer.
- 2 volume controls—500,000 ohms.
- 11 fixed resistances: 30,000 ohms (R11); 2 100,000 ohms (R9, R10); 250,000 ohms (R6); type F½. 2 750 ohms (R3, R7); 30,000 ohms (R5); 50,000 ohms (R4); type F1. 20,000 ohms (R8); type F3. 2 1,600 ohms (R12, R13); type Spirohm.
- 10 fixed condensers: 4 mfd. (C8), type 95; 2 8 mfd. (C4, C7), type 805; 4 mfd. (C3), type 812; 2 8 mfd. (C9, C10), type FT150V; 2 25 mfd. (C1, C5), type FT25V; .25 mfd. (C6), type 250; .02 mfd. (C2), type 300.

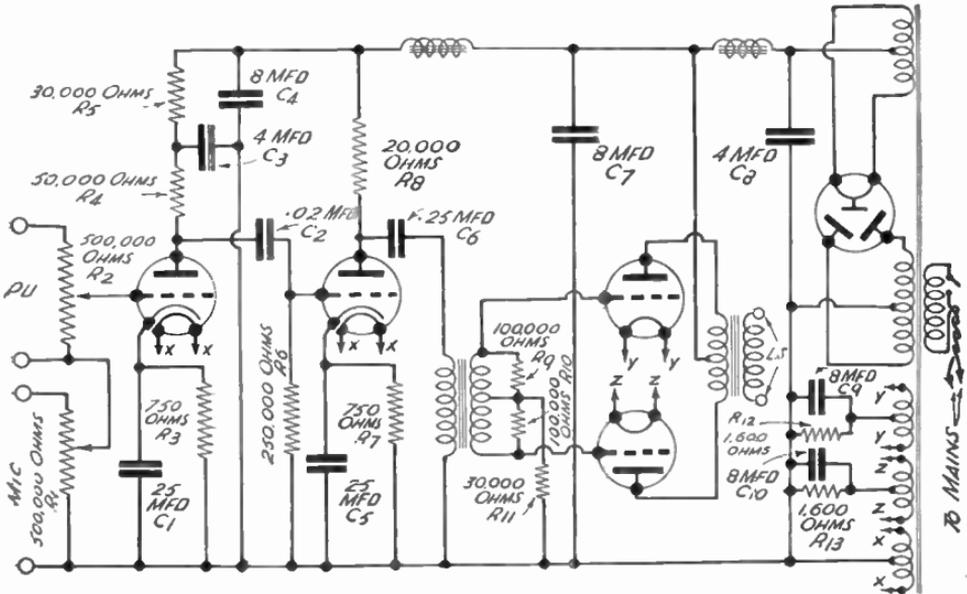


FIG. 120.—Circuit No. 22: A 12-watt Amplifier.

CIRCUIT

- 2 L.F. chokes: 50H/25 mA.; 20H/150 mA.
- 1 mains transformer: 400-0-400V/120 mA.; 4V/2.5A; 4V/2A; 4V/2A; 4V/2A.
- 5 valve holders: two 5-pin; three 4-pin; type V1 without terminals.
- 6 insulated terminals.
- 1 on-off switch.
- 1 fuse plug.
- 18 in. metal-screened lead.
- Connecting wire and screws.
- 5 valves: MH4 (non-met.); ML4 (non-met.); 2 PX25A; MU14.
- Metal chassis.
- 1 12-watt speaker with separate push-pull output transformer to match two PX25A.

A Battery Universal Amplifier. This amplifier is called "Universal," as it is so wired that it may be connected to any battery 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 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

CIRCUIT — COHERER

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 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 corresponding 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.

CLASS A-B.—The method of L.F. amplification where the voltage applied to the grid is half-way between the normal bias and the double value used for Class B working.

CLASS B.—A form of push-pull amplification in which two similar valve assemblies are mounted in one glass envelope. The valves are of the type which require no grid bias, and the working point is so arranged that grid current flows. The transformer used to feed this dual valve is of the step-down variety (as compared with the step-up of ordinary L.F. amplification), and the secondary winding has to be of extremely low resistance to avoid distortion due to the grid current. The transformer is called a "driver" transformer, and the valve which feeds it is called the "driver" valve. The output is arranged as in push-pull. (See *Driver Transformer and Driver Valve.*)

C L O S E COUPLING.—The arrangement of two inductances to obtain maximum induced currents.

CLUBS.—See *Directory of Radio Societies*, p. 148.

COAXIAL.—Term applied to a special cable for television land-line transmission and H.F. work. One conductor is

placed inside the other.

CODE.—See *Morse, Q.R.T., Colour Codes*, and Abbreviations on p. vii.

COERCIVE FORCE.—The magnetomotive force required to annul the residual magnetism of a substance.

COHERER.—A form of detector in which a non-conducting tube is filled

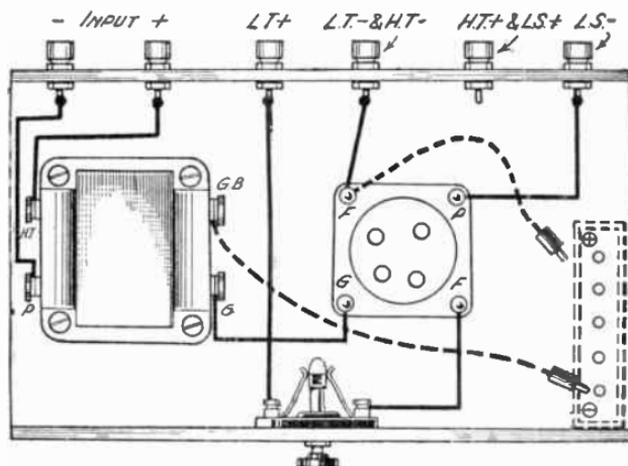


FIG. 121.—A On-valve Amplifier.

Components for Universal Amplifier
 1 L.F. transformer; 1 valve holder;
 1 on-and-off switch; 6 terminals;
 Elbonite strip.

CIRCUIT, REJECTOR.—See *Rejector Circuit*.

CLASS A.—The method of L.F. amplification where the valves receive the correct values of grid bias. (See also *Amplification, Class A-B, and Class B.*)

COIL

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.

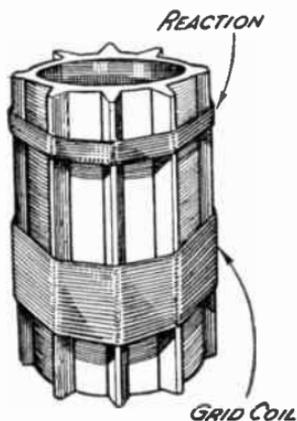


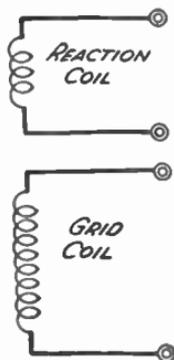
FIG. 122.—Theoretical and actual diagrams of an Aerial Tuning Coil.

COIL.—An aerial tuning inductance, incorporated so that the circuit will respond or tune to various frequencies. (See also *Chokes and High-frequency Chokes*, and a companion volume, *Coils, Chokes, and Transformers, and How to Make Them, Tuning Coils and Tuning Systems*. For Oscillator Coils, see *Intermediate-frequency Transformers*.)

Making Tuning Coils. The first type of coil here described 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, with the circumference of the block. If you then mark the positions for the nails, just under $\frac{1}{8}$ in. apart,

starting from any given point, you will find them practically regular.

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

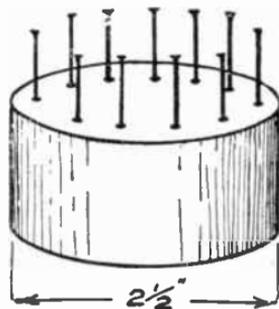


FIG. 123.—The wooden block and nails for making a Basket-weave Coil.

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

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

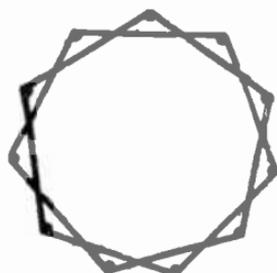


FIG. 124.—The finished Coil.

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

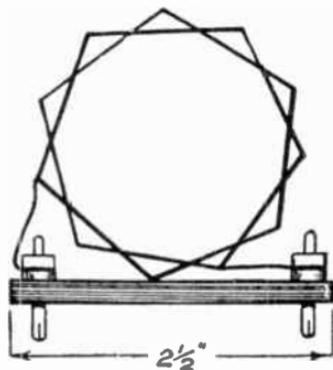


FIG. 125.—The Coil mounted on a strip of ebonite.

COIL

Another and more elaborate scheme is shown in Fig. 128. 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

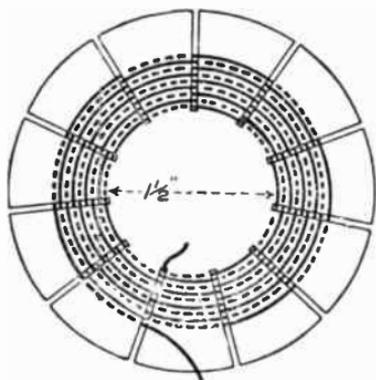


FIG. 126.—The Coil ready for mounting.

the reaction coil still apply—use the next smallest in the scale through-out.

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. 126 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

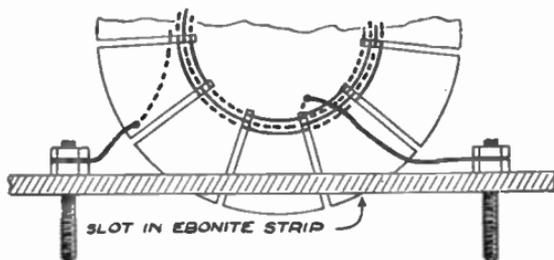


FIG. 127.—How the Coil is mounted.

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.

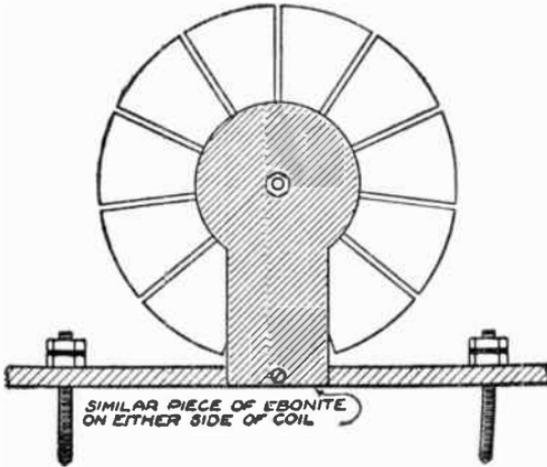


FIG. 128.—The finished Coil.

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. 127 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. 128. 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 tapings 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

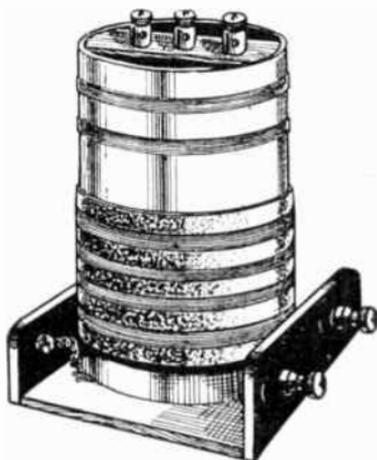


FIG. 129.—The completed Coil.

shown in Fig. 129 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

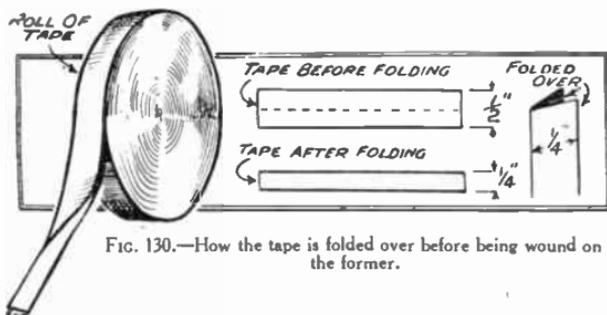


FIG. 130.—How the tape is folded over before being wound on the former.

—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

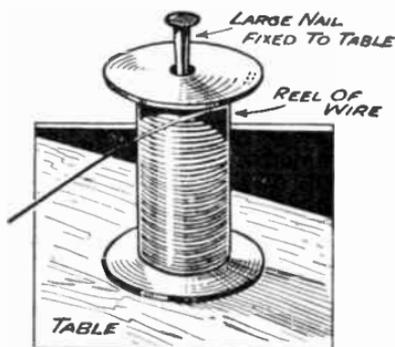


FIG. 131.—A nail driven in the bench to hold the reel while the wire is wound on the coil.

is a proved success, and provides a simple method of adjustment.

To start the Former. This is wound with five windings of insulat-

COIL

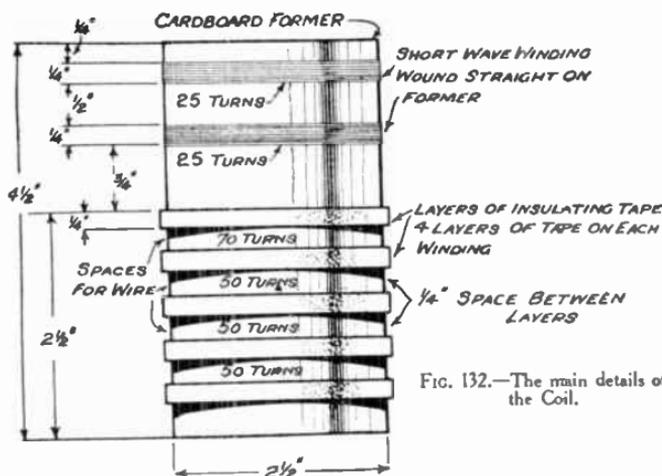


FIG. 132.—The main details of the Coil.

ing or electricians' tape (as it is called). These "windings" are $\frac{1}{4}$ 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. 130. 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. 131), 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. 132). Drill

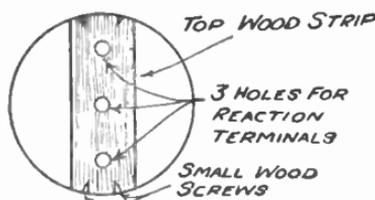


FIG. 133.—The top wooden Strip.

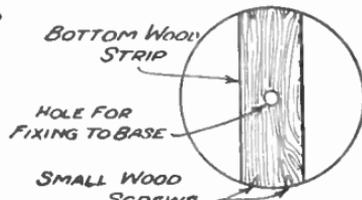


FIG. 134.—The bottom wooden Strip.

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,

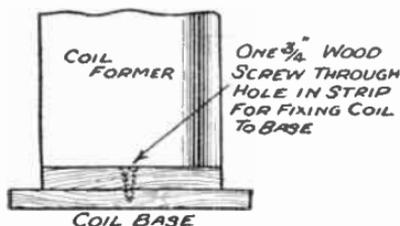


FIG. 135.—The Coil fixed to the base.

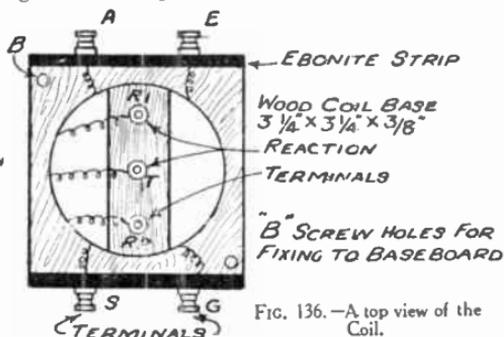


FIG. 136.—A top view of the Coil.

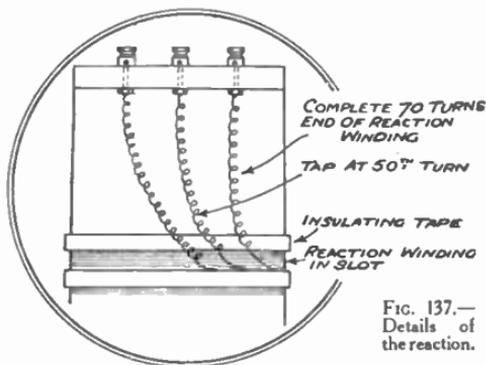


FIG. 137.—
Details of
the reaction.

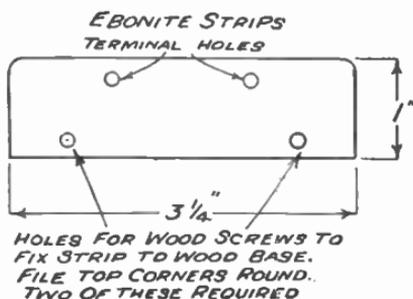
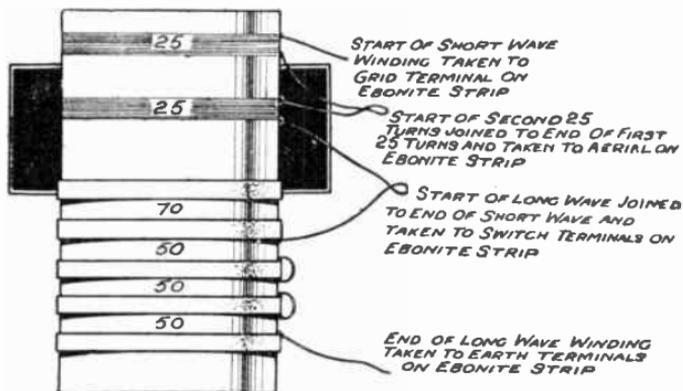


FIG. 138.—The Ebonite Strip.



The Short-wave Windings.

FIG. 139.—The various connections.

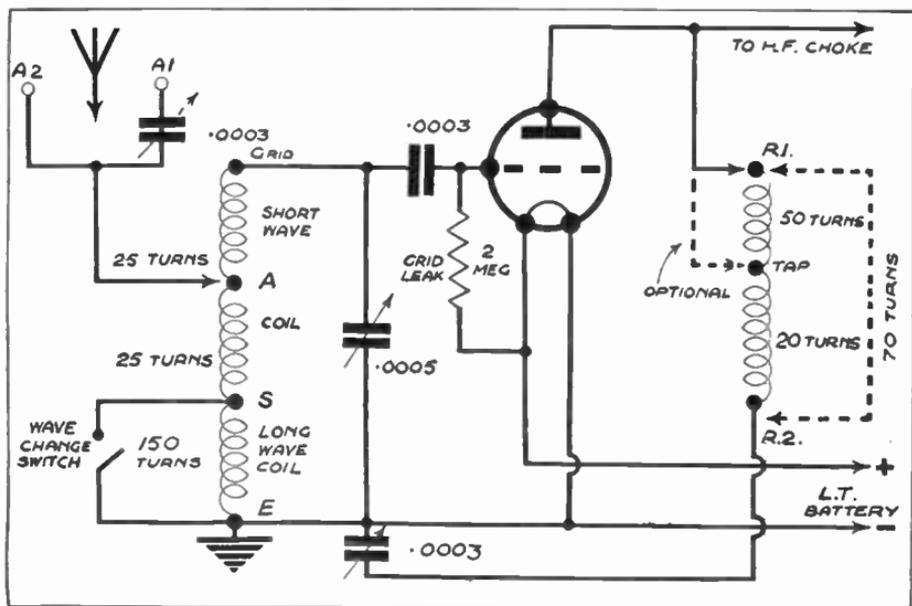


FIG. 140.—A circuit diagram showing the Coil fitted in the set.

COIL

and so on. No mistake or miscount is then made, and one can complete the *whole* of the windings in a few minutes.

The short-wave windings are not wound in slots owing to the small amount of wire used, but be careful that these windings are wound on fairly tight to prevent them "springing" after completion.

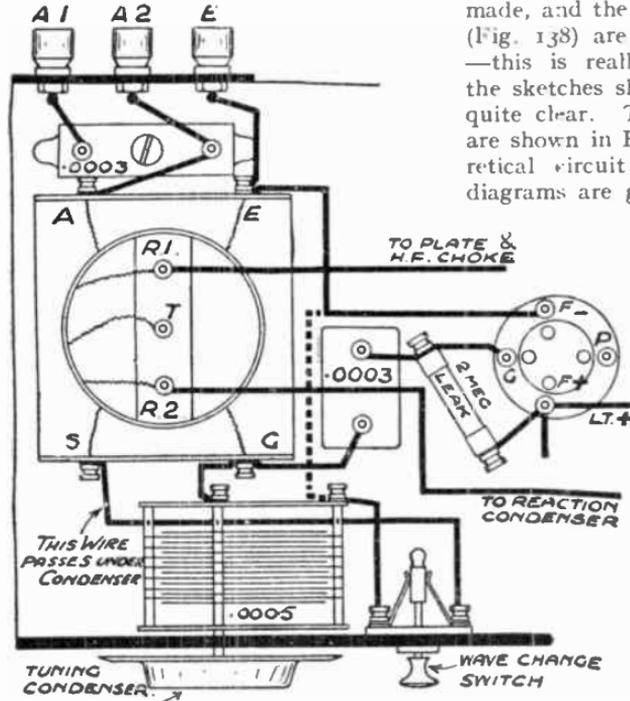


FIG. 141.—How the Coil is fitted in the set.

Holes are drilled in the former for all the winding ends, and these are pushed *inside* the former.

The Wooden Strips. To connect up, these ends are brought down *inside* the former, to their respective terminals, taking care that the different ends do not touch.

The two wooden strips are next cut to size (Figs. 133 and 134), and holes are drilled in them ready for

fixing to the coil ends. One strip is used for fixing the coil to the base (Fig. 135), and the others as the reaction terminal strip (Fig. 136). Before fixing this, connect up the reaction windings (Fig. 137) and terminals to the strip, for if the strip (top) is fixed *before* connecting up, difficulty will be experienced in reaching the windings from the inside of the coil. The base is now made, and the ebonite terminal strips (Fig. 138) are cut to size and fixed—this is really a simple job, and the sketches should make everything quite clear. The actual connections are shown in Fig. 139, and the theoretical circuit and practical wiring diagrams are given in Figs. 140 and 141, so that no further explanation is necessary.

Points to Watch.

Do not forget to test the coil before fitting it to the set. This test is for continuity, and is quite simple, as a break which is not discovered until after the coil is installed in a set may lead to endless trouble in searching for a fault in the remainder of the circuit. Connect up as Fig. 141, first

using the two *outer* terminals on the reaction coil. If reaction is too fierce reduce the high tension on your first valve (detector) to as low as 30 volts if necessary. If this fails, connect to the middle terminal on the reaction coil as shown in Fig. 140, but be careful to adjust with only *one* wire at a time, *preferably* the one leading to the plate and H.F. choke, leaving the wire on R.2 (which

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	36 enam.	80	4	36 enam.	92	5	38 D.S.C.	95
	5	36 D.S.C.	69	5	36 enam.	80	6	36 enam.	85
½ in.	3	36 D.S.C.	71	3	36 enam.	81	3	36 enam.	97
	4	36 D.S.C.	57	4	36 D.S.C.	65	4	36 enam.	76
	5	34 D.S.C.	53	5	34 enam.	60	5	36 D.S.C.	72
2 in.	3	34 enam. or 36 D.S.C.	56	3	36 D.S.C.	65	3	36 enam.	77
	4	34 D.S.C.	45	4	34 D.S.C.	51	4	36 D.S.C.	61
	5	34 D.S.C.	38	5	34 D.S.C.	44	5	34 enam. or 36 D.S.C.	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.	84	1·01	32 enam.	93	1·11	30 D.S.C.	115	1·71
	30 D.S.C.	93	1·38	30 D.S.C.	102	1·52	32 enam.	102	1·22
1¼ in.	30 D.S.C.	74	1·10	30 D.S.C.	82	1·22	30 D.S.C.	90	1·34
1¾ in.	30 D.S.C.	63	0·94	30 D.S.C.	68	1·01	30 D.S.C.	76	1·13
	28 D.S.C.	67	1·16	28 D.S.C.	73	1·26	28 D.S.C.	80	1·38
2 in.	30 D.S.C.	54	0·805	30 D.S.C.	59	0·88	30 D.S.C.	65	0·97
	28 D.S.C.	58	1·01	28 D.S.C.	64	1·13	28 D.S.C.	70	1·24
2¼ in.	26 D.C.C.	70	1·96	26 D.C.C.	78	2·18	26 D.C.C.	86	2·40
	28 D.S.C.	52	0·925	28 D.S.C.	57	1·01	28 D.S.C.	62	1·10
	24 D.C.C.	65	2·08	24 D.C.C.	72	2·30	24 D.C.C.	80	2·56
2½ in.	28 D.S.C.	47	0·835	28 D.S.C.	51	0·91	28 D.S.C.	56	1·0
	24 D.C.C.	58	1·85	24 D.C.C.	64	2·04	24 D.C.C.	70	2·24
3 in.	26 D.S.C.	41	0·86	26 D.S.C.	45	0·95	26 D.S.C.	49	1·03
	22 D.C.C.	50	1·90	22 D.C.C.	55	2·09	22 D.C.C.	61	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 × 3¼ in. by about ¾ in. thick. Two strips of wood 2½ × 1 in. by about ¼ in. thick. Two strips of ebonite 3¼ × 1 in. up to ¼ in. thick. One doz. small brass wood screws (about ⅜ in. long). One ¼-in. wood screw (for screwing coil to base).

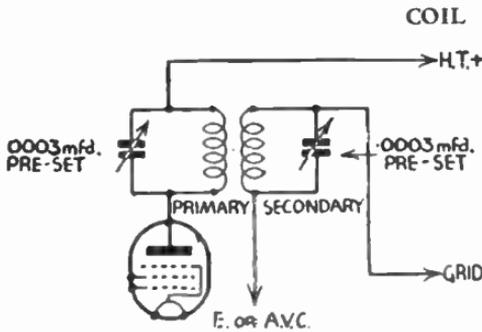


FIG. 142.—In this H.F. Transformer coupling between the two windings is carried out inductively.

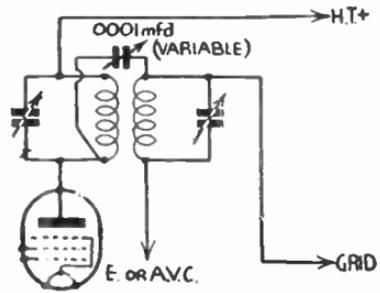


FIG. 144.—In this arrangement a small variable condenser provides the coupling and thus the selectivity may be varied.

Making 465 Kc/s I.F. Transformers. A transformer to tune to 465 kc/s—which approximates to an equivalent wavelength of 650 metres—can be made by using 120 turns of 36-gauge d.c.c. or enamelled wire for primary and for secondary. This is the total number of turns on each former, although they are split up

into sections to minimise self-capacity.

The transformer can be used as shown in the circuit in Fig. 142 by connecting a 0003-mfd. pre-set condenser across each winding for trimming purposes. It is better to employ one of the new types of trimmer on steatite or similar bases.

By following the form of construction shown in Fig. 143 it is possible to alter the coupling between primary and secondary, and thus to vary the band-width covered; in other words, to obtain variable selectivity. The only objection is that the selectivity cannot be varied by means of an external control, and is therefore only pre-set, being adjustable only after removing the screening can and probing inside the set.

There are various methods of providing an external adjustment, one of the simplest being by using a 0001-mfd. variable condenser to provide "top-capacity" band-pass coupling. It is wired between the high-potential ends of the windings, as shown in Fig. 144 between the anode terminal of the primary and the grid terminal of the secondary. When using this system, the I.F. transformer should be mounted near to the panel control, so that the extremely short leads can be used between the condenser and the transformer. Still further to assist in eliminating unwanted "pick-

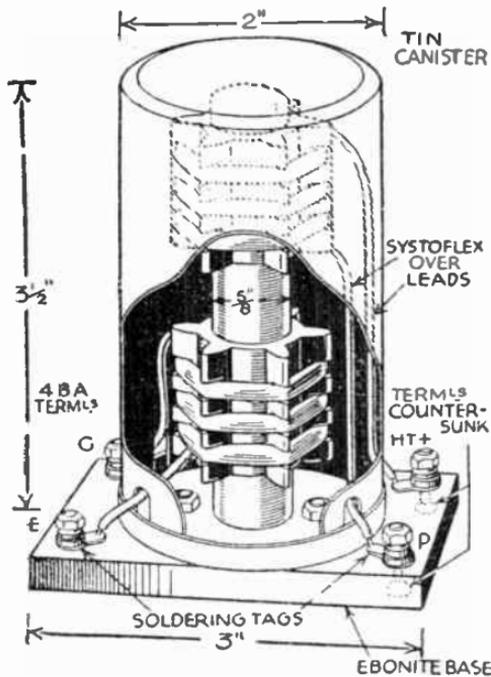


FIG. 143.—A simple form of I.F. Transformer in which variable coupling can be introduced.

COIL

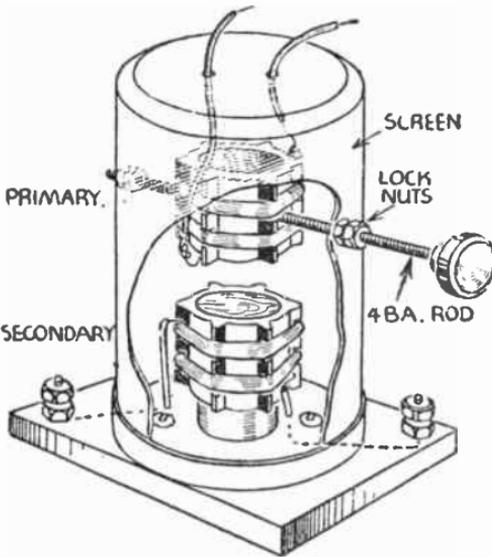


FIG. 145.—Variable selectivity is carried out in this I.F. Transformer by rotating one of the windings.

up" and coupling, it is often an advantage to screen the leads. With the arrangement described, preliminary adjustment can be made by varying the distance between the two coils, the variable condenser being used only when the set is tuned to a signal. In general, it will be found that the coils must be well separated, for otherwise the coupling will be too great.

Another arrangement is to mount the two coils so that one of them can be rotated. The idea is shown in Fig. 145. Another system is to place a third coil (which is not connected to any part of the circuit) between the primary and secondary windings. The form of construction referred to is illustrated in Fig. 146. Each winding is divided into three sections $\frac{1}{2}$ in. apart, and there is a space of 1 in. between primary and secondary. In this space are wound fifty turns of 36-gauge enamelled wire, the ends of the winding being connected to two terminals of a variable resistance,

having a value of about 2500 ohms—the exact resistance is not very critical.

When the resistance is set to its maximum value, the coil provides a fair degree of coupling between primary and secondary, but when it is moved to zero the coupling is appreciably reduced. Thus the degree of selectivity is increased, as is required when listening to distant stations or when interference is experienced. Experiment with different sizes of coupling winding.

It will be understood that with any of the forms of I.F. transformer described it is necessary to include the .0003-mfd. pre-set condensers in parallel with the two windings for trimming purposes.

Oscillator Coils. In making an oscillator coil for use in conjunction with these 465 kc/s I.F. coils, it will be necessary to understand the principal difference between an oscillator coil and one used for tuning to the

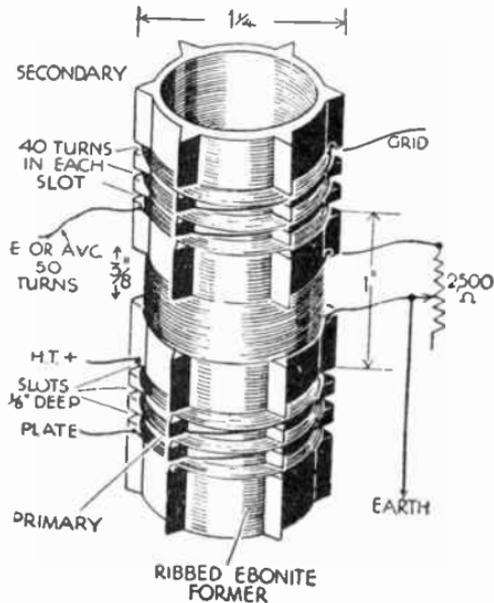


FIG. 146.—A third winding is used in this I.F. Transformer to control the degree of selectivity.

COIL

signal frequency. An aerial coil has to cover the wavelength ranges (very approximately), 200 to 600 metres, and 900 to 2000 metres. The corresponding frequency ranges are, roughly, 1500 kc/s to 500 kc/s and 333 kc/s to 150 kc/s, and these are quite different from the tuning ranges which must be covered by the oscillator coil. The ranges of the latter, in kilocycles per second, are 1965 to 965, and 798 to 615 (the original figures, plus 465). This is for a superhet using the now general intermediate frequency of 465 kc/s.

The ratios between maximum and minimum for the two ranges are also different. For example, whereas the ratio between maximum and minimum frequencies covered by the aerial circuit on short waves is 3:1, the corresponding ratio in the case of the oscillator circuit is only about 2:1. On long waves there is still greater divergence, for the aerial circuit frequency ratio is about $2\frac{1}{2}$:1, and the oscillator ratio is about $1\frac{1}{4}$:1.

Considered in another way, the wavelength ranges of the oscillator coil approximate to 150 metres to 310 metres, and 375 metres to 500 metres. This means that the oscillator coil requires to have fewer turns of wire than the signal-frequency coil. On medium waves the oscillator coil requires about three-quarters of the number of turns used for the standard coil, and on long waves less than half the number of turns is required. Thus, if the aerial coil is wound on a 1-in. diameter paxolin former, the numbers of turns for the two windings are about 100 and 300; the corresponding oscillator coil requires about 75 to 150 turns.

A typical frequency-changer circuit using a pentagrid valve is shown in Fig. 147. In the figures given above an approximate allowance has been made for the maximum frequency (minimum wavelength) difference, but

we have still to compensate for the difference in ratio of the coverages. This is done in part by the specially shaped vanes of the oscillator section of the 465 kc/s superhet tuning condenser, but further compensation must be provided by use of a padding and tracking condenser (C.3 and C.4 in Fig. 147). These two condensers are of the pre-set type, and should have maximum capacities of .00016 mfd. and .0003 mfd.

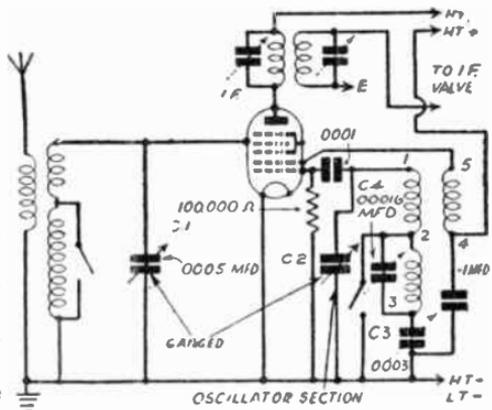


FIG. 147.—Theoretical circuit of the frequency-changing stage of a superhet receiver.

Using the number of turns mentioned above, the reaction winding should have about 100 turns, these being arranged as shown in Fig. 148. The complete coil should be screened.

The position is less complicated when the oscillator coil is intended for use in a set with 110 kc/s intermediate frequency, for the frequency and frequency-ratio variations are then much less. Thus, if the aerial tuning circuit covers the range 1500 kc/s to 500 kc/s and 333 kc/s to 150 kc/s, the corresponding oscillator frequencies are 1610 kc/s to 610 kc/s and 413 kc/s to 260 kc/s; these ranges are equivalent to wavelength variations of approximately 160 metres to 500 metres, and 600 metres to 1150 metres. Thus the approxi-

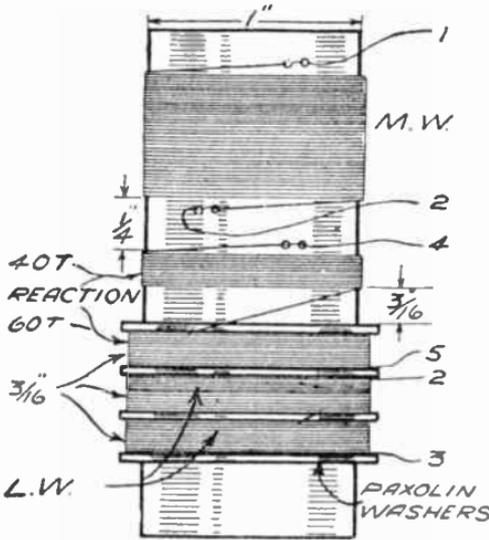


FIG. 148.—Constructional details of an efficient oscillator coil.

mate numbers of turns on a 1-in. diameter former would be 85 and 240; the reaction winding should have about 120 turns in all.

The circuit for a 110-kc/s frequency changer is given in Fig. 149, a pentagrid again being used. The special superhet (110 kc/s type, of course) tuning condenser provides the correct tracking, but a long-wave pre-set padding condenser of .002 mfd. is required to compensate for the different frequency ratio. This is short-circuited by the wave-change switch on medium waves, but is actually in series with the oscillator section of the tuning condenser on long waves. Its effect is to reduce the maximum resonant wavelength when the tuning condenser approaches its maximum capacity, but it has a negligible effect on low settings; the .0003-mfd. padding condenser used in the 465 kc/s I.F. circuit has a similar function. In passing, it should be mentioned that although a single-circuit aerial tuner is shown in Fig. 149 for simplicity, a band-pass filter is a practical essen-

tial when using 110 kc/s I.F. If it were not used, there would probably be a good deal of second-channel interference. Even when using 465 kc/s, a band-pass circuit is desirable, but not quite as important, since second-channel troubles are less severe.

When experimenting with the home-made oscillator coils, it is essential to deal with each wavelength separately. First tune to medium waves and, with the condenser set to tune to a wavelength of the local station, try the effect of setting the trimmers. If it is found that what appears to be accurate tuning can be obtained when neither trimmer is at its maximum or minimum capacity, it can be assumed that the windings are reasonably correct. On the other hand, if one of the condensers can be turned to its full capacity, it will be an indication that the oscillator coil needs to be modified. Thus, if the trimmer of the oscillator section is "full in," additional turns must be used on the medium-wave section of the coil; if the trimmer of the aerial section is "full-in"—or if the oscillator one is "full-out"—a few turns must be removed. A rough guide to the extent of the discrepancy can be

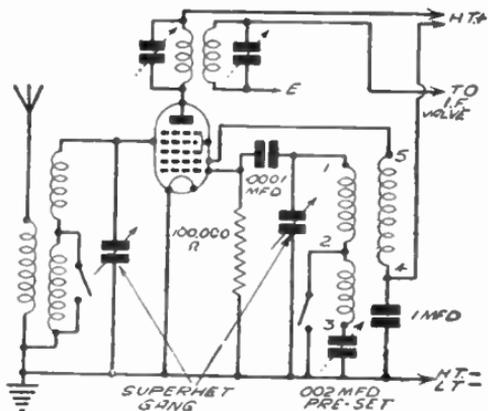


FIG. 149.—Here is the circuit of the frequency changer stage of a superhet employing an I.F. of 110 kc/s.

COIL

obtained by connecting a .0001-mfd. variable condenser in parallel with the condenser section, whose trimmer is screwed right down. Should this condenser require to be set to more than half its total capacity, a start can

Another strip of insulating tape and a third washer complete the winding sections for the primary.

So as to give correct spacing between the primary and secondary windings a $\frac{1}{2}$ -in.-wide strip of insulating tape is wound round the tube, just touching the third washer. After that, another set of three washers can be fitted in exactly the same way as the first three were arranged. A "U" mounting bracket must, of course, be attached to the lower end of the former as it was in the previous coils, and then the windings can be put on. Start with the primary and anchor the end of the wire in a pair of small holes made in the paxolin tube, wind on 250 turns in the first slot, pass over to the second slot, and complete the winding by putting on another 250 turns, so making 500

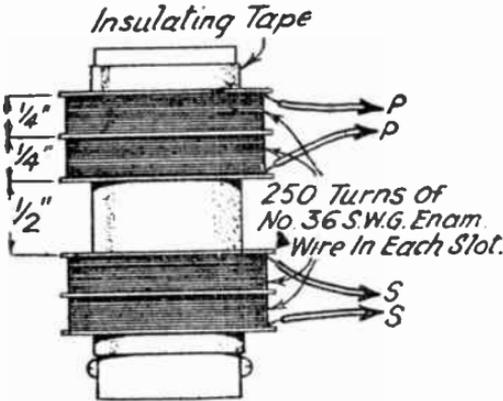


FIG. 150.—Constructional details of an I.F. transformer for 110 kc/s.

be made by removing about five turns.

The same general method of procedure can be adopted on long waves, after setting the padding and tracking condensers to various positions in order to note their effect. After obtaining a "balance" when the set is tuned to the powerful local station, it should be tuned to another and the tests repeated.

Intermediate-frequency Transformers for 110 Kilocycles. An intermediate-frequency transformer of the band-pass type can be made as shown in Fig. 150. A 1-in. diameter paxolin former is fitted with six washers, so that four winding sections are provided; two of these will take the primary, and two the secondary windings. First, a strip of insulating tape $\frac{1}{4}$ in. wide is wound twice round the former, and then a washer is pressed closely against it. A second strip of similar width is then wound on at the other side of the washer, after which a second washer is fitted.

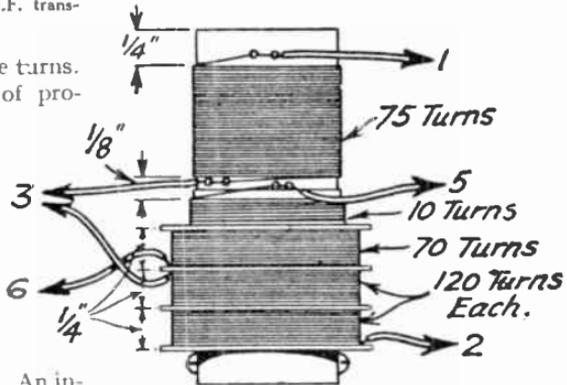


FIG. 151.—Here are the details for an oscillator coil for use with the I.F. transformer shown above.

in all. The "finishing" end of the wire can be anchored by passing it through two holes made in the former, or by running a spot of sealing-wax on to it. When the primary is finished, the secondary can be wound in exactly the same manner, and using the same number of turns.

The ebonite measures 4 in. long by 2 in. wide, and is drilled with eleven holes. Seven of the holes are to take terminals, and are $\frac{7}{16}$ in. diameter, and

COIL — COLOUR CODES

counter-bored $\frac{3}{8}$ in. to receive the rounder heads of the terminals, two are $\frac{1}{8}$ in. to take the mounting screws, whilst the remaining two holes are drilled $\frac{7}{8}$ in., and are then tapped out to $\frac{1}{4}$ B.A.

Details of the windings for an oscillator coil are shown in the dimensioned drawing at Fig. 151. In order to obtain correct coupling on both

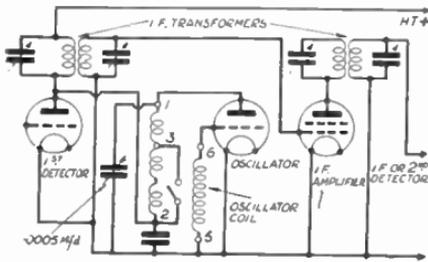


FIG. 152.—Connections for an oscillator coil in a standard circuit.

wavebands, the reaction winding is arranged in two parts, one of which is wound as side-by-side turns comparatively near to the medium-wave winding, and the other, of seventy turns, placed in a slot next to the long-wave sections. All the turns are of 34-gauge d.c.c. or enamelled wire, and are put on in the same direction. The coil is mounted on an ebonite baseplate measuring about 3×2 in., with six terminals. The connections for the oscillator coil in a battery-operated superhet of that kind using a separate oscillator valve (which is generally better in home-constructed battery sets) are given in the circuit at Fig. 152.

COLD VALVE.—This name is actually a misnomer and is used in reference to a special type of high-frequency metal rectifier. It consists essentially of the same elements as the metal rectifier used for changing alternating electric current into D.C., but it is designed to have a particularly low self-capacity. This cold valve, or

I.F. metal rectifier, can be used in place of the detector valve in superheterodyne receivers, and can also be employed in various ways to provide A.V.C. Another use is as an "economiser" of H.T. current in conjunction with large battery-operated power valves. (See also *Electron Multiplier*.)

COLOUR CODES.—A method of identifying resistances, condensers, leads, and fuses by colours indicating their value. In the case of resistances the body is marked with one colour, the tip with another, and a dot or band of colour is finally marked on the body. To read the value the body colour is taken first, then the tip colour, and finally a number of noughts as denoted by the dot (or band) are added. The code is as follows: 0—Black; 1—Brown; 2—Red; 3—Orange; 4—Yellow; 5—Green; 6—Blue; 7—Violet; 8—Grey; 9—White.

Examples: A 25,000-ohm resistance would have a red body, green tip, and orange dot.

A 100,000-ohm resistance would have a brown body (1), black tip (nought), and a yellow dot (the final four noughts).

The colour code adopted for fuses is: Black, 60 mA.; Grey, 100 mA.; Red, 150 mA.; Brown, 250 mA.; Yellow, 500 mA.; Green, 750 mA.; Dark Blue, 1 amp.; Lt. Blue, 1.5 amps.; Purple, 2 amps.; White, 3 amps.

Mains transformers are sometimes provided with coloured leads to indicate the various outputs. The official code is as follows: Primary: Black, zero; Black and Green, 10 volts; Black and Yellow, 210 volts; Black and Red, 230 volts; and Black and Brown, 250 volts. The secondary windings are as follows: H.T., Red, with the centre tap Red and Yellow; rectifier heater winding, Green with Green and Yellow centre tap; valve heaters, Brown with Brown and Yellow centre tap. Any additional

COLOUR CODES — CONDENSER

L.T. windings are coloured Blue with Blue and Yellow centre-tap. If a screen is fitted between primary and secondary a bare wire should be joined to this for earthing purposes.

Battery leads may be coloured as follows, or plain leads may be used with wander plugs, bearing the colours indicated: Highest H.T., Red; 2nd highest positive H.T., Yellow; 3rd highest positive H.T., Green; 4th highest positive H.T., Blue; L.T. positive, Pink; Negative (L.T. -, H.T. -, and G.B. +), Black; maximum G.B. negative, Brown; 2nd G.B. negative, Grey; 3rd G.B. negative, White. If a 5th H.T. positive lead is provided it will be coloured Violet.

Cable connections, or flexible leads to multiple condenser blocks are coloured as follows—from which it will be seen that they are the same as for battery H.T. leads: Highest positive voltage, Red; 2nd highest, Yellow; 3rd highest, Green; 4th highest, Blue; 5th highest, Violet;

designed for the reception of amateur transmissions. It is a short-wave receiver incorporating every form of circuit control.

COMPENSATED DUAL LOUD-SPEAKERS.—See *Loudspeaker*.

CONDENSER.—A piece of apparatus designed to store electricity under electrical pressure. It consists essentially of two or more metal plates separated by an insulator. For wireless purposes two types of condenser are in general use, fixed and variable condensers. The property of a condenser is known as the capacity, and this varies directly as the size of the conductors, and inversely as the distance separating them. The material used between the plates will also affect the capacity of the condenser. The material separating the plates of a condenser is known as the dielectric.



FIG. 153.—Theoretical Symbol of Fixed Condenser.

Making Fixed Condensers. Fig. 154 shows the construction.

To make up a selection of condensers, then, the requirements are:

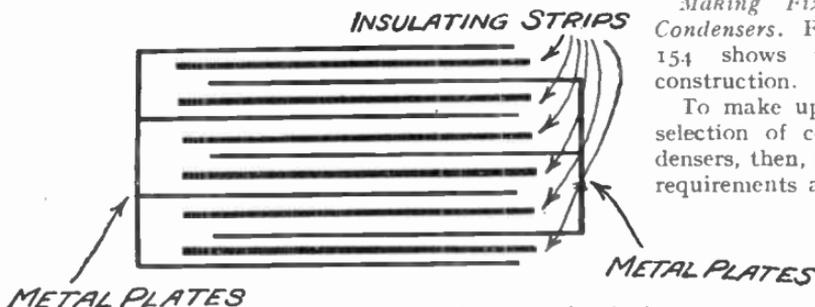


FIG. 154.—The plates in a condenser, shown on an enlarged scale.

principal negative connection is Black, the 2nd negative connection, Brown, and the 3rd negative connection is Grey. The centre connection for voltage-doubler condensers is White. If a condenser has two wires only, they will be Red and Black for positive and negative respectively.

COMMUNICATIONS RECEIVER.—A special type of receiver primarily

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.

Two formulæ are given on the next page, one with centimetre units, the other inch units. However,

CONDENSER

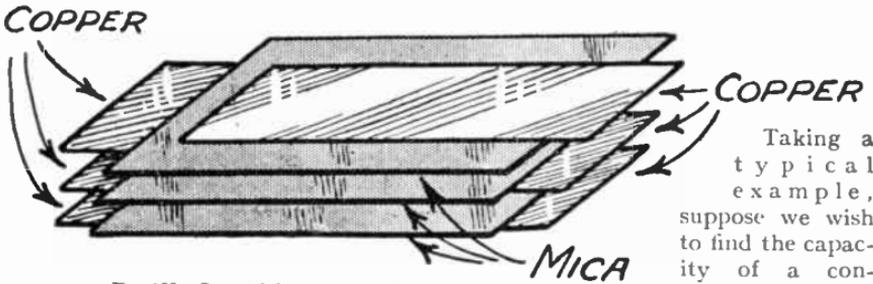


FIG. 155.—Pictorial diagram of the Copper and Mica Layers.

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 $\frac{1}{2}$ millimetre thick.

Substituting the values for the symbols:

$$\begin{aligned} C &= \frac{0.0885 \times a \times K \times N}{1,000,000 D} \\ &= \frac{0.0885 \times 4 \times 6 \times (11 - 1)}{1,000,000 \times .5} \\ &= 0.000424 \text{ micro-farad.} \end{aligned}$$

For practical purposes this can be called .0004 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:

$$\begin{aligned} C &= \frac{0.225 \times 1 \times 0.5 \times 6 \times 5}{1,000,000 \times 0.002} \\ &= \frac{3.375}{2.000} \\ &= .00168 \text{ micro-farad.} \end{aligned}$$

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 $\frac{3}{4} \times \frac{1}{2}$ in. and mica insulators each 0.002 in.

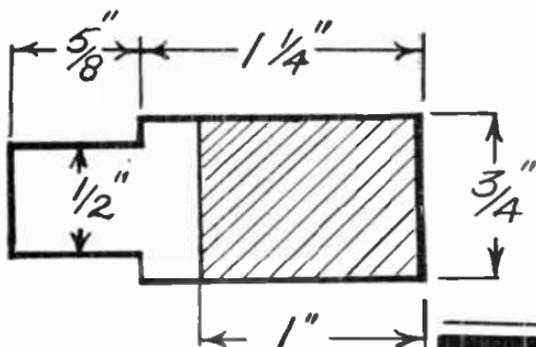


FIG. 156.—Size and shape of the copper foils. The additional area on the left enables the plates to be joined together.

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.

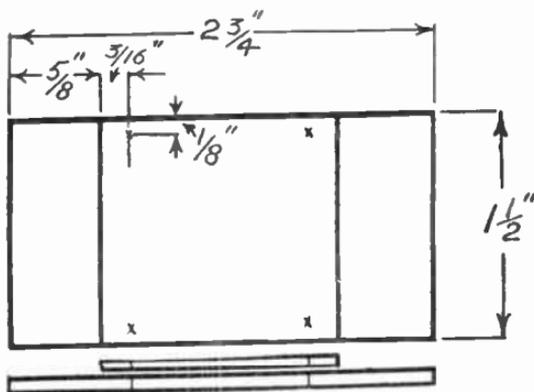
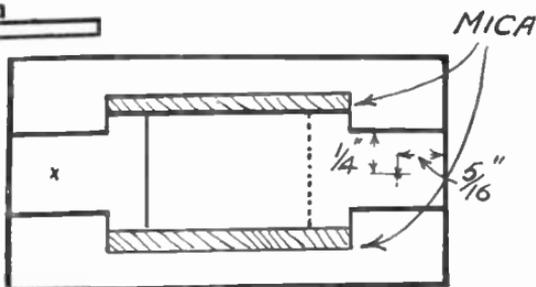


FIG. 157.—Dimensions of the Ebonite Plates for making fixed condensers.

FIG. 160A.—Plan view of the Fixed Condenser, showing how the alternate laminae 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 formulæ, 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.

C in Micro-farad.	Dimension of Plate in In.	No. of Plates.
.001	$\frac{3}{4} \times \frac{1}{2}$	5
.002	$1 \times \frac{1}{2}$	7
.003	$1 \times \frac{3}{4}$	7
.00015	$\frac{1}{2} \times \frac{1}{2}$	3
.0005	$\frac{1}{2} \times \frac{3}{4}$	4
.0006	1×1	2
.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 $2\frac{3}{4} \times 1\frac{1}{2}$ 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 $2\frac{3}{4}$ -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

CONDENSER — CORROSION

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. Reciprocal of resistance. 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 on p. viii. 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.

CONVERTER.—See *Circuit* and *Short-wave Converter*

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	.0120	83.3	148.8	6.67		7.64	7.55	7.35	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	17.2
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	.09448	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	37.0
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	.4109	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 .003 mfd., say .001 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 .05 mfd. and .5 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 intervalve 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

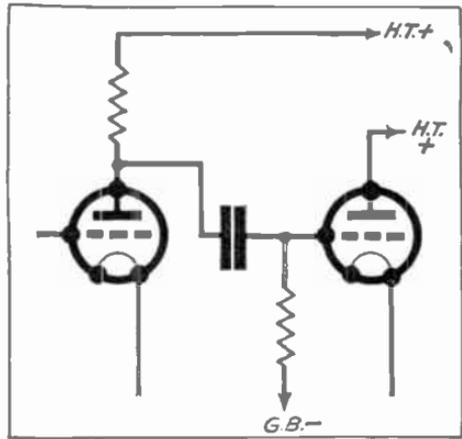


FIG. 161.—R.C. Coupling.

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

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.

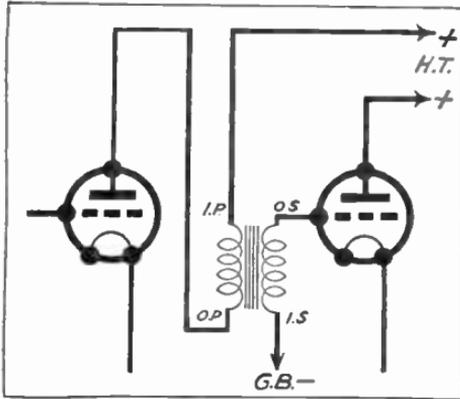


FIG. 162.—Transformer primary directly in anode circuit

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-

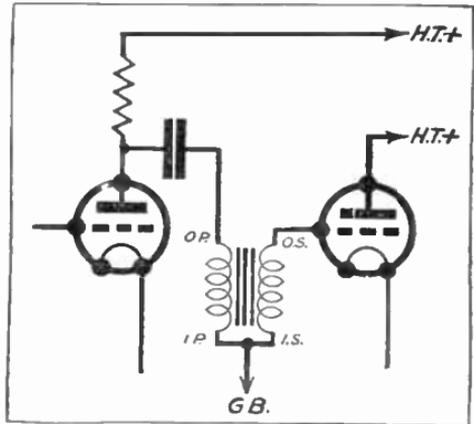


FIG. 163.—Parallel-fed Transformer. With this arrangement direct current does not pass through the primary.

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 the 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. An L.F. choke is sometimes used instead of a resistance.

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 retained when the detector is not preceded by a high-frequency valve. The great mistake when using two valves

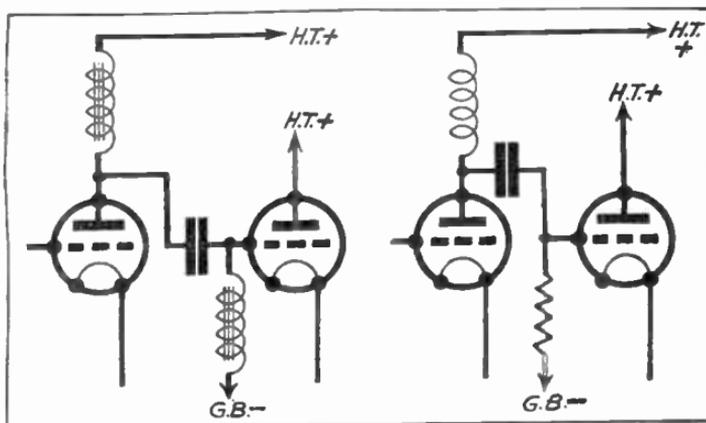


FIG. 164.—Two forms of Choke Coupling.

following the detector is to arrange for too much amplification, with the result that the output valve is overloaded.

Suppose, for example, that the detector valve gives a 7-volt swing in its anode, which is not unreasonable on a high-powered station, and that a $3\frac{1}{2} : 1$ transformer is used, we shall get almost 7 volts on the grid of the next valve. Assuming that this is an L.F. type, it might well have a working amplification factor of 12, which will give 84 volts in the anode. Assume a 3 : 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 indicates what would

CRYSTAL DETECTOR — DANIELL CELL

happen if either the second or third valve overloaded.

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
Ghane	Silicon
Graphite	Tellurium
Hessite	Zincite

CRYSTALS.—Minerals and mineral ores used for the purpose of detecting, or rectifying, wireless signals. 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. 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.

The best form of crystal cup is that in which three screws are used. Wherever it is thought better to fix the crystal by means of solder, a particular grade known as Wood's metal (which see) should be used. In using crystals it is desirable that they be handled with a pair of tweezers, for the slightest trace of greasiness upsets their sensitivity.

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 $4\frac{1}{2}$ -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 near the aerial terminal.

CURRENT.—The flow of electricity in a circuit. Unit is the ampere (which see).

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.

CYMOMETER.—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 $\frac{1}{8}$ 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

DANIELL CELL — DECIBEL

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, with risk of serious damage to the skin of the face, hands, etc., as well as spoiling the clothes.

The copper plate provides the positive terminal and the zinc rod the negative. There are thus two free terminals, copper and zinc.

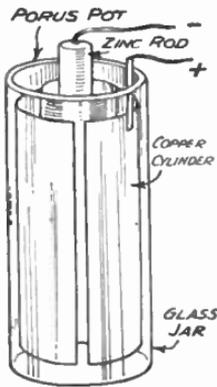


FIG. 165.—Constructional details of Daniell Cell.

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.

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 for some seconds before coming to rest. The dead-beat instrument avoids this.

DECAY, RATE OF.—Time taken to absorb sound energy.

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.

Due to the fact that the human ear does not perceive simple increases of sound intensity as such, but tends to follow approximately a logarithmic law, the decibel is logarithmic in character and is independent of frequency.

If P_1 is the input power to an amplifier or attenuator, and P_2 the output power, then the simple power ratio is $\frac{P_2}{P_1}$. The logarithmic unit, the bel, is the logarithm of the simple power ratio, so that power ratio (bels) is $\text{Log}_{10} \frac{P_2}{P_1}$ (common logarithms to the base 10 being used). Since the bel, as a unit, is too large for practical purposes, the decibel is used, this being a tenth part of a bel; thus power ratio (decibels) is $10 \text{Log}_{10} \frac{P_2}{P_1}$.

Since the power output is proportional to the square of the voltage or current, when dealing with these units the power ratio becomes $10 \text{Log}_{10} \frac{I_2^2}{I_1^2}$, which is $20 \text{Log}_{10} \frac{I_2}{I_1}$.

In the case of loudspeakers it is becoming common practice to give a graph of the power output over the entire audio-frequency range in decibels above and below the output at some standard frequency, such as Middle C (256 cycles per sec.). If the output is greater than the standard frequency, then the ratio in decibels is positive, whilst if less it is negative.

It is interesting to note that a change of power output of three decibels is the smallest change in

DECIBEL — DECOUPLING

intensity that can be detected by the average ear.

The decibel is also used to express power level transmitted in a circuit. It is necessary to refer it to an arbitrary standard called zero level or 0 decibels, it being recognised that this shall represent .006 watt of audio-frequency power. Thus 10 decibels is .06 watt and 20 decibels .6 watt, etc. To express values below the zero level a negative sign is put in front of the sign for the decibel, so that -10 decibels is .0006 watt and -20 decibels .00006 watt. (See also *Bel, Decibel, Neper, Acoustic Watt, and Phon.*)

RELATIONSHIP BETWEEN DECIBELS AND POWER RATIO

Decibels.	Power Ratio.	Decibels.	Power Ratio.
1	1.25	- 1	$\frac{1}{1.25} = .8$
2	1.6	- 2	$\frac{1}{1.6} = .625$
3	2.0	- 3	$\frac{1}{2} = .5$
4	2.5	- 4	$\frac{1}{2.5} = .4$
5	3.2	- 5	$\frac{1}{3.2} = .3125$
6	4.0	- 6	$\frac{1}{4} = .25$
7	5.0	- 7	$\frac{1}{5} = .2$
8	6.0	- 8	$\frac{1}{6} = .166$
9	8.0	- 9	$\frac{1}{8} = .125$
10	10.0	- 10	$\frac{1}{10} = .1$
20	100.0	- 20	$\frac{1}{100} = .01$
30	1000.0	- 30	$\frac{1}{1,000} = .001$

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

$\frac{1}{16}$	.015625	$\frac{1}{16}$	.0625
$\frac{1}{8}$	.03125	$\frac{1}{8}$	.125
$\frac{3}{16}$	.046875	$\frac{1}{4}$	.25
$\frac{1}{4}$	.0625	$\frac{3}{8}$	.375
$\frac{5}{16}$	.078125	$\frac{1}{2}$	.5
$\frac{3}{8}$	.09375	$\frac{5}{8}$	.625
$\frac{7}{16}$	.09375	$\frac{3}{4}$	.75
$\frac{1}{2}$	.1250	$\frac{7}{8}$	.875
$\frac{1}{4}$	.2500	$\frac{1}{2}$	.5000
$\frac{3}{8}$	.3750	$\frac{3}{4}$	.7500
$\frac{1}{2}$	.5000	$\frac{5}{8}$	.6250
$\frac{3}{4}$	.7500	$\frac{3}{4}$	.7500
$\frac{5}{8}$	.6250	$\frac{1}{2}$	.5000
$\frac{3}{4}$	.7500	$\frac{3}{4}$	.7500
$\frac{1}{2}$	.5000	$\frac{1}{2}$	.5000

$\frac{1}{16}$	.015625	$\frac{1}{16}$	.0625
$\frac{1}{8}$	.03125	$\frac{1}{8}$	.125
$\frac{3}{16}$	.046875	$\frac{1}{4}$	.25
$\frac{1}{4}$	.0625	$\frac{3}{8}$	.375
$\frac{5}{16}$	.078125	$\frac{1}{2}$	.5
$\frac{3}{8}$	.09375	$\frac{5}{8}$	.625
$\frac{7}{16}$	.09375	$\frac{3}{4}$	.75
$\frac{1}{2}$	.1250	$\frac{7}{8}$	.875
$\frac{1}{4}$	.2500	$\frac{1}{2}$	.5000
$\frac{3}{8}$	.3750	$\frac{3}{4}$	.7500
$\frac{1}{2}$	.5000	$\frac{5}{8}$	.6250
$\frac{3}{4}$	.7500	$\frac{3}{4}$	.7500
$\frac{5}{8}$	.6250	$\frac{1}{2}$	.5000
$\frac{3}{4}$	.7500	$\frac{3}{4}$	.7500
$\frac{1}{2}$	.5000	$\frac{1}{2}$	.5000

DE-COHERER.—A device for breaking down the circuit formed by the contents of the coherer. It is usually mechanical in action and consists of a small hammer arrangement which taps the tube (or coherer) and causes the contents of the coherer to fall apart when current has ceased.

DECOUPLING.—In the ordinary straightforward three-valve set, the H.T. sides 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.

DECOUPLING

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 valve 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 con-

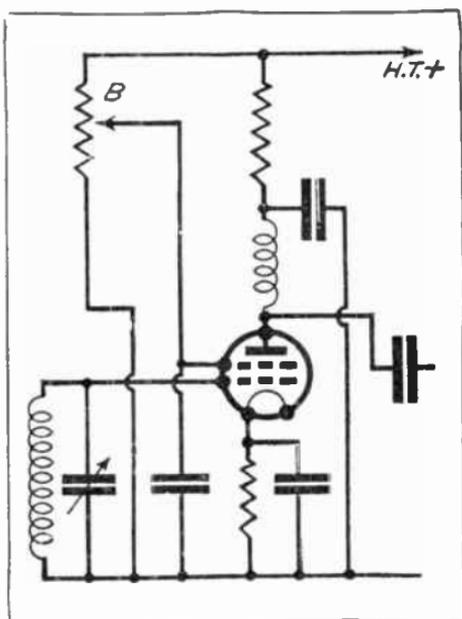


FIG. 167.—With the usual arrangement of a mains set the potentiometer acts as a decoupler.

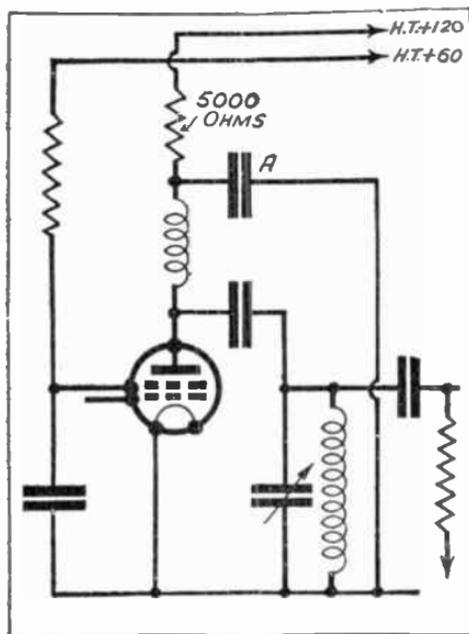


FIG. 166.—S.G. stage decoupled.

denser 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 f-ed 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 is efficient, the resistance in ohms when multiplied by the capacity of the condenser in micro-farads should not be less than 40,000.

It would appear that the cheapest

DECOUPLING

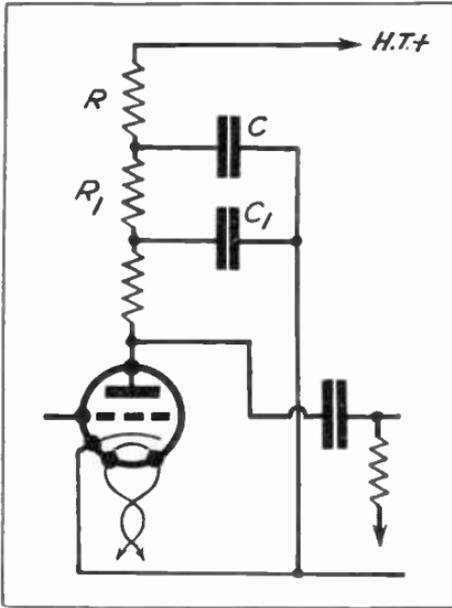


FIG. 168.—R.C.C. stage with double decoupling by resistance R and R_1 , C and C_1 .

way 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

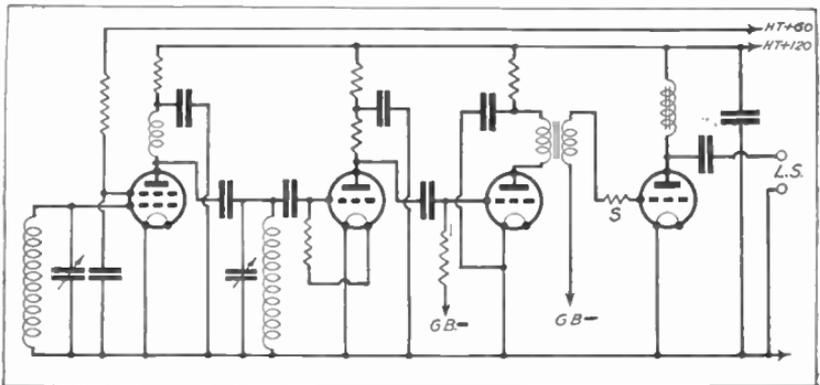


FIG. 169.—A typical four-valve circuit showing the method of inserting the decoupling resistances.

DECOUPLING — DIELECTRIC

TABLE NO. 1

Anode Resistance.	Grid Leak.	Condenser.
<i>Ohms.</i>	<i>Meg.</i>	<i>Mfd.</i>
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.

in small receivers. (See also *Quiet Automatic Volume Control* and *Automatic Volume Control*.)

DEPOLARISER.—The substance used to prevent local action (polarising) in a primary cell.

DETECTOR.—See *Valve*.

D.F.—The abbreviation for Direction Finding or Direction Finder.

DIAMAGNETIC.—Having the property of taking up, when freely suspended and acted on by magnetism,

TABLE NO. 2
Volts Drop.

Anode Current. <i>mA.</i>	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	1
3			15,000	3	20,000	2	30,000	2	70,000	1
4			10,000	4	15,000	3	25,000	2	50,000	1
5					12,000	3	20,000	2	40,000	1
6					10,000	4	15,000	3	35,000	1
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 carrying the current flowing. Condenser must be capable of carrying 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 indicated.

Table No. 2 indicates a number of values from which it will be simple to arrive at any intermediate figure.

In a first L.F. stage the result can usually be lowered to 30,000.

DELAYED A.V.C.—A system of automatic volume control in which the A.V.C. bias is not applied to the variable- μ stages until the signal currents applied to the detector valve reach some minimum intensity. With this form of A.V.C. the effect does not manifest itself except on fairly powerful signals, and thus the signal strength of comparatively weak transmissions is not reduced in the slightest degree. Because of this, delayed A.V.C. is particularly suitable for use

a position transverse to that of the magnetic axis. Opposed to *Paramagnetic* (which see).

DIAKATHODE RAYS.—Ions, positively charged, which travel at a reduced velocity as compared with kathode (cathode) rays. Sometimes referred to as Canal Rays or, more generally, Positive 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

DIELECTRIC CAPACITY — DIELECTRIC STRENGTH

as 1, and therefore the dielectric constant is rated as a comparative figure to the air dielectric. For instance, the dielectric constant (or S.I.C.) of ebonite is $2\frac{3}{4}$, which means that for a given size of plate, and a given separation between them, a

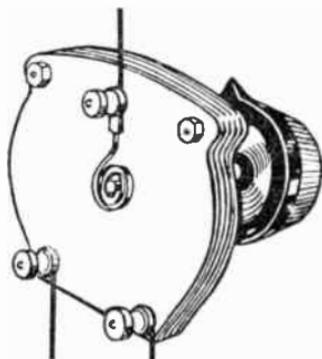


FIG. 170.—A Differential Condenser of the solid Dielectric type.

condenser with ebonite as a dielectric would have a capacity $2\frac{3}{4}$ times as

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

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.

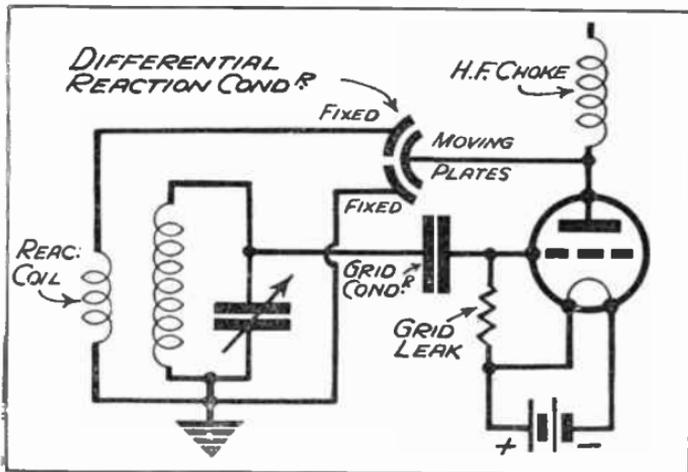


FIG. 171.—The method of connecting a differential condenser when the reaction coil is joined to the earth line. The connections to the reaction coil govern the differential condenser connections.

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. The actual connections will depend upon the coil used; in some cases it may be desirable to earth the moving vanes and *vice versa*. 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.—Duplex.

DI-POLE AERIAL.—A form of aerial used for ultra-short wave work. It consists of two short lengths of metal rod, vertically disposed on the same axis, with a space separating

them. The transmitter is joined to the centre. A similar arrangement may be used for reception. The overall length of the aerial must be equivalent to one-half of the wavelength of the transmission. Also known as half-wave aerial.

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 aeri-als 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.—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

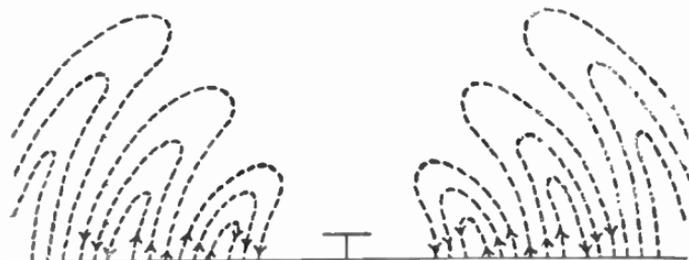


FIG. 172.—How the Lines of Stress radiate.

piano string when struck 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

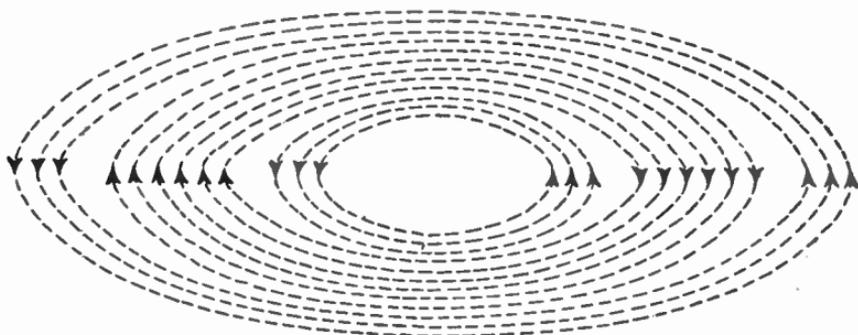


FIG. 173.—A diagram of the Lines which accompany the Radiation illustrated in Fig. 172.

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

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.

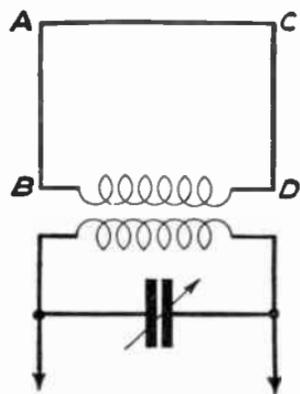


FIG. 174.—The Frame Aerial with its small coil coupled to the main tuning circuit.

charge and radiates outwards in the form of annular loops. The current then flowing in the reverse direction produces a reverse effect. The illus-

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 "off-setting." By a judicious use of the

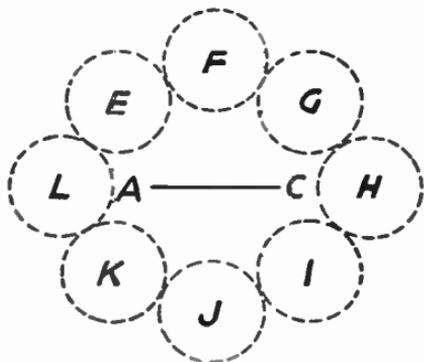


FIG. 175.—The Wave-forms of different stations approaching the frame aerial A—C.

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.

The presence of any metallic body will affect the directional property of the frame.

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- International DX'ers Alliance:** 9 Stanton Road, West Wimbledon, London, S.W.20.
- International Short-wave Club (Brighton):** Sec., J. C. Bennett, 205 Braeside Avenue, Brighton, 6.
- International Short-wave Club (Guernsey):** Hon. Sec., F. S. Le Pavoux (2BTP), "Newlands," Rue Maze, St. Martin's, Guernsey, C.I.
- International Short-wave Club (London):** Headquarters, R.A.C.S. Hall, Cavendish Grove, Wandsworth Road, S.W.8. Hon. Sec., A. E. Bear, 100 Adams Garden Estate, London, S.E.16.
- International Short-wave Club (Manchester):** H. Wild, 1 Elm Street, Middleton, Manchester.
- Ipswich and District Amateur Radio Society:** Hon. Sec., D. H. Barbrook (G8AN), Radio House, St. Peter's Street, Ipswich.
- Irish Short-wave Club:** 3 Clare Lane, Dublin.
- Jersey Short-wave Club:** Sec., Martin G. Bonoke, Crediton, Samares, Jersey.
- Kentish Town and District Radio Society:** 46 Lady Margaret Road, Kentish Town, N.W.5.
- Kettering Radio and Physical Society:** I. L. Holmes, "Miami," The Close, Headlands, Kettering.
- Kew Ministry of Labour Radio Society:** Ministry of Labour, Ruskin Avenue, Kew.
- Kidderminster and District Radio Club:** Hon. Sec., H. A. Brown, 12 Stourport Road, Kidderminster.
- Kilmarnock and District Short-wave Society:** Hon. Sec., R. Mitchell, 151, Brompton Road, Kilmarnock, Ayrshire.
- Kingston and District Amateur Radio Society:** Hon. Sec., R. K. Shergold, "Reculver," Manor Lane, Sunbury-on-Thames.
- King's Lynn Short-wave Club:** Hon. Sec., G. Rodgers, 112A High Street, King's Lynn.
- Knutsford Amateur Radio Club:** Hon. Sec., J. McDermott, Shaw Heath Cottages, Mobberley Road, Knutsford, Cheshire.
- Lambda Radio Society:** C. F. Lamb, 4 Howley Street, York Road, S.E.1.
- Leamington and Warwick Amateur Radio Society:** c/o M. C. Bunting, Khuaine, Clarendon Square, Leamington Spa.
- Leeds and District Radio Society:** Hon. Sec. J. Kavanagh, 63 Dawlish Avenue, Leeds.
- Leeds Radio Society:** Hon. Sec., G. F. Webster, 14 Birfield Crescent, Leeds, 4.
- Leicester Amateur Radio Society:** T. Cribb, 55 Knighton Drive, Leicester.
- Liverpool Amateur Radio Society:** Hon. Sec., J. McLelland (2CIP), 38 Andrew Street, County Road, Walton, Liverpool.
- Liverpool Short-wave Radio and Transmitting Club:** Hon. Sec., C. E. Cunliffe, 368 Stanley Road, Bootle, Liverpool, 20.
- Maldstone Amateur Radio Society:** Hon. Sec., M. Hedgeland, 8 Hayle Road, Maidstone.
- Medway Amateur Transmitting Society:** S. Howell, 124 Trafalgar Road, Gillingham, Kent.
- Midland Amateur Radio Society:** A. T. Marton, 3 Gladys Road, Yardley, Birmingham.
- Milnes Radio and Television Society:** Hon. Sec., F. Ridler, 7 Royd Avenue, Gilstead, Bingley, Yorks.
- Morpeth Amateur Radio Society:** Hon. Sec., C. L. Towers, 2 Edward Street, Morpeth.
- Newark News Radio Club:** 215 Market Street, Newark, New Jersey.
- Newbury and District Short-wave Club:** Hon. Sec., L. Harden, 11 Highfield Avenue, Newbury, Berks.
- Newcastle and District Short-wave Club:** Hon. Sec., K. Scott, 1 Farquhar Street, Newcastle-on-Tyne, 2.
- New Eltham Ratepayers' Association (Radio Section):** Hon. Sec., E. A. Gilborn, 87 Montbelle Road, New Eltham, S.E.9.
- Newtownards Amateur Radio Club (N. Ireland):** Hon. Sec., T. L. Kirk, Chapel View, Newtownards, Ulster.
- New Zealand DX Radio Association:** Hon. Sec., E. Watson, 37 Chancellor Street, Christchurch, N.Z.
- New Zealand Short-wave Radio Club:** Sec., A. B. McDonagh, 4 Queen Street, Wellington, E.1, N.Z.
- North Ireland Radio Society:** Hon. Sec., F. A. Robb, 46 Victoria Avenue, Sydenham, Belfast.
- North Manchester Radio Society:** Hon. Sec., R. Lawton, 10 Dalton Avenue, Thatch Leach Lane, Whitefield.
- North Middlesex Radio Society:** Sec., H. A. Crouch, 27 Middleton Park, Whetstone, N.20.
- North Shields Radio Society:** Hon. Sec., G. A. Lee, 9A Saville Street West, North Shields.
- Northampton Radio Society:** Hon. Sec., D. W. Harries, 99 Ardington Road, Northampton.
- Northwest Ireland Amateur Radio Society:** Hon. Sec., S. Foster, 2 Florence Street, Park Street, Derry.
- Oxford Short-wave Radio Club:** Hon. Sec., E. G. Arthurs (2BHP), 13 Walton Well Road, Oxford.
- Peckham District Short-wave Club:** L. J. Orange, 11 Grenard Road, Peckham, S.E.15.
- Perth Radio Society:** R. Adams, 120 Canal Street, Perth.
- Peterborough and District Short-wave Club:** Hon. Sec., W. Cornwell (2ACP), 80 Elmfield Road, Peterborough.
- Portsmouth and District Wireless and Television Society:** Hon. Sec., F. L. Moore, 78 Laburnum Grove, Portsmouth.

DIRECTORY OF RADIO CLUBS AND SOCIETIES

- Port Talbot Radio Club:** W. Ryan, 47 Margam Terrace, Port Talbot.
- Prestatyn Short-wave Club:** Hon. Sec., R. J. Stelling, Komir, Victoria Road, Prestatyn.
- Radio Physical and Television Society:** Hon. Sec., V. R. Walker, 49 Fitzjames Avenue, London, W.14.
- Radio Society of Great Britain:** Sec., J. Clarricoates, 53 Victoria Street, London, S.W.1.
- Radio Society of Great Britain (Bristol Area):** Sec., A. J. Webb (2AJW), 12 Mervyn Road, Bishopston, Bristol, 7.
- Radio Society of Northern Ireland:** Hon. Sec., H. F. Ruberry, 19 Little Victoria Street, off Great Victoria Street, Belfast.
- Radio Transmitters Union:** c/o W. H. Martin, Knocknagh, Cloughfern, Whiteabbey, Northern Ireland.
- Redhill and District Radio Society:** Hon. Sec., H. Cartwright, Radio House, Victoria Road, Horley, Surrey.
- Redhill and District Short-wave Club:** Sec., S. Hassenauer, 139 Frenches Road, Redhill, Surrey.
- Robert Blair Radio Society:** Hon. Sec., A. R. Richardson, 24 Mercers Road, London, N.19.
- Romford and District Amateur Radio Society:** Sec., R. Beardow, 3 Geneva Gardens, Chadwell Heath.
- Rousdon Short-wave Club:** Sec., E. A. D. Rutherford, Whitlands, Nr. Lyme Regis, Dorset.
- Sale and District Radio Society:** Sec., C. Allen, 31 Ennerdale Drive, Ashton-on-Mersey, Sale.
- Sale and District Short-wave Radio Club:** Pub. Sec., N. Postles (2CXH), "Norward," 56 Firs Road, Sale, Cheshire.
- Salisbury and District Short-wave Club:** Hon. Sec., C. A. Harley, 85 Fisherton Street, Salisbury, Wilts.
- Sheffield Short-wave Club:** Sec., D. H. Tomlin, 32 Moorsyde Avenue, Sheffield, 10.
- Sheppey Amateur Radio Club:** Hon. Sec., F. G. Maynard, 161 Invicta Road, Sheppey.
- Short-wave Radio and Television Society (Thornton Heath):** Hon. Sec., J. T. Webber, 368 Brigstock Road, Thornton Heath.
- Slade Radio Society:** Hon. Sec., L. A. Griffiths, 47 Welwyndale Road, Erdington, Birmingham, 24.
- Slough and District Short-wave Club:** K. A. Sly, 16, Buckland Avenue, Slough.
- Smethwick Wireless Society:** Hon. Sec., E. Fisher, 33 Freeth Street, Oldbury, Nr. Birmingham.
- Southall Radio Society:** Hon. Sec., H. F. Reeve, 26 Green Drive, Southall.
- Southend and District Radio and Scientific Society:** Hon. Sec., J. M. S. Watson, 23 Eastwood Boulevard, Westcliff-on-Sea, Essex.
- South Hants Radio and Transmitting Society:** Sec., E. J. Williams, "Rochdale," London Road, Portsmouth.
- South London and District Transmitters Society:** Sec., H. Cullen, 164 West Hill, Wandsworth, S.W.7.
- Southport Amateur Radio Society:** Birch Villa, Lulworth Road, Southport.
- S.T.C.:** The Chief Instructor, Training Battalion, R. Signals, Catterick Camp, Yorks.
- Stoke-on-Trent Radio Society:** H. Churton, 26 Victoria Street, Smallthorne, Stoke-on-Trent.
- Stourbridge and District Radio Society:** Hon. Sec., Donald Rock, 4 Linton Road, Old Hill, Staffs.
- Surrey Radio Contact Club:** Hon. Sec., E. C. Taylor, 35 Grant Road, Addiscombe, Croydon.
- Sutton-in-Ashfield Society:** Hon. Sec., A. W. Fowler, 78 Kirkyard, Sutton-in-Ashfield.
- Swansea Radio Club:** Hon. Sec., R. J. Davies, Messrs. Watson & Davies, Mansel Lane, Swansea.
- Swindon and District Short-wave Society:** Hon. Sec., W. C. Barnes, 7 Surrey Road, Swindon.
- Tamworth Radio Experimental Society:** Hon. Sec., P. H. Lawrence, 38 Market Street, Taniworth, Staffs.
- Television Society:** Sec., G. Parr, 68 Crompton Road, London, N.21.
- Thames Estuary Radio Society:** F. S. A. Jenkins, R.N.W.A.R., "Cranleigh," Spencer Close, Rochford, Essex.
- Thames Valley Amateur Radio and Television Society:** Sec., J. N. Roe, 19A The Barons, St. Margarets-on-Thames, Middlesex.
- Thorne Amateur Radio Society:** Hon. Sec., G. Beaumont, 15 Marshland Road, Moor-Ends, Nr. Doncaster.
- Tonyrefail Short-wave Club:** E. Powell, 44 Pritchard Street, Tonyrefail, Glam.
- Torrington and District Short-wave Club:** Hon. Sec., A. E. Cornish, 1 Halsdon Road, Torrington, N. Devon.
- Tottenham Short-wave Club:** Hon. Sec., Edwin Jones, 60 Walmier Terrace, Firs Lane, Palmers Green, N.13.
- Tottenham Wireless Society:** Hon. Sec., F. E. R. Neale, 17 Whitley Road, Tottenham, N.17.
- Tuffnell Park Radio Club:** Hon. Sec., J. G. Wright, 78 Glasnuir Road, Highgate, N.10.
- Tunbridge Wells and District Amateur Transmitting Society:** Sec., W. H. Allen, 32 Earl's Road, Tunbridge Wells.
- Waldron Radio Society:** Hon. Sec., W. E. Simmons, 35 Trannere Road, Earsfield, S.W.18.
- Wallasey Junior Radio Club:** A. M. Wilding, 2 Wallace Road, Wallasey, Cheshire.
- Warwick School Radio Society:** Sec., P. N. G. Whitlam, Warwick School, Warwick.
- West Herts Radio Club:** Hon. Sec., D. Steward, 9 Weymouth Street, Apsley, Herts.
- West London Radio Society:** Hon. Sec., D. Reid, 15 Tring Avenue, Ealing Common, W.5.
- West Sussex Short-wave and Television Club:** Hon. Sec., C. J. Rockall (G2ZV), "Aubretia," Seafield Road, Rustington, Sussex.
- Weymouth Short-wave Club:** W. E. G. Bartlett, 59A Franchise Street, Weymouth, Dorset.
- Willesden Radio Club:** S. A. Reeve, 115 Willesden Lane, Kilburn, N.W.6.
- Wirral Amateur Transmitting and Short-wave Club:** Hon. Sec., J. R. Williamson, 49 Neville Road, Bromborough, Birkenhead.
- Wolverhampton Short-wave Radio Society:** Hon. Sec., W. A. Hill, 76 Darlington Street, Wolverhampton.
- Woodford and District Radio Society:** Sec., R. A. Ledgerton, 64 High Road, Woodford Bridge, Essex.
- World Friendship Society of Radio Amateurs:** Hon. Sec., A. H. Bird (G6AQ), 35 Bellwood Road, Waverley Park, Nunhead, S.E.15.
- Worthing and District Short-wave Club:** Hon. Sec., G. A. Lambourne, 16 Angola Road, Worthing.

DISSOLVER — DISTORTION

DISSOLVER.—See *Fader*.

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-

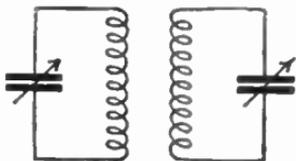


FIG. 175A.—Inductively coupled coils.

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

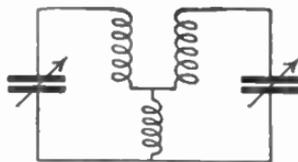


FIG. 175B.—Coil common to both tuned circuits.

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 loudspeaker 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 overloaded, or even under biased. To

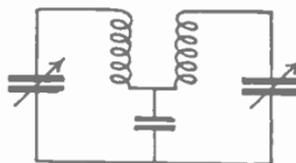


FIG. 175c.—Capacity-coupled Circuit.

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

DISTORTION—DRILLS AND DRILLING

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.

Reaction. Mention must be made of reaction. Keep this control adjusted so that it is as far off oscillation point as possible.

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 respec-

tively for negative and positive high-tension supplies (D.C.). (See also *Eliminator*.)

DOUBLE DIODE PENTODE.—The combination of a double diode valve and the electrodes of a pentode valve (which see). The two diodes are generally employed for detection and automatic volume control, whilst the pentode acts by the variable-bias method as a controlled L.F. valve.

DOUBLE DIODE TETRODE.—The combination of a double diode valve and the electrodes of a tetrode. Its use is exactly the same as the double diode pentode, excepting the difference in amplification between the tetrode and the pentode section of the valve.

DOUBLE DIODE TRIODE.—A multi-electrode valve which really contains all the elements of two separate valves. There are the usual heater, a cathode, two "auxiliary" anodes, a grid, and a main anode. The first four electrodes operate together as a full-wave detector, whilst the first two and last two act as a normal triode L.F. amplifier. This valve is used principally for providing A.V.C.

DOUBLET.—Another name for a dipole, divided, or half-wave aerial. (See *Dipole*.)

DOWN-LEAD.—The wire leading from an aerial down to the receiver. Also termed the lead-in.

D.P.—Double Pole. Difference of Potential.

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 for brass and aluminium.

Standard twist drills are commercially obtainable in fractional sizes ranging from $\frac{1}{8}$ in. diameter to 1 in. diameter by increments of $\frac{1}{16}$ in. In

DRILLS AND DRILLING

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).

For wireless work, however, most requirements are covered in the tables given on a later page.

These drills, and a $\frac{7}{16}$ -in. and $\frac{1}{2}$ -in. diameter and possibly a few extra fractional sizes below $\frac{1}{2}$ in., should complete the range required. To keep them together 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

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		

that the drill is almost rubbing. This will produce a clean-cut countersink.

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.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.
Tapping size	$\frac{3}{16}$ in.	No. 31	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	Letter D
Clearing size	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.

B.S.F. THREADS

Diameter	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.	$1\frac{3}{4}$ in.
Tapping size	No. 5	Letter B	Letter G	Letter O
Clearing size	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.

B.A. THREADS

Diameter	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{4}$ in.	$1\frac{3}{4}$ in.	$2\frac{1}{8}$ in.
Tapping size	No. 10	No. 17	No. 24	No. 29	No. 32	No. 37	No. 43	No. 46	No. 50	No. 50
Clearing size	Letter B	No. 3	$\frac{1}{8}$ in.	No. 19	No. 27	No. 30	No. 43	No. 39	No. 43	No. 43

WOOD SCREWS

Size No.	00	0	1	2	3	4	5	6	7	8
Clearing size	No. 52	No. 51	No. 50	No. 44	No. 40	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.

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 H); if as shown in Fig. 176 I (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 $\frac{1}{8}$ 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 $\frac{1}{2}$ -in. diameter $\frac{1}{8}$ -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

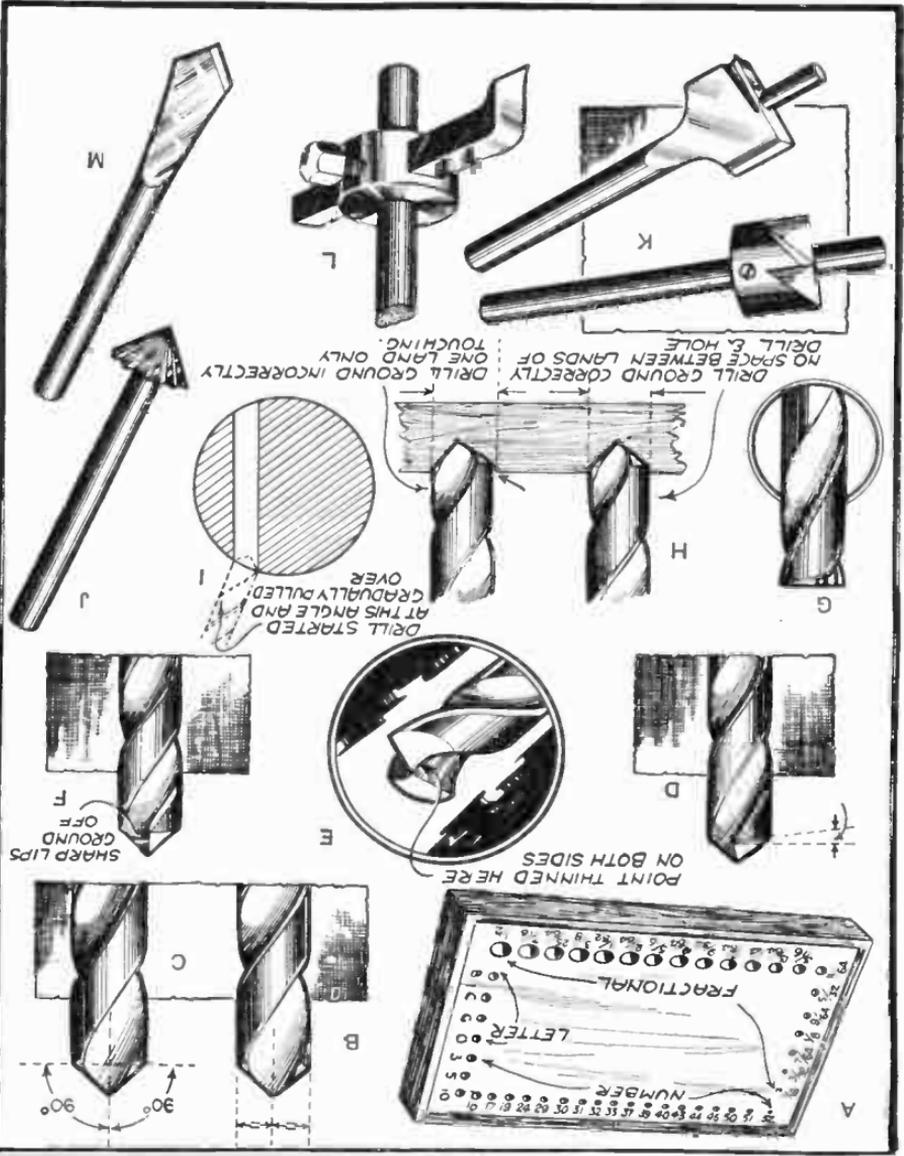


FIG. 176.—Various Hints about Drills and Drilling.

DRILLS, SHARPENING

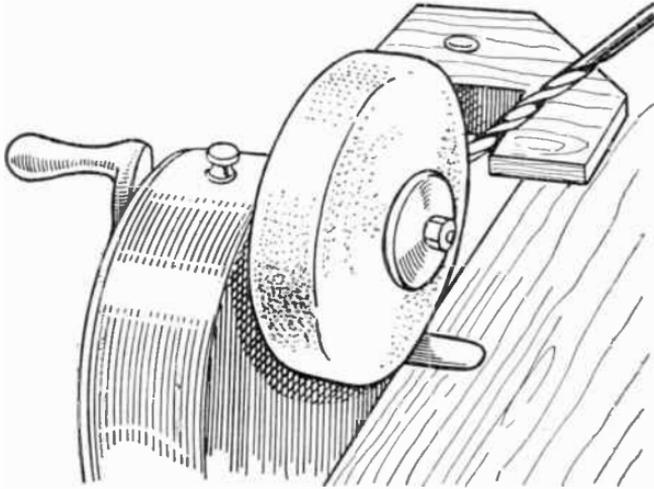


FIG. 177.—The correct angle at which to hold the Drill—and a Drill Rest.

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 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

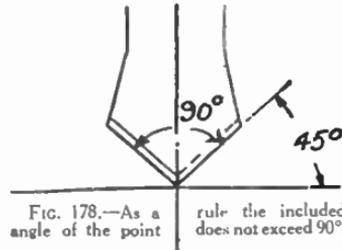


FIG. 179.—Grinding groove edge of twist to prevent the drill digging in on brass work.

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

DRILLS — DRY CELL

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 twist drill (Fig. 180) has two

L.F. intervalve transformer used to supply signals to a Class B output stage. It differs from an ordinary L.F. transformer in that it is of step-down ratio and the secondary is wound to a low resistance of heavy gauge wire to avoid voltage drop due to the grid current flow.

DRIVER VALVE.—The valve which feeds a Class B output stage.

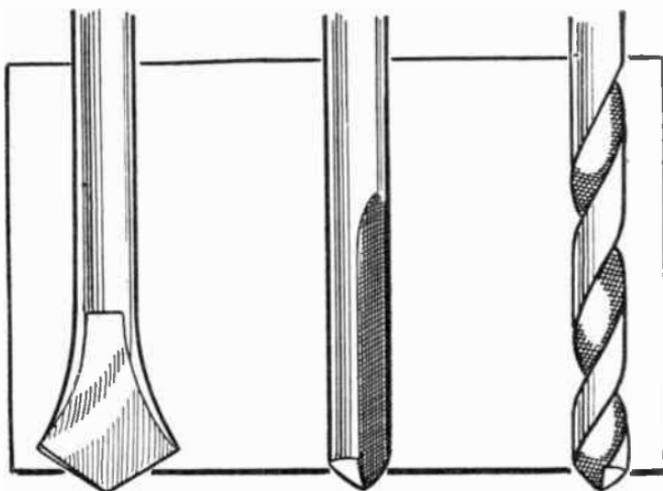


FIG. 180.—Three types of Drill—the Diamond, Straight Flute, and Twist.

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).

DRIVER TRANSFORMER.—The

It is simply a small power valve, but gets its name from the fact that it supplies a fairly large power to a step-down transformer feeding a Class B dual valve.

DRY CELL.—A combination of chemicals giving forth electrical energy. Active elements consist 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

cus 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 required from them is small. (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*.)

DUAL LOUDSPEAKER.—See *Loudspeaker*.

DULL EMITTER.—This is the name which some years ago was given

to valves whose filaments could scarcely be seen to glow and which thus emitted electrons when heated to only a dull red. The term was used in opposition to "bright emitter," the name given to valves whose filaments were heated to incandescence like the filament of an ordinary electric lamp bulb.

DUMB AERIAL.—An artificial aerial (which see).

DUPLEX.—Duplex. Two-way telegraphy and telephony.

D.X.—An abbreviation for the word "distance."

"D.X. UNIT."—Those listeners who do not employ an H.F. stage will no doubt have found that the strength of the foreign transmissions falls off during the summer season. Of course, atmospheric 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

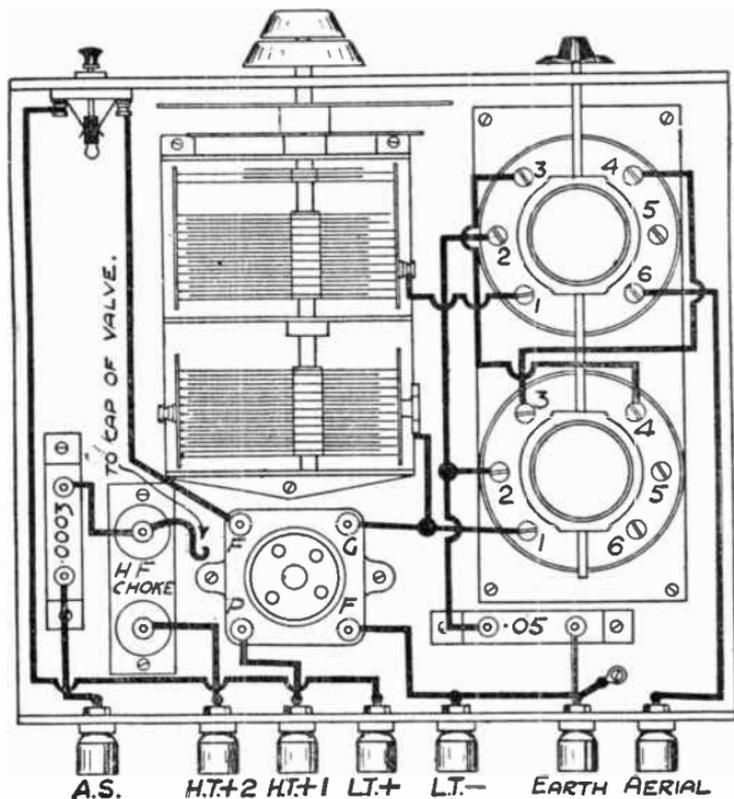


FIG. 181.—The wiring diagram of the D.X. Unit.

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

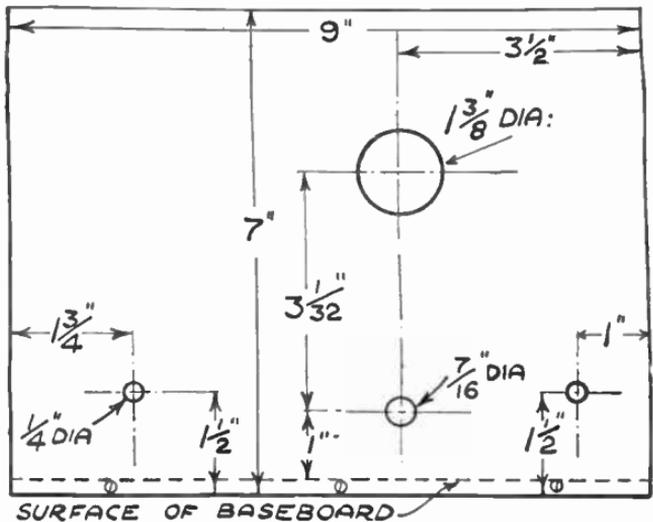


FIG. 182.—The Panel Layout for the D.X. Unit.

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 AS 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. 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.

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 per second when acting on a mass of 1 gramme: 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.

Weights and Areas of Sheet Ebonite

Thickness	Area of 1 oz.	Area of 1 lb.	Weight of 1 sq. ft.
<i>in.</i>	<i>in.</i>	<i>sq. in.</i>	<i>oz.</i>
$\frac{1}{8}$	2 $\frac{1}{2}$	44	52
$\frac{1}{16}$	3 $\frac{1}{2}$	56	39
$\frac{1}{32}$	5 $\frac{1}{2}$	88	26
$\frac{1}{64}$	7 $\frac{1}{2}$	117.5	20
$\frac{1}{8}$	11	176	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 or paste. It is not a condenser until a potential is applied, whereupon a film forms over one of the plates, and this film is an insulator. The positive electrode takes this film, and the result of this insulation is to stop the flow of cur-

ELECTROLYTIC CONDENSER — ELECTRON MULTIPLIER

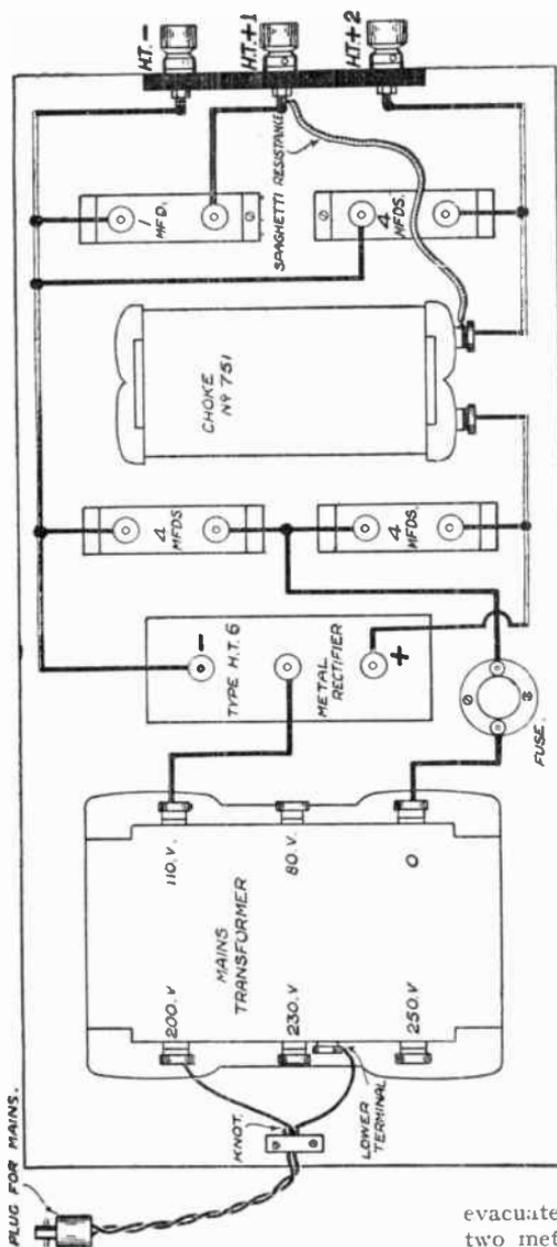


Fig. 183.—The Wiring Diagram of the A.C. Mains Unit.

These condensers are principally used in large capacities (up to 4,000 mfd.) for mains smoothing purposes.

ELECTROLYTIC RECTIFIER.—See *Accumulator.*

ELECTROMALUX.—The electric eye, or photoelectric mosaic pick-up tube used in the television camera. The Iconoscope or the Emitron Camera (which see).

ELECTRON.—The final particle of negative electricity. A negative ion is an atom plus an electron. A positive ion is an atom minus an electron. Mass = 9.00×10^{-28} gramme.

ELECTRONIC MUSIC.—Music produced entirely by electrical means. The principle of electronic music is the same as that of an oscillating valve, which produces a "whistle" or high-pitched note. Music of this kind is produced by varying the capacity to earth of the grid circuit of an oscillating valve, and the "earth" consists of the hands of the performer since he moves them about a metallic rod connected to the grid of the valve. (See also *Theremin Principle.*)

ELECTRON MULTIPLIER.—Sometimes referred to as a "cold valve." It consists of an

evacuated tube in which are placed two metal anodes, which are coated with caesium or similar light-sensitive material, and a central anode. The anode takes the form of a ring so

evacuated tube in which are placed two metal anodes, which are coated with caesium or similar light-sensitive material, and a central anode. The anode takes the form of a ring so

ELECTROPHORUS — ELIMINATOR

that an electron emission from one cathode passes through the anode to the other cathode. By so doing a secondary emission is liberated by the second cathode.

In use a positive potential is applied to the anode which is surrounded by a coil through which is passed a low current. The effect of the coil is to focus the electron stream through the anode from cathode to cathode.

ELECTROPHORUS.—An instrument for producing very small charges of electricity.

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

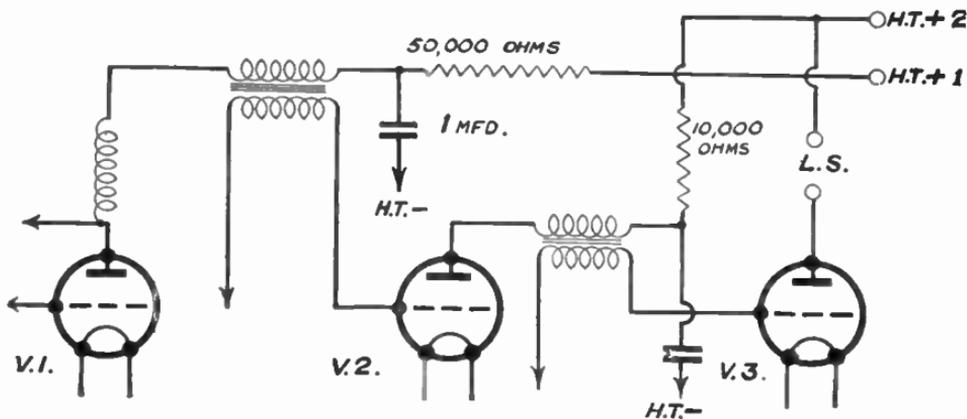


FIG. 184.—The Battery Connections of a simple three-valver.

ELECTROSCOPE.—An arrangement of metal foils in a container for detecting charges of static electricity.

ELIMINATOR.—An abbreviation of "Battery Eliminator" (which see).

Making Eliminators. This A.C. mains unit is intended for receivers of not more than three valves (Fig. 183).

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

ELIMINATOR

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 base-board, 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-valve 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-

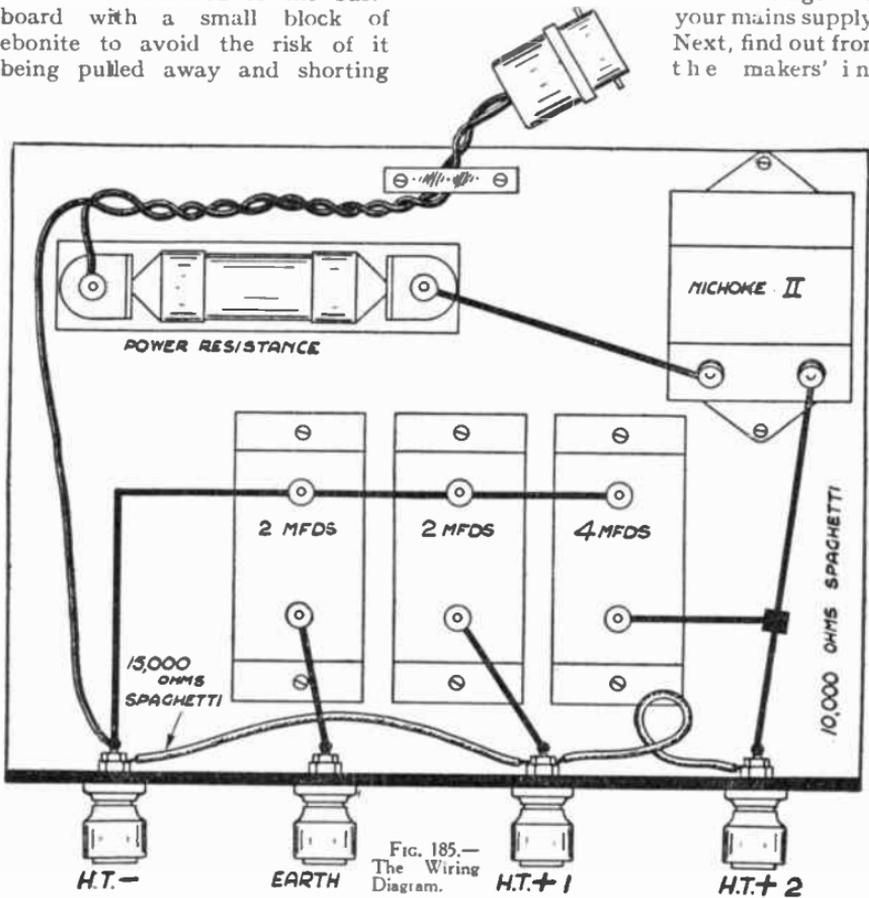


FIG. 185.—
The Wiring
Diagram.

ELIMINATOR

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.

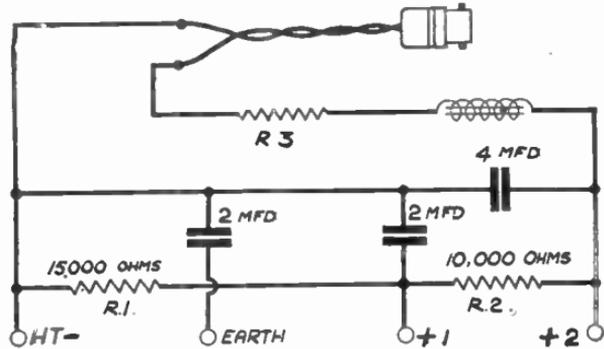


FIG. 186.—The Circuit Diagram.

Last valve rated at 150 volts 8 milliamps.

Detector valve takes 2 milliamps.

First L.F. valve takes 6 milliamps.

Therefore, total current = 16 + 8 = 24 milliamps.

Volts to be dropped = 250 - 150 = 100 volts.

$$\frac{100 \times 1,000}{24} = 4,166 \text{ ohms.}$$

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.

Four insulated terminals.

E.M.F. — EUROPEAN BROADCASTING STATIONS

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.

EMITRON. — Registered trade-name of the Marconi-E.M.I. television camera, incorporating the principle of Dr. Zworykin's Iconoscope.

EMPIRE CALL SIGNS. — See *B.B.C. Empire Call Signs*.

ENDODYNE.—A method of reception differing from heterodyne reception, in that no particular valve is specially set aside for generating heterodyne frequency.

ENERGISED SPEAKER. — See *Loudspeaker*.

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. Speed of ether waves is 186,000 miles per second, the same as the speed of light.

EUROPEAN BROADCASTING STATIONS

(See also *Short-wave Stations*, *International Call Signs*, and *British Broadcasting Stations*)

(Subject to alteration during hostilities and as from March 1940)

The following is a list of those European and some extra-European broadcasting stations which are normally heard in this country. The wavelengths of most stations will be changed in March 1940, and a list of the main alterations is given on page 11.

Kc/s	M	kW	Station
			<i>Band No. 1</i> 150-300 kc/s
152	1973.5	5	Istanbul (Turkey).
153	1961	7	Kaunas (Lithuania).
160	1875	{ 120	Hilversum (No. 1) (Holland). (Transmits A.V.R.O., V.A.R.A., and
		{ 120	V.P.R.O. Programmes.) (Power 10kW only until 2.40 p.m. G.M.T.)
		{ 130	Radio-Romanian (Romania).
166	1807	220	Lahti (Finland).
172	1744	500	Moscow (No. 1) (U.S.S.R.).
182	1548	80	Radio-Paris (France).
183	1639	120	Ankara (Turkey).
187.5	1600	20	Irkoutsk (U.S.S.R.).
191	1571	150	Deutschlandsender (Germany).
200	1500	150	Droitwich.
208	1442	{ 35	Minsk (U.S.S.R.).
		{ 100	Reykjavik (Iceland).
216	1389	150	Motala (Sweden).
217.5	1379	100	Novosibirsk (U.S.S.R.).
224	1339	120	Warsaw (No. 1) (Poland).
232	1293	{ 150	Luxembourg.
		{ 100	Moscow (No. 2) (U.S.S.R.).
240	1250	60	Kalundborg (Denmark).
248	1209.6	100	Kiev (No. 1) (U.S.S.R.).
256.4	1170	{ 25	Tashkent (U.S.S.R.).
		{ 20	Bergen (Norway).
260	1153.8	{ 60	Oslo (Norway).
		{ 10	Vigra (Aalesund) (Norway).
		{ 100	Leningrad (No. 1) (U.S.S.R.).
271	1107	10	Tromsø (Norway).
282	1064	10	Tiflis (U.S.S.R.).
283	1060	35	Tiflis (U.S.S.R.).

EUROPEAN BROADCASTING STATIONS

Kc/s	M	kW	Station
			<i>Band No. 2</i>
300	1000		300-500 kc/s
340	882.3	100	Moscow (No. 3) (U.S.S.R.).
		20	Saratov (U.S.S.R.).
		10	Finmark (Norway).
347	864.6	10	Bodo (Norway).
350	857.1	10	Archangel (U.S.S.R.).
359.5	834.5	18	Budapest (No. 2) (Hungary).
375	800	40	Sverdioudsk (U.S.S.R.).
		10	Lulea (Sweden).
392	765	30	Banska-Bystrica (Czecho.) (Power 15 kW after 6 p.m. G.M.T.).
395	759	20	Rostov-on-Don (U.S.S.R.).
401	748	1.3	Geneva (Switzerland).
		10	Ostersund (Sweden).
413.5	726	10	Voronezh (U.S.S.R.).
431	696	10	Oulu (Uleaborg) (Finland).
			<i>Band No. 3</i>
			500-1,500 kc/s
519	578	1	Innsbruck (Austria).
		0.7	Hamar (Norway).
520	576	50	Baranowicze (Poland).
		6.3	Ljubljana (Yugoslavia).
527	569.3	10	Viipuri (Finland).
		10	Bolzano (Italy).
536	559.7	50	Wilno (Poland).
546	549.5	120	Budapest (No. 1) (Hungary).
556	539.6	100	Bernmünster (Switzerland).
		100	Radio Eireann (Eire).
		10	Klaipeda (Lithuania).
565	531	3	Palermo (Italy).
		3	Catania (Italy).
574	522.6	100	Stuttgart (Germany).
		50	Madona (Latvia).
583	514.6	20	Alpes-Grenobles (PTT) (France).
592	506.8	100	Vienna (Austria).
		20	Rabat (Morocco).
601	499.2	10	Sundsvall (Sweden).
610	491.8	20	Florence (Italy).
620	483.9	15	Brussels (No. 1) (Belgium).
		20	Cairo (No. 1) (Egypt).
625	480	10	Konibyshev (U.S.S.R.).
		100	Vigra (Aalesund) (Norway).
		20	Trondelag (Norway).
629	476.9	20	Lisbon (Emissora Nacional) (Portugal).
		20	Christiansand (Norway).
638	470.2	120	Prague (No. 1) (Czechoslovakia).
		100	Lyons (PTT) (France).
648	463	10	Petrozavodsk (U.S.S.R.).
658	455.9	100	Cologne (Germany).
668	449.1	20	Jerusalem (Palestine).
		70	North Regional.
677	443.1	100	Sottens (Switzerland).
686	437.3	20	Belgrade (Yugoslavia).
695	431.7	120	Paris (PTT) (France).
704	426.1	55	Stockholm (Sweden).
713	420.8	120	Rome (No. 1) (Italy).
722	415.5	17	Hilversum (Jaarsveld) (Holland) (Relays Hilversum: No. 1).
		10	Kharkov (No. 1) (U.S.S.R.).
		3	Madrid (EAJ2) (Spain).
		5	Seville (Spain) (EAJ5).
731	410.4	20	Tallinn (Estonia).
		38	Turi (Estonia).
740	405.4	100	Munich (Germany).
749	400.5	100	Marseilles (PTT) (France).
758	395.8	10	Katowice (Poland).
		60	Burghead.
767	391.1	70	Scottish Regional.
		10	Stalion (U.S.S.R.).
776	386.6	120	Toulouse (PTT) (France).
285	382.2	120	Leipzig (Germany).
795	377.4	7.5	Barcelona (EAJ1) (Spain).
		50	Lwów (Poland).
804	373.1	5	Rennon (Anglesey).
		70	West Regional.

EUROPEAN BROADCASTING STATIONS

Kc/s	M	kW	Station
814	358.6	50	Milan (No. 1) (Italy).
823	354.5	{ 12 10 35	Bucharest (Romania). Bodø (Norway). Kiev (U.S.S.R.).
832	350.6	{ 10 20 20	Stavanger (Norway). Christiansand (Norway). Trondelag (Norway).
841	356.7	100	Berlin (Germany).
850	352.9	{ 100 1 3	Sofia (Bulgaria). Portsgrund (Norway). Valencia (Spain).
859	349.2	{ 10 100	Saragossa (Spain). Simferopol (U.S.S.R.). Strasbourg (France).
868	345.6	16	Poznań (Poland).
877	342.1	70	London Regional.
886	338.6	{ 15 15	Linz (Austria). Graz (Austria).
895	335.2	10	Helsinki (Finland).
904	331.9	100	Hamburg (Germany).
913	328.6	{ 10 60	Dniepropetrovsk (U.S.S.R.). Toulouse (Radio-Toulouse) (France).
922	325.4	32	Brno (Czechoslovakia).
932	321.9	15	Brussels (No. 2) (Belgium).
941	318.8	{ 12 10	Algiers (North Africa). Göteborg (Sweden).
950	315.8	100	Breslau (Germany).
959	312.8	60	Poste Parisien (France).
968	309.9	{ 5 10	Madrid (E.A.J.) (Spain). Odessa (U.S.S.R.).
971	309	2	Montpellier (France).
977	307.1	100	Northern Ireland Regional.
986	304.3	{ 50 24	Bologna (Radio-Marconi) (Italy). Torun (Poland).
995	301.5	60	Hilversum (No. 2) (Holland) (10kW only until 8.40 p.m. B.S.T.).
1004	298.8	13.5	Bratislava (Czechoslovakia).
1013	296.2	{ 70 4	Midland Regional. Chernigov (U.S.S.R.).
1022	293.5	3	Barcelona (E.A.J.15) (Spain).
1031	291	{ 100 5	Königsberg (No. 1) (Germany). Paredo (Portugal).
1040	288.5	{ 10 120	Leningrad (No. 2) (U.S.S.R.). Rennes-Bretagne (France).
1050	285.7	50	West of England Regional.
1050	285.7	100	Start Point.
1059	283.3	20	Bari (No. 1) (Italy).
1068	280.9	{ 2 10	Radio-Cité (Paris) (France). Tiraspol (U.S.S.R.).
1077	278.6	60	Bordeaux-Lafayette (France).
1086	276.2	2	Falun (Sweden).
1095	274	{ 20 10 25	Radio Normandie (France). Vinnitsa (U.S.S.R.). Kuldiga (Latvia).
1104	271.7	{ 10 50 50	Naples (Italy). Kuldiga (Latvia). Tripoli (N. Africa).
1113	269.5	{ 100 60 60	Melnik (Czechoslovakia). Prague (No. 2) (Czechoslovakia). Stagshaw (Newcastle).
1122	267.4	6.25	Nyregyhaza (Hungary).
1131	265.3	100	Horby (Sweden).
1140	263.2	{ 10 30 10	Genoa (No. 1) (Italy). Turin (No. 1) (Italy). Trieste (Italy).
1149	261.1	{ 40 40 50	London National. North National. Scottish National.
1158	259.1	{ 10 1.5	Kassa (Hungary). Moravska-Ostrava (Czechoslovakia).
1167	257.1	15	Monte Ceneri (Switzerland).
1176	255.1	10	Copenhagen (Denmark).
1185	253.2	60	Nice-Côte-d'Azur (France).

EUROPEAN BROADCASTING STATIONS — FADING

Kc/s	M	kW	Station
1195	251	$\left\{ \begin{array}{l} 2 \\ 25 \\ 5 \end{array} \right.$	Collenz (Germany).
			Frankfurt (Germany).
			Freiburg-im-Breisgau (Germany).
1204	249.2	5	Troppau (Germany).
1213	247.3	60	Lille (Radio PTT Nord) (France).
1222	245.5	$\left\{ \begin{array}{l} 2 \\ 60 \end{array} \right.$	Nurnberg (Germany).
			Rome (No. 2) (Italy).
1231	243.7	$\left\{ \begin{array}{l} 5 \\ 5 \end{array} \right.$	Gleitwitz (Germany).
			Gorlitz (Germany).
1235	242.9	1	Cork (Eire).
1249	240.2	$\left\{ \begin{array}{l} 17 \\ 1 \end{array} \right.$	Saarbrucken (Germany).
			Florence (No. 2) (Italy).
1258	238.5	$\left\{ \begin{array}{l} 15 \\ 20 \end{array} \right.$	Riga (Latvia).
			Burgos (Spain).
1267	236.8	2	Nurnberg (Germany).
1276	235.1	$\left\{ \begin{array}{l} 1 \\ 2 \end{array} \right.$	Frederikstad (Norway).
			Varna (Bulgaria).
1285	233.5	5	Abordeen.
1294	231.8	$\left\{ \begin{array}{l} 5 \\ 5 \end{array} \right.$	Klagenfurt (Germany).
			Vorarlberg (Germany).
1303	230.2	10	Naples (No. 1) (Italy).
1312	228.7	$\left\{ \begin{array}{l} 2.5 \\ 1.25 \end{array} \right.$	Malmo (Sweden).
			Magyarovar (Hungary).
1321	227.1	$\left\{ \begin{array}{l} 1 \\ 27 \\ 2 \end{array} \right.$	Radio Méditerranée (France).
			Bremen (Germany).
			Hanover (Germany).
1330	225.6	$\left\{ \begin{array}{l} 2 \\ 2 \\ 2 \end{array} \right.$	Flemburg (Germany).
			Stettin (Germany).
			Montpelier (PTT) (France).
1339	224	$\left\{ \begin{array}{l} 1 \\ 2 \\ 0.5 \end{array} \right.$	Lodz (Poland).
			Dublin (Eire).
			Salzburg (Germany).
1348	222.6	$\left\{ \begin{array}{l} 2 \\ 0.7 \\ 1 \\ 1.5 \end{array} \right.$	Tampere (Finland).
			L'Île de France (France).
			Naples (No. 2) (Italy).
			Königsberg (No. 2) (Germany).
1357	221.1	$\left\{ \begin{array}{l} 1 \\ 4 \\ 5 \\ 5 \end{array} \right.$	Rome (No. 3) (Italy).
			Milan (No. 2) (Italy).
			Turin (No. 2) (Italy).
			Genoa (No. 2) (Italy).
1363.5	220	—	Thessaloniki (Greece).
1366	219.6	$\left\{ \begin{array}{l} 25 \\ 1 \end{array} \right.$	Bordeaux-Sud-Ouest (France).
			Tallinn (Estonia).
1375	218.2	0.5	Berne (Switzerland).
1384	216.8	7	Warsaw (No. 2) (Poland).
1393	215.4	25	Radio-Lyons (France).
1402	214	2	Stara-Zagora (Bulgaria).
1420	211.3	$\left\{ \begin{array}{l} 10 \\ 2.5 \end{array} \right.$	Vaasa-Vasa (Finland).
			Kaiserslautern (Germany).
1429	209.9	$\left\{ \begin{array}{l} 1 \\ 5 \\ 1.25 \end{array} \right.$	Naples (No. 2) (Italy).
			Turin (No. 3) (Italy).
			Miskole (Hungary).
1438	208.6	5	Eiffel Tower (Paris) (France).
1456	206	1.25	Pecs (Hungary).
1465	204.8	20	Clovedon.
1474	203.5	$\left\{ \begin{array}{l} 0.1 \\ 0.5 \\ 0.1 \end{array} \right.$	Chatelineau (Belgium).
			Santiago (Spain).
			Liège Experimental, Radio-Cointe (Belgium).
1500	200	$\left\{ \begin{array}{l} 0.1 \\ 0.6 \end{array} \right.$	Wallonia, Seraing, Verviers (Belgium).
			Santander (Spain).
1530	196	0.2	Karlskrona (Sweden).

EXTENSION SPEAKERS.—See *Loudspeaker.*

F

FADING.—When wireless waves

are sent out from a transmitter they divide into two portions. One part, called the “ground wave,” follows the curvature of the earth and in time is all absorbed by metallic

FADING — FAULTS AND THEIR REMEDY

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.

FADER.—A device for switching out radio reproduction and switching in gramophone reproduction without a sudden break. It consists of a potentiometer with a fixed centre-tapping as well as a moving contact. The pick-up is joined across one half of the potentiometer and the remaining half is joined across an ordinary L.F. transformer. When the arm is at one end the radio reproduction is at a maximum and, as the arm moves across, the radio reproduction gradually diminishes in volume until inaudible. (See also *Dissolver*.)

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.

FASCICULATION.—The term applied to the manner in which the electrons emitted from the cathode of the cathode-ray tube bunch together.

FAULTS AND THEIR REMEDY.

The more likely faults are (1) a complete cessation of signals, (2) a falling off in signal strength, (3) intermittent reception, and (4) reception accompanied by crackling sounds.

When Reception fails entirely.—First, suspect the aerial and earth. Test the down-lead for continuity

with a flash-lamp battery and bulb (Fig. 187). Failure of the bulb to light, or an intermittent light, indicates a broken wire. Should the aerial and earth wires prove to be in order, test, in a similar manner, the loudspeaker and battery leads. Test the batteries. A voltmeter or flash-lamp bulb is most useful for this purpose, but the tests must be applied whilst the set is switched on. 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 tapping. 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. 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. To decide whether or not the valve is wrong connect a high-resistance voltmeter between the negative filament

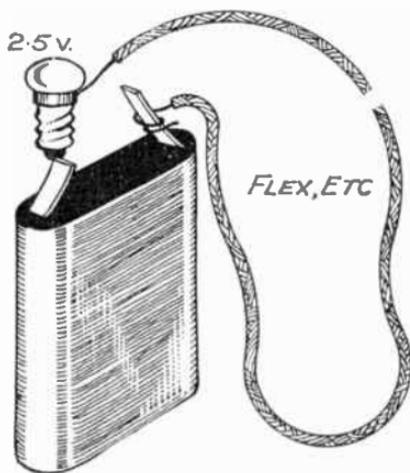


FIG. 187.—The simplest form of Tester.

FAULTS AND THEIR REMEDY

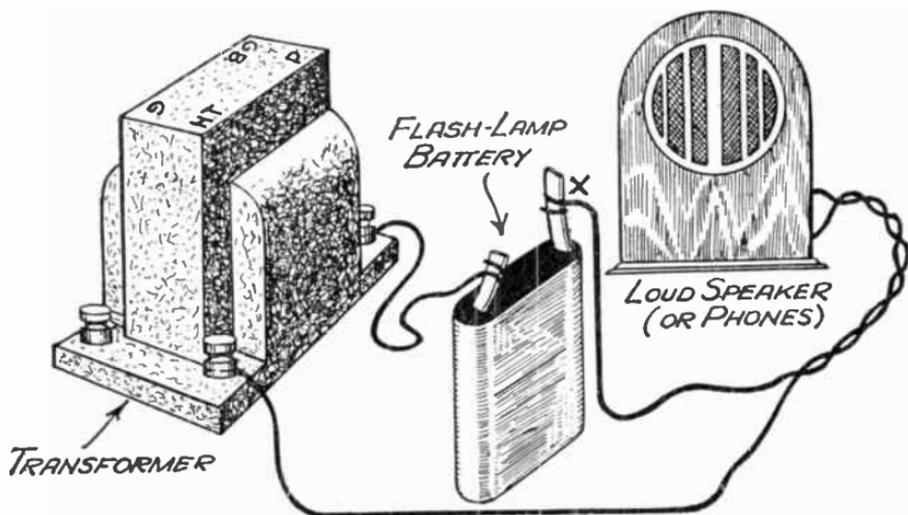


FIG. 188.—The way to test a Transformer Winding.

terminal 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-

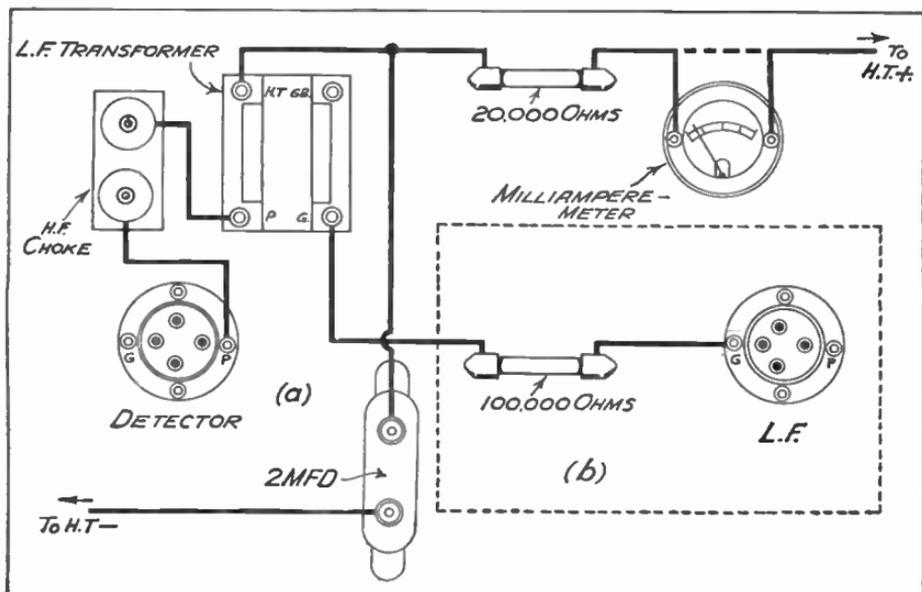


FIG. 189.—A decoupling resistance in the anode lead, and a resistance in the grid lead to cure instability.

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

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 intercoupling between the loudspeaker leads and the first valve. In that case the remedy is to connect a .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

FAULTS AND THEIR REMEDY — FLUX

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

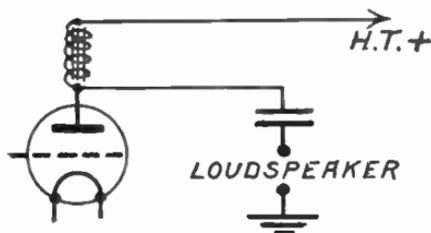


FIG. 191.—The Filter Circuit. (See also Fig 354.)

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-

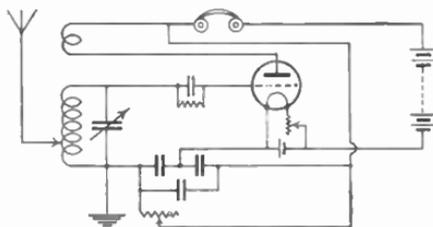


FIG. 192.—The Flewellyn Circuit.

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 many similar unorthodox circuit arrangements, it is now chiefly used for short-wave work (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

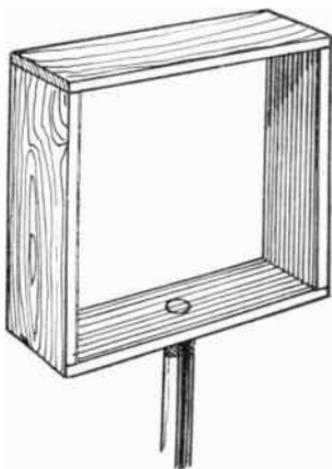


FIG. 193.—Framework for a Square Frame Aerial.

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. (See also *Soldering*.)

FLUX DENSITY.—The strength of magnetic field around a magnet, permanent or electro. 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.

FOOT-CANDLE—UNIT OF LIGHT INTENSITY.—Degree of light produced by a source of light equal to one candle-power on the surface of an object placed 1 ft. away, with its surface at right angles to the source of light. (See also *Lumen*, *Angström Unit*, *Lux*, and *Micron*.)

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 portable sets. It may be used with the ordinary type of broadcast receiver. 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 useful. 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

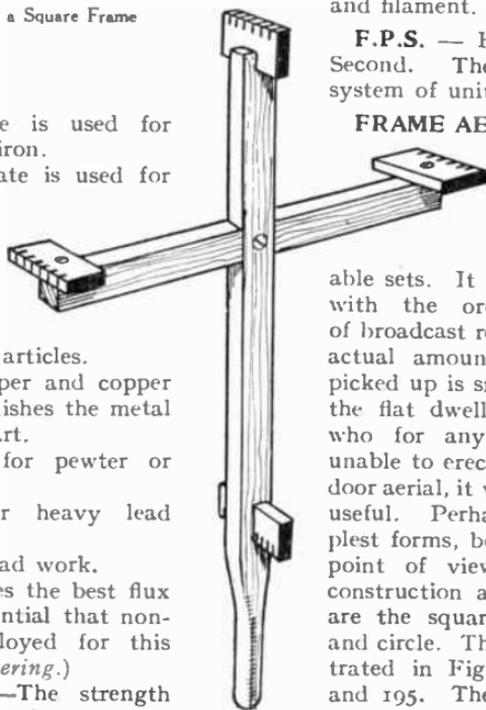


FIG. 194.—A Diamond Aerial.

FRAME AERIAL

that actually this is a very large tuning coil.

Directional Property. The principal feature of this type of aerial is

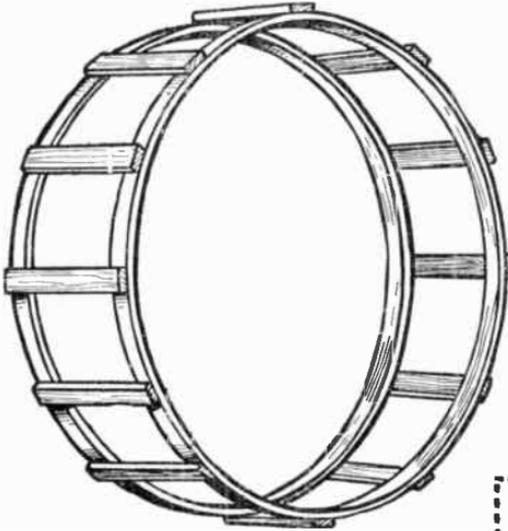


FIG. 195.—A Circular Aerial.

its directional property, and it is this which makes it so valuable. In use, the frame acts as two vertical aeri- als, 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 aeri- als 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,

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 un- licensed transmitting stations and those listeners who spoil the reception of the pro- grammes by oscillating. Lis- teners who live near a high- powered station will often be able to carry out satisfactory reception of distant stations by means of the frame, pro- vided, of course, that the de- sired 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

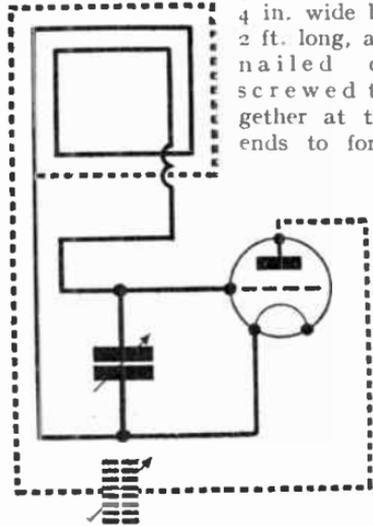


FIG. 196.—The Connections for a Frame Aerial: the dotted lines show the additional connections for capacity-controlled reaction.

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

SHORT-WAVE AERIAL SYSTEMS

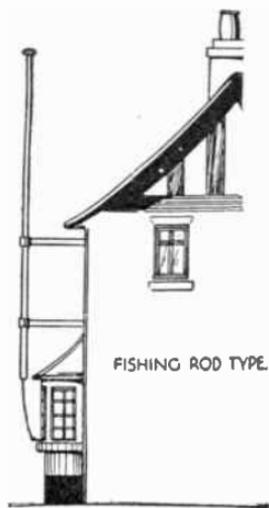


FIG. 197.—A "fishing-rod" type of vertical aerial.

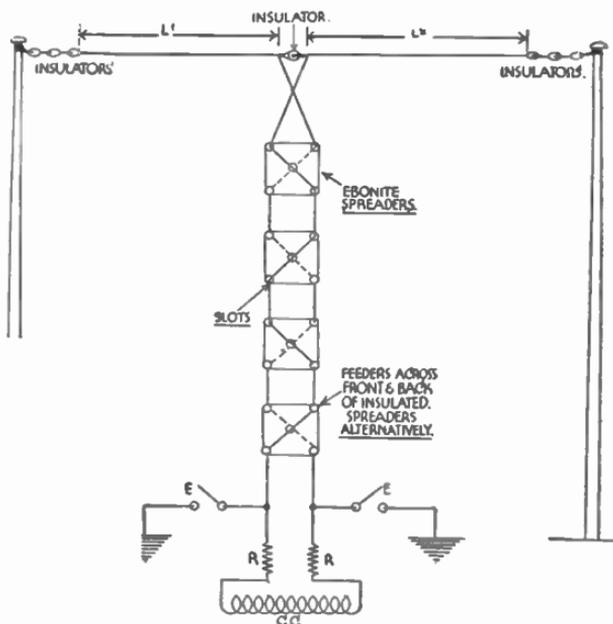


FIG. 197A.—Transposed or horizontal doublet aerial. E = earthing switches. CC = coupling coil. RR = 600-ohm resistances. L^1 , L^2 = 40-ft. aeriels.

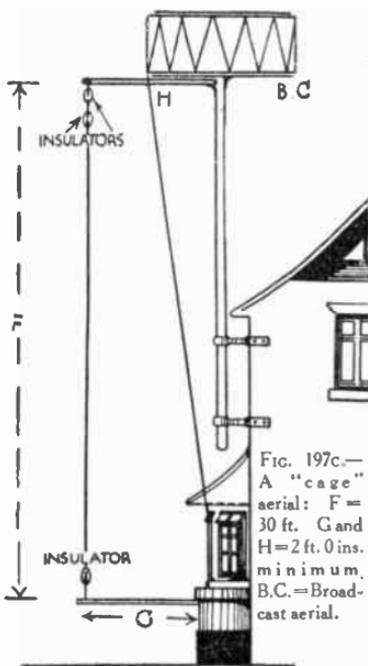


FIG. 197C.—A "cage" aerial: F = 30 ft. G and H = 2 ft. 0 ins. minimum. B.C. = Broadcast aerial.

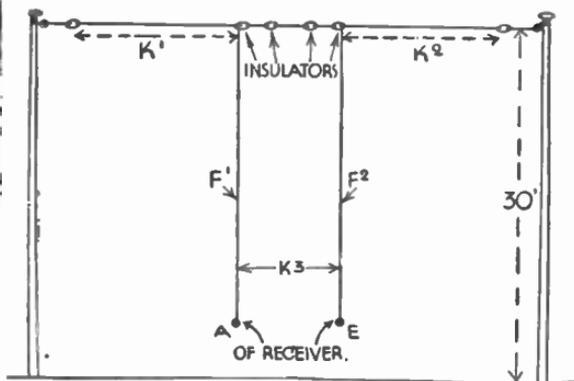


FIG. 197B.—A divided aerial: K^1 and K^2 are equal in length to half the wavelength. K^3 = $4\frac{1}{2}$ inches.

FRAME AERIAL

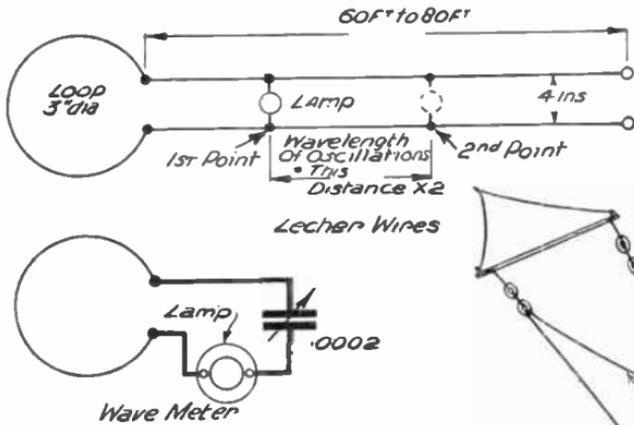


FIG. 198.—The Lecher-wire circuit used for calibration purposes. The upper loop is connected to the oscillator, whilst the lower one is in circuit with a lamp which glows to indicate resonance. (See Lecher Wires.)

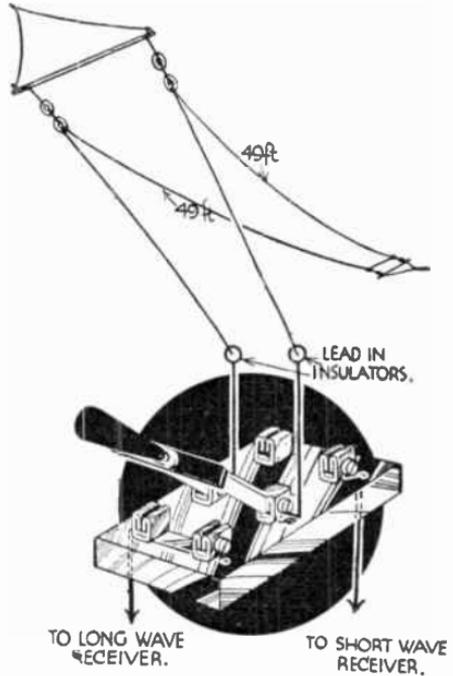


FIG. 198A.—A duplex aerial arrangement for long and short waves.

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 arrangement which may be made to look very effective if varnished. Two ordinary hoops of the kind used by children, and about 24 in. in dia-

meter, are held about 4 in. apart by strips of ebonite fixed round the periphery. Shallow grooves or saw-

FRAME AERIAL DATA

Length of Side of Square Frame.	No. of Turns.	Space between Wires.	Inductance. (Micro-henrys.)	Self-capacity. (Micro-farads.)	Natural Wave-length in Metres.
8 ft.	3	$\frac{1}{2}$ in.	96	75	160
6 "	4	$\frac{1}{4}$ "	124	66	170
4 "	6	$\frac{1}{4}$ "	154	55	175
3 "	8	$\frac{1}{8}$ "	193	49	185

FRAME AERIAL — FUSE

cuts should be made in these ebonite spacers to hold the wire.

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. 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 $\frac{1}{8}$ in. between each turn. A "collector" should be 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.

Formula for frequency is: $f = \frac{10^6}{2\pi\sqrt{LC}}$

where L = inductance in microhenrys and C = capacity in microfarads.

FREQUENCY CHANGER. — The part of a superheterodyne 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-

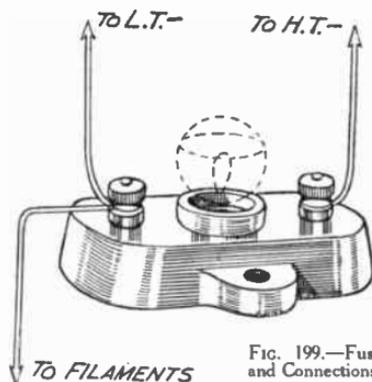


FIG. 199.—Fuse and Connections.

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 WAVELENGTH. — The natural wavelength of a 100-ft. aerial is approximately 120 metres. (See *Aerial, Natural Wavelength of*.)

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. Small fuses for wireless sets should be inserted in the H.T.—lead. It is generally inserted between H.T.— and L.T.—

FUSE VALUES.—The value of fuses for various types of receiver must be chosen with care. On the input side to mains receivers (either D.C. or A.C.) at least 1 amp. should be employed, and preferably a 1-amp. fuse should be included in each main lead. A 5-amp.

fuse should be included in the H.T. negative lead of the mains section of an A.C. receiver, and in all filament or heater circuits the value of fuse chosen should be such that it will break down before any of the valves. It will vary, of course, according to the method of wiring the filaments or heaters. In battery receivers, where the filaments are in parallel, the fuse should be of the type which will blow before the current rises sufficiently high to damage the valve of the lowest rating.

G

GAIN.—See *Amplification.*

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. 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, $2 \times 2\frac{1}{4} \times 1\frac{1}{4}$ 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 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. 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

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 $\frac{1}{4}$ 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

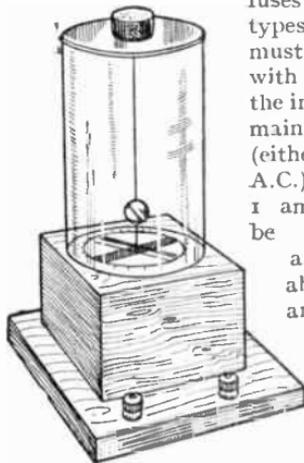


FIG. 200.—The finished Galvanometer.

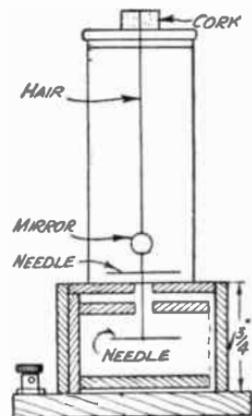


FIG. 201.—A sectional view of the completed instrument.

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.

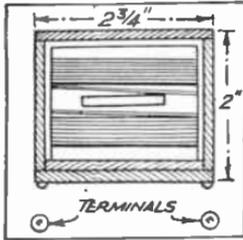


FIG. 202.—A plan view of the Cabinet with the top removed.

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 $\frac{1}{8}$ -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 $\frac{1}{4}$ 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

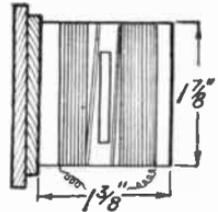


FIG. 203.—The Former for winding the Coil.

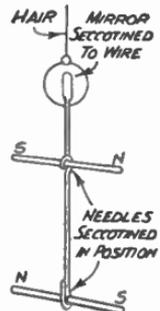


FIG. 204.—Details of the Hair, Magnetic Needles, and Mirror.

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. To use for polarity testing, the needle will move towards the

GAUSS.—The C.G.S. electro-magnetic unit of flux density of field strength, named after Carl F. Gauss (1777-1855). In a unit magnetic field a unit pole experiences a force of one dyne. In a field of strength H a unit pole experiences a force of H dynes. A pole of strength m webers in a field of H gauss will experience a force of mH dynes. The strength of the earth's

field in a horizontal direction at Greenwich is about 0.17 gauss at present. One gauss equals one maxwell per square centimetre. (See *Maxwell* and *Weber*.)

GETTER.—See *Valve*.

GILBERT.—One thousand Unit Magnetic Poles (which see). See also *Maxwell* and *Weber*.

GONIOMETER.—A special instrument for measuring angles. (See also *Radio Goniometer*.)

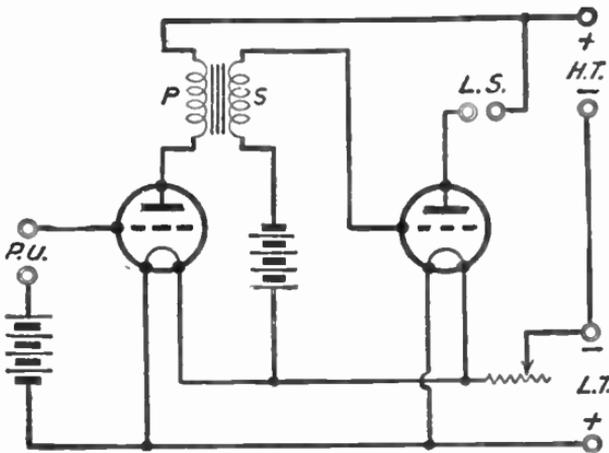


FIG. 205.—Circuit Diagram for a Two-Valve Gramophone Amplifier.

positive terminal.

GAMMA RAYS.—The term applied to those frequencies above those of the so-called X-rays. The exact band of frequencies covered by the gamma rays has not yet been defined.

GANG.—Any series of similar components joined together and operated by a common control.

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. In a pick-up the needle is attached to a small armature which is capable of vibrating

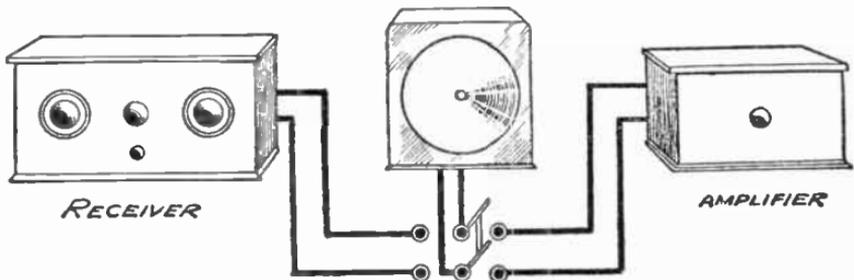


FIG. 206.—How the Gramophone Amplifying Apparatus is connected

GRAMOPHONE AMPLIFIER

between the 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 vibrating armature. It will be realised that the electrical currents generated have to be amplified. The recommended amplifier has two valves, as will be seen from the theoretical diagram shown in Fig. 205. The two wires from

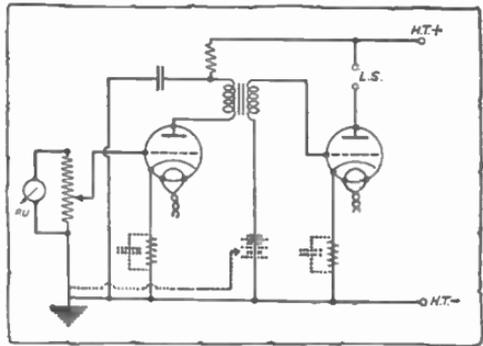


FIG. 208.—Mains version of Circuit shown in Fig. 207.

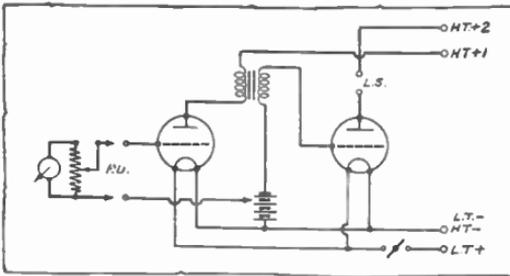


FIG. 207.—Theoretical Circuit of Two-Valve Gramophone Amplifier.

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

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

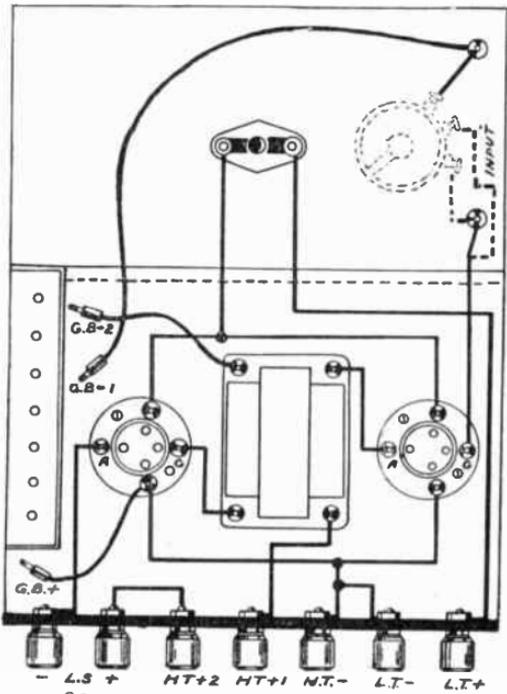
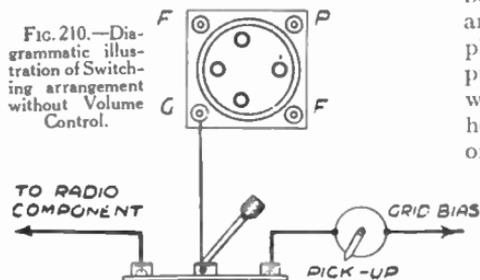


FIG. 209.—Wiring diagram of Gramophone Amplifier shown in Fig. 207.

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

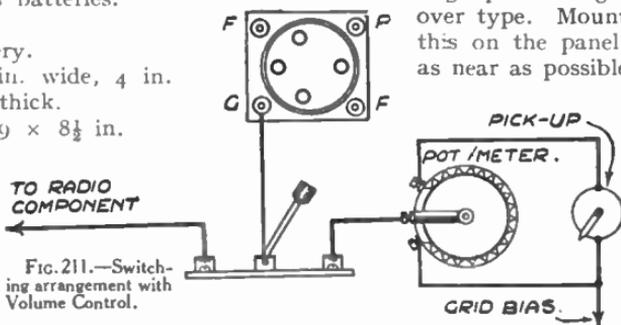
- 1 detector valve.
- 1 L.F. or power valve.
- 2 9-volt dry grid-bias batteries.
- 1 4-volt accumulator.
- 1 150-volt H.T. battery.
- 1 ebonite panel, $9\frac{1}{2}$ in. wide, 4 in. high and $\frac{3}{16}$ in. thick.
- 1 wooden baseboard, $9 \times 8\frac{1}{2}$ in.
- 1 ebonite terminal strip, $9\frac{1}{2} \times 1 \times \frac{1}{8}$ 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



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).

GREENWICH TIME SIGNAL.—

See *Time Signal*.

THE GREEK ALPHABET.—

The Greek alphabet is as follows:

A α (alpha), B β (bēta), Γ γ (gamma), Δ δ (delta), E 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 ς (sigma), Τ τ (tau), Υ υ (ūpsilon), Φ φ (phi), Χ χ (chi), 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

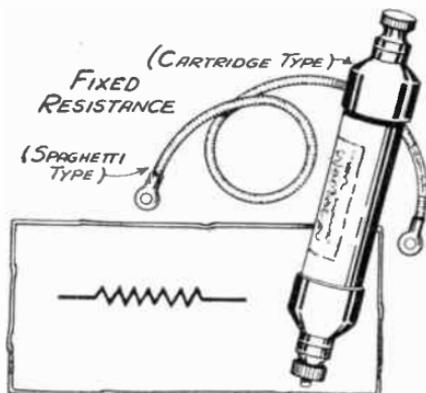


FIG. 212.—Theoretical and actual diagrams of Grid Leak and Fixed Resistances.

automatically by the insertion of resistances in the cathode or grid return leads. (See also *Bias and Automatic Grid Bias*.)

GRID CONDENSER.—A condenser (usual values $\cdot 0003$ mfd. and $\cdot 0001$ mfd.) used to control the grid potential of the detector valve. Usually has a grid leak of from $2\ \Omega$ to $5\ \Omega$ connected in parallel with it.

GRID LEAK.—A fixed resistance of the non-inductive type (usually $2\ \Omega$ 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 — HARD VALVE

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.

GRID STOPPER.—A device used to prevent the flow of H.F. currents in the grid circuit of an L.F. valve. The stopper usually takes the form of a fixed resistance having a value of about 100,000 ohms, but an H.F. choke can frequently be employed instead. Stoppers are nearly always desirable in a short-wave receiver, although of value in any set which is subject to L.F. oscillation or serious "hand-capacity."

GROUND WAVE.—See *Fading*.

H

HALF-WAVE RECTIFICATION.

—See *Accumulator* and *Eliminator*.

HALF-WAVE AERIAL. — See *Dipole*.

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

HARMONIC — HIGH-FREQUENCY CHOKE

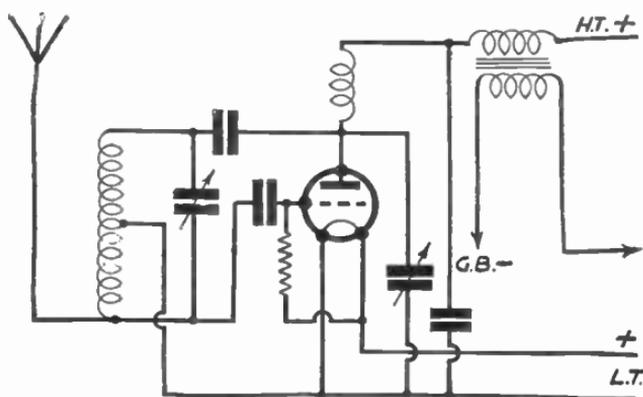


FIG. 213.—The Hartley Circuit.

may be made of the filament electron stream. (See also *Soft Valve*.)

HARMONIC.—A component possessing 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.—An ionised layer of the atmosphere about forty miles above the surface of the earth.

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 *millihenry* (one-thousandth of a henry), and *microhenry* (one-millionth of a henry).

HEPTODE.—See *Pentagrid*.

HERTZIAN WAVES.—Ether waves (discovered by Hertz).

HEXODE.—Same as *Heptode*.

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 im-

pulses 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 sec-

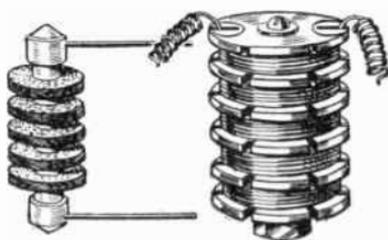


FIG. 214.—Typical short-wave and broadcast-band H.F. Chokes with sectional windings.

tions, a device which reduces the capacity. (See also *Choke*, *Anti-break-through Choke*, and *Break Through*.)

HIGH-FREQUENCY CHOKE

Making High-frequency Chokes. Reaction, S.G., and mains H.F. chokes can all be made in a similar manner. The first requirement will be some kind of former. Bearing in mind the necessity for keeping self-capacity down to its lowest possible limit, the best material is a six-ribbed ebonite coil former. This can be obtained for 6d. per 4-in length of 1-in.

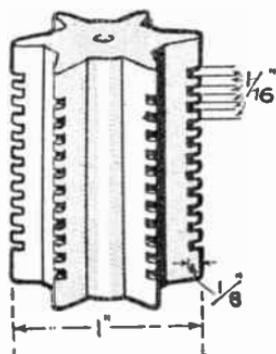


FIG. 215.—Method of cutting ebonite former for the H.F. Choke.

(outside) diameter. Two kinds are available, one of which is solid, whilst the other has a $\frac{1}{8}$ -in. diameter hole running through it; the latter is most convenient, as will be seen later.

First, a number of slots must be made in the six ribs. For the "reaction" and S.G. chokes these should be $\frac{1}{16}$ in. wide, $\frac{1}{8}$ in. deep, and $\frac{1}{8}$ in. apart; in the case of the mains chokes, however, they should be $\frac{1}{8}$ in. wide, $\frac{1}{8}$ in. deep, and $\frac{1}{16}$ in. apart (see Fig. 215). The former for the S.G. choke will require twenty slots, but the other two will need only ten each. The smaller slots can be made quite easily with a widely set hacksaw, but the wider ones must be formed with a warding file. In winding the "reaction" choke, a total of 1500 turns of 38-gauge enamelled wire will be

used, of which 150 turns are placed in each slot. The S.G. choke is similar, but will have twice as many turns. As regards the mains choke, this will be wound with 1700 turns of 28-gauge wire, putting 170 in each slot.

Count the turns carefully to ensure that they are equally divided, because unevenness might possibly cause the choke to "peak," or have a "dead spot" at some particular wavelength.

The method of mounting and making terminal connections will depend upon whether or not the choke is to be screened. Assuming that it is not, 4B.A. terminal can be screwed into the ends of the former (they will make their own thread if a little force is used). Soldering tags can be fitted under the terminal nuts and the ends of the winding soldered to these (see Fig. 216). When this method of connection is used, the choke can be suspended in the wiring of the set.

Should it be required to fit a screening box (the chokes described have sufficient inductance to permit of screening), the most convenient method of mounting will be that shown in Fig. 217. The choke, along

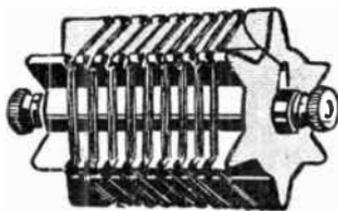


FIG. 216.—The ends of the winding are anchored as shown here.

with a $1\frac{1}{2}$ -in. diameter "lid," is attached to an ebonite base by means of a length of 6B.A. rod. Two terminals are mounted on the base, and leads from the winding are brought to these through lengths of insulating sleeving. The screen must, of course,

HIGH-FREQUENCY CHOKE

be earthed, and a small terminal is anti-break-through choke can easily therefore attached to the top of the be made. The same material will be

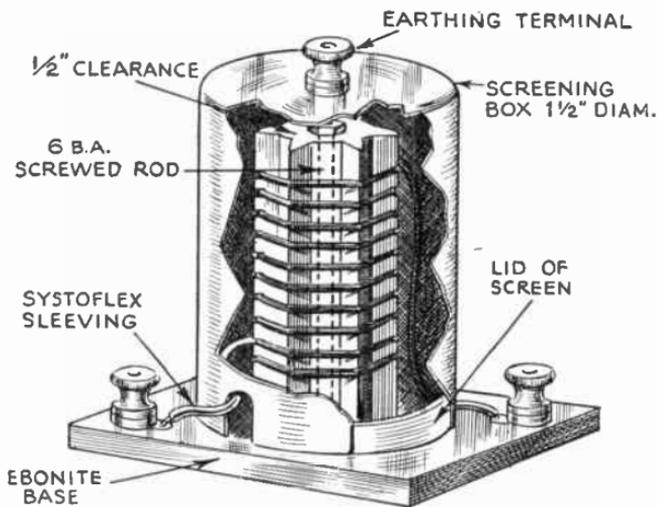


FIG. 217.—Complete assembling details of a screened H.F. Choke.

“box” for this purpose. It is important that the box and lid should be a perfect fit.

An Anti-break-through Choke. An

used for the former, but only three $\frac{1}{8}$ -in. slots are required. A winding consisting of 210 turns of 38-gauge enamelled wire is equally divided be-

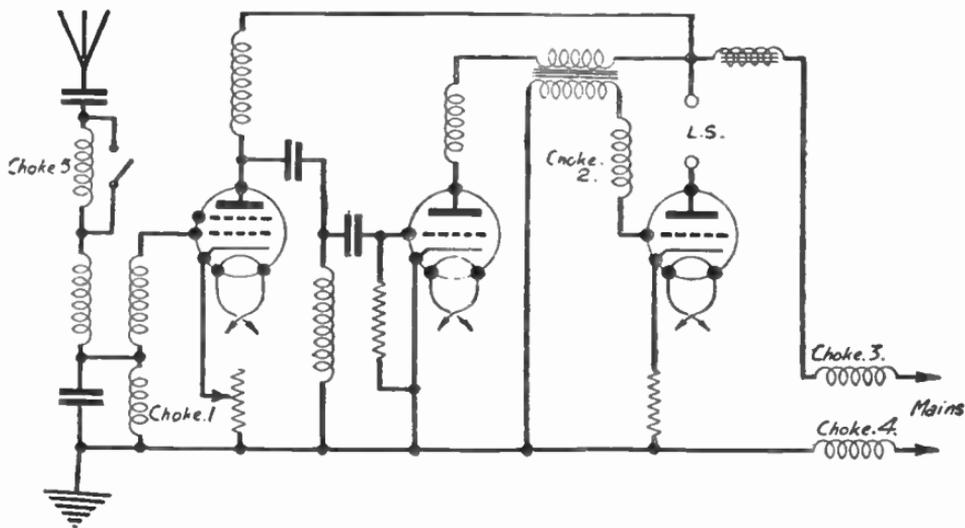
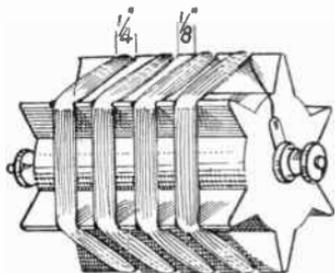


FIG. 218.—Theoretical circuit showing positions of H.F. chokes, and anti-break-through choke in aerial lead.

HIGH-FREQUENCY CHOKE

tween the three slots. As can be seen from Fig. 218, the choke must be short-circuited by means of a switch when receiving on the lower waveband.

Short-wave Chokes. It is desirable



**30 TURNS 38 GAUGE WIRE
IN EACH SLOT:**

FIG. 219.—An easily made short-wave H.F. choke.

to wind the turns side by side as well as to divide them into sections, and the simplest way of doing this is illustrated in Fig. 219. Ribbed ebonite coil former of 1-in. diameter is used, but the "slots" are only $\frac{1}{8}$ in. deep by $\frac{3}{4}$ in. wide, and are $\frac{1}{2}$ in. apart. To cover wavelengths from 10 to 100 metres, a total of 120 turns of 38 S.W.G. enamelled wire are required, and these are divided into four equal parts of thirty turns each. No attempt should be made to screen an S.W. choke, since this cannot be done without introducing serious losses.

It is sometimes required to make a set to cover both "broadcast" and short waves, and in that case it is better to use two chokes in series, or to combine both long- and short-wave windings on one former. One end of the short-wave winding must be connected to the anode terminal of the detector valve. With this arrangement there is no need to short-circuit either component, since they will both come into use quite automatically according to the wavelength to which the set is tuned.

Making L.F. and Smoothing Chokes. The essentials of a smoothing choke are: An inductance of not less than 50 henries at the normal working current, a resistance to D.C. current of 2,000 ohms or less, and a safe current-carrying capacity of not less than 20 m/A. It is also an advantage, if the choke is provided with a tapping point, to enable alternative ratios to be obtained when it is employed to feed a loudspeaker.

In order to cover all the above requirements with an ample "reserve," the choke described has an inductance of about 50 henries when carrying 25 milliamps. and a D.C. resistance of 1700 ohms. The winding is centre tapped, and consequently the components can successfully be employed for a wide variety of purposes.

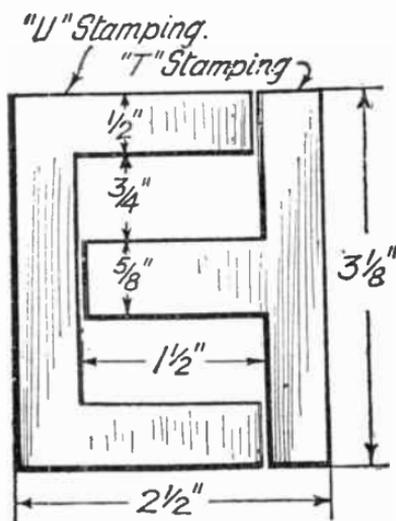


FIG. 220.—Standard "U" and "T" stampings, with dimensions, for use in L.F. chokes and various transformers.

The core consists of about $3\frac{1}{2}$ dozen pairs of No. 5 Stalloy stampings of "T" and "U" shape, whilst rather less than $\frac{3}{4}$ lb. of 38-gauge enamelled wire is used for the winding. Stamp-

HIGH-FREQUENCY CHOKE

ings of the size mentioned can be obtained from certain firms who specialise in the supply of such parts, but, incidentally, this size was employed for many of the better-quality L.F. transformers that were made a few years ago. The dimensions of the stampings are shown in Fig. 220, and by referring to these it will be an easy matter to tell if the core of an old burnt-out transformer which happens to be on hand can be made use of.

The first thing is to make a winding spool, which may have either a

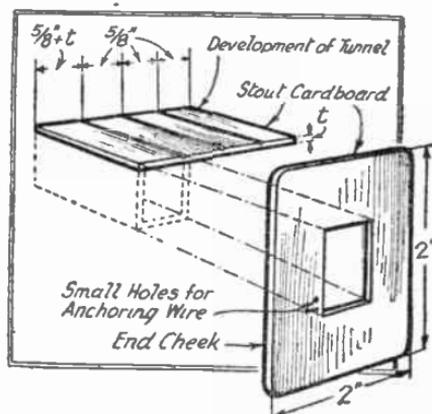


FIG. 221.—How to make the winding bobbin from paxolin sheet for chokes and transformers.

square or circular section "tunnel." If it is square, it should be of the dimensions shown in Fig. 221, and can be made up by bending a strip of stout card in the manner indicated. When the card has been bent to shape it should be fitted with two end cheeks 2 in. square. The latter can be fixed in position with "tacky" glue, after which the complete spool should be given a coat of thin shellac varnish to make it rigid. Before winding is commenced it is a good plan to wrap a layer of insulating tape round the spool to cover the otherwise sharp corners, which might tend to cut the fine wire.

A circular spool is somewhat easier to make, but is not quite so efficient. It is built up on a cardboard tube $\frac{7}{8}$ in. inside diameter, and fitted with a pair of 2-in. diameter end cheeks, after which shellac is applied as before.

After the winding spool has been made, two small holes should be made near the inside of one end cheek and a short length of rubber-covered flex threaded through these, leaving about 4 in. projecting outside and 6 in. projecting inside the spool. Next carefully solder the bared end of the 38-gauge enamelled wire to the end of the flex which is on the inside of the spool. It then only remains to wind on the wire.

After winding on one-quarter of the wire, the turns should be covered with a layer of insulation, such as waxed paper, oiled silk, or empire tape, and this should be so put on that it will be impossible for later turns to slip past it. The winding should then be continued to 4000 turns (it is not necessary to count, and an approximation based on the total quantity of wire will suffice), at which a tapping point should be made. Fit another layer of insulation, continue to the 8000th turn, again insulate, and then complete the winding. Solder a third length of flex to the last turn, pass this once round the spool, and then anchor it in a pair of holes made in a convenient position in the end cheek. The winding should finally be covered with a protecting layer of empire tape.

Once the coil has been wound, the stampings can be fitted into the spool. The method of fitting is perfectly simple if it is remembered that "T"- and "U"-shaped pieces are alternated throughout. Another point to remember is that each stamping is insulated on one side, and, to ensure that this shall be effective, the

HIGH-FREQUENCY CHOKE

insulated (white or grey) side of every stamping should face in the same direction. The method of assembly is shown in Fig. 222.

It has been stated that the choke should be added that it is also entirely suitable for I.T. smoothing in mains equipment, where the total current does not exceed about 50 milliamps. When passing the maximum current, the choke will have an inductance of rather more than 30

excess of some 50 milliamps., it is advisable to employ a smoothing choke of greater dimensions and having a lower resistance to D.C. It is also an advantage to make the component of the so-called constant-inductance type, so that its inductance varies by only the very slightest amount when the current passing through the winding is varied. In order that a choke should show such characteristics, there must be an air-gap in the core; that is, the "T"- and "U"-shaped stampings should not touch each other, but should be arranged with a small gap between them. Particulars will be given of a component of this type which has an inductance of 50 henries, a D.C. resistance of about 1300 ohms, and a maximum current-carrying capacity of nearly 100 milliamps.

Six dozen pairs of No. 4 Stalloy stampings are required for the core, and the winding should consist of approximately 12,000 turns, or 1½ lb. of 36-gauge enamelled wire. The winding arm of the core will measure $\frac{1}{8} \times 1 \frac{1}{8} \times 2 \frac{5}{8}$ in. long, so a spool of these dimensions, and fitted with end cheeks measuring $2 \frac{3}{4} \times 2 \frac{3}{4}$ in., should first be made. This will be wound in exactly the same manner as was described for the smaller component, taking tapings if desired.

The only real difference occurs when the core stampings are to be fitted, since arrangements have to be made to provide the necessary air gap. This is easily done by fitting all the "T" stampings into the spool from one end, and then arranging all the "U" stampings opposite to them. The necessary gap is fixed by slipping strips of card $\frac{1}{16}$ in. thick between the ends of the "U" stampings and the sides of the "T's." Additionally, to prevent the gap being short-circuited, slips of paper must be placed between the core stampings and the core itself.

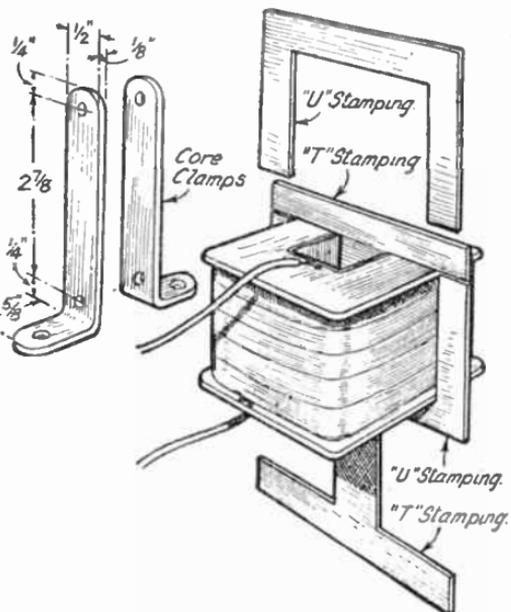


FIG. 222.—Method of constructing supports and assembling the core of an L.F. choke and L.F. or mains transformer.

henrys and will produce a voltage drop of 85. The choke is really most suitable for use in an eliminator sub-described above can be used for various L.F. coupling purposes, but it plying about 30 milliamps., and under such conditions its inductance is sufficiently high to give adequate smoothing, whilst the voltage-drop produced will be 51 (a reasonably low figure).

When dealing with currents in

HIGH-FREQUENCY TRANSFORMER — HIGH TENSION

HIGH-FREQUENCY TRANSFORMER.—A component used for coupling H.F. valves. It consists of two coils coupled together. These 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.

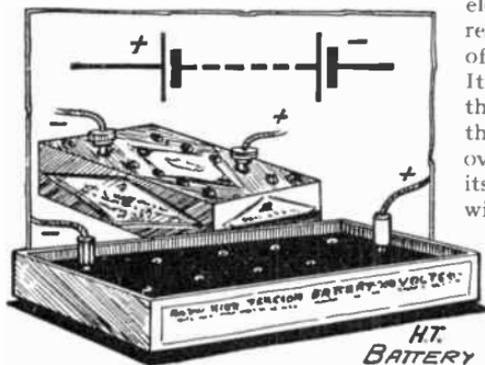


FIG. 223.—Theoretical and actual diagrams of a High-tension Battery.

HIGH TENSION AND LOW TENSION.—High tension usually refers to voltages above 6 volts, and low tension to 6 volts and under.

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 overall 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.

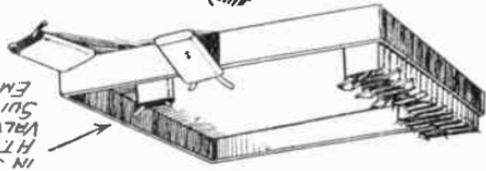
"Double" capacity for 4 to 5-valve sets taking up to 10-16 milliamperes.

"Triple" capacity for multi-valve sets taking anything up to 30 milliamperes.

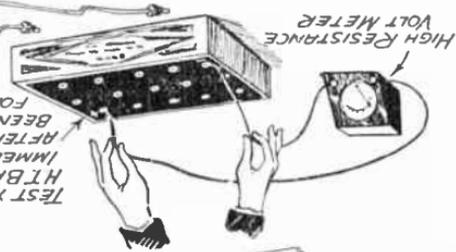
The battery having a "double" capacity does not cost twice as much as the "standard," although if used on the same set will give twice its life. Another good feature of the larger capacity is that its voltage

HINTS ON HIGH TENSION BATTERIES

FLASH LAMP CELLS CONNECTED IN SERIES MAKE A USEFUL VALVE SET, BUT ARE NOT SUITABLE FOR RECEIVERS EMPLOYING LARGE POWER VALVES



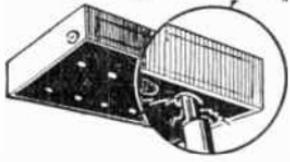
TEST YOUR HT BATTERY IMMEDIATELY AFTER IT HAS BEEN IN USE FOR SOME HOURS



NEVER JOIN A PARTLY EXHAUSTED HT BATTERY TO A NEW ONE



SCRATCHING SOUNDS WILL BE HEARD IN THE LOUD SPEAKER IF THE PLUGS ARE NOT TIGHT FITTING



REMOVE HT PLUGS BEFORE USING A SOLDERING IRON, SCREWDRIVER, OR ANY METAL TOOL INSIDE THE RECEIVER.

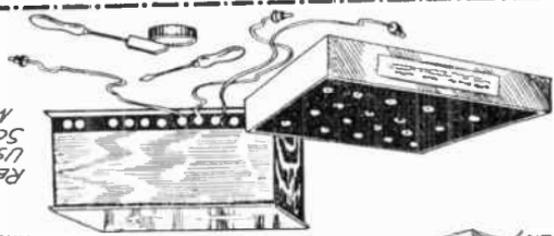


Fig. 224.—The battery user should carefully study the various points shown in this diagram.

HIGH-TENSION BATTERY — INDUCTANCE

drops more slowly; this means a more uniform output and a better performance of the set.

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.

HORSE - POWER. — Electrical equivalent = 746 watts. Mechanical unit = 33,000 ft.-pounds per minute, or 550 ft.-pounds per second.

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*.

HUM-BUCKING COIL.—A coil of wire arranged on a moving-coil loud-speaker or a gramophone pick-up to reduce the interference caused by mains hum. The coil is wound in opposition to the main windings and is of only small dimensions so that it does not affect the proper working of the speaker or pick-up. The hum is balanced out by the passage of the current through the two coils.

HUM-DINGER.—A small potentiometer which is wired across the heater supply secondary winding of the mains transformer of an A.C. mains receiver. In place of the usual centre-tap on this winding, the arm of the potentiometer is joined to earth, and it may thus be adjusted to find the electrical centre and thus balance the circuit, with the consequent removal of hum caused by an unbalanced heater circuit.

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

ICONOSCOPE.—See *Television*.

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.

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 (which see).

The formula for inductance in microhenrys is:
$$L = \frac{9.86/D^2N^2K}{1,000}$$

where L = inductance, D = diameter of coil in centimetres, l = length of coil in centimetres, N = number of turns per centimetre, and K = a constant. See table.

THIS TABLE SHOWS THE VALUE OF K, WHICH MUST BE CALCULATED FROM $\frac{D}{l}$

$\frac{D}{l}$	K	$\frac{D}{l}$	K
4.00	.3654	1.25	.6381
3.75	.3743	1.00	.6884
3.5	.3944	.90	.7110
3.25	.4111	.80	.7351
3.00	.4292	.70	.7609
2.75	.4545	.60	.7885
2.5	.4719	.50	.8181
2.25	.4972	.40	.8499
2.0	.5255	.30	.8838
1.75	.5579	.20	.9201
1.5	.5950	.10	.9588

INDUCTANCE AND CAPACITY.

—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

INDUCTANCE COIL — INTERACTION

the inductance and the capacity, the former being expressed in microhenrys 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 microhenrys for the medium waves, and about 2,000 microhenrys for the long-wave band, having become standard. 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.

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. (See *Interrupter*.)

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*.

INDUCTIVE REACTANCE.—Calculated from the formula $2\pi fL$, where f =frequency and L =the inductance.

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.

INPUT ADMITTANCE.—The reciprocal of impedance. See also *Miller Effect*.

INTERACTION.—If one compares the average home-constructed receiver with a commercial product of similar size, both for appearance and performance, 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." 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.

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.

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-

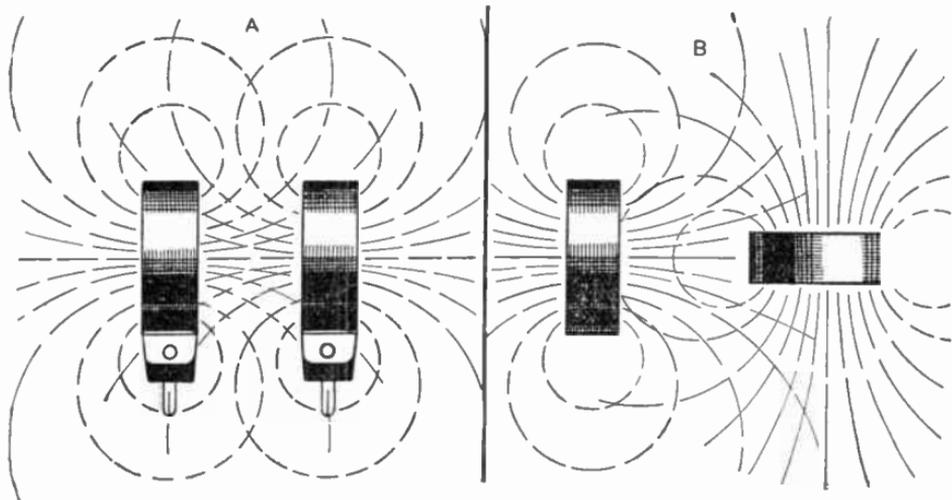


FIG. 225.—Showing the shape of the electro-magnetic field of coils of the usual plug-in type.

tor (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. 225 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. 226, and that a screen should be arranged between them. A small piece

of metal, moreover, is not sufficient. A screen of sensible size is well worth any trouble involved in the construction of the set. 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. 226). 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. 226, 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

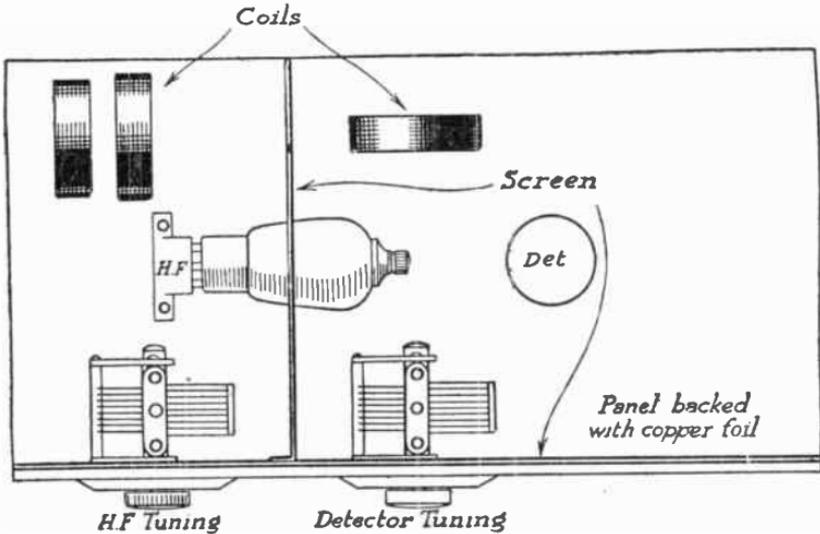


FIG. 226.—A Screen the same depth as the Baseboard is used for "partitioning off" the H.F. stage.

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. 226A). 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

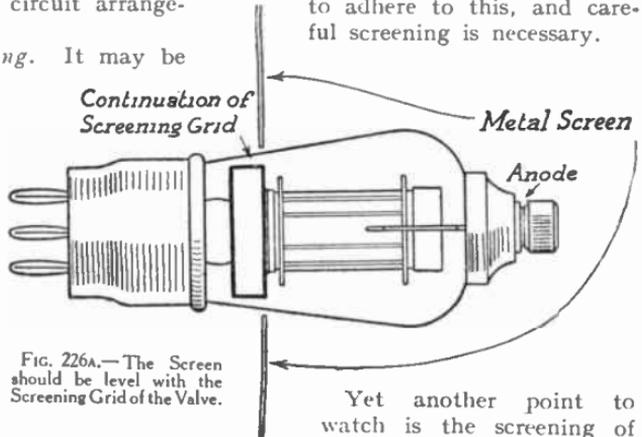
INTERACTION

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 226B), it will be seen that the input and output ends of the receiver come close together. Screen-

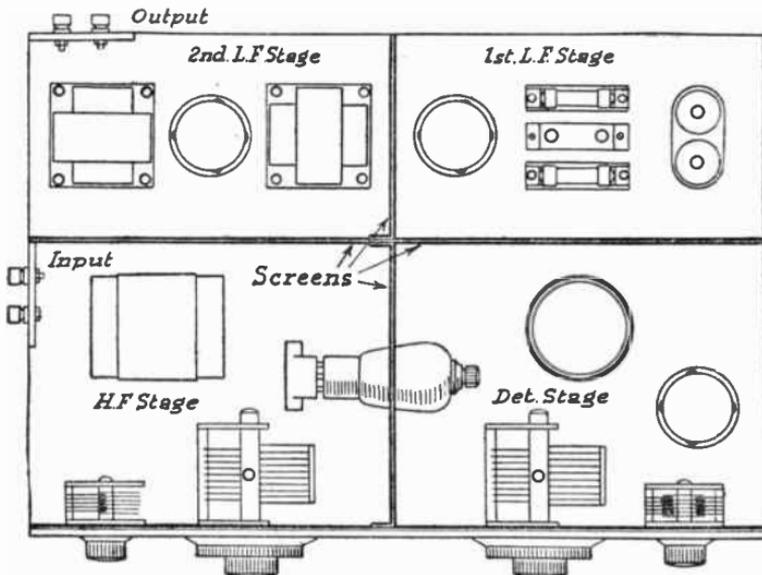


FIG. 226B.—When the Input and Output ends of the receiver come close together the set should be screened as shown.

INTERCALATION — INTERNATIONAL CALL SIGNS

ing, as indicated, is necessary.

INTERCALATION — Synonymous term for interlacing, used in reference to television scanning.

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 superheterodyne, the frequency produced by the frequency changer before amplification by the following valves.

INTERMEDIATE - FREQUENCY AMPLIFIER.—In superheterodynes, two closed oscillatory circuits. Great selectivity of the det. circuit results.

INTERMEDIATE - FREQUENCY TRANSFORMER.—Two coils of wire, coupled together and tuned by pre-set condensers to the intermediate frequency and connected between the I.F. valves of a superhet. (See also *Coils* (p. 123) and *Superheterodyne*.)

INTERNATIONAL AMPERE.—The current which, when passed through a solution of nitrate of silver in water, deposits silver at the rate of .00111800 gramme per second.

INTERNATIONAL CALL SIGNS.—

AC4	Tibet
AR	Syria
CE	Chile
CM	Cuba
CN1	Tangier Zone
CNB	Morocco
CO	Cuba (fone)
CP	Bolivia
CR4	Cape Verde Islands
CR5	Portuguese Guinea
CR6	Angola
CR7	Mozambique
CRS	Portuguese India
CR9	Macao
CR10	Timor
CT1	Portugal
CT2	Azores

CT3	Madeira Island
CX	Uruguay
D	Germany
EA	Spain
EA6	Balearic Islands
EA8	Canary Islands
EA9	Spanish Morocco
EI	Irish Free State
EL	Liberia
EP	Iran (Persia)
EQ	Iran (Persia)
ES	Estonia
ET	Ethiopia (Abyssinia)
F	France
FA	Algeria
FB	Madagascar
FD	French Togoland
FE	French Cameroons
FF	French West Africa
FG	Guadeloupe
FI	French Indo-China
FK	New Caledonia
FL	French Somaliland
FM	Martinique
FN	French India
FO	French Oceania
FP	St. Pierre and Miquelon
FQ	French Equatorial Africa
FR	Reunion Island
FT	Tunisia
FU	French New Hebrides
FY	Guyane (French Guiana)
G	British Isles
	(G—England; GM—Scotland; GW—Wales)
GI	North Ireland
HA	Hungary
HB	Switzerland
HC	Ecuador
HH	Haiti
HI	Dominican Republic
HJ	Colombia
HK	Colombia
HP	Republic of Panama
HR	Honduras
HS	Siam
HZ	Hedjaz
I	Italy
J	Japan
J8	Chosen (Korea)
J9	Formosa

INTERNATIONAL CALL SIGNS

K4	Porto Rico	U9, 0	Asiatic Russian S.F.S.R.
K4	Virgin Islands	(Note: Prefix letters UX, UE, UK	
K5	Canal Zone	also used occasionally)	
K6	Hawaii	VE1	Canada
K6	Guam	VE2	Canada
K6	Samoa	VE3	Canada
K6	Midway and Wake Islands	VE4	Canada
K7	Alaska	VE5	Canada
KA	Philippines	VE5	North West Territories
LA	Norway	VK2	Australia
LU	Argentina	VK3	Australia
LX	Luxembourg	VK4	Australia
LY	Lithuania	VK5	Australia
LZ	Bulgaria	VK6	Australia
MX	Manchukuo	VK7	Tasmania
NY	Canal Zone	VK8	Australia
OA	Peru	VK9	New Guinea
OE	Austria	VO	Newfoundland, Labrador
OH	Finland	VP1	British Honduras
OK	Czechoslovakia	VP2	Windward Islands
OM	Guam	VP2	Leeward Islands
ON	Belgium	VP3	British Guiana
OQ5	Belgian Congo	VP4	Trinidad, Tobago
OX	Greenland	VP5	Jamaica, Caicos, Cayman
OY	Faroe Islands		Islands, Turks Islands
OZ	Denmark	VP6	Barbados
FA	Netherlands	VP7	Bahamas
PJ	Curaçao	VP8	Falkland Is., South Georgia
PK1, 2, 3	Java	VP9	Bermuda
PK4	Sumatra	VQ1	Fanning Island
PK5	Dutch Borneo	VQ2	Northern Rhodesia
PK6	Celebes-New Guinea	VQ3	Tanganyika
PX	Andorra	VQ4	Kenya
PY	Brazil	VQ5	Uganda
PZ	Surinam (Dutch Guiana)	VQ6	British Somaliland
SM	Sweden	VQ8	Mauritius
SP	Poland	VQ8	Chagos Archipelago
ST	Anglo-Egyptian Sudan	VQ9	Seychelles
SU	Egypt	VR1	Gilbert and Ellice Islands
SV	Greece	VR2	Fiji Islands
SX	Greece	VR4	Solomon Islands
TA	Turkey	VR5	Tonga Islands
TF	Iceland	VR6	Pitcairn Island
TG	Guatemala	VS1	Straits Settlements
TI	Costa Rica	VS2	Federated Malay States
U1, 3, 4, 7	European Russian S.F.S.R.	VS3	Non-Federated Malay
U2	White Russian S.S.R.		States
U5	Ukranian S.S.R.	VS4	North Borneo
U6	Transcaucasian S.F.S.R.	VS5	Sarawak
U8	Uzbek S.S.R. and Turko-	VS6	Hong Kong
	man S.S.R.	VS7	Ceylon

INTERNATIONAL CALL SIGNS — IRON-CORE TUNING COILS

VS8	Bahrein Islands
VS9	Maldive Islands
VU	India
W1	U.S.A.
W2	U.S.A.
W3	U.S.A.
W4	U.S.A.
W5	U.S.A.
W6	U.S.A.
W7	U.S.A.
W8	U.S.A.
W9	U.S.A.
XE	Mexico
XU	China
XZ	Burma
YA	Afghanistan
YI	Iraq
YJ	New Hebrides
YL	Latvia
YM	Danzig
YN	Nicaragua
YR	Roumania
YS	Salvador
YT	Jugoslavia
YU	Jugoslavia
YV	Venezuela
ZA	Albania
ZB1	Malta
ZB2	Gibraltar
ZC1	Transjordan
ZC2	British Cocos Islands
ZC3	Christmas Island
ZC4	Cyprus
ZC5	Palestine
ZD1	Sierra Leone
ZD2	Nigeria, British Cameroons
ZD3	Gambia
ZD4	Gold Coast, British Togoland
ZD6	Nyasaland
ZD7	St. Helena
ZD8	Ascension Island
ZE	Southern Rhodesia
ZK1	Cook Islands
ZK2	Niue
ZL	New Zealand
ZM	British Samoa
ZP	Paraguay
ZS	Union of South Africa
ZT	Union of South Africa
ZU	Union of South Africa
ZU9	Tristan da Cunha

INTERNATIONAL OHM.—The resistance offered to a current by a column of mercury at the temperature of melting ice, 14.4521 grammes in mass, of a constant cross-sectional area, and of a length of 106.3 centimetres.

INTERNATIONAL VOLT.—The electrical pressure which causes 1 international amp. 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 at 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 with an induction coil. (See *Pulsator* and *Buzzer*.)

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*.)

IONISATION.—The separation of molecules into ions. When air is ionised it becomes a conductor.

IRON-CORE TUNING COILS.—The inductance of a solenoid is increased when an iron core is included. Ordinary iron is not suitable for increasing the inductance of tuning

IRON PYRITES — KNIFE SWITCH

coils owing to H.F. losses introduced by the iron. A high inductance with a low H.F. resistance is, however, a valuable feature of an efficient tuning coil, and a method of using iron has now been developed. Finely divided iron

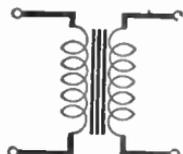


FIG. 226c.—Theoretical diagram of an L.F. Transformer.

is used to impregnate paper, ebonite, etc., and this is moulded to form a core over which a small coil is wound. The result is a low H.F. resistance with a high inductance value, giving a coil of extremely small dimensions having the efficiency of a large-diameter, low-loss, Litz-wound coil. (See also *Permeability Tuning*.)

IRON PYRITES.—Iron sulphide.

IRON SULPHIDE.—A crystal used as a rectifier in connection with a gold or bronze cat whisker.

ISOCHRONISM.—Equality of time; the quality of being done in equal times. Two circuits are isochronous when they have the same frequency.

J

JAMMING.—The simultaneous reception of two or more stations.

JAR.—A unit of capacity. 1 jar = 1,000 cm.; 900,000 \approx 1 mfd.; therefore 1 jar = $\frac{1}{900}$ 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 in-

verted 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. If the jelly acid hardens add 3 or 4 spoonfuls of distilled water before every recharge.

JIGGER.—Slang for transformer.

THE JOULE.—This is the unit of energy, and is equal to 1 watt per second. The watt-hour joule = 100,000,000 ergs. The Board of Trade Unit equals 3,600,000 joules, and is known as the kilowatt-hour. Named after Joule, the English physicist. Joule's Law states that the heat produced by a current I passing through a resistance R for time t is proportional to I^2Rt .

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 thousand kilocycles (abbreviated kc/s) corresponds approximately to a wavelength in metres of 300. (The exact relationship is 299,820 metres = 1,000 kilocycles.) 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.

KILOLINES.—1,000 lines (flux density).

KILOVOLT-AMPERE. — 1,000 volt-amperes (which see).

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*.)

LAG — LAYING OUT COMPONENTS

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.—

Many overlook the primary 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

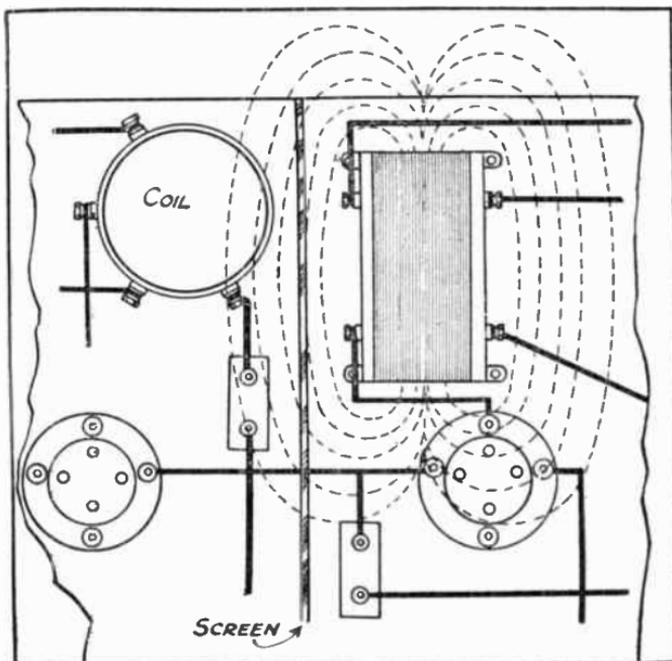


FIG. 226D.—The placing of a Transformer near a Coil (even if there is a Screen) is bad.

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

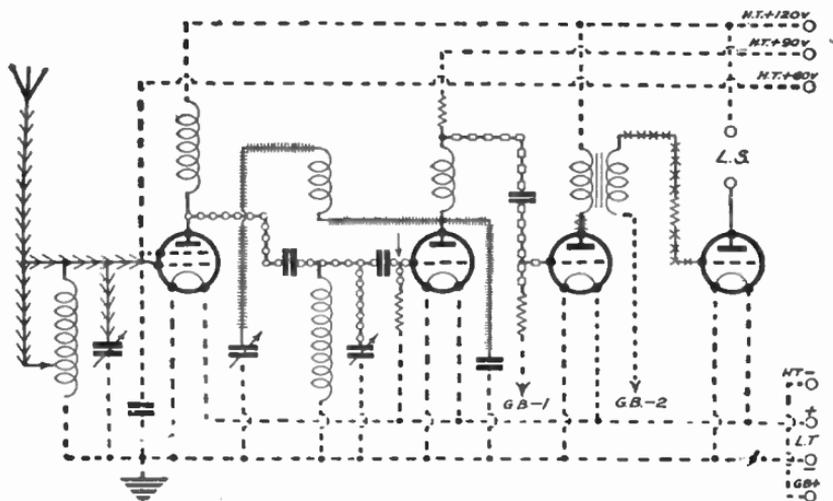


FIG. 226E.—A Circuit with the various Circuits indicated by different types of lines.

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. 226D). 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. 226E 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. 226E 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. 226E 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.

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 possible to the point of connection, wiring is as short as practicable.

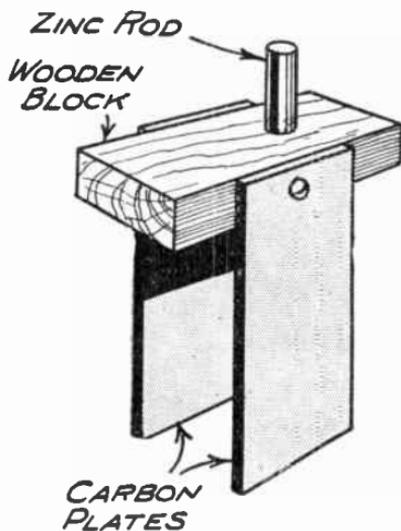


FIG. 227A.—The Carbon Plates for a Leclanche Cell.

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.

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.

LECHER WIRES.—Bare wires used in ultra-short wave work, and connected to a valve, generally in the grid and anode circuits. A bridge connects these wires and may be adjusted along them to provide various effects, such, for example, as measuring the actual wavelength of oscillations, etc. For circuit arrangement see page 174.

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. 227A shows one simple arrangement.

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.

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. (See also *Accumulator*.)

LENZ LAW.—Any induced current

LETTER DRILLS — L.F. AMPLIFIER

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. 227c shows the most common—illustrating the use of an 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.

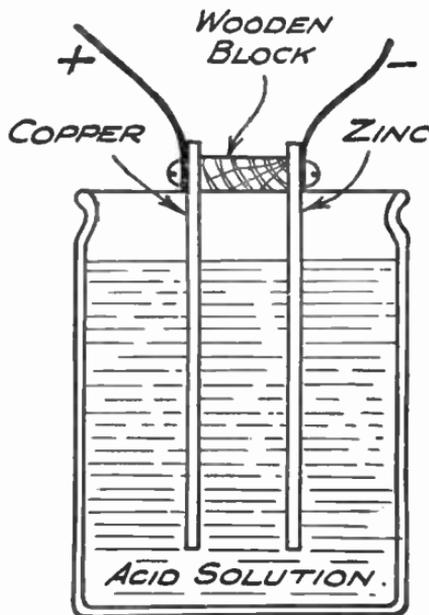


FIG. 227b.—A Voltaic Cell.

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. 227D 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

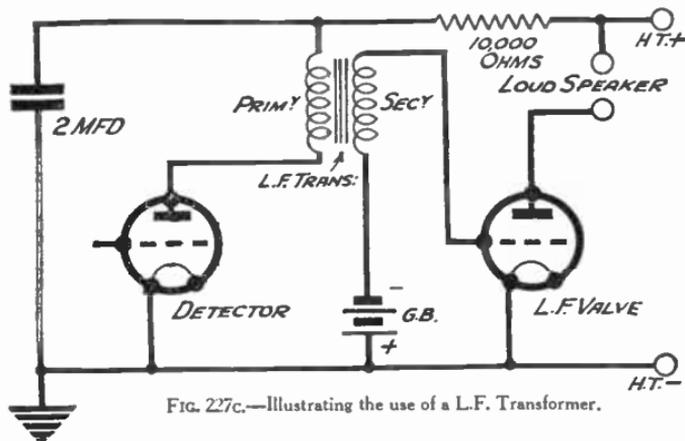


FIG. 227c.—Illustrating the use of a L.F. Transformer.

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

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

L.F. AMPLIFIER

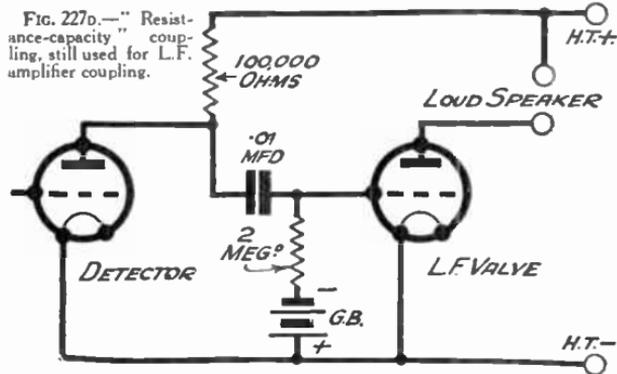
a high ratio transformer, even if another valve is to follow.

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.

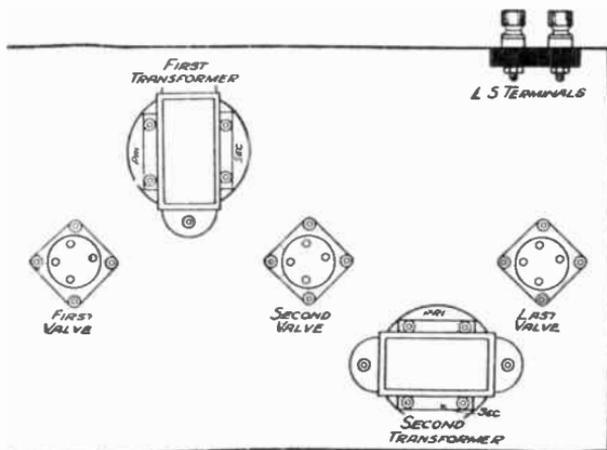


FIG. 228.—The Transformers should be mounted as far away from each other as possible to avoid interaction between them.

L.F. AMPLIFIER — LIGHT-RAY CONTROL

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 neither 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.

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. 227c, 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, SPEED OF.—186,000 miles, or 300,000,000 metres per second.

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 valve filament, 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-

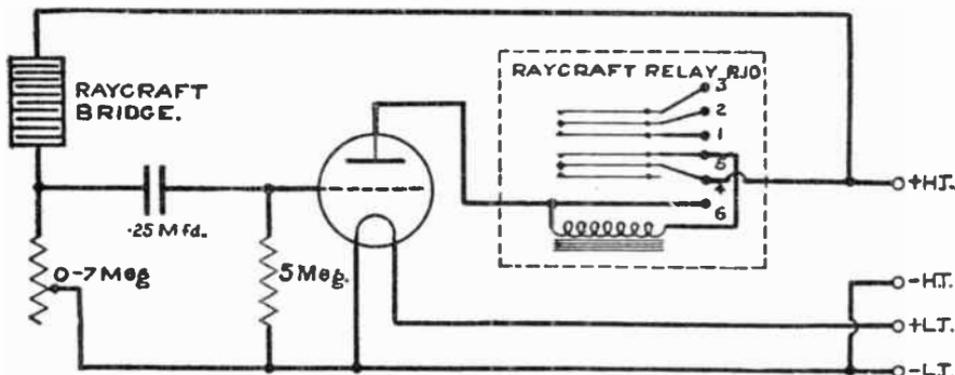


FIG. 229.—The circuit diagram for Light-Ray Control.

LIGHT-RAY CONTROL — LITMUS PAPER

necting terminals 4 and 5 (Fig. 232).

It will now be found that interrupting the ray will light the lamp, but

L.T. ACCUMULATOR

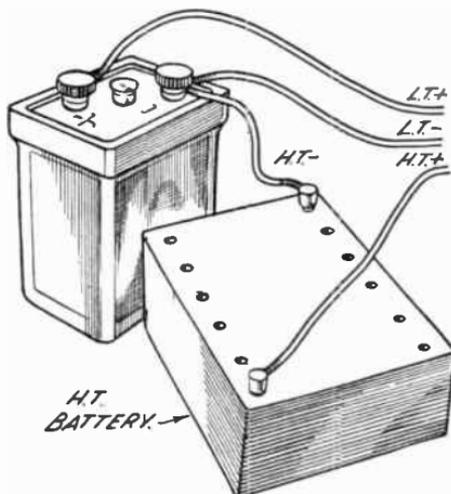


FIG. 230.—The Battery Connections.

that the restoration of the ray will 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. This connection can be used to switch off a wireless set, the electric light acting as the ray. 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.

LIGHT, SPEED OF.—Light waves travel at 186,000 miles per second. This speed is also that of wireless waves.

LINE.—It is usual to express field strength as a flux of magnetic lines of force, the flux density being the number of lines per square centimetre. The maxwell (which see) is the unit of magnetic flux density. (See also *Kiloline.*)

LITMUS PAPER.—A paper which is used for testing the presence of acids and alkalis. It is turned red by acids, and blue by alkalis. Litmus paper is obtainable in red and blue—

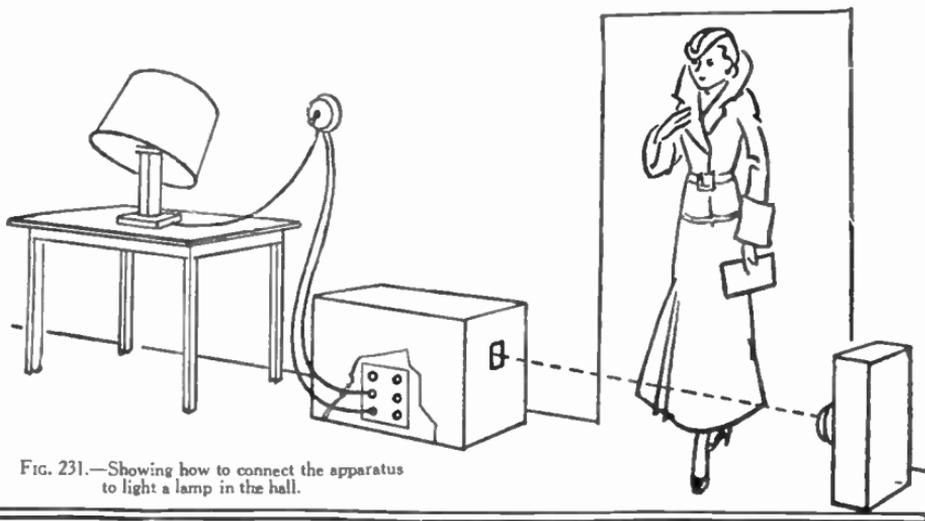


FIG. 231.—Showing how to connect the apparatus to light a lamp in the hall.

LITZENDRAHT WIRE—LOUDSPEAKERS

the red remains unchanged in colour when immersed in acid, but turns blue when immersed in an alkali, changing back to red when re-immersed in acid. The blue remains unchanged when immersed in an alkali, but changes to red when immersed in an acid, changing back to blue when immersed in an alkali.

LITZENDRAHT WIRE.—This is a special wire for winding coils and other components which require minimum high-frequency resistance. It consists of strands of insulated copper wire plaited together in multiples of three with silk covering.

LOAD.—The amount of energy taken from a battery, motor, etc. The total work to be done.

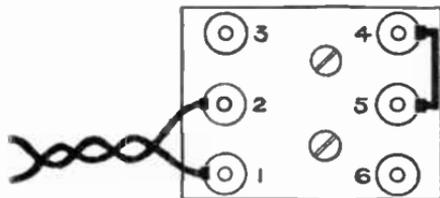


FIG. 232.—The connections to the relay for a burglar alarm.

LOADED AERIAL.—An aerial whose frequency or electrical length is varied by the addition of capacity or inductance in series.

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-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.

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

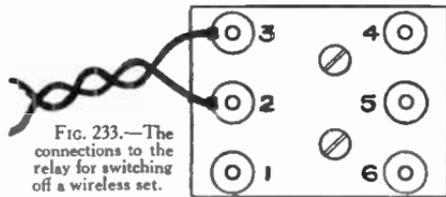


FIG. 233.—The connections to the relay for switching off a wireless set.

changing the relative position of the coils they are said to be loose coupled.

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

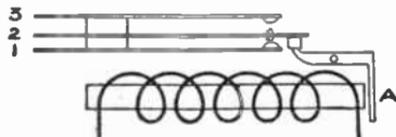


FIG. 234.—Diagram of the Switch in the relay.

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

to either speech or music passing through this magnet winding, so the

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

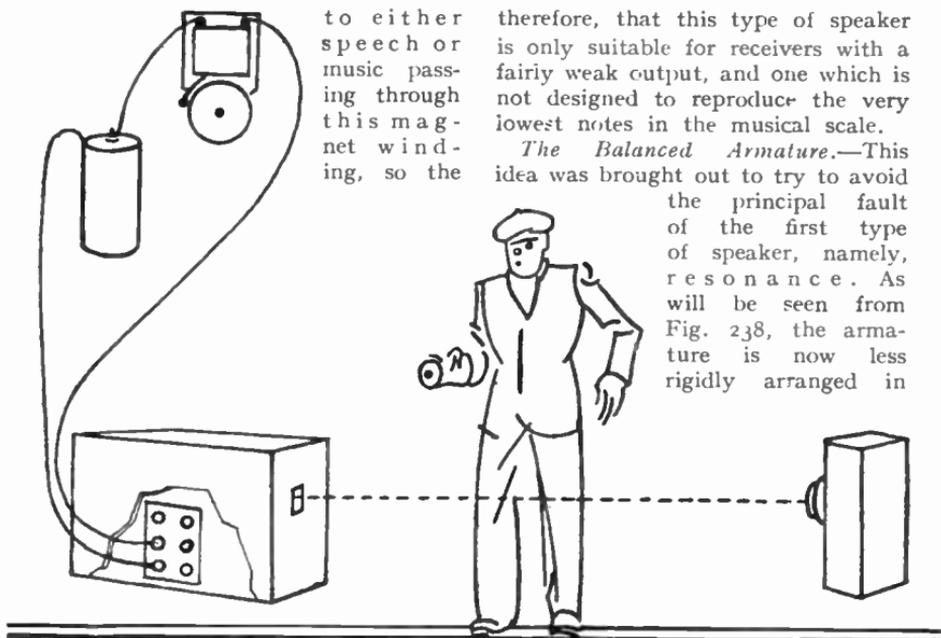


FIG. 235.—The connections for the invisible-ray burglar alarm.

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,

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

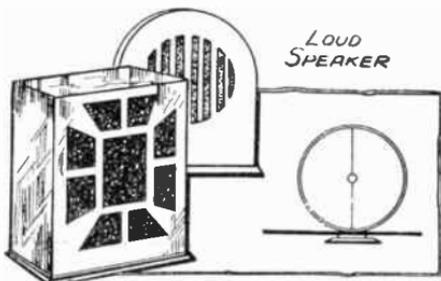


FIG. 236.—Theoretical and Pictorial Diagrams of a Loudspeaker.

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.

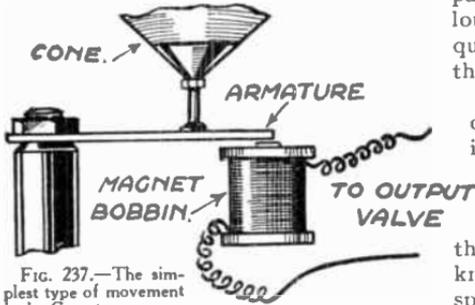


FIG. 237.—The simplest type of movement is the Cone type.

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.

Compensated Loudspeakers. Another term for dual loudspeakers (which see).

Dual Loudspeakers. Two speakers, mounted on a single mounting, each of which has different characteristics. In this way a more even response curve is obtained, as the deficiencies of one speaker are covered by its partner. In some matched pairs, one loudspeaker deals with the higher frequencies whilst the other deals with the low notes.

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

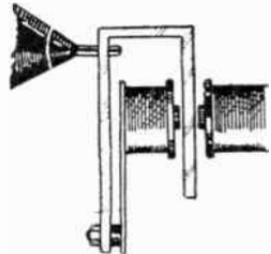


FIG. 238.—The Balanced Armature. As will be seen, the Armature is less rigidly arranged between the two magnets.

impulses it must travel in a true horizontal direction, and the restoring force in any direction is equal.

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-

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tained, either permanent magnet or mains energised, will give a reproduction identical with the original. As will be seen from Fig. 240 (mains energised type) at the point of the cone diaphragm a light ring of paper is fixed, round which is wound a coil of wire known as the "speech winding." In the mains energised speaker

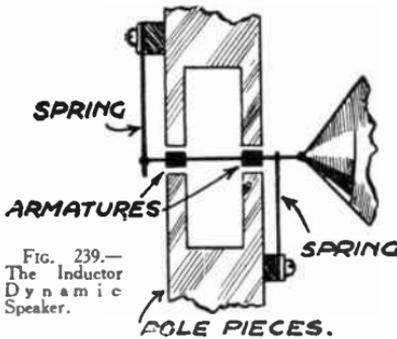


FIG. 239.—
The Inductor
Dynamic
Speaker.

a metal cylinder, having a central rod (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

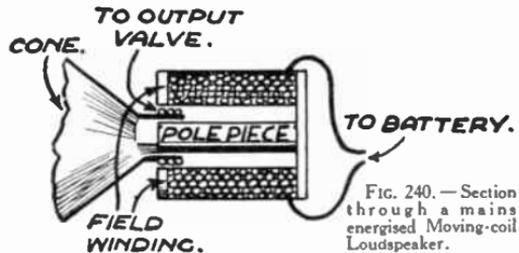


FIG. 240.—Section through a mains energised Moving-coil Loudspeaker.

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-

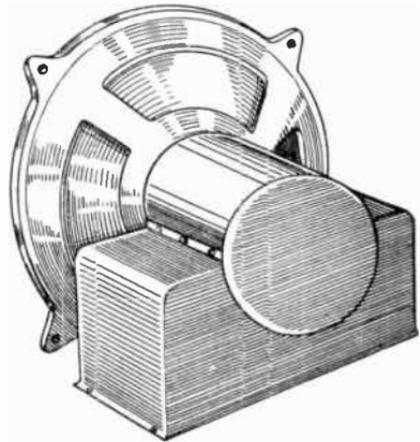


FIG. 241.—A mains energised Moving-coil Loudspeaker.

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-

FIG. 242 (right).—Showing the simplest method of connecting an extra speaker; it is in parallel with the "permanent" speaker.

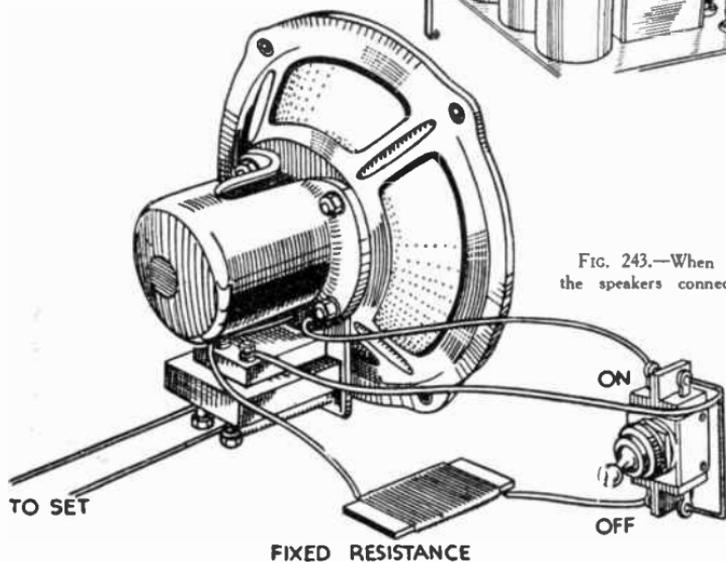
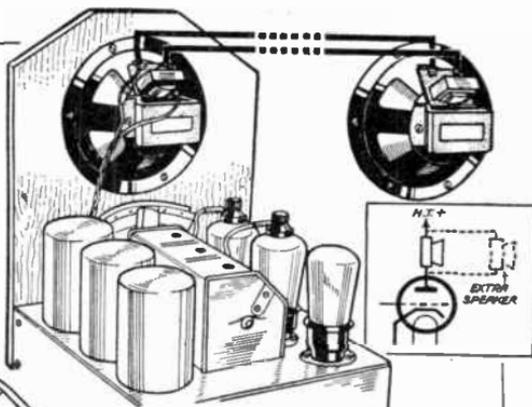


FIG. 243.—When switching out one of the speakers connected in parallel it is sometimes an advantage to leave the primary winding of the output transformer in circuit. In that case it is well to replace the speech coil by a fixed resistance of similar value.

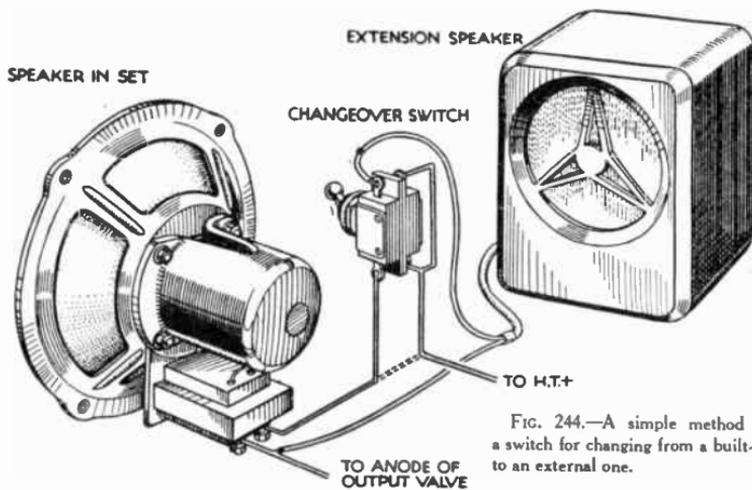


FIG. 244.—A simple method of fitting a switch for changing from a built-in speaker to an external one.

Methods of connecting extra Loudspeakers

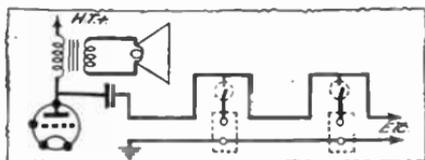
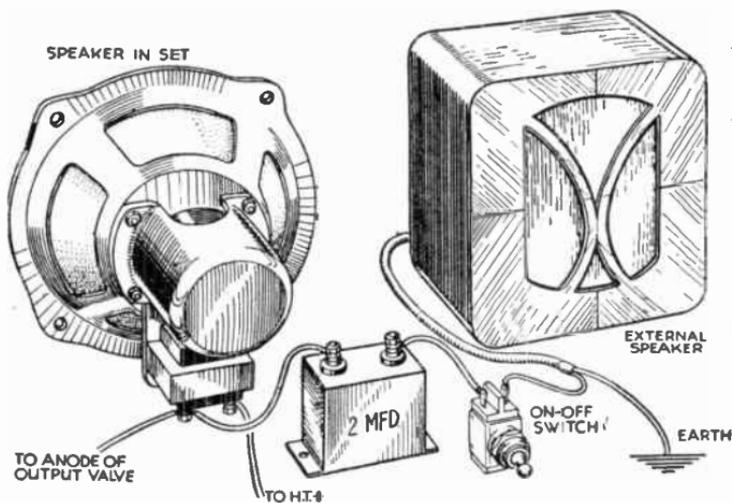


FIG. 245 (above).—Showing how the primary winding of the output transformer attached to the built-in speaker may be used as an output choke to feed an extension speaker.

FIG. 245A (left).—A simple switching system for use in conjunction with a number of extension speakers.

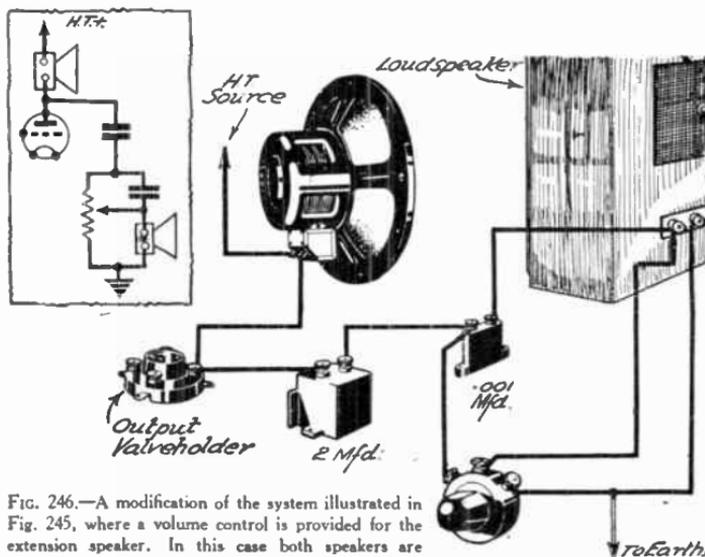


FIG. 246.—A modification of the system illustrated in Fig. 245, where a volume control is provided for the extension speaker. In this case both speakers are always kept in circuit.

LOUDSPEAKERS

fore, one wishes the horn speaker to reproduce the lowest note of the piano with the same degree of ampli-

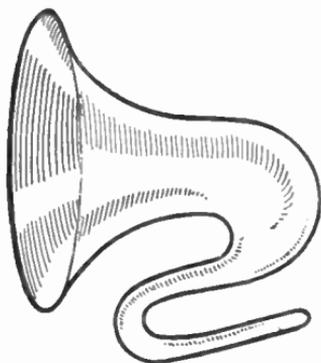


FIG. 247.—A method of forming to avoid bulkiness.

fication as middle C, it must double its area every 2 ft. So far the example has decided upon one figure in the design, and it is necessary

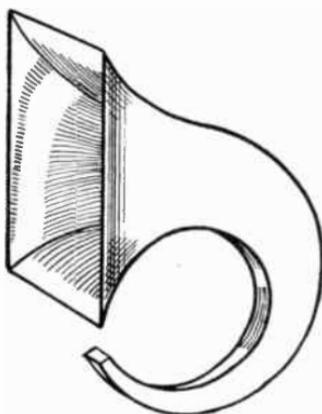


FIG. 248.—A method of curving to avoid bends.

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 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

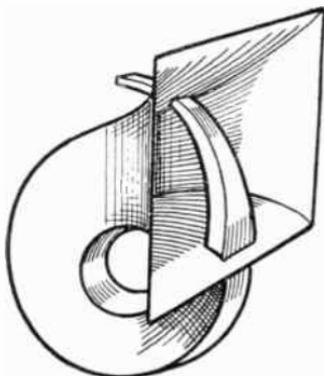


FIG. 249.—How the very large Cinema Horns are formed.

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

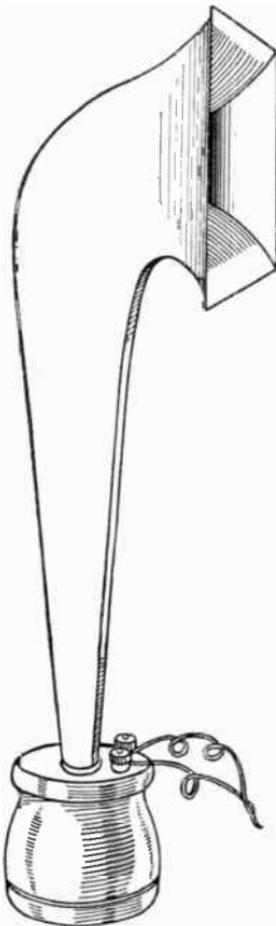


FIG. 250.—"Straight" Pattern Logarithmic Horn.

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

l o u d - s p e a k e r 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

$\frac{1}{4}$ 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 cumbersomeness, but—and this is important—avoid angular bends. Endeavour, if possible, to get nice steady curves of the swan-neck type to avoid "echoes."

Speaker units for use with this type of horn should be capable of reproducing all frequencies equally.

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 CHOKE.—

A coil of wire having an iron core, and used for smoothing and coupling low-frequency circuits (see Fig. 257). It should have a low resistance to D.C. and high resistance to A.C. (See also *Chokes* and *High-frequency Chokes* for constructional details.)

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

one 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

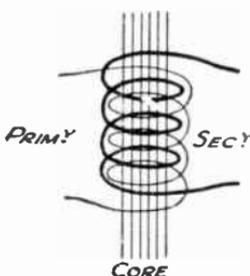


FIG. 251.—Diagrammatic illustration of the L.F. Transformer. See also Fig. 1.

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 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 milliamps. 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 interval transformer is equipped with a rather small primary, and will not take more current than 7 or 8 milliamps. 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

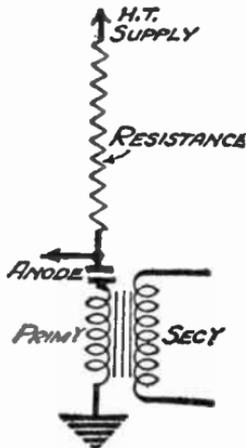


FIG. 252.—Resistance-fed Transformer Couplings. A condenser should be inserted between anode tap and primary.

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 milliamps. From Ohm's Law we know that 150 volts are required to pass a current of 5 milliamps. 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.

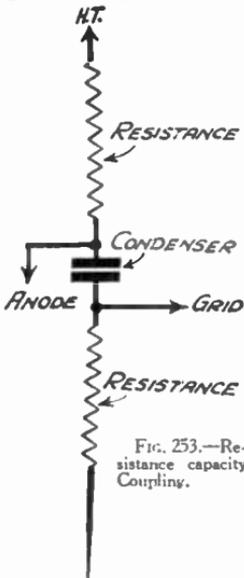


FIG. 253.—Resistance capacity Coupling.

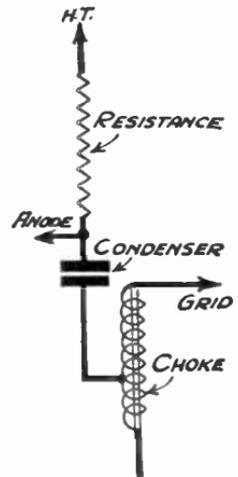


FIG. 254.—The Resistance-fed Auto-transformer arrangement.

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

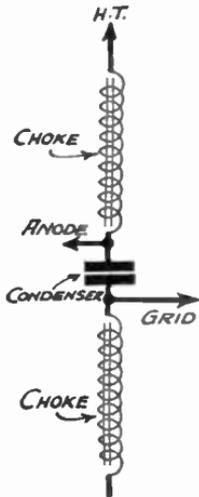


FIG. 255.—Choke Impedance Coupling.

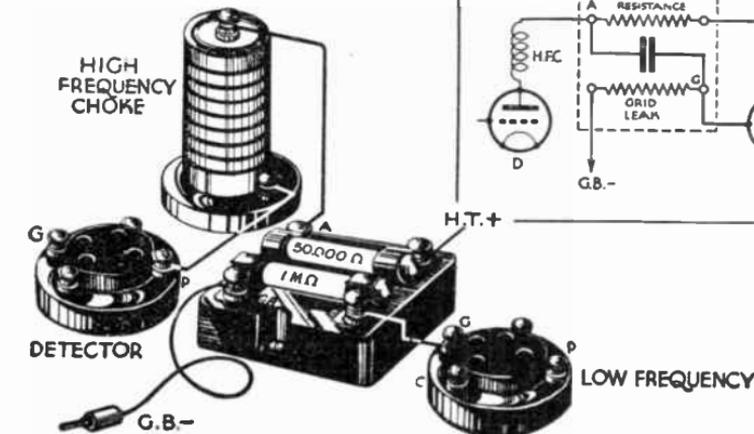
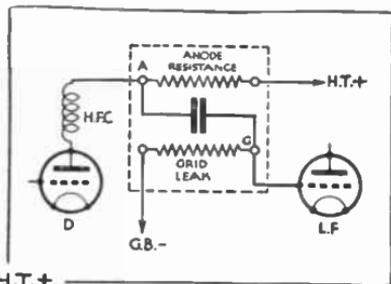


FIG. 256.—Resistance-capacity Coupling.



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

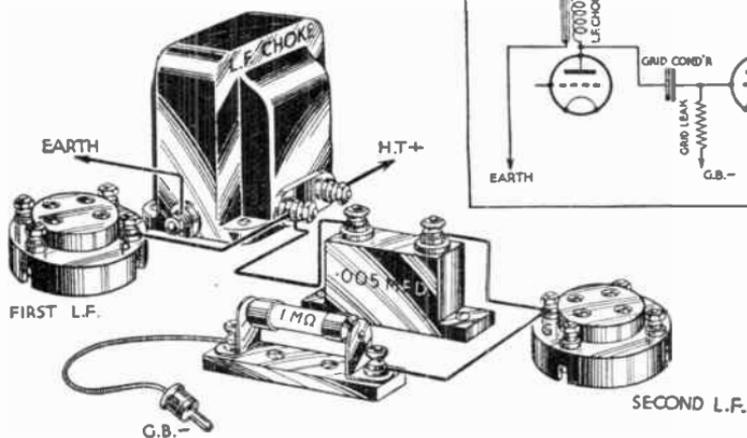


FIG. 257.—Choke-capacity Coupling.

LOW-FREQUENCY COUPLINGS

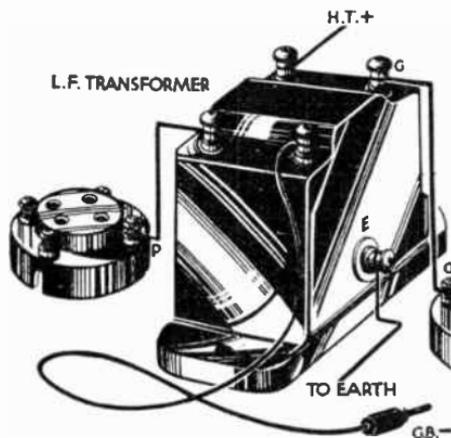
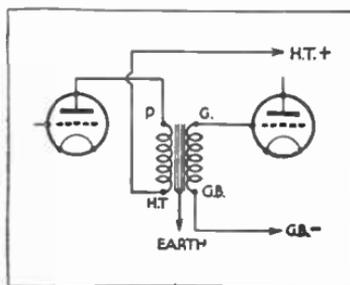


FIG. 258.—L.F. Transformer Coupling.

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

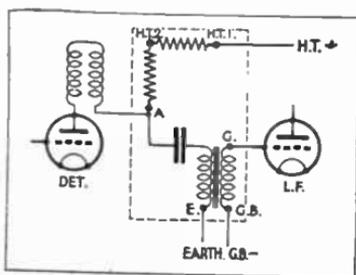
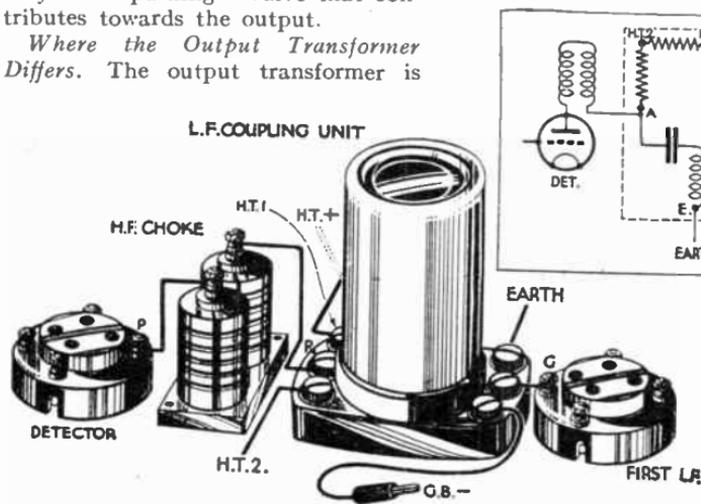


FIG. 259.—
Resistance-fed
Transformers.

LOW-FREQUENCY COUPLINGS — MAINS HUM

than a single valve unless the input to it is greater.

Even 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.

Decouple the Grid Circuits. To prevent or to cure mains hum and to ensure freedom from certain forms of instability, it is usual, and better, to decouple the grid circuits by inserting a non-induc-

of the inner surface of a hollow sphere having at its centre a light source of one candle-power. One candle-power = 4π lumens. (See *Foot-candle, Lux, Micron, and Angström Unit.*)

LUX.—A metric unit of illumination. The illumination produced on the surface of a sphere having a radius of one metre by a uniform point source of one candle situated at its centre. It corresponds to a flux density of one lumen per square metre. One lux = 0.093 foot-candle. (See *Angström Unit, Foot-candle, Lumen, Lux, and Micron.*)

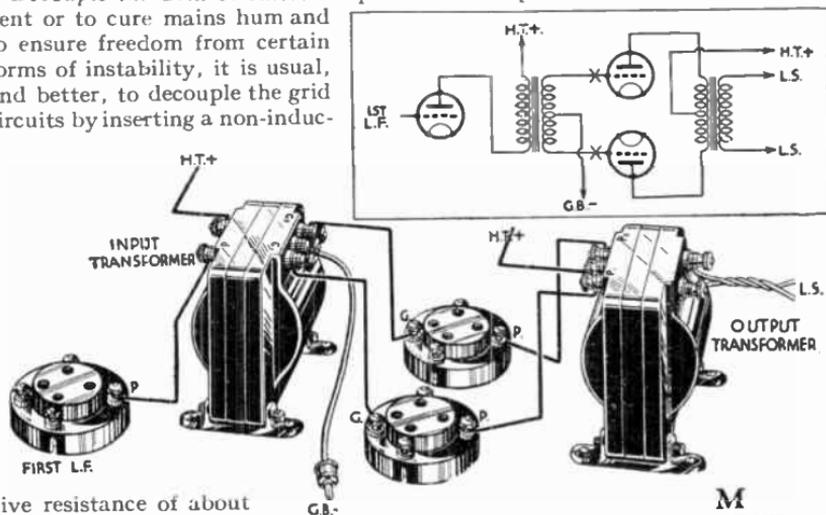


FIG. 260.—Push-pull system of L.F. Coupling.

tive resistance of about 100,000 ohms between the 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 cycles per second.

LOW-FREQUENCY TRANSFORMER.—See *Transformer.*

LOW TENSION.—Low voltage or pressure—usually under 12 volts.

LUMEN.—The unit of light energy. One lumen is the amount of light energy falling upon one square foot

M
MAGIC EYE.—See *Visual Tuning Indicator.*

MAGNETIC FLUX.—The number of unit magnetic lines of force traversing a given surface. Unit = maxwell (which see).

MAGNETIC INDUCTIVE CAPACITY.—The same as magnetic inductivity. Air is considered as 1. (See also *Dielectric Constants.*)

MAINS ELIMINATOR.—See *Eliminator.*

MAINS HUM.—Hum is sometimes difficult to remove. A good earth connection is essential.

MAINS HUM

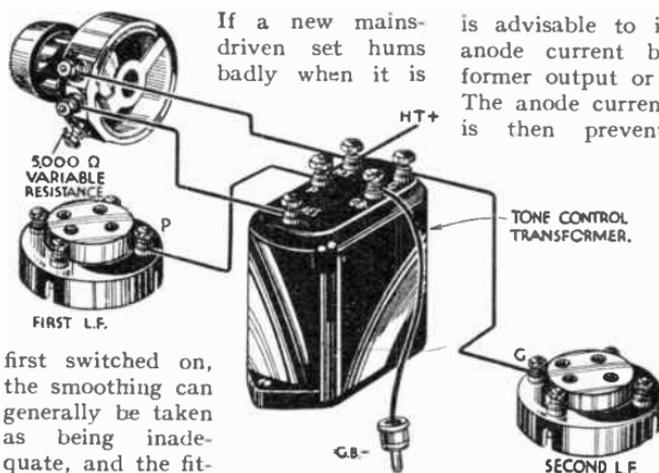


FIG. 261.—Tone-control Transformer Coupling.

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 $\cdot 1$ -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

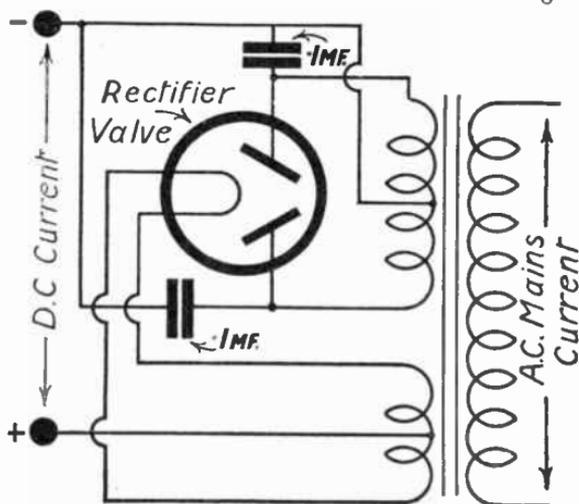


FIG. 262.—Rectifier Hum can be cured by connecting two $\cdot 1$ mfd. Fixed Condensers between the two Rectifier Anodes and High-tension Negative.

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 alternat-

ing 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

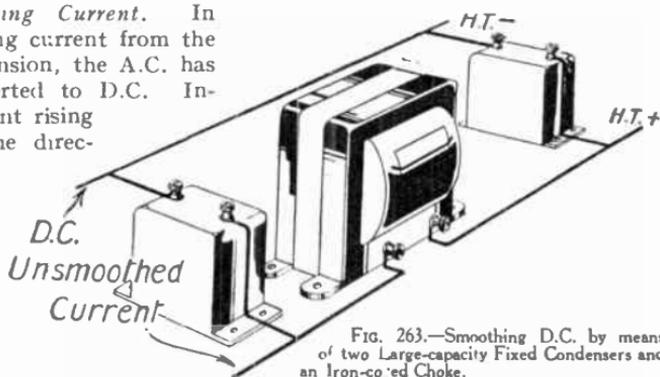


FIG. 263.—Smoothing D.C. by means of two Large-capacity Fixed Condensers and an Iron-core'd Choke.

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 baseboard.

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 — MAINS TRANSFORMER

transformer and valve circuits, and ensures a steady flow from the supply.

It is when the mains are exceptionally noisy that they show up

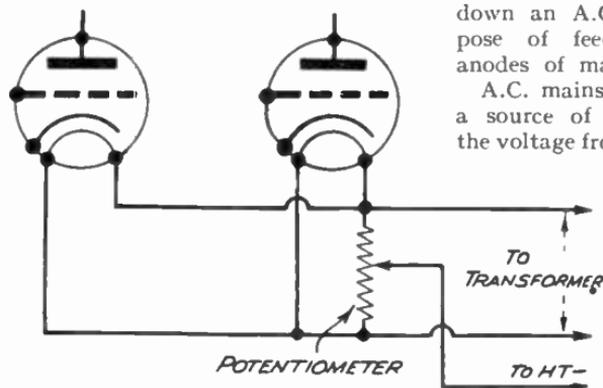


FIG. 264.—A cure for Mains Hum—a Potentiometer is connected across the Heater Supply Wiring.

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.

A device that is worth trying is the fitting of a 30- or 40-ohm potentiometer across the heater supply wiring. The use of a potentiometer 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 TRANSFORMER.—An instrument for stepping up or stepping down an A.C. voltage for the purpose of feeding the heaters and anodes of mains valves.

A.C. mains are extremely useful as a source of electrical energy, since the voltage from them can be changed

to any required figure with the greatest ease. All that is needed is a step-up or step-down transformer. Suitable transformers can very easily be constructed.

A transformer consists essentially of an iron core, upon which are placed primary and secondary windings. The type of core most frequently employed for small transformers is that consisting

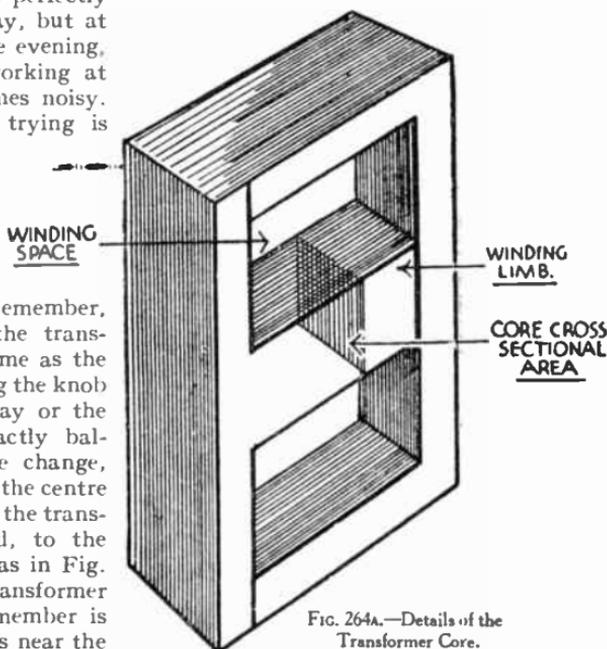


FIG. 264A.—Details of the Transformer Core.

MAINS TRANSFORMER

of pairs of "U"- and "T"-shaped Stalloy stampings of the kind shown in Fig. 264A. When these are assembled they form a semi-solid core with two "windows" and a "winding limb" (see Fig. 264A). Assuming that the stampings are of correct proportion

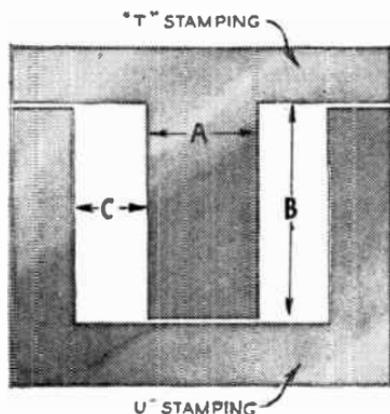


FIG. 264B.—Illustration of the Transformer Stampings to be used in conjunction with the table on p. 238.

(as all those on the market are), the numbers of "turns per volt" for both primary and secondary windings depend upon the cross-sectional area of the winding arm and the frequency of the mains supply. For example, if the area is 1 sq. in. and the frequency fifty cycles, eight turns should be allowed for every volt. If the area were halved, the numbers of turns must be doubled, and *vice versa*; on the other hand, if the frequency were doubled, the turns should be halved, and *vice versa*. This rule is invariable, and forms the basis of all transformer design.

The Stalloy stampings are made in a variety of sizes, some of which are listed in Table I (page 238), where the "A," "B," and "C" dimensions are those defined in Fig. 264B. In order to determine the most suitable size of stampings, it is necessary to know the power, in watts, which the

transformer has to handle. This is easily calculated by multiplying together the voltage and current (in amperes) of the secondary winding. For example, suppose the transformer had to supply 20 volts at 2 amperes, the wattage would be 20×40 watts. This assumes an efficiency of 100 per cent., but as the actual efficiency is generally about 80 per cent., the result must be increased by 25 per cent., which gives the power to be handled as 50 watts. Reference to Table I then shows that a core consisting of six dozen No. 4 stampings will be suitable.

Once the core size has been determined, the winding data can be compiled. Starting with the primary, which has to handle the total amount of power (50 watts), it will be seen from table, p. 238, that eight turns per volt will be required, so decide upon the gauge of wire necessary to carry the current involved. The current is found by dividing the wattage by the voltage of the supply: for instance, supposing the voltage to be 200, the current would be $50 \div 200$, or 0.25 ampere. The correct gauge of wire could then be determined by looking up a book of wire tables, but to save this trouble the necessary information in regard to the gauges in most common use is given in Table II, where the smallest possible gauge is seen to be No. 30. As this table is based on a current density of 2000 amperes per square inch, it is slightly better, where space permits, to employ a gauge of wire one size larger than the minimum shown. The secondary winding will consist of 8×20 , or 160 turns, and since it has to carry 2 amperes, the wire should be not less than 20-gauge.

In regard to the covering of the wire, this may conveniently be enamel in all gauges less than about 24, but for the stouter gauges it is better to employ double-cotton-covered, since

MAINS TRANSFORMER

enamel is liable to crack, and so allow turns to short-circuit.

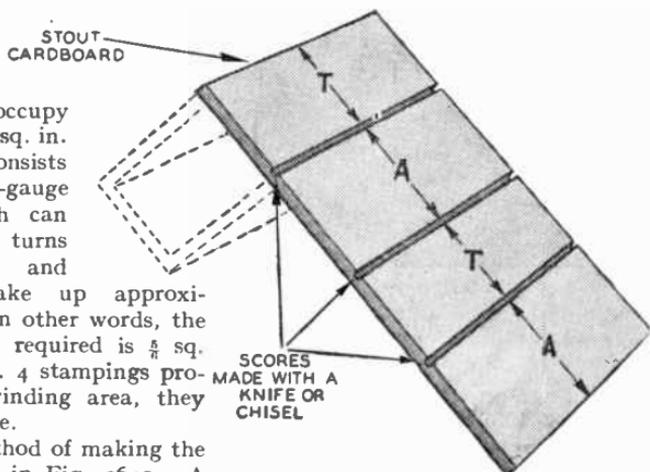
The size of core was provisionally decided on in the first place, but as the winding data are now known, a check should be made by finding the actual "winding area" required. This area can easily be determined by making use of the "Winding turns per square inch" given in Table II. Taking the same example as before, we see that 28-gauge enamelled wire can be wound

3,760 turns per square inch, and therefore our 1,600 turns will occupy rather less than $\frac{1}{2}$ sq. in. The secondary consists of 160 turns of 20-gauge d.c.c. wire, which can be wound 472 turns per square inch, and will therefore take up approximately $\frac{1}{3}$ sq. in. In other words, the total winding area required is $\frac{5}{6}$ sq. in., and as the No. 4 stampings provide $1\frac{1}{2}$ sq. in. winding area, they will be amply large.

The simplest method of making the spool is illustrated in Fig. 264c. A square-section cardboard tube is first required and can be made by scoring and bending a strip of stout card of the dimensions shown. Next, a pair of end cheeks must be made to fit tightly over the ends of the tube, and these can be cut out of stiff card or thin plywood and secured by means of strong glue. To make the bobbin more rigid, it should finally be given one or two applications of thin shellac varnish and dried quickly. To cover the sharp edges of the bobbin, which might cut the wire whilst winding, a few turns of empire cloth or insulating tape should be wound on.

Solder a short length of flex to the end of the 28-gauge wire, anchor this by passing it through a pair of holes

in an end cheek and wind on the correct number of turns for the primary. The winding can be done most expeditiously by fitting the spool on to a mandrel, which can be turned in the lathe or a hand-drill gripped in a vice, but it can be done by hand if desired by cutting a handle of wood which is a tight fit in the spool. After every four layers, or approximately 500 turns, it is advisable to cover the winding with a



**T = THICKNESS
OF CORE**

FIG. 264c.—Method of marking out and folding the Winding Spool.

layer of empire tape, oiled silk, or waxed paper to avoid the possibility of any two turns at widely differing potential getting close together. Take care that no later turns are allowed to slip past the layer of insulation.

After winding the requisite number of turns a second length of flex should be soldered to the end of the wire, taken once round the spool and anchored as before. Thoroughly insulate the primary by covering it with two or three layers of empire tape, etc., and then continue to wind the secondary, following the same procedure as with the primary. Finally,

MAINS TRANSFORMER

cover the outer layer with insulating material to ensure that the windings cannot be damaged in any way.

The core stampings must next be fitted, and the method of fitting is clearly shown in Fig. 264A. First a "T" and then a "U" are inserted from one end of the spool, after which a similar pair of stampings is inserted from the other end, this process being repeated until the spool is quite full. In order to make the core a tight fit (as it must be to

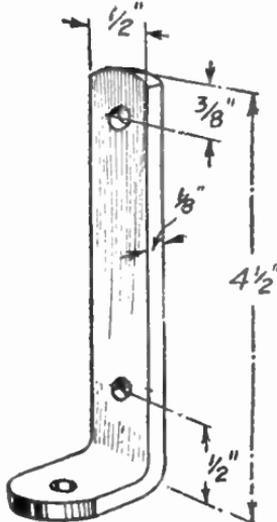


FIG. 265A.—Dimensions of supporting foot of Transformer.

prevent vibration), it might be necessary lightly to tap the last few stampings into position, but undue force must not be used, or else there might be a danger of "bursting" the spool. It will be noticed that one side of each stamping is covered with a white insulating film, and, to ensure that every one shall be insulated from the next, the white sides must face in the same direction.

The last step is to fit suitable clamps to the core to hold the stampings tightly together and provide a simple means of mounting the complete transformer. These clamps can be made from $\frac{1}{8}$ in. thick strip brass or steel, shaped and bent as shown in Fig. 265A. They are attached by means of $1\frac{1}{2}$ -in. bolts and can be fitted with a terminal strip, if desired,

or connections can be made directly by means of the flexible leads from the windings. Both methods of finishing are shown in Figs. 265B and

All the details given above, although they have been applied to a particular component, are equally applicable to any pattern of mains transformer that the reader may require. In some cases it is more convenient to design the transformer, so that it can be used on any mains having a voltage of between, say, 200 and 250 volts. In that case the primary winding would require an additional 400 (eight 50) turns, and tapings would have to be taken after winding 80, 240, and 400 turns for 240, 220, and 200 volts respectively. The tapings would be made by sold-ring suitable lengths of flex and passing these out through holes made in the end cheeks. To safeguard against short-circuit between the tapping points, the soldered joints should be covered with a strip of insulating tape, or even with a piece of stamp edging.

When more than one secondary winding is required, such as for H.T.

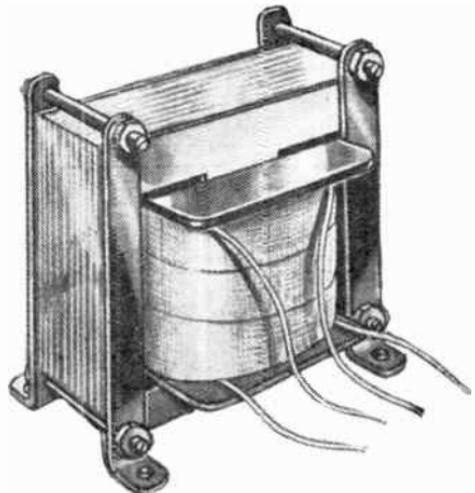


FIG. 265B.—One method of finishing off. Flexible leading-out wires are used.

MAINS TRANSFORMER — MARKING OUT

and L.T. supply for a wireless receiver, it is generally most convenient to divide the winding spool into three or more sections by fitting extra cheeks. The position of these will be determined by the area required for winding in the different sections. In order to prevent mains

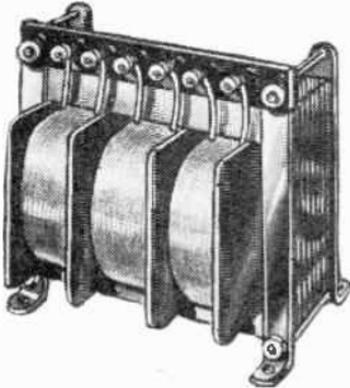


FIG. 265c.—In this method the windings are brought out to a terminal strip.

hum it is best to place the L.T. secondary in the centre section, where it will serve as an effective screen between the primary and H.T. secondary windings. With all other kinds of "dual-secondary" transformers the primary winding should be arranged between the other two.

TABLE I

(See Fig. 264B on page 235.)

DETAILS OF STALLOY CORE STAMPINGS.

Size No.	Dimensions.			Number of Stampings	Approx. Watts	Turns Volt (50 cycles)	Approx. Winding Area
	A	B	C				
	in.	in.	in.	doz. prs.			sq. in.
4	1 1/2	2 1/2	1 1/2	6	50	8	1 1/2
5	1 3/4	3	1 3/4	6	30	12	2 1/2
28	2 1/2	4 1/2	2 1/2	6	250	6	3
29	2 1/2	4 1/2	2 1/2	6	300	4	5 1/2
30	2 1/2	4 1/2	2 1/2	6	45	8	8
31	2 1/2	4 1/2	2 1/2	6	100	8	12
32	2 1/2	4 1/2	2 1/2	6	75	8	12
33	2 1/2	4 1/2	2 1/2	6	125	6	12
35	2 1/2	4 1/2	2 1/2	6	200	5	12

This table covers most of the commoner sizes of stampings, but some makers give different numbers to stampings of similar size.

TABLE II
COPPER WIRE DATA

Standard Wire Gauge	Max. Working Current (amps.)	Enamelled		Double Cotton-Covered	
		Winding Turns per sq. in.	Yards per lb.	Winding Turns per sq. in.	Yards per lb.
16	6.5	226	26.3	173	25.5
18	3.6	392	46.9	297	45.5
20	2.0	685	83.3	472	79.4
22	1.25	1,110	137	592	129
24	0.76	1,770	221	977	203
26	0.51	2,560	330	1,280	294
28	0.35	3,760	488	1,630	422
30	0.25	5,370	694	1,990	587
32	0.18	6,890	915	2,550	755
34	0.13	9,610	1,202	3,020	1,024
36	0.10	13,500	1,840	4,100	1,477
38	0.06	20,400	2,810	5,100	2,287

In the above table the "Max. Working Current" (in amperes) is based on a figure of 2,000 amperes per square inch.

MAINS UNIT.—See *Eliminator* and *D.C. Mains Unit*.

MANSBRIDGE CONDENSER.—A patented form of high-capacity condenser in which the electrodes consist of thin films of metal electrically deposited on the paper dielectric.

MARCONI-STILLE RECORDER.—See *Blattnerphone*.

MARKING OUT.—Tools are illustrated in Fig. 265D. The scriber 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.

In its simplest style marking out takes the form of laying a blueprint on a baseboard and pricking the necessary holes off with a scriber. 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 pricked off the drawing. In such cases the dividers are adjusted to suit the various hole centres and measured with a rule or

MARKING-OUT TOOLS AND METHODS

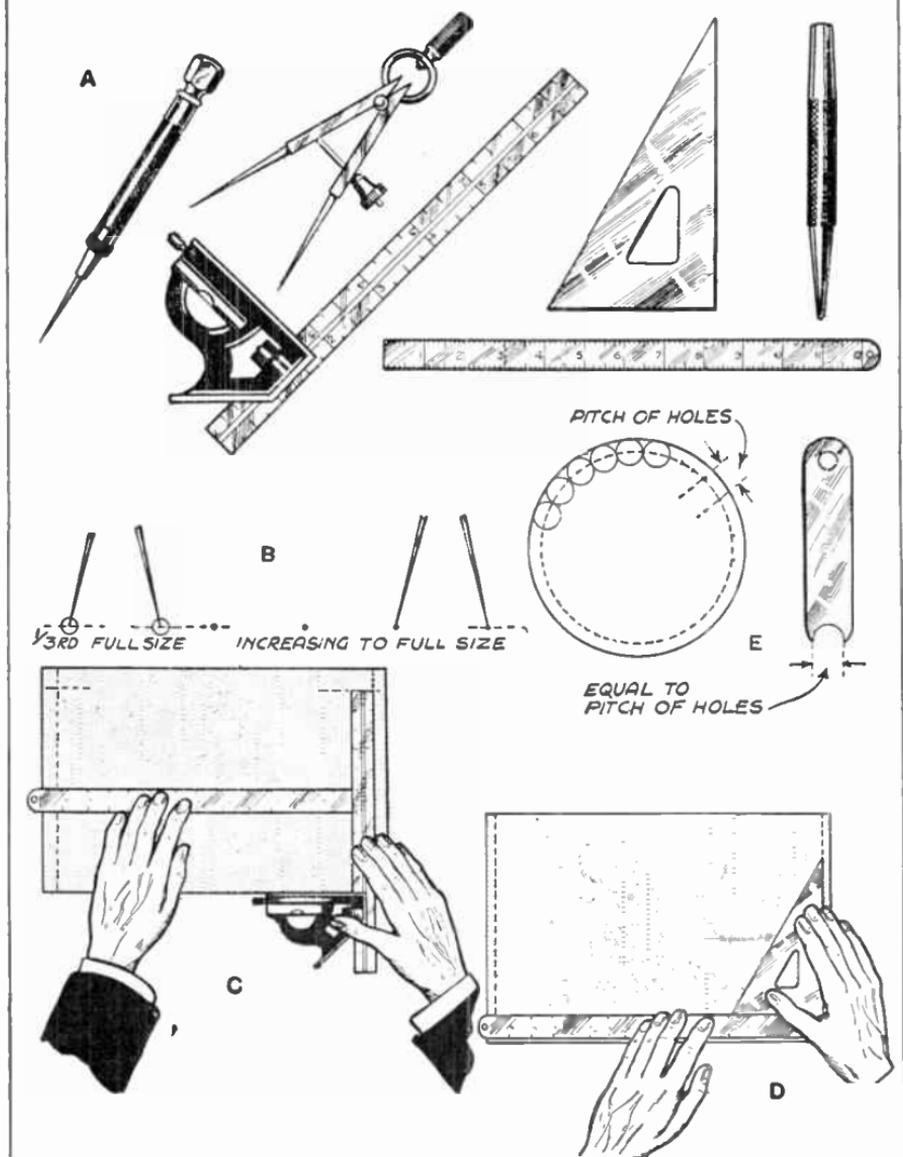


FIG. 265D.—The tools used for Marking Out, and various methods of using them.

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.

It should be noted that it is the *impedance* of the speaker, and not its *resistance*, which should be used in this calculation. If 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.

MAXWELL.—The C.G.S. electromagnetic unit of magnetic flux. (See *Gilbert, Weber, and Unit Magnetic Pole.*)

MAXWELL'S LAW.—(a) Any two circuits carrying current tend to so dispose themselves as to include the largest possible number of lines of force common to the two. (b) Every electromagnetic system tends to change its configuration so that the exciting circuit will embrace the largest number of lines of force in a positive direction.

MEGA.—One million.

MEGACYCLES.—One million cycles or one thousand kilocycles. This term is used in reference to the frequency of short-wave transmissions. (See also *Frequency.*)

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 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.

METAL VALVES.—Transmitting valves are usually arranged so that the anode forms the outside envelope of the valve. By doing this water may be permitted to pour over the anode during operation to reduce the high temperature which is developed in these power valves. Ordinary receiving valves are now manufactured in this form in which the very minimum of glass is employed. The seal between metal and glass is not affected by temperature and greater uniformity in valve characteristics is obtained. The valves are fitted with the ordinary valve base and are interchangeable with standard valves.

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.

The other type of instrument in general use is known as a "moving-coil" instrument, and this consists of a coil of wire which is suspended between the poles of a permanent magnet system, and the pointer is attached to this coil. The passage of current through the coil 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 type has the scale divided into equal sections. Both types are invariably fitted with a small hairspring in order to restore the indicating pointer to zero.

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 sag—otherwise, 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

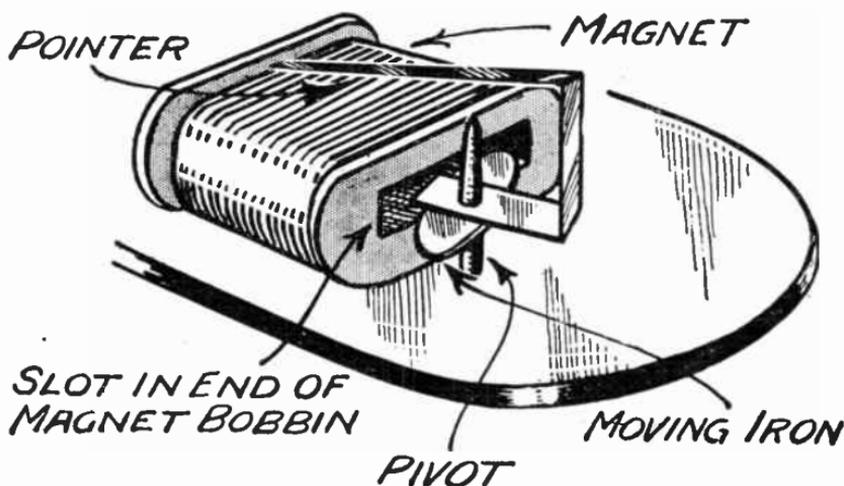
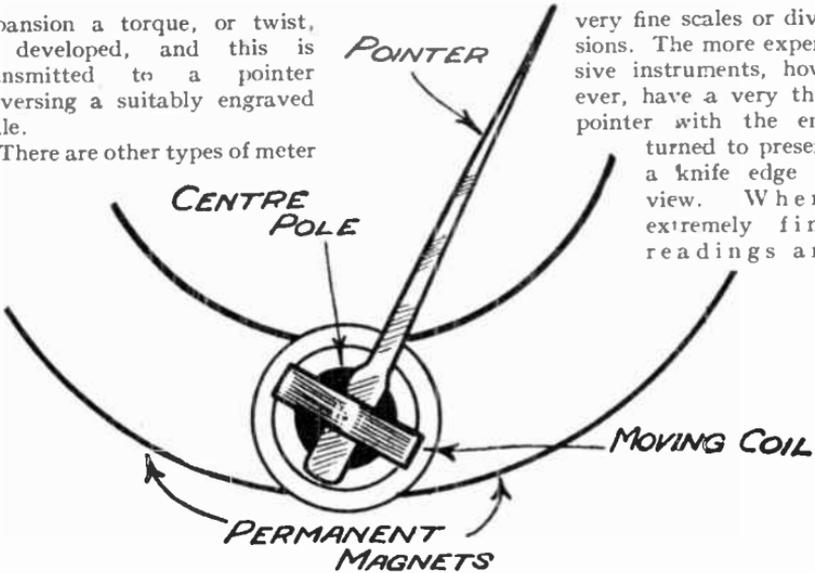


FIG. 266.—A cheap Moving-iron Movement. The top plate carrying bearing for pivot has been removed to enable the movement to be shown.

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

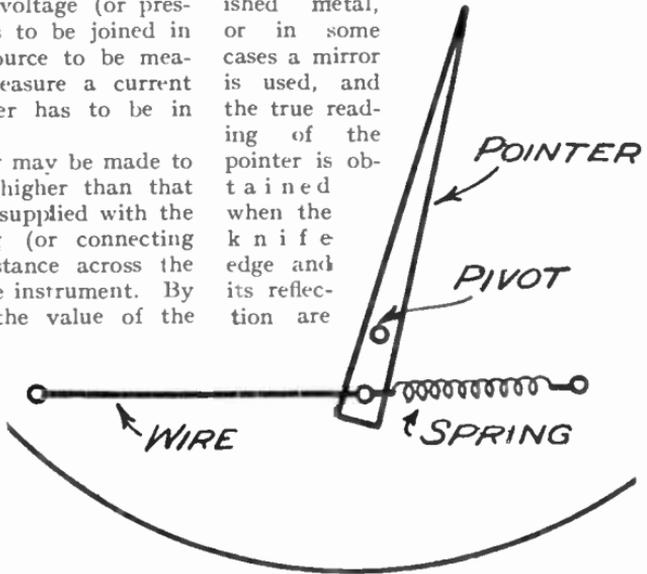


FIG. 268.—Elements of a hot-wire instrument. View showing Spring, Bearing and method of making connection.

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.

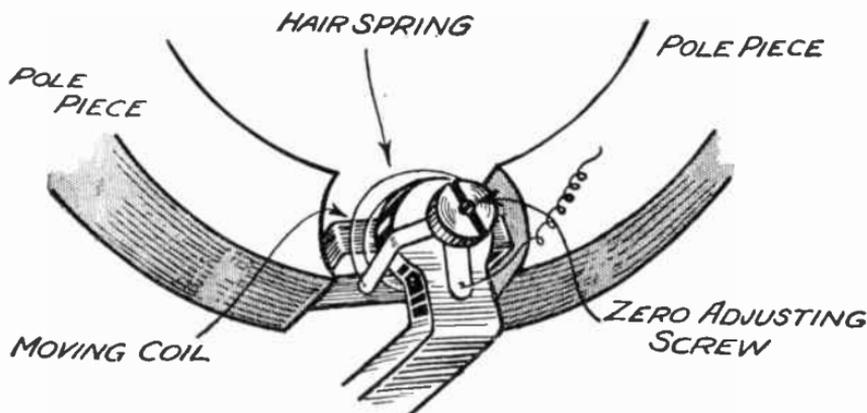


FIG. 269.—Perspective view of the active elements of a moving-coil instrument.

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

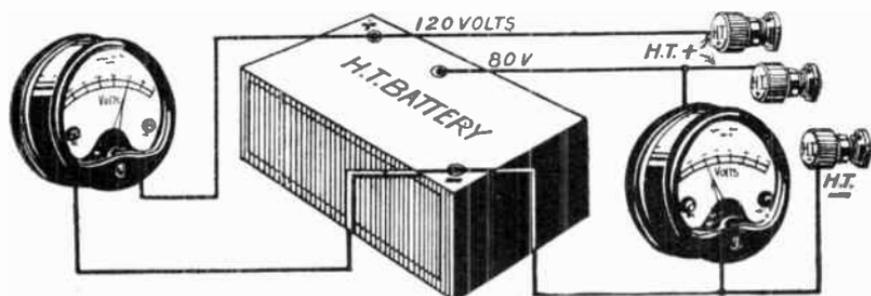


FIG. 270.—Voltmeters for checking different values of high tension.

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

it does not result in overloading the last valve. A very good scheme is to have two aerials and arrange a switch to change from one aerial to

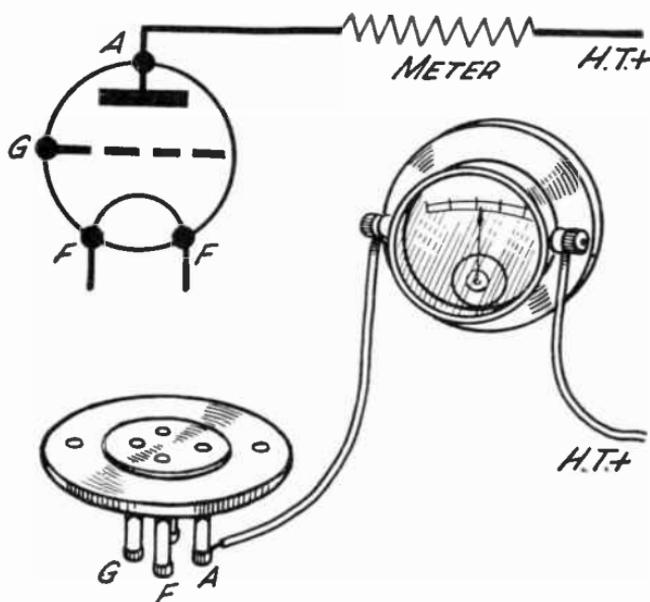


FIG. 271.—A Milliammeter connected in the Anode Circuit of a Valve to determine its consumption.

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 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 overloaded a more suitable valve must be used in the last stage or the input to the receiver reduced. All that is necessary is to reduce the signal input slightly to that point where

another. If the set is used for long distance then the original aerial may be used, but when listening to local stations switch on to the shorter aerial, which only needs to be a few yards in length. Several of the modern sets of to-day have these shorter aerials incorporated in the top part of the cabinet.

Testing for Leakages. Tests should be made with a milliammeter in the H.T. circuit 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 attached 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 instru-

METERS, USING — MAKING A TEST METER

ments. 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, it means that a connecting piece

because the user has failed to appreciate some of the "finer" points of working. To rectify this he must be introduced to meters, as in this way adjustments made on the set

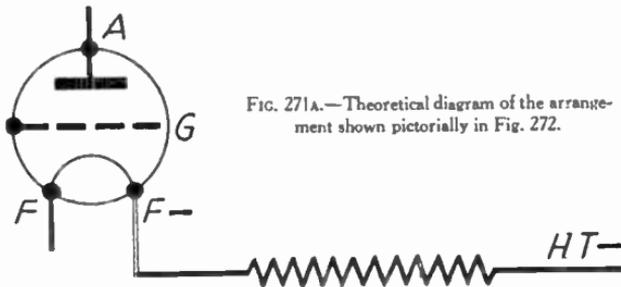


FIG. 271A.—Theoretical diagram of the arrangement shown pictorially in Fig. 272.

must be made to remake the circuit after using the milliammeter (see Fig. 273).

MAKING A TEST METER.—

Everyone possessing a wireless receiver is anxious to ensure that the results obtained represent the maximum efficiency for the set in question. Unfortunately, the final efforts frequently fall far short of the ideal,

do not then become just "shots in the dark," but arise from an analysis of the effects shown by the meter needle 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

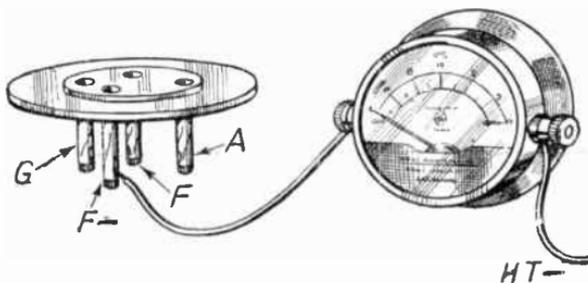


FIG. 272.—Reading the Anode Consumption of the Set in Milliamps.

MAKING A TEST METER

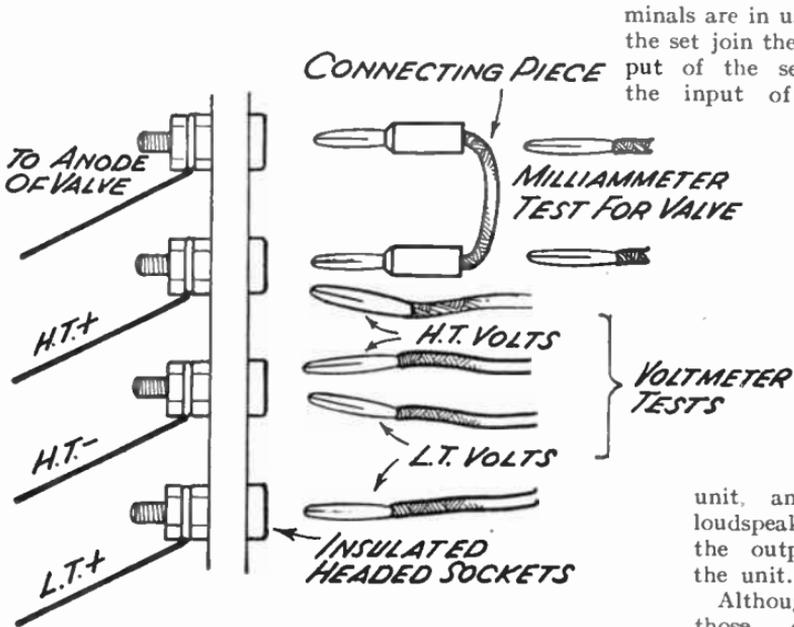


FIG. 273.—Fitting Sockets on the Panel enabling the milliammeter and voltmeter tests to be made from the exterior of the set.

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-

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

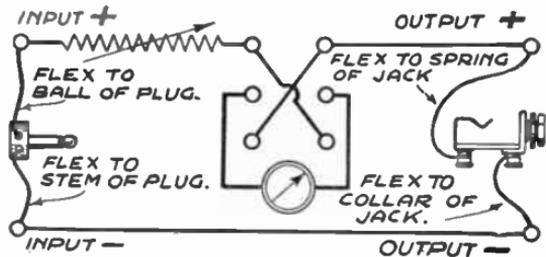


FIG. 274.—The Theoretical Circuit.

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.

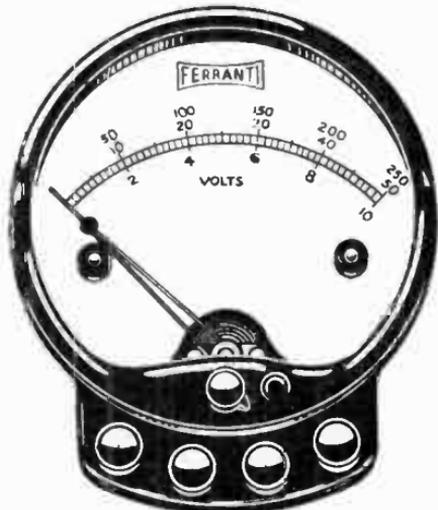


FIG. 276.—A Voltmeter.

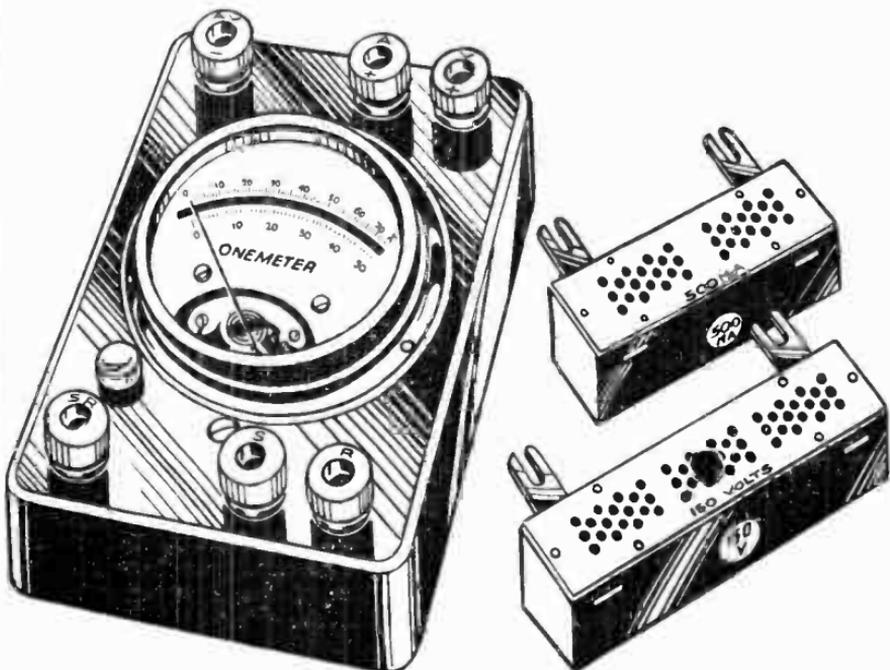


FIG. 277.—Another type of all-in meter.

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 milliamper. 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-

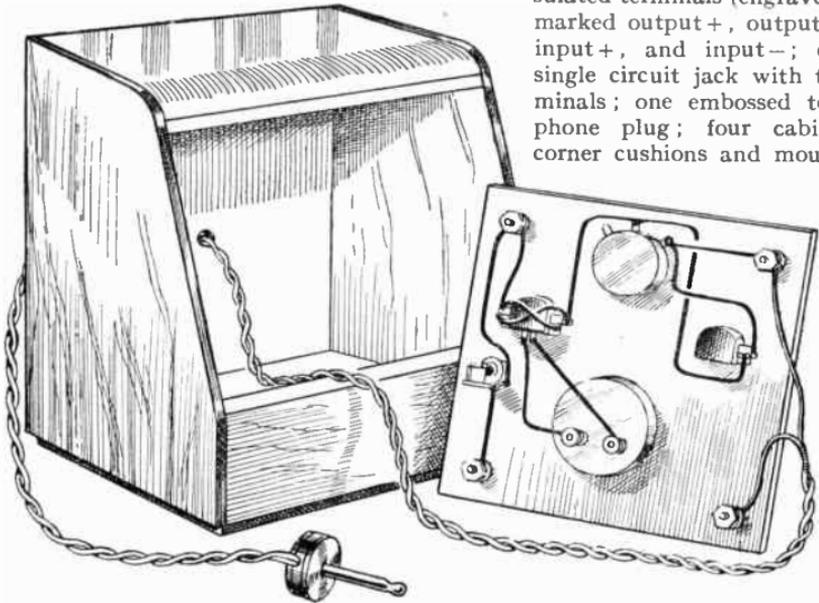


FIG. 278.—A view of the Tester with the front Panel removed to show the Wiring.

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

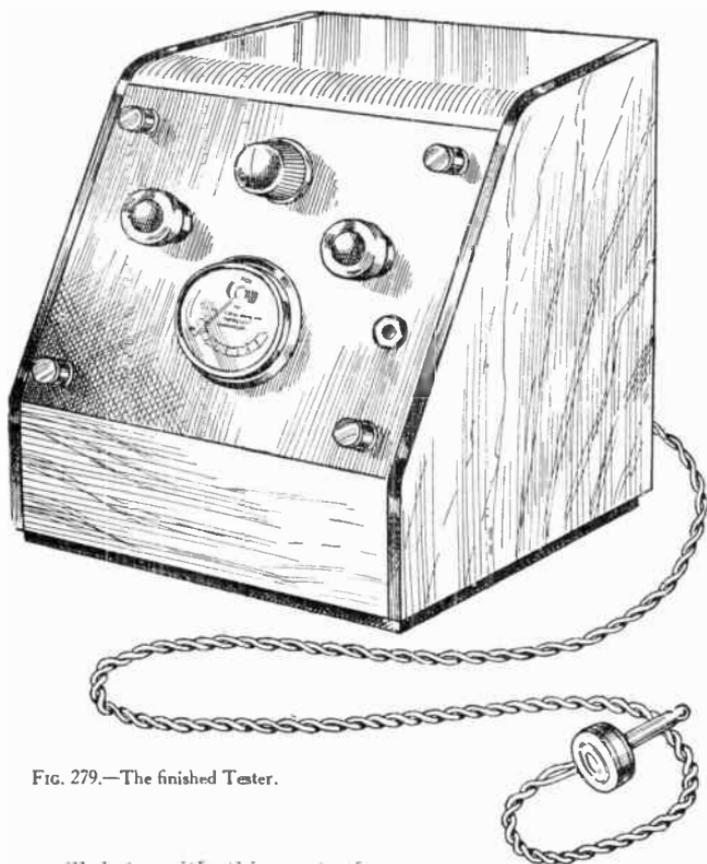


FIG. 279.—The finished Tester.

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 milliamperes 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 milliamper 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 = 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.

Length

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 Equivalents

1 inch = 2.54 centimetres, or
25.4 millimetres.
1 foot = 30.4799 centimetres,
304.799 millimetres, or .3047
metre.
1 yard = .914399 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	× .03937 or ÷ 25.4
Centimetres to inches	× .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	× .6214 or ÷ 1.6093
Kilometres to feet	× 3,280.8693
Square millimetres to square inches	× .00155 or ÷ 645.1
Square centimetres to square inches	× .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	× .06 or ÷ 16.383
Cubic metres to cubic feet	× 35.315
Cubic metres to cubic yards	× 1.308
Cubic metres to gallons (231 cubic inches)	× 264.2
Litres to cubic inches	× 61.022
Litres to gallons	× .2642 or ÷ 3.78
Litres to cubic feet	÷ 28.316
Hectolitres to cubic feet	× 3.531
Hectolitres to bushels (2,150.42 cubic inches)	× 2.84
Hectolitres to cubic yards	× .131
Hectolitres to gallons	÷ 26.42

(Continued on next page)

MFDS. — MILLIAMMETER

Grammes to ounces (avoirdupois) . . .	× '035 or ÷ 28·35
Grammes per cubic cm. to lb. per cubic inch	÷ 27·7
Joules to foot-lb. . .	× '7373
Kilogrammes to oz. . .	× 35·3
Kilogrammes to lb. . .	× 2·2046
Kilogrammes to tons . .	× '001
Kilogrammes per sq. cm. to lb. per sq. inch . .	× 14·223
Kilogramme-metres to foot-lb. . .	× 7·233
Kilogramme per metre to lb. per foot . . .	× '672
Kilogramme per cubic metre to lb. per cubic foot . . .	× '062
Kilogramme per cheval to lb. per h.p. . .	× 2·235
Kilowatts to h.p. . .	× 1·34
Watts to h.p. . .	÷ 746
Watts to foot-lb. per second . . .	× '7373
Cheval vapeur to h.p. . .	× '9863
Gallons of water to lb. .	× 10
Atmospheres to lb. per sq. inch . . .	× 14·7

MFDS.—Microfarads. (See also *Microfarad*.)

MHO.—The unit of conductivity (the word *ohm* reversed). The reciprocal of resistance.

MHYS.—Microhenrys.

MICRO.—One-millionth.

MICROAMPERE. — One-millionth of an ampere.

MICROFARAD.—One-millionth of a farad.

MICROHENRY.—One-millionth of a henry.

MICROHM.—One-millionth of an ohm.

MICROLUX.—One-millionth of a lux (which see).

MICRON.—A term signifying a one-thousandth of a millimetre. It is used in expressing the wavelength of light. (See *Angström Unit*, *Lux*, *Foot-candle*, *Lumen*.)

MICROPHONE.—A device for converting into electrical currents sounds which are produced in its proximity. The simplest microphone consists of carbon granules bridging two electrical contacts and sound vibrations vary the resistance of the carbon bridge so made. This results

in current variations which may be made to reproduce the original sounds through an amplifier and reproducer. An alternative form of mike has the carbon covered by a disc or diaphragm which provides the necessary movement of the carbon. A condenser microphone consists of two plates arranged very close together, the front plate being flexible. Sounds impinging on the top plate thus vary the capacity between the two plates, and these are part of the grid circuit of a valve, thus giving rise to a means of reproducing the original sounds. A ribbon or velocity microphone consists of a permanent magnet between the poles of which a thin narrow metallic tape or ribbon is suspended. The crystal mike consists of a thin quartz or piezo-crystal, sounds impinging upon which vary its resistance.

MICRO WAVES.—Wavelengths of less than 1 metre.

MILLER EFFECT.—The feed-back of energy from anode to grid; input admittance. After John M. Miller.

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 an H.T. battery, and any 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.

MILLIAMMETER — MUSICAL NOTES FREQUENCY

In theory, the needle of the milliammeter should remain perfectly stationary whilst music is being received. If the needle kicks in an upward direction, it shows that the grid bias applied is higher than is required. If the needle kicks in a downward direction, insufficient bias is applied. Should the needle oscillate backwards and forwards, the valve is being overloaded. Connecting the meter in the H.T. negative lead will indicate the total current consumption of the set. (See also *Meter*.)

MILLIAMP.—A thousandth part of an ampere.

MILLIHENRY.—One thousandth of a henry (which see).

MILLILUX.—One thousandth of a lux. (See *Lux* and *Microlux*.)

MILLIMICRON.—One-thousandth of a micron (which see).

MIXER.—Controls used to combine output from one microphone with another or other apparatus.

MMF.—Abbreviation for micro-microfarad—one-millionth part of a microfarad.

MODELS, WIRELESS CONTROL OF.—A licence is not required for wireless control of models. You may not use a spark transmitter, and as the apparatus you use may cause interference, adequate steps must be taken to avoid this. The P.M.G. advises restriction of transmission during broadcasting hours, a limitation of the power to a maximum of 2 watts and a wavelength between 100/150 metres.

MODULATION.—A process of varying the frequency of a circuit by introducing into it the frequencies of the matter being transmitted.

MODULATOR.—The circuit used to apply the frequencies of any desired signal to a transmitter.

MOLECULE.—The smallest part of matter capable of existing alone.

MONITOR.—A device used for checking. It can be a small receiver

or similar device for checking output of a transmitter or amplifier.

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.

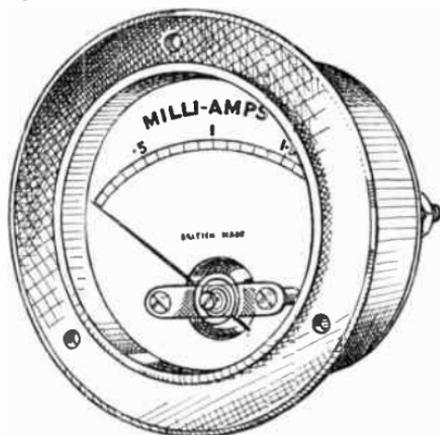


FIG. 280.—A panel-mounting Milliammeter.

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	G 96	F 341	E 1,280
B 30	A 106	G 384	F 1,365
C 32	B 120	A 426	G 1,536
D 36	C 128	B 480	A 1,706
E 40	D 144	C 512	B 1,920
F 42	E 160	D 576	C 2,048
G 48	F 170	E 640	D 2,304
A 53	G 192	F 682	E 2,560
B 60	A 213	G 768	F 2,730
C 64	B 240	A 853	G 3,072
D 72	C 256	B 960	A 3,413
E 80	D 288	C 1,024	B 3,840
F 85	E 320	D 1,152	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.

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).

NEGATRON.—A four-electrode valve in which a negative resistance effect is produced.

NEON STABILISER.—A special neon lamp arranged to be included across the output from a small mains battery eliminator so that it may deliver an even current when used with Q.P.P. or Class B amplification. The sudden high currents taken by the valves working on these principles result, with most mains units, in sudden voltage drops and consequent

distortion. The neon lamp, when a large current is taken, has a lower resistance, and consequently tends to even up the load on the unit.

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. It is the neon lamp which makes visible the images received by a television set.

NEPER.—Unit of level. One neper equals 8.6 decibels. (See also *Bel, Decibel, Phon, and Acoustic Watt*.)

NEUTRALISING CIRCUITS.—See *Neurodyne Circuit*.

NEUTRALISING CONDENSER. See *Neurodyne 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 "neurodyne" 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,

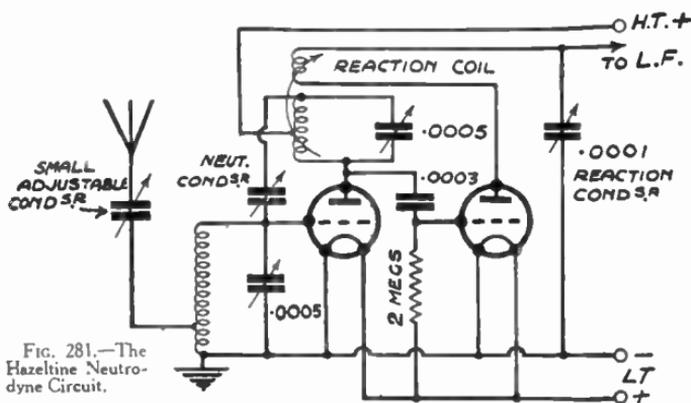


FIG. 281.—The Hazeltine Neutrodyne Circuit.

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.

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-

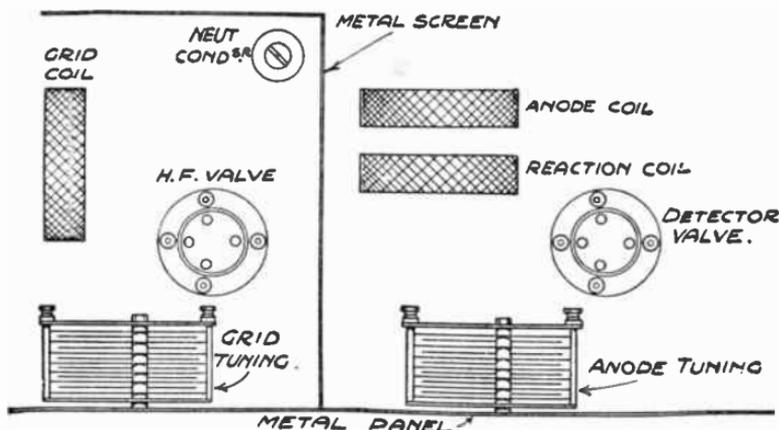


FIG. 282.—Suggested Layout for the Circuit shown in Fig. 281.

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. 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-

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

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*.)

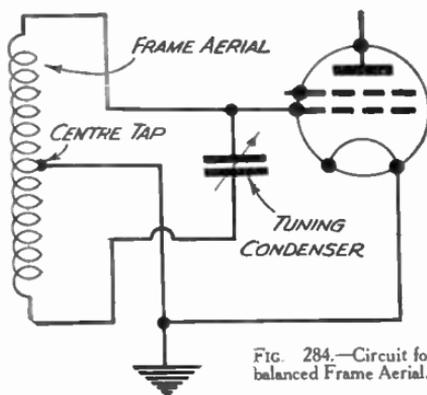


FIG. 284.—Circuit for balanced Frame Aerial.

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*, p. 6.

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

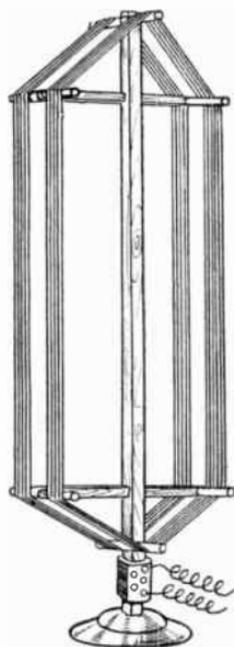


FIG. 283.—A dual-range Frame Aerial.

NOISES

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

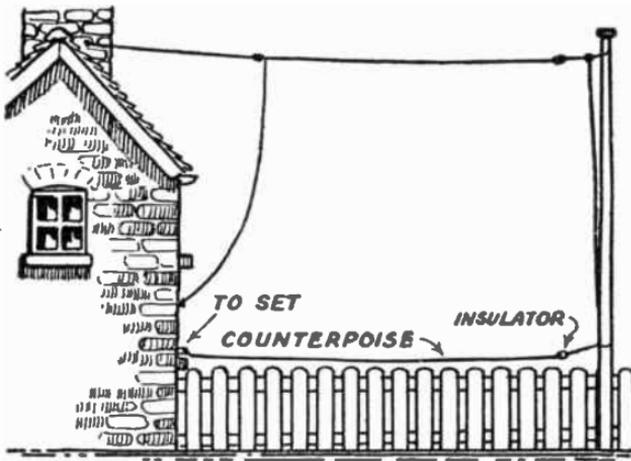


FIG. 285.—A Counterpoise Earth.

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

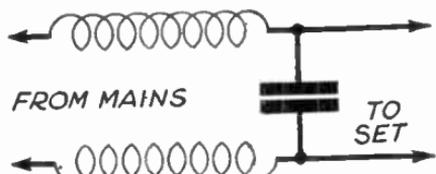


FIG. 286.—A Cure for H.F. Interference via the Mains.

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

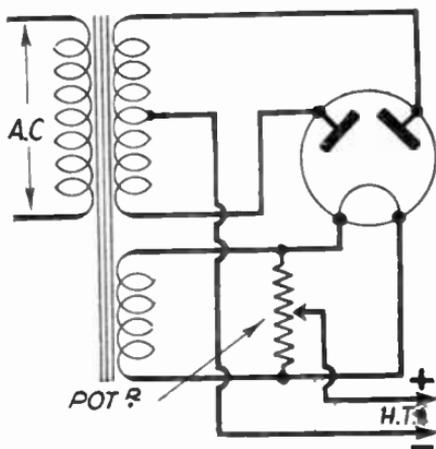


FIG. 287.—Another Cure for Mains Hum.

be of much help with an ordinary aerial.

Using a Counterpoise. The use of band-pass tuning and variable- μ

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

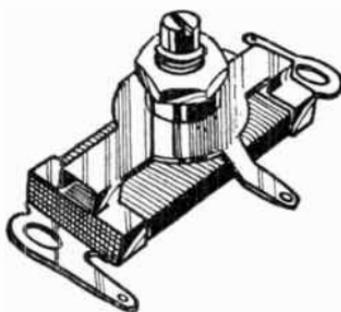


FIG. 288.—Suitable Potentiometer for eliminating Hum.

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 100-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-

NOISES, CURING

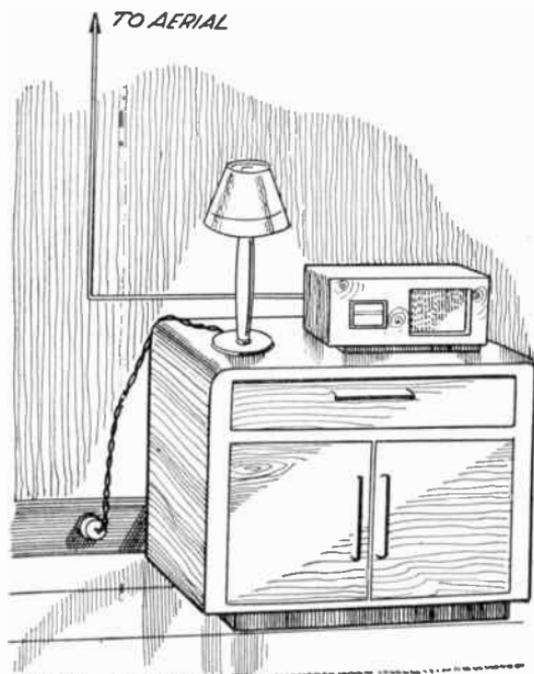


FIG. 289.—One cause of Hum is the Aerial. Earth or Speaker Leads running parallel to the Supply Mains.

rive via the aerial or the mains, such as atmospheric, 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

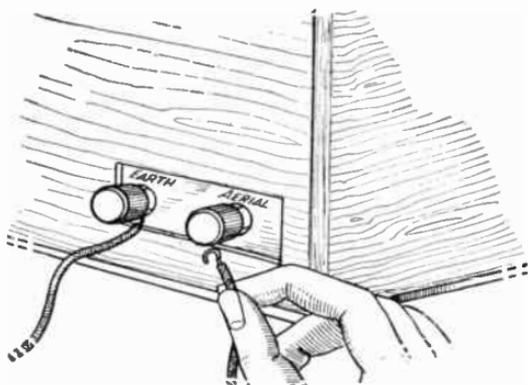


FIG. 290.—If crackling noises cease when the aerial is disconnected, this is certain proof that they are caused by atmospheric.

NOISES, CURING

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

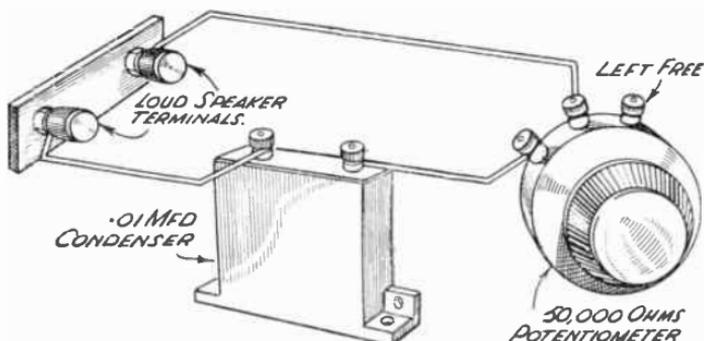


FIG. 291.—A high-note Filter—a cure for whistle, caused by heterodyning.

“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

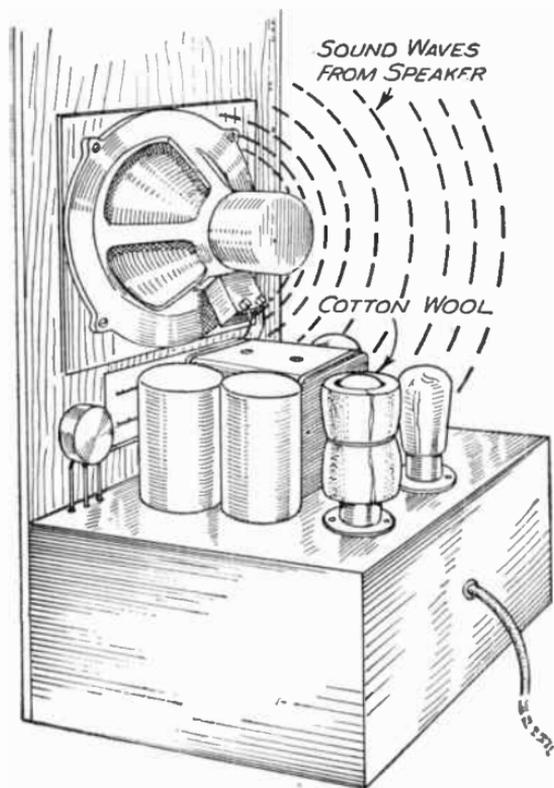


FIG. 292.—A jacket of cotton-wool round the detector valve, so as to prevent sound waves from the speaker impinging on it, will often stop a microphonic howl.

NOISES, CURING

be included, as is also shown in Fig. 297.

H.F. Oscillation. Unsuitable components, bad layout, and inadequate

UNSUPPORTED VANES

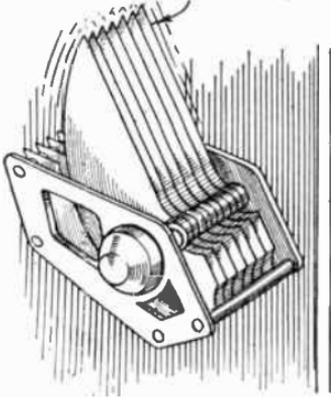


FIG. 293.—Vibrating condenser vanes may cause a microphonic howl.

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

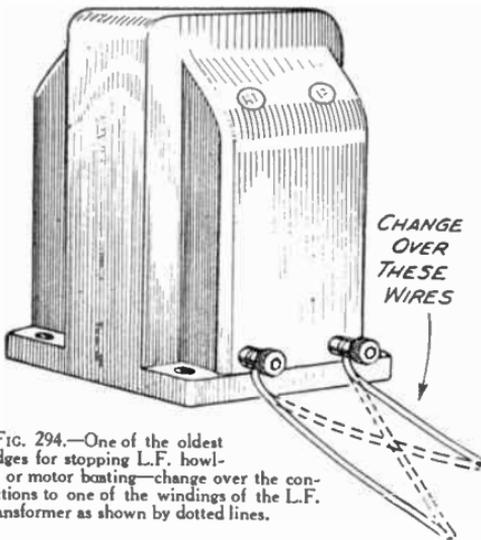


FIG. 294.—One of the oldest dodges for stopping L.F. howling or motor beating—change over the connections to one of the windings of the L.F. Transformer as shown by dotted lines.

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

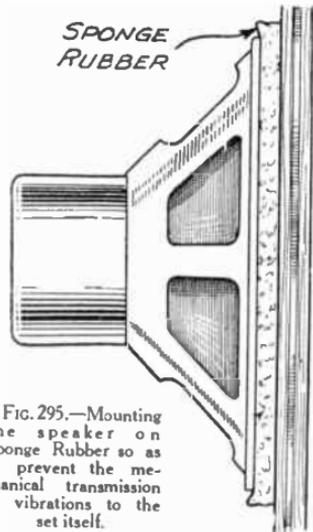


FIG. 295.—Mounting the speaker on Sponge Rubber so as to prevent the mechanical transmission of vibrations to the set itself.

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

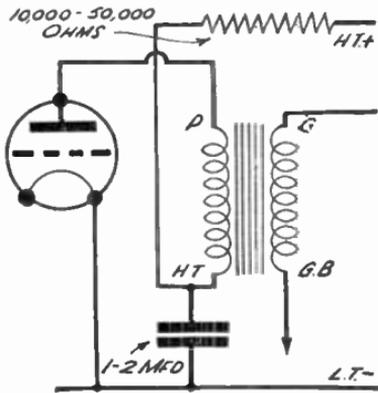


FIG. 296.—How to fit a decoupling resistance and condenser to stop motor-boating.

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,

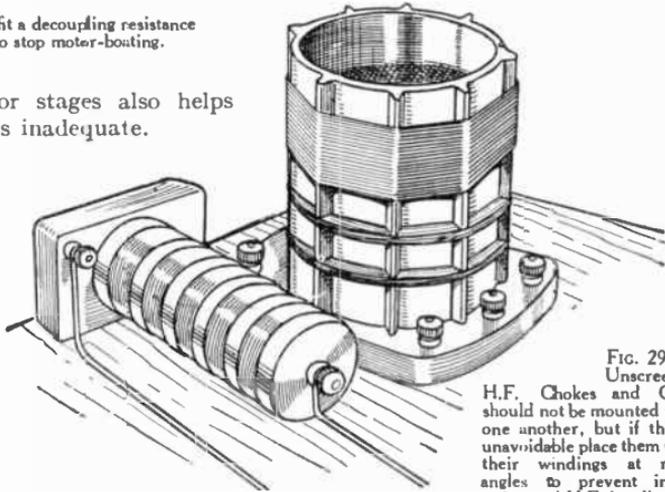


FIG. 298.—Unscreened H.F. Chokes and Coils should not be mounted near one another, but if this is unavoidable place them with their windings at right angles to prevent interaction and H.F. howling.

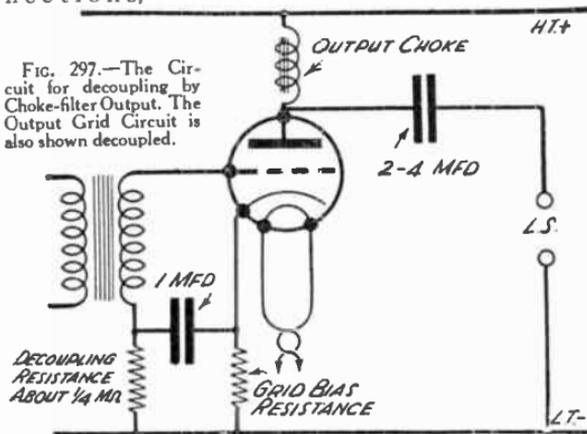


FIG. 297.—The Circuit for decoupling by Choke-filter Output. The Output Grid Circuit is also shown decoupled.

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

“burnt-out” transformer windings, and faulty resistances. If it is known definitely that the H.T. battery is the cause, the remedy is obvious, but if this is not certain, the voltmeter will give some idea. Usually, if the voltage has dropped by 25 per cent., the battery has little useful life left in it, and is more than likely to crackle. If the battery is O.K., it is quicker to test the receiver stage by stage than to try to guess the cause. Disconnect the loud-

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

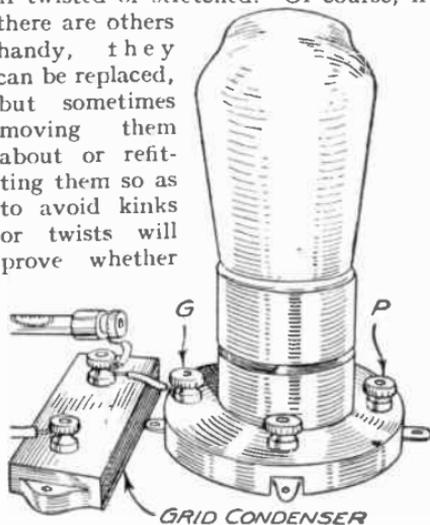


FIG. 299.—By placing the grid Condenser close to the Valve-holder the lead from Grid to Condenser is kept short—which makes for stability.

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 values 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

NOISES, CURING

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

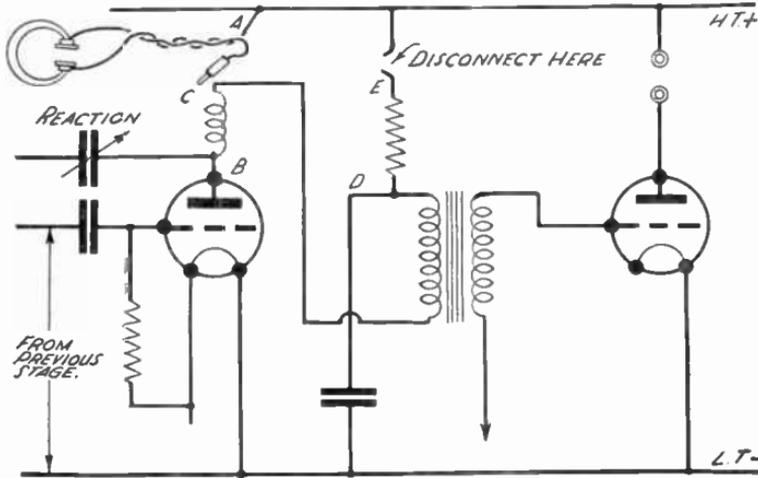


FIG. 300.—How to test for "crackling" noises. To test the H.F. and detector stages disconnect H.T. from E and join phones across A and B. To test H.F. choke as well join phones across A and C. To include transformer join them across A and D. To include decoupling resistance join across A and E.

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

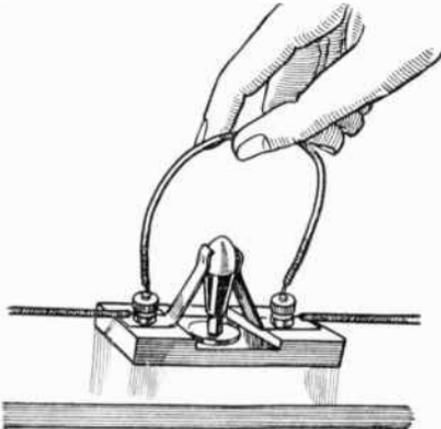


FIG. 301.—Shorting a Switch in this manner will indicate whether crackling noises are due to faulty contact.

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. Re-

dress 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.

NOMOGRAM.—An abac (which see).

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.

O

OCTODE.—A combined first detector-oscillator valve having six grids in addition to the anode and cathode. It is similar to the heptode or pentagrid except for the additional screening grid.

The two sections of the valve appear as an H.F. pentode (first detector) and a triode (oscillator).

OHM.—The unit of resistance defined by that resistance offered by a column of mercury at the tempera-

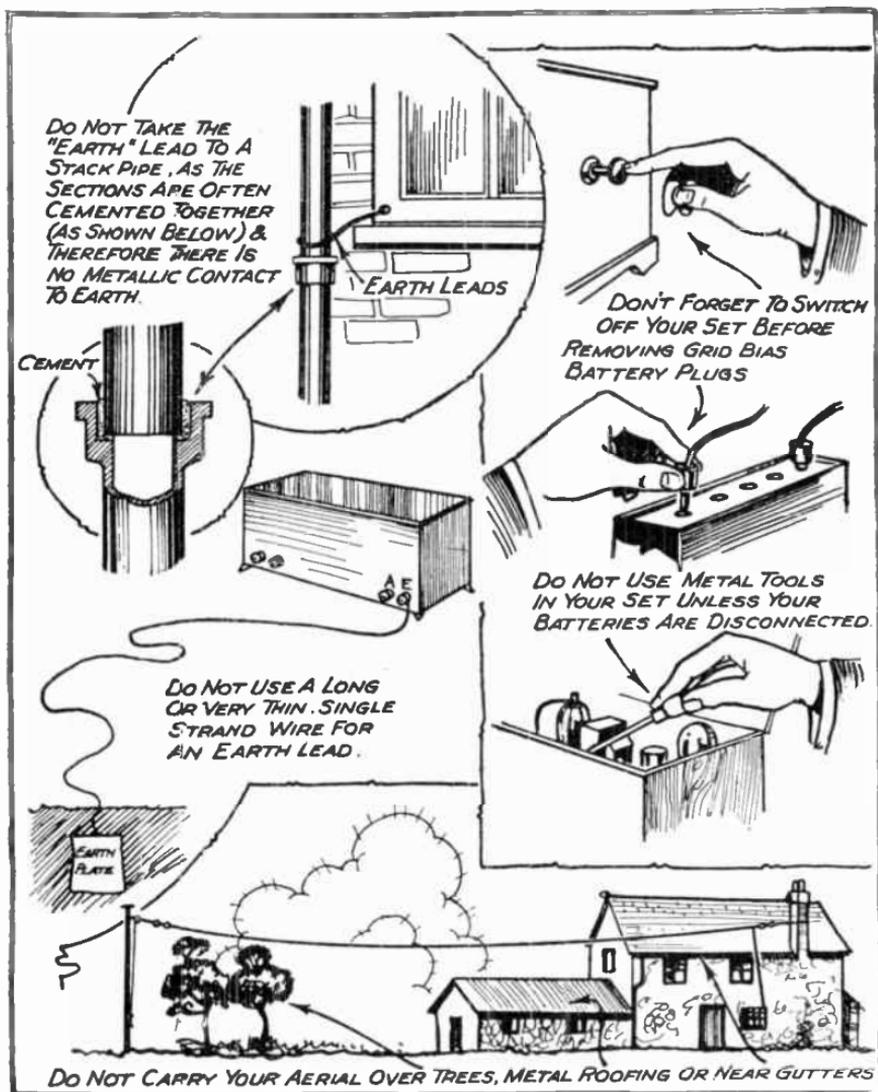


FIG. 302.—Various simple tests to apply, and causes of trouble.

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: current = voltage ÷ resistance, which is set down in mathematical form thus:

$$I = \frac{E}{R} \text{ (I being the electrical symbol)}$$

OHM'S LAW — OSCILLATORY CIRCUIT

for current, E the symbol for voltage, 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 mea-

only, the formula is: $I = 2\pi f c E$, or $E = \frac{I}{2\pi f C}$.

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 of cycles a second.

OSCILLATOR.—An instrument for generating radio frequencies for test purposes. It consists essentially of an oscillating valve in a coil-condenser circuit which can be tuned over a band of frequencies or wavelengths. The generated signal can be used in place of a normal broadcast signal for checking receiver performance, for locating faults, and for accurate adjustment of trimmers.

OSCILLATOR COIL.—Two coils of wire (one of which is tuned) coupled together and connected respectively in the grid and anode circuits of the oscillator portion of the frequency-changing valve of a superhet. (See also *Coils*.)

OSCILLATORY CIRCUIT.—Any circuit having inductance and capacity.

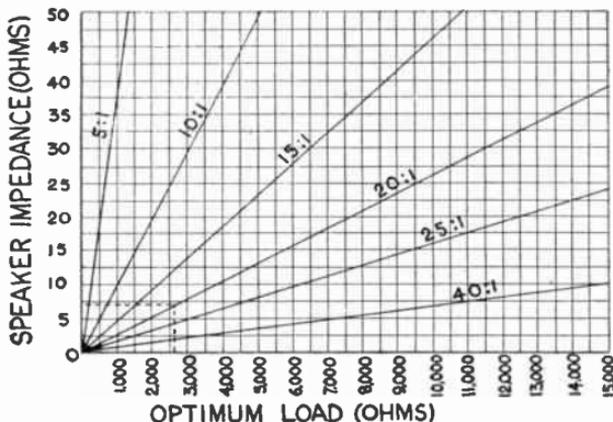


FIG. 303.—Graph for Moving-coil Speaker.

surements, 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 ohms, and this results in a current of 2 amps.

$$\text{Current} = \frac{6}{3} = 2 \text{ amps.}$$

$$\text{Resistance} = \frac{6}{2} = 3 \text{ ohms.}$$

$$\text{Voltage} = 2 \times 3 = 6 \text{ volts.}$$

OHM'S LAW FOR A.C.—Circuits having inductance: $I = \frac{E}{2\pi f L}$. Ohm's law for an A.C. circuit having inductance and resistance: $I = \frac{V}{\sqrt{R^2 + (2\pi f L)^2}}$. For A.C. circuits having capacity

OSCILLOGRAM — OUTPUT STAGE

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 Tube.*)

OSCILLOTRON.—Another name for Oscillograph.

OUTPUT STAGE.—It is a prevalent idea that an improvement follows the fitting of a new speaker. Any will function with an efficient receiver *provided that it is connected in a suitable manner.* 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 mathematically, 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 2,600 ohms. The correct transformer ratio would be $\sqrt{\frac{2,600}{7}}$ 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

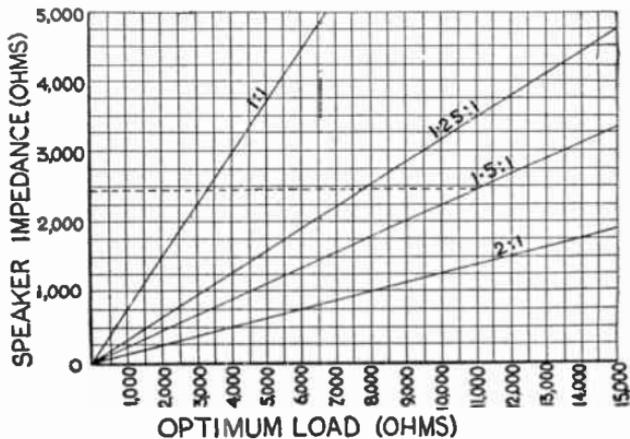


FIG. 304.—Graph for Moving-iron Speaker.

have been prepared. To use these, first 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

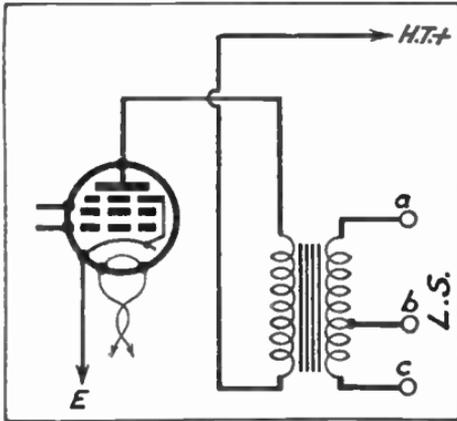


FIG. 305.—Transformer Output.

transformer ratio should therefore be $\sqrt{\frac{5,600}{2,400}}$, 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 tappings 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 — PERMEABILITY TUNING

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.

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 indicates the correct ratio.

If two speakers are connected in parallel, the effective impedance is halved; in series it is doubled.

P

PAPER CONDENSER.—A fixed condenser having a dielectric of paraffin-waxed paper. (See also *Condenser, Variable Condenser, Mansbridge Condenser, Billi Condenser, etc.*)

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.*

PARAMAGNETIC.—Having the property of being attracted by the pole of a magnet, and hence, when suspended or placed freely in a magnetic field, of taking a position parallel to the lines of force. Opposite to *Diamagnetic* (which see).

PARAPHASE.—A special form of push-pull amplification in which the usual centre-tapped transformer is not used. A second input voltage 180° out of phase with the normal input voltage is obtained by means of a paraphasing valve. The grid is connected in the anode circuit of the valve preceding the push-pull stage.

P.D.—Potential Difference. The pressure in volts existing between two

parts of a circuit.

PELTIER EFFECT.—The term applied to the effect where liberation (or absorption) of heat takes place at the joint where current passes from one material to another.

PENTAGRID.—The American term for a 7-electrode valve or Heptode. The electrodes consist of cathode, anode, and five grids, and the combination is designed to function as a

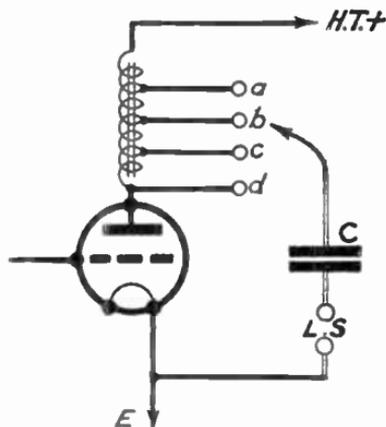


FIG. 306.—Choke-capacity Output.

combined first detector and oscillator in a super-heterodyne receiver. The coupling exists only as an electronic stream. One grid and the anode act as in the ordinary first detector, whilst the remaining grids are employed as oscillator grid and oscillator anode and screening grid.

PENTODE.—The five-electrode valve. (See also *Valve.*)

PERIKON DETECTOR.—A crystal detector consisting of zincite in contact with copper pyrites.

PERMEABILITY (symbol μ) is the ratio of magnetic flux produced by a magnetic force to the magnetic flux produced by the same force in a vacuum. (See also *Iron-core Coil.*)

PERMEABILITY TUNING.—An arrangement where the usual tuning condenser is omitted, and tuning is

PERMEABILITY TUNING — PHOTO-ELECTRIC CELL

carried out by varying the inductance of the coil. This is effected by employing an iron-core and moving either the core or the coil in relation to each other. Constant selectivity is obtained by such a scheme, and efficiency does not fall off in the circuit at high wavelengths due to the

Phons—

- 130—Threshold of feeling or pain.
- 110-120—Vicinity of aeroplane engine.
- 105-110—Vicinity of pneumatic drill.
- 100-105—Vicinity of loud motor horn.
- 90-95—Interior of tube train, windows open.
- 80-85—Interior of express train, windows open.
- 60-75—Conversation (average to loud).
- 40-50—Quiet street.
- 20-30—Quiet country house.
- 0—Threshold of audibility.

(See also *Bel*, *Decibel*, *Neper*, and *Acoustic Watt*.)

PHONES.— 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 operates a neon lamp.

PHOTO - ELEC-

TRIC 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

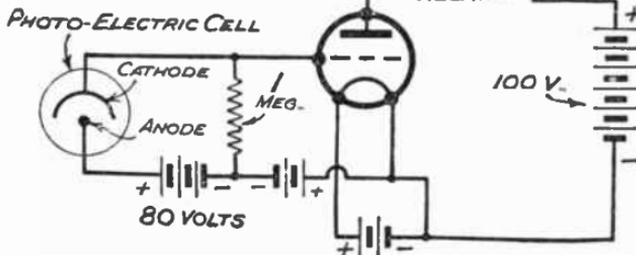


FIG. 307.—The standard method of connecting the Photo-electric Cell.

use of small inductance and high capacity as in the usual arrangement.

PERMEANCE.—The reciprocal of reluctance (which see).

PERMITTIVITY.—The ratio between the capacitance of two conductors, when surrounded by the medium, to the capacitance in a perfect vacuum.

PHASE.—The difference between two identical oscillating currents at any instant is known as the phase difference. If one oscillating current is at zero and another is at maximum, the phase difference is 90° . If both currents are at the same value, they are in phase.

PHASE DIFFERENCE.—The time difference between maximum voltage and maximum current in A.C.

PHASMAJECTOR.—An image emitter providing a standard video signal source to aid television experiments. Actually a "television tuning-in" signal emitter.

PHON.—The unit of loudness arrived at by the Ministry of Transport. Some idea of the phon can perhaps be obtained from this noise chart:

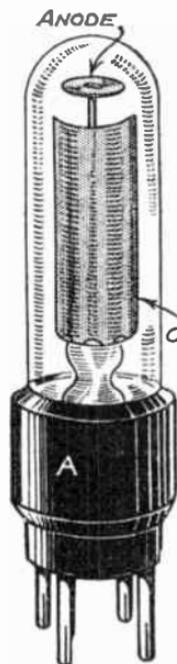


FIG. 308.—The Photo-electric Cell, showing the shape of the Electrodes.

PHOTO-ELECTRIC CELL

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

may be mentioned burglar alarms, switching lights on or off at predetermined times, or giving warning of the arrival of a customer in a shop.

One or two suggestions may be

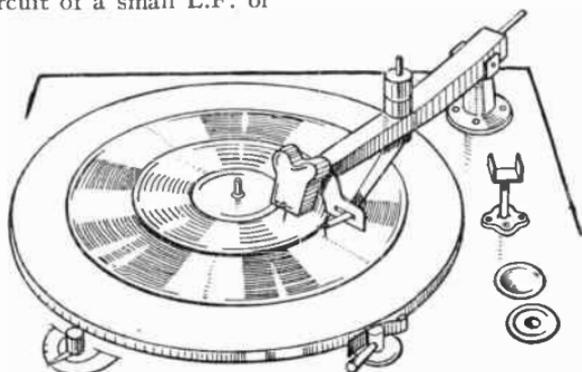


FIG. 309.—The Recorder in process of cutting a Record.

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 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

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, 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

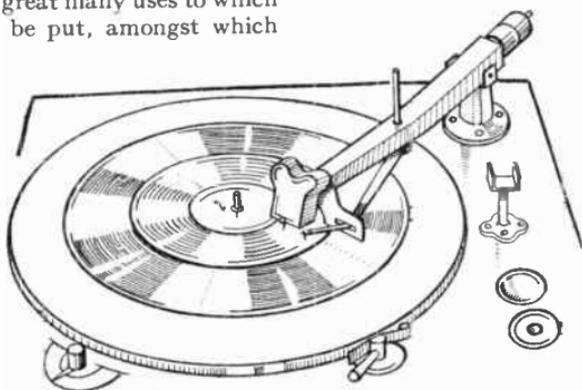


FIG. 310.—The Recorder as a reproducer. The Tracking Arm is out of action, and weights are placed on the back of the arm.

PICK-UP, RECORDING

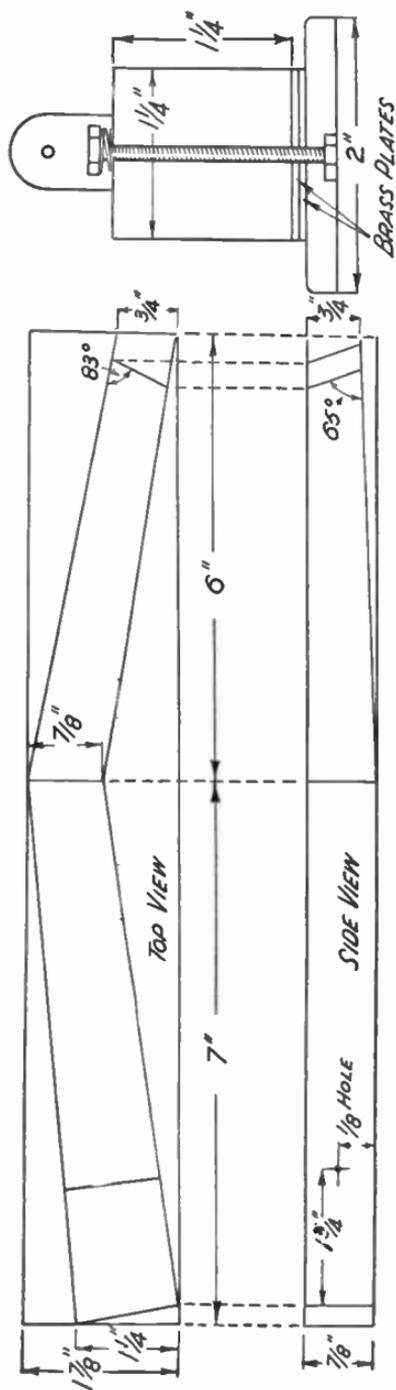


FIG. 311.—Showing how to work and cut the wood for the pick-up arm.

FIG. 312.—Section of the Pivot and Base

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 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.

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 $\frac{1}{8}$ 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

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 $\frac{1}{16}$ in. deep to hold the flex lead to the pick-up. Drill a $\frac{1}{8}$ -in. hole horizontally through the arm $1\frac{3}{8}$ in. from the wider end and $\frac{1}{2}$ in. from the bottom.

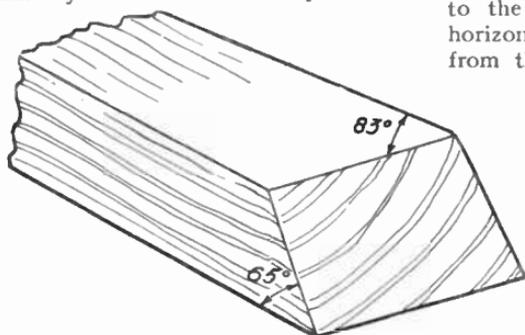


FIG. 313.—The end of the arm is cut as shown here.

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 $1\frac{7}{8} \times \frac{7}{8}$ -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 $\frac{7}{8}$ in. to $\frac{3}{4}$ in. from the

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 $\frac{1}{4}$ -in. oak for the base and drill a $\frac{3}{16}$ -in. hole through the centre. Also drill three equidistant $\frac{1}{8}$ -in. holes around the edge of the base about $\frac{3}{16}$ in. in.

Now obtain a round piece of oak or other hardwood for the pillar, $1\frac{1}{4}$ in. in diameter, and $1\frac{1}{4}$ in. long. Drill a $\frac{3}{16}$ -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 18 gauge sheet brass, using a coarse metal fret-saw for the job. Drill $\frac{3}{16}$ -in. holes through the centre of each of these, and a $1\frac{1}{4}$ -in. hole 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

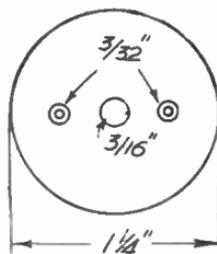


FIG. 314.—Bearing Discs for the pick-up.

two $\frac{3}{16}$ -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

PICK-UP, RECORDING

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

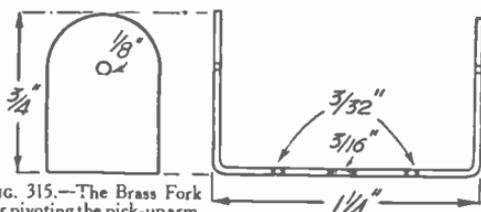


FIG. 315.—The Brass Fork for pivoting the pick-up arm.

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 $\frac{3}{32}$ -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 hacksaw 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 $\frac{3}{32}$ -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

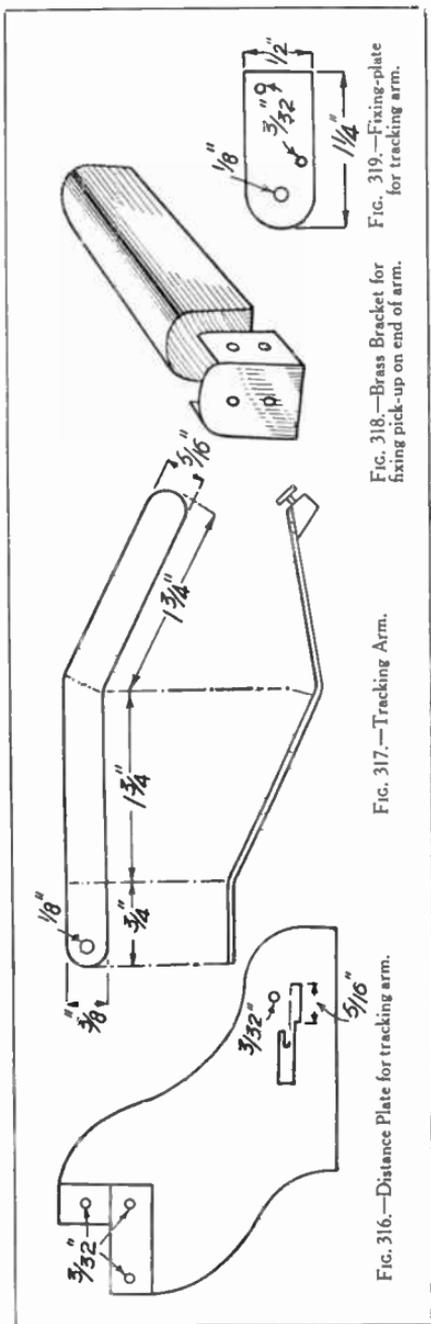
PICK-UP, RECORDING

recorder is being used for reproducing purposes.

The cam is cut from 13 gauge brass and a $\frac{3}{32}$ -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 $\frac{1}{16}$ -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 $\frac{3}{8}$ -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



PICK-UP, RECORDING

$\frac{1}{8}$ -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

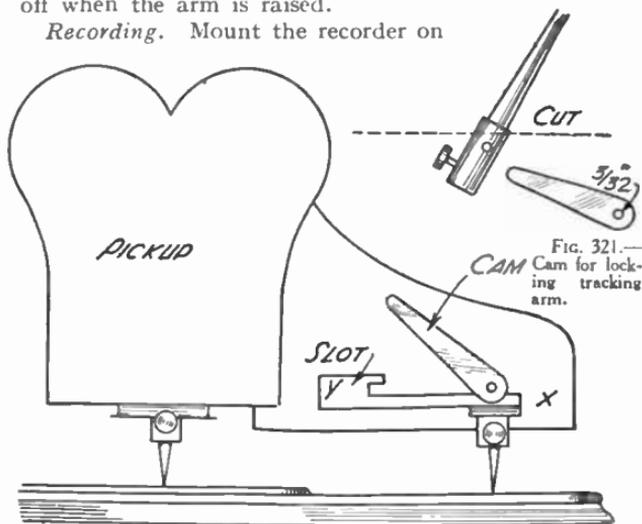


FIG. 320.—Diagram showing relative positions of Cutting and Tracking Needles.

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

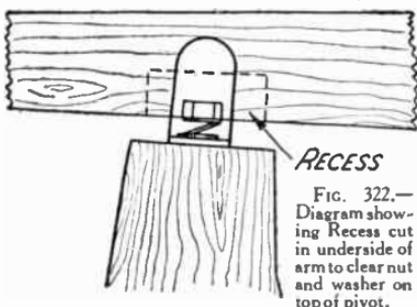


FIG. 322.—Diagram showing Recess cut in underside of arm to clear nut and washer on top of pivot.

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

PICK-UP, RECORDING — PLUG

$\frac{1}{8}$ 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.

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.

To make personal records, a microphone of some kind is necessary. 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.

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.

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.

PIEZO-ELECTRICITY.—The property possessed by certain substances of forming electric voltages on opposing surfaces when subjected to mechanical pressure. These voltages are of opposing kinds, giving rise to differences of potential. The best known piezo-electric substances are

quartz and Rochelle salt crystals. The latter are now widely used in microphones, pick-ups, and speakers. The principle forms the fundamental basis of the Stenode (which see). (See also *Bimorph*.)

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.

PLANTÉ 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

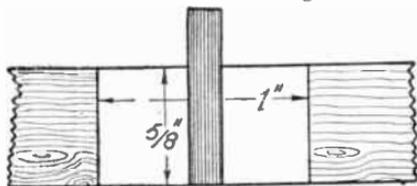


FIG. 323.—The Mould for casting the weights.

quickly to be completed or broken.

Briefly the uses of plugs and jacks are as follows:

- (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

PLUG

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-

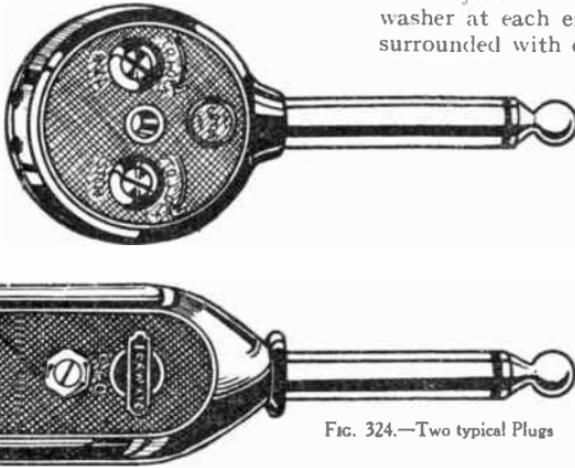


FIG. 324.—Two typical Plugs

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

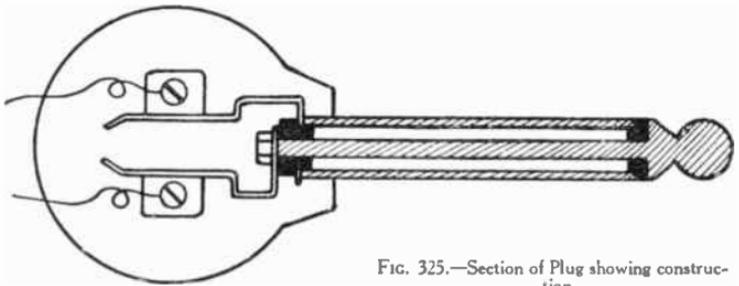


FIG. 325.—Section of Plug showing construction.

according 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

PLUG

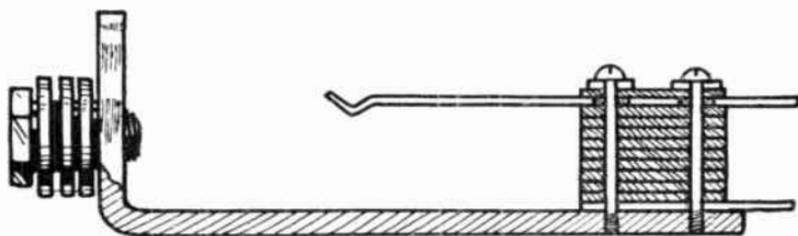


FIG. 326.—Details of Single-circuit Jack.

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. This is the simplest switching operation possible with a plug and jack.

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

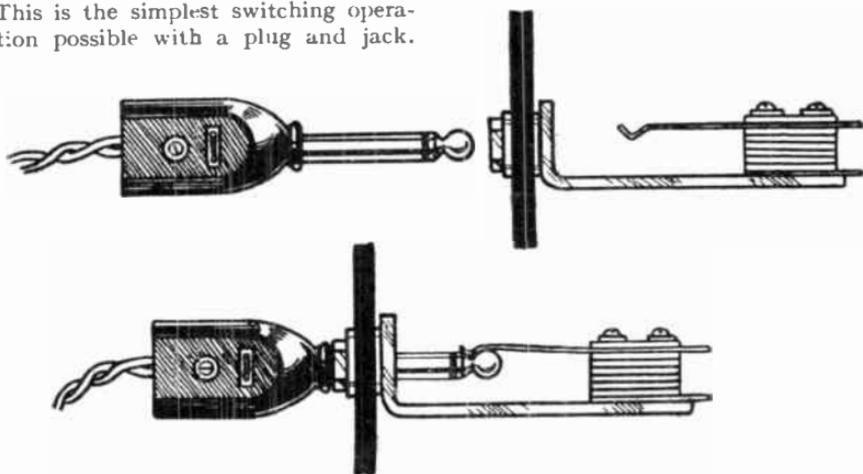


FIG. 327.—How the Plug and Jack connect.

PLUG

against which the lower spring presses when it is forced upwards by the ball ;

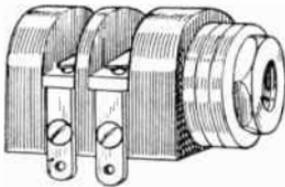


FIG. 328.—A Midget Jack for use in H.F. circuits.

the lower spring because the fibre peg is an insulator, but it does connect with the upper one which has

thus the middle spring is also bent upward. It does not actually make contact with

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.

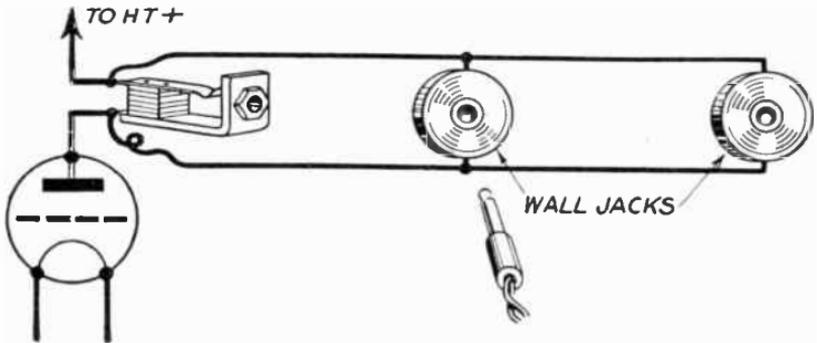


FIG. 329.—Speaker Points can be arranged in different rooms by means of Wall Jacks.

a special silver contact for the purpose.

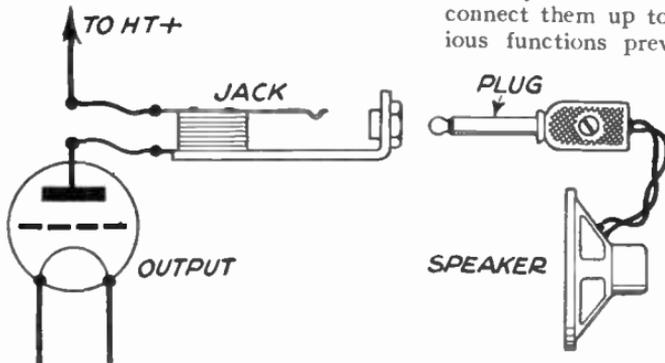


FIG. 330.—Plugging-in the Speaker.

Various Circuits. Now consider what jacks to use, and how to connect them up to perform the various functions previous 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."

Other Types. The type of jack previously described with its metal

on your receiver, you use a single open circuit jack. The two wires

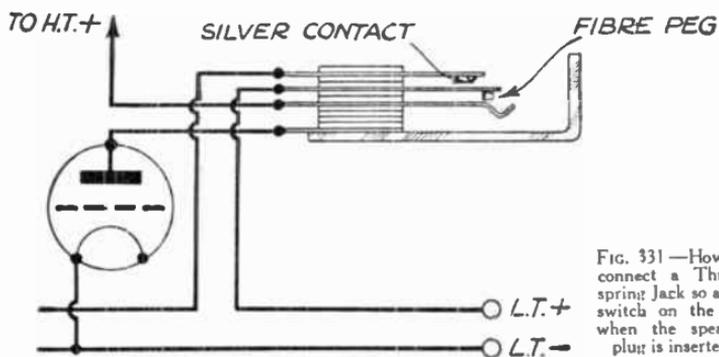


FIG. 331.—How to connect a Three-spring Jack so as to switch on the set when the speaker plug is inserted.

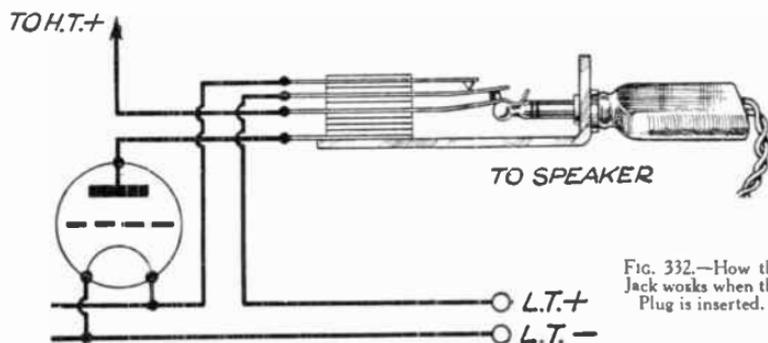


FIG. 332.—How the Jack works when the Plug is inserted.

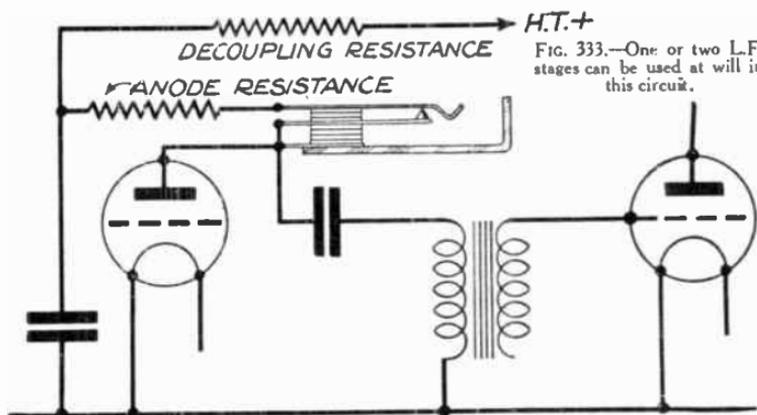


FIG. 333.—One or two L.F. stages can be used at will in this circuit.

PLUG

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-

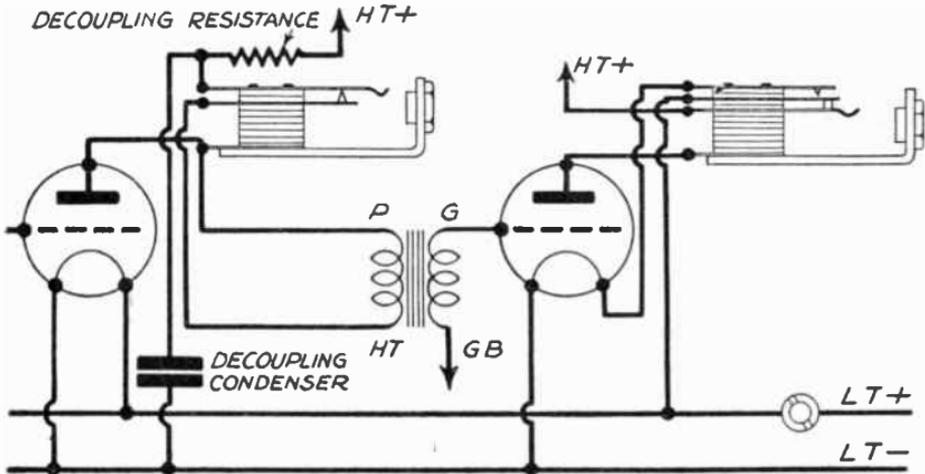


FIG. 334.—The modification necessary to the circuit in Fig. 340 when parallel-fed is used.

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-

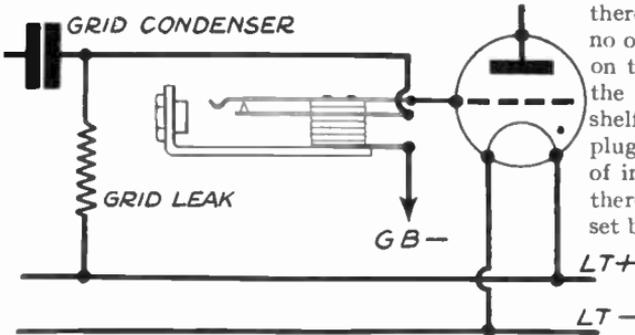


FIG. 335.—An easy way to plug in the Pick-up to the Detector Valve of a battery set.

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

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

jack which is used has previously been described, and a further study of the illustrations should make the connections quite clear. The two

PLUG

upper springs are connected to the wires which normally go to the filament switch, and the lower spring and

on the left, that is, the one in the plate circuit of the first L.F. valve, is of the single, closed-circuit type.

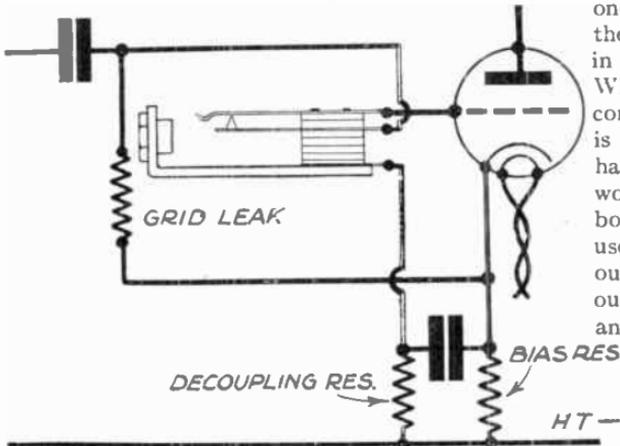


FIG. 336.—The mains version of Fig. 335. Note grid bias is cut out when the radio is in use.

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

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 ball and the frame

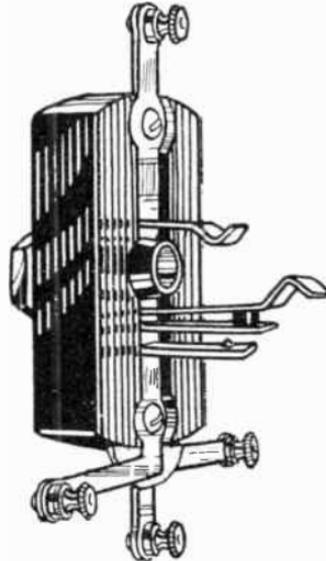


FIG. 337.—A Two-circuit Jack.

with the stem of the plug. The raising of the upper spring causes it to break

PLUG — POLAR FLUX

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 in 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 plate voltage, and so get distortion owing to insufficient bias. However, automatic adjustment of bias *can* be arranged by using a five-spring jack.

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 simple 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 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.

P.M.G. AERIAL.—The maximum length of outdoor aerial permitted by the Postmaster-General is 100 ft., inclusive of lead-in.

POLAR FLUX. — The magnetic field of an electric generator. The magnetic flux produced by the poles thereof.

POLARISATION.—A term indicating the changing of the polarity due to bubbles of hydrogen forming on the positive plate. The internal resistance of the cell increases during this action.

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.—Blotting paper impregnated with neutral salt of sodium and a trace of phenol phthalein. The paper is moistened and the two wires laid on it, when the area in contact with the negative pole turns red.

POLE STRENGTH, UNIT OF.—See *Weber*.

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

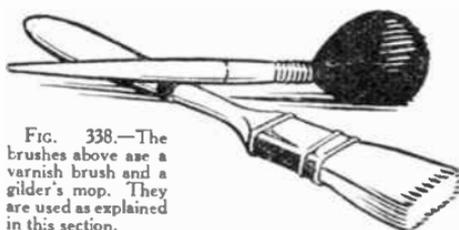


FIG. 338.—The brushes above are a varnish brush and a gilder's mop. They are used as explained in this section.

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

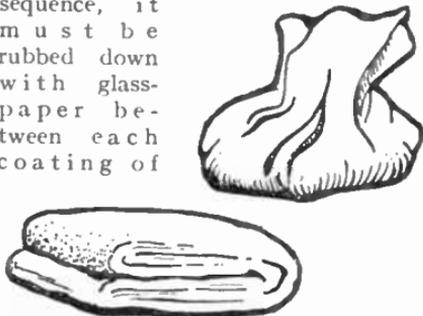


FIG. 339.—The pad below is of wadding or similar absorbent substance—to be used as a polisher. It is wrapped in linen to the shape shown by the upper drawing.

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

POLISHING AND STAINING

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

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 amateur, however, is confined to darkening the actual woods in their natural shades.

Wax Polishing. A special polishing process, as its name implies, in

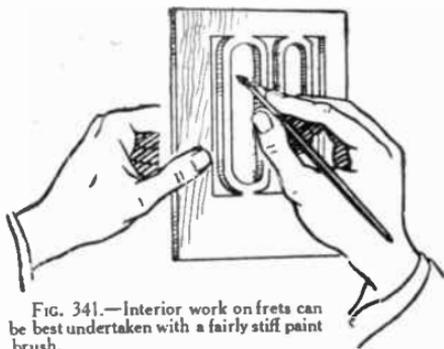


FIG. 341.—Interior work on frets can be best undertaken with a fairly stiff paint brush.

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

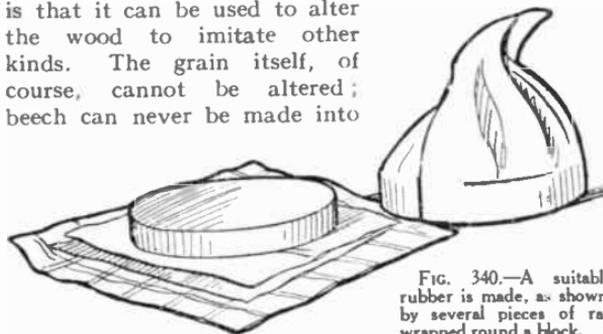


FIG. 340.—A suitable rubber is made, as shown, by several pieces of rag wrapped round a block.

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

POLISHING AND STAINING

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.

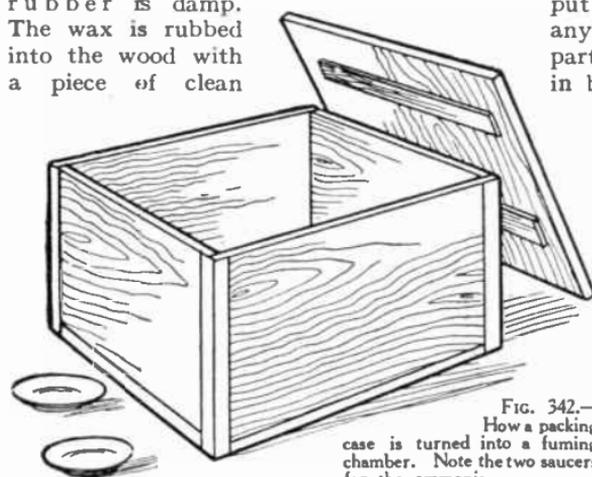


FIG. 342.—How a packing case is turned into a fuming chamber. Note the two saucers for the ammonia.

rag, and applied evenly over the whole surface. See that a level surface and coating is maintained—the actual direction of the rubbing does not matter greatly. The great thing in wax polishing is great pressure, for only by hard rubbing is a good surface obtained.

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,

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

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.

POLISHING AND STAINING

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 of 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

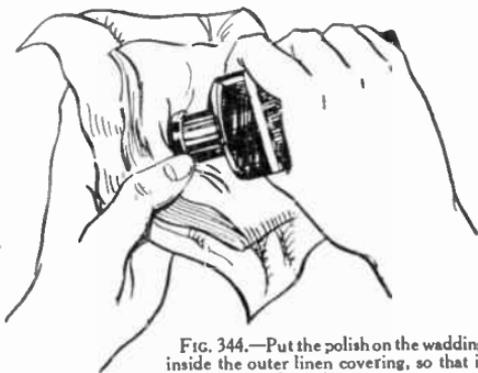


FIG. 344.—Put the polish on the wadding inside the outer linen covering, so that it just squeezes through.

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

POLISHING AND STAINING

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

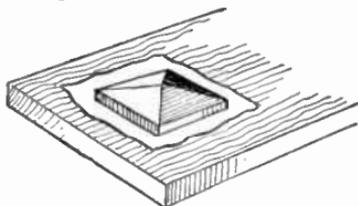


FIG. 346.—An ornament is glued to a piece of paper on a board when polishing.

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

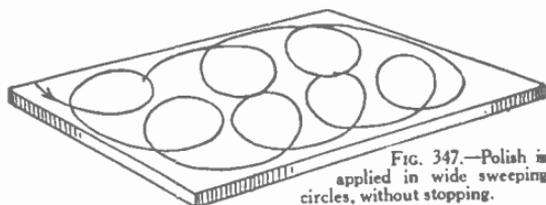


FIG. 347.—Polish is applied in wide sweeping circles, without stopping.

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-

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 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

POLISHING AND STAINING — POTENTIOMETER

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).

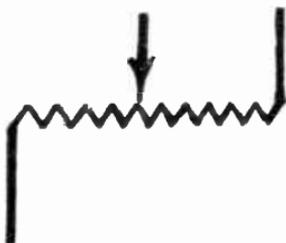


FIG. 348.—A Potentiometer shown theoretically

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.

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*.

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

POUNDAL — PUSH-BUTTON TUNING

be confused with an ordinary rheostat or resistance, for it is shunted 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. (centimetre-gramme-second) units 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 mfd. and .25 megohm. The detector circuit is standard, except for these latter values.

POWER LEVEL. — See *Decibel* and *Phon*.

PRESSPAHN. — A proprietary insulating material manufactured from wood fibre.

PRIMARY CELL. — A cell of the bichromate, Bunsen, Daniell, 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 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 an electric current.

PRIMARY CIRCUIT. — Any circuit which supplies current to another.

PROTON. — The positive electric charge in an atom; this is neutralised by the negative ions. The fundamental unit of positive electricity. Its mass = 1.66×10^{-24} grammes.

PULSATOR. — An interrupter or buzzer. (See *Interrupter* and *Buzzer*.)

PUSH-BUTTON TUNING. — A system wherein station selection is

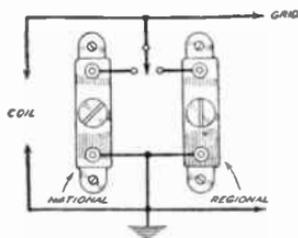


FIG. 349A. — Selecting preset condensers, by means of a change-over switch, for automatic tuning.

accomplished by pushing button indicators instead of turning a tuning condenser. There are two systems, one of which causes fixed condensers

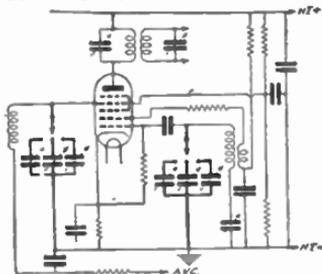


FIG. 349B. — In a modern superhet two tuned circuits may be automatically switched by using two or more presets on the lines shown in Fig. 349A.

PUSH-PULL CIRCUIT — QUENCHING COILS

to be included in the circuit and thus to tune to the desired station, and that in which an electric motor is set in motion when the button is pushed. This motor rotates the tuning condenser and it is automatically stopped

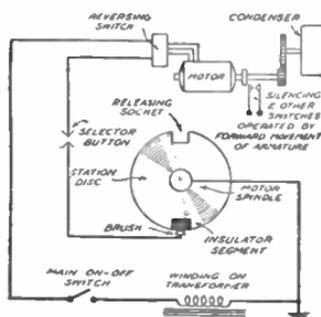


FIG. 349c.—Some forms of automatic tuners are motor driven, the basic principle being as shown here.

at a predetermined setting. A large number of buttons may be used and provided with name plates for the most easily received stations on the receiver. The circuit may be fitted with A.F.C. to overcome any slight loss introduced by the motor failing to turn the condenser to the exact setting. (See Figs. 349A, B, and c.)

PUSH-PULL CIRCUIT.—Fig. 349d shows that the coupling of the penultimate stage is by transformer, the

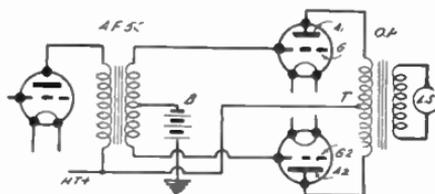


FIG. 349d.—Diagram explaining the Push-pull Circuit.

secondary of which feeds the grids of two power valves, G1 and G2, in opposite phase, *i.e.* when the one swings positive the other is negative. 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 G1 and G2 alike. The anodes of the valves A1 and A2 connect to the terminals of the primary of the transformer, and the H.T. is supplied by centre tapping T.

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; and the transformer core is normally without field. Under these conditions the effective inductance is about double or treble. This results in the 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.

Thirdly, distortion is very greatly reduced; the valves being in opposite phase result in the two correcting one another.

Two valves coupled in push-pull will give far more output. (See also *Class A*, *Class B*, and *Class AB*.)

PYRITES.—Mineral disulphide of iron. Chemical formula FeS_2 .

PYRON DETECTOR.—An iron pyrites crystal. A copper cat's whisker should be used in connection with it.

Q

Q CODE.—See abbreviations, p. vii.

Q.A.V.C.—Quiet Automatic Volume Control (which see).

Q.M.B.—Quick make and break.

Q.P.P.—See *Quiescent Push-pull*.

Q.S.A. CODE.—See abbreviations, p. vii.

QUENCHING COILS.—These are used in super-regenerative receivers for the purpose of providing the "quenching" oscillations which combine with the signal-frequency oscillations to produce the regenerative effect. The quenching coils can either be included in the grid and anode cir-

QUIESCENT PUSH-PULL — RECTIFICATION

cuits of the signal-frequency valve (when the circuit includes a single valve) or in the circuits of a quenching valve when two are used.

QUIESCENT PUSH-PULL. — A form of push-pull amplifications characterised in that instead of biasing the two valves at the middle portion of their curves the bias applied is approximately twice that normally required. This brings the standing anode current down to nearly zero, and the arrival of a signal causes an increase in anode current. When the two valves are correctly chosen the standing current is only of the order of one or two milliamps., and this rises on a loud signal to 15 to 20 m/A. The current varies according to the type and volume of music received. Best results are obtained with two pentodes.

QUIET A.V.C.—Also referred to as "Squelch" (which see) and "Noise Suppression." An additional valve which renders the L.F. amplifier inoperative on signals below some predetermined strength. The valve is referred to as a "Q.A.V.C." or "Squelch" valve because of its function, and it works by applying an excessive G.B. negative voltage to the grids of the L.F. valves until a signal of "programme" strength is tuned in. (See also *Delayed A.V.C.* and *Automatic Volume Control.*)

R

R CODE.—See abbreviations, p. vii.

RADIOACTIVE.—A term applicable to substances like radium, which unceasingly emit helium nuclei (X-rays), which carry a positive charge.

RADIO FREQUENCIES. — Frequencies above audio frequencies; any frequency over 20,000 cycles per sec.

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.

RADIOSONDAGE.—System of testing temperature and pressure at high altitudes, by sending up small balloons to each of which is attached a tiny short-wave transmitter, which transmits back to earth every change of the thermometer and barometer. The balloon bursts at a certain altitude, and as the equipment falls a parachute attached opens and brings the equipment safely to the ground. They drop from a height of about 7 miles.

RASTER.—The rectangular picture area built up by the scanning spot on the end of the cathode-ray tube.

RATIO OF TRANSFORMATION. —The ratio between the number of turns in the primary and the secondary of a transformer.

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). The reactance of a condenser is found from the

formula: $\frac{1}{2\pi fC}$ ohms, where C is capacity in farads and f=frequency.

REACTION CHOKE.—A coil of wire used to prevent the passage of H.F. current into the L.F. amplifier so that it can be used as feed-back (reaction) to the grid circuit. (See also *Chokes* and *High-frequency Chokes* for constructional details.)

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.

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

REMOTE CONTROL BY RELAY

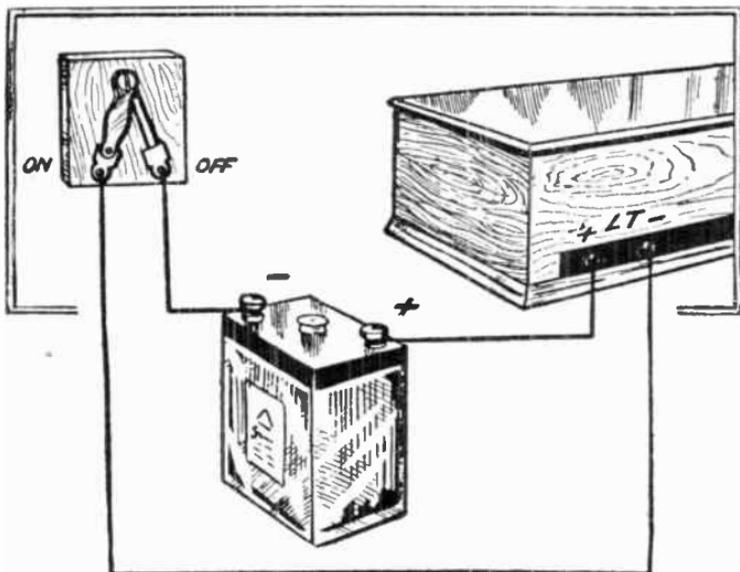


FIG. 351.—The method of Wiring-up when the Loudspeaker is in one room and the Receiver in another.

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

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-

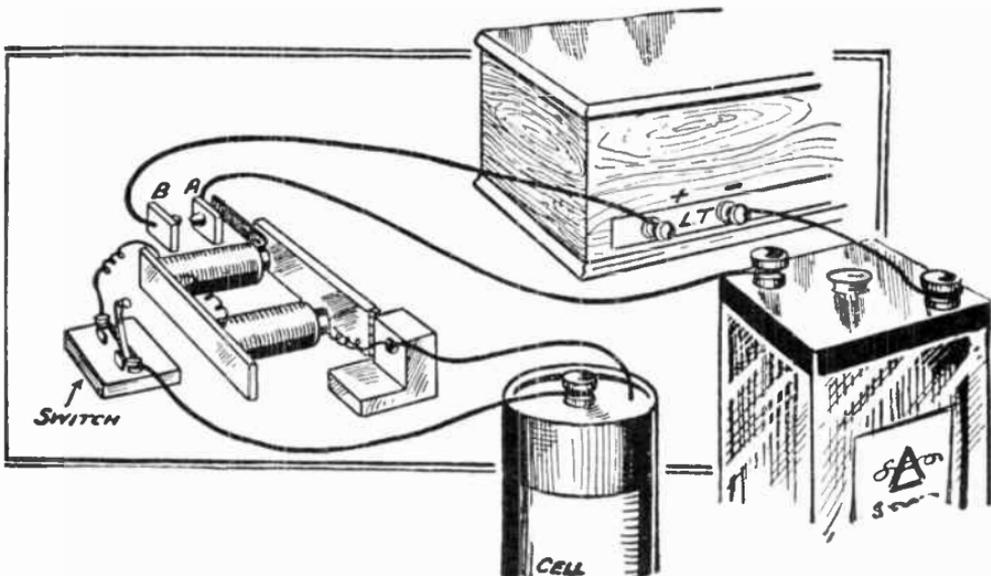


FIG. 352.—A Relay which consists of the Magnets and Armature of an electric bell.

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 mag-

nets 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-

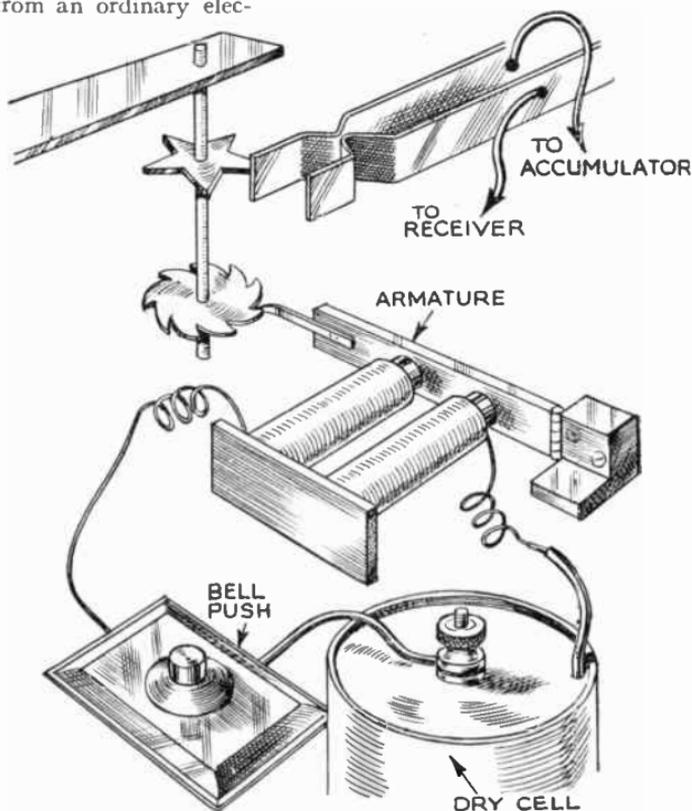


FIG. 353.—A more ambitious scheme for a Relay.

itious 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.

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

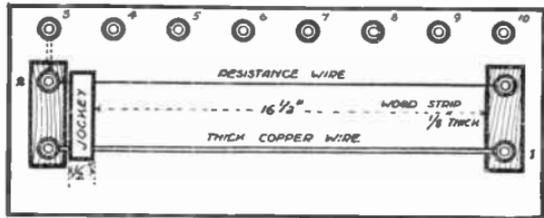


FIG. 355.—A plan view of the Box.

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.

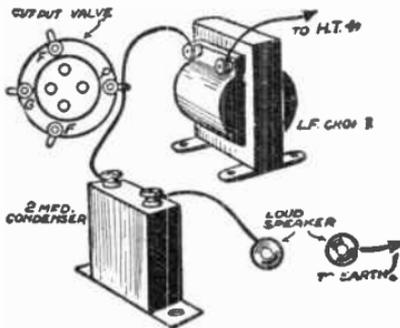


FIG. 354.—The Filter Output Circuit. See also Fig. 191.

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,

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. × 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

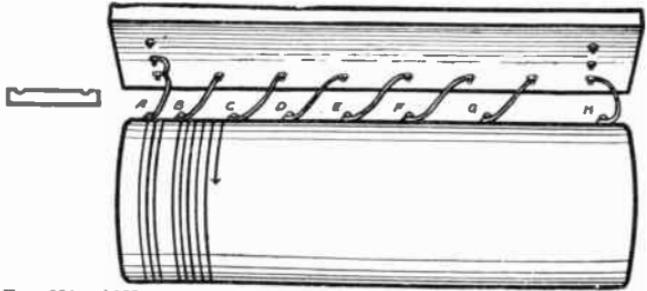
resistance wire must be bared by having the whole of its silk covering stripped off. Now mount a second pair of terminals an inch away from these, and between them stretch a piece of thick copper wire (about $\frac{1}{16}$ in. thick). This, too, must be bared. All terminals must be raised $\frac{1}{8}$ 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 $\frac{1}{16}$ 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

RESISTANCE BOX — RESISTANCE CALCULATIONS

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. (See also *Ohm's Law*.)

$$\text{Voltage} = \text{current} \times \text{resistance} \\ \text{or } (E = I \times R).$$

$$\text{Resistance} = \frac{\text{voltage}}{\text{Current}}$$

$$\text{or } \left(R = \frac{E}{I} \right)$$

$$\text{Current} = \frac{\text{voltage}}{\text{resistance}}$$

$$\text{or } \left(I = \frac{E}{R} \right)$$

$$\text{Wattage} = \text{voltage} \times \text{current} \\ \text{or } (W = E \times I).$$

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)

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 occur. Another re-

“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.

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 over-all gain of from two-thirds to five-sixths of the valve's amplification factor. Thus, if a valve has an

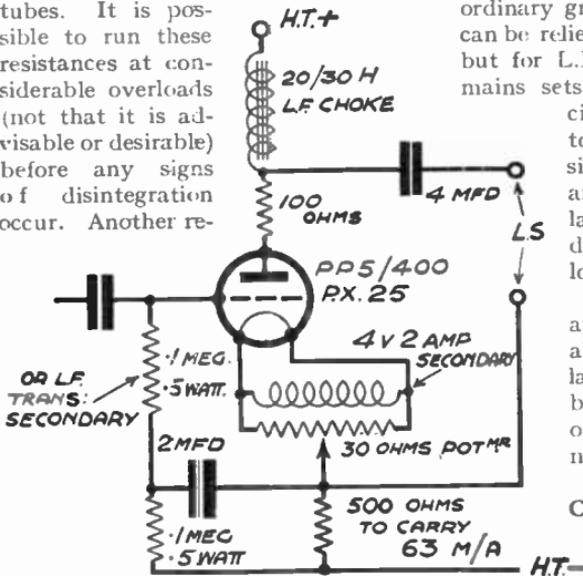


FIG. 359.—An Output Valve which is Mains Operated, and the Power Rating of all Resistances which are included in the Circuit.

sistance 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, not only disintegrate, but cause

RESISTANCE VALUES—SCRATCH FILTER

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.

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.

RESONANCE PEAK.—The point in the frequency scale at which a loudspeaker, pick-up, or other component gives maximum response. This point is frequently at the natural frequency of the component. The name "Resonance Peak" actually applies to the graph upon which response or amplification is plotted against frequency.

REVERSED CHARGE.—See *Accumulator*.

R. F.—Radio frequency.

RHEO-STAT.—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 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.

S.C.—Silk Covered.

SCANNING DISC.—See *Television*.

S.C.C.—Single cotton covered.

SCHNELL CIRCUIT.—A circuit claimed to be extremely selective and to bring in stations outside the range of a normal receiver.

SCOPHONY.—A method of television reception. Full details are not available at the moment of going to press, but it is believed that a form

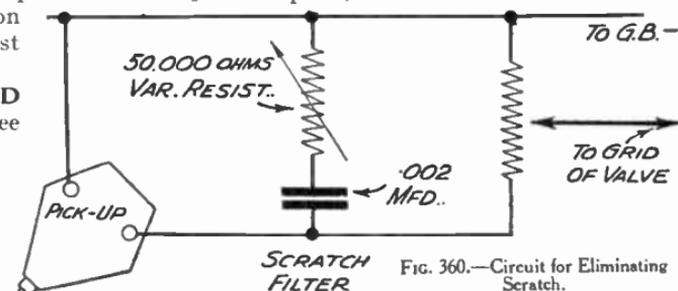


FIG. 360.—Circuit for Eliminating Scratch.

of mirror-drum reception is employed, with the mirror drum stationary instead of rotating, as in the usual method, and a single special lens or mirror runs round the drum.

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

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.

SCREEN-GRID CHOKE.—Coil of wire connected in the anode lead of a screen-grid valve to offer high impedance to H.F. current. (See also *Chokes and High-frequency Chokes.*)

SCREEN-GRID VALVE. — See *Valve.*

SCREWS: BRITISH ASSOCIATION (B.A.)

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	0.29	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	181.4	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	0.0232
4	3.6	0.66	38.5	0.142	0.0260
3	4.1	0.73	34.8	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	0.236	0.0394

The Committee recommend that for screws less than 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.—Abbreviation for Specific Gravity, also Screen Grid.

SHELLAC — SHORT-WAVE BROADCASTING STATIONS

SHELLAC.—A species of resin obtained from the sap of Indian trees. It is soluble in methylated spirit and alcohol, and it is an excellent insulator. Specific inductive capacity is 3.

S.H.M.—Simple Harmonic Motion.

SHORT CIRCUIT.—Any circuit having negligible resistance. To cut out a component by connecting its terminals together.

SHORT-WAVE CHOKE.—A coil of wire offering low resistance to the passage of D.C., and high impedance to H.F. current. (See also *Chokes* and *High-frequency Chokes*.)

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 transmission, or in other words, the wave-

length. 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." (For *Short-wave Aerial Systems* see pages 180 and 181.)

SHORT-WAVE ADAPTOR.—A single-valve detector stage which, connected to the I.F. stage of a broadcast set, enables short waves to be received. (See *Circuit*.)

SHORT-WAVE COILS.—See *Coil*.

SHORT-WAVE CONVERTER.—A unit for use with a broadcast receiver which has H.F. amplification which enables short waves to be received. It converts the receiver to a superhet.

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 kc/s. This is the separa-

SHORT-WAVE BROADCASTING STATIONS

(150 metres and below, and as from March 1940.)

(See also *British Broadcasting Stations, European Broadcasting Stations, and International Call Signs*.)

It is, unfortunately, impossible to include schedules of short-wave transmitters, which change almost monthly, in this book.

Station	Call Sign	Metres	Mc/s	kW
Amateurs	—	2.67 to 2.50	112.00 to 120.00	—
Amateurs	—	5.35 to 5.00	56.00 to 60.00	—
Amateurs	—	10.71 to 10.00	28.00 to 30.00	—
Bound Brook (N.J., U.S.A.)	W3XAL	13.87	21.63	26
Daventry	GST	13.92	21.55	10-50
Pittsburgh (Pa., U.S.A.)	W8XK	13.93	21.54	26
Daventry	GSJ	13.93	21.53	10-50
Philadelphia (U.S.A.)	W3XAU	13.94	21.52	10
Schenectady (N.Y., U.S.A.)	W2XAD	13.95	21.50	20-25
Daventry	GSH	13.97	21.47	10-50
Boston (Mass., U.S.A.)	W1XAL	13.99	21.46	20
Zeesen (Germany)	DJS	13.99	21.45	5-40
Radio Nations	HBH	16.23	18.48	20
Paris (Radio Mondial, Fr.)	TPB3	16.81	17.85	25

SHORT-WAVE BROADCASTING STATIONS

Station	Call Sign	Metres	Mc/s	kW
Athlone (Eire)	—	16-82	17-84	—
Rome (Italy)	1zRO8	16-84	17-82	5-50
Daventry	GSV	16-84	17-81	10-50
Chungking (China)	XGON	16-85	17-80	35
Daventry	GSG	16-86	17-79	10-50
Tokio (Japan)	ZNL	16-87	17-78	50
Bound Brook (N.J., U.S.A.)	W3XL	16-87	17-78	25
Huizen (Holland)	PHI	16-88	17-77	20
Zeesen (Germany)	DJE	16-89	17-76	5-40
Hicksville (U.S.A.)	W2XGB	17-33	17-31	10
Zeesen (Germany)	DJR	19-56	15-34	5-40
Treasure Island (U.S.A.)	W6XVE	19-57	15-33	20
Schenectady (N.Y., U.S.A.)	W2XAD	19-57	15-33	20-25
Skamleback (Denmark)	OZH2	19-58	15-32	6
Daventry	GSP	19-6	15-31	10-50
Rome (Italy)	I2RO6	19-61	15-30	50
Delhi (India)	BUD4	19-62	15-29	10
Buenos Aires (Argentina)	LRU	19-62	15-28	7-5
Zeesen (Germany)	DJQ	19-63	15-28	5-40
Philadelphia (U.S.A.)	W3XAU	19-65	15-27	10
Daventry	GS1	19-66	15-26	10-50
Boston (Mass., U.S.A.)	W1XAL	19-67	15-25	20
Paris (Radio Mondial, Fr.)	TPA2	19-68	15-24	12
Huizen (Holland)	PCJ2	19-71	15-22	60
Lisbon (Portugal)	CSW4	19-72	15-21	10
Pittsburgh (Pa., U.S.A.)	W8XK	19-72	15-21	18
Ankara (Turkey)	TAQ	19-71	15-20	20
Zeesen (Germany)	DJB	19-74	15-20	5-40
Daventry	GSO	19-76	15-18	10-50
Moscow (U.S.S.R.)	RW96	19-76	15-18	100
Guatemala City	TGWA	19-78	15-17	10
Tokio (Japan)	JZK	19-79	15-16	50
Daventry	GSF	19-82	15-14	10-50
Tokio (Japan)	JLU3	19-82	15-14	50
Paris (Radio Mondial, Fr.)	TPB6	19-83	15-13	25
Boston (Mass., U.S.A.)	W1XAR	19-83	15-13	20
Vatican City	HVJ	19-84	15-12	25
Zeesen (Germany)	DJL	19-85	15-11	5-40
Rome (Italy)	I2RO10	19-87	15-10	50
Moscow (U.S.S.R.)	RKJ	19-89	15-08	25
Moscow (U.S.S.R.)	RZZ	20-05	14-96	15
Marapicu (Brazil)	PSE	20-08	14-93	15
Radio Nations (Prangins, Switzerland)	HVJ	20-64	14-54	20
Barcelona (Spain)	EAJ1	21-35	14-06	—
Reykjavic (Iceland)	TFJ	24-52	12-23	7-5
Moscow (U.S.S.R.)	RNE	25	12-00	20
Chungking (China)	XGOY	25-21	11-90	35
Rome (Italy)	I2RO13	25-21	11-90	50
Paris (Radio Mondial, Fr.)	TPA3	25-24	11-88	12
Pittsburgh (Pa., U.S.A.)	W8XK	25-26	11-87	24
Madras (India)	VUM2	25-28	11-87	10
Daventry	GSE	25-29	11-86	10-50
Zeesen (Germany)	DJP	25-31	11-85	5-40
Lisbon (Portugal)	CSW5	25-34	11-84	10
Wayne (N.J., U.S.A.)	W2XE	25-36	11-83	10
Daventry	GSN	25-38	11-82	10-50
Rome (Italy)	I2RO4	25-4	11-81	25
Tokio (Japan)	JZJ	25-42	11-80	50
Zeesen (Germany)	DJO	25-42	11-80	5-40
Vienna (Germany)	DJZ	25-42	11-80	50
Boston (Mass., U.S.A.)	W1XAL	25-45	11-79	20
Zeesen (Germany)	DJD	25-49	11-77	5-40
Daventry	GSD	25-53	11-75	10-50
Vatican City	HVJ	25-55	11-74	25
Oslo (Norway)	LKQ	25-56	11-73	5
Huizen (Holland)	PHI	25-58	11-73	20
Boston (Mass., U.S.A.)	W1XAL	25-58	11-73	20
Paris (Radio Mondial, Fr.)	TPA4	25-6	11-72	12
Tokio (Japan)	JLG3	25-63	11-70	50
Motala (Sweden)	SVP	25-63	11-70	12
Moscow (U.S.S.R.)	RIA	25-66	11-69	15
Radio Nations (Prangins, Switzerland)	HBO	26-31	11-40	20
Lisbon (Portugal)	CSW6	27-17	11-04	10

SHORT-WAVE BROADCASTING STATIONS

Station	Call Sign	Metres	Mc/s	kW
Taihiku (Formosa, Japan)	JIB	28-48	10-53	10
Buenos Aires (Argentina)	SLX	28-99	10-35	12
Ruyssedele (Belgium)	ORK	29-04	10-33	9
Marapicu (Brazil)	PSH	29-35	10-22	15
Darien (Kwantung, China)	JDY	30-23	9-92	10
Madrid (Spain)	EAQ	30-43	9-86	10
Lisbon (Portugal)	CSW7	30-8	9-74	10
Buenos Aires (Argentina)	LRA1	30-96	9-69	10
Daventry	GRX	30-96	9-69	10-50
Guatemala City	TGWA	30-98	9-68	10
Zeesen (Germany)	DJX	31-02	9-67	5-40
Rome (Italy)	I2RO0	31-02	9-67	50
Bound Brook (N.J., U.S.A.)	W3XAL	31-02	9-67	25
Buenos Aires (Argentina)	LRX	31-06	9-66	7-5
Vatican City	HVJ	31-06	9-66	25
Wayne (N.J., U.S.A.)	W2XE	31-09	9-65	10
Tokio (Japan)	JLT2	31-1	9-64	50
Rome (Italy)	I2RO3	31-15	9-63	25
Oslo (Norway)	LLG	31-22	9-61	5
Cape Town (South Africa)	XRL	31-23	9-61	5
Moscow (U.S.S.R.)	RAL	31-25	9-60	20
Daventry	GRY	31-25	9-60	10-50
Athlone (Eire)	—	31-27	9-59	—
Delhi (No. 2) (India)	BUD2	31-28	9-59	10
Philadelphia (U.S.A.)	W3XAU	31-28	9-59	10
Huizen (Holland)	PCJ	31-28	9-59	60
Sydney (Australia)	VK2ME	31-28	9-59	20
Daventry	GSC	31-32	9-58	10-50
Millis (Mass., U.S.A.)	W1XK	31-35	9-57	10
Lima (Peru)	OAX4T	31-37	9-56	10
Zeesen (Germany)	DJA	31-38	9-56	5-40
Bombay (India)	B2	31-4	9-55	10
Schenectady (N.Y., U.S.A.)	W2XAD	31-41	9-55	20-25
Vatican City	HVJ	31-41	9-55	25
Zeesen (Germany)	DJN	31-45	9-54	5-40
Calcutta (India)	VUC2	31-48	9-53	10
Treasure Island (U.S.A.)	XW6BE	31-48	9-53	20
Schenectady (N.Y., U.S.A.)	W2XAF	31-48	9-53	20-25
Skamleback (Denmark)	OZF	31-51	9-52	5
Moscow (U.S.S.R.)	RW96	31-51	9-52	100
Daventry	GSV	31-55	9-51	10-50
Melbourne (Australia)	VK3ME	31-55	9-51	5
Rio de Janeiro (Brazil)	PRF5	31-58	9-50	12
Mexico City (Mexico)	ZEWW	31-58	9-50	10
Bangkok (Siam)	HS8PJ	31-58	9-50	10
Madrid (Spain)	EAR	31-62	9-49	10
Ankara (Turkey)	TAP	31-7	9-46	20
Havana (Cuba)	COCH	31-79	9-44	5
Radio Nations (Switzerland)	HVL	32-10	9-34	20
Radio Nations (Switzerland)	HVP	38-48	7-80	20
Tokio (Japan)	JVP	39-95	7-51	50
Mexico City (Mexico)	XECR	40-65	7-38	20
Tokio (Japan)	JLG	41-21	7-28	50
Paris (Radio Mondial, Fr.)	TPB7	41-21	7-28	25
Paris (Radio Mondial, Fr.)	TPA4	41-21	7-28	12
Rome (Italy)	I2RO11	41-55	7-22	50
Amateurs	—	42-85	7-00	—
	to			
	—	41-09	7-30	—
Radio Nations (Switzerland)	HVQ	44-94	6-67	20
Vatican City	HVJ	48-47	6-19	25
Wayne (U.S.A.)	W2XE	48-62	6-17	10
Pittsburgh (U.S.A.)	W8XK	48-86	6-14	28
Mexico City (Mexico)	XEUZ	49-02	6-12	20
Wayne (U.S.A.)	W2XE	49-02	6-12	10
Daventry	GSL	49-10	6-11	10-50
Bound Brook (U.S.A.)	W3XL	49-18	6-10	25
Lima (Peru)	OAX4Z	49-24	6-09	15
Zeesen (Germany)	DJM	49-35	6-08	5-40
Vienna (Germany)	DJY	49-40	6-07	50
Motala (Sweden)	SBO	49-46	6-06	12
Philadelphia (U.S.A.)	W3XAU	49-50	6-06	10
Cincinnati (U.S.A.)	W8XAL	49-50	6-06	10

SHORT-WAVE BROADCASTING STATIONS—SOFT VALVE

Station	Call Sign	Metres	Mc/s	kW
Daveentry	GSA	49.59	6.05	10-50
Tandjong Priok (Java)	YDA	49.67	6.04	10
Boston (Mass., U.S.A.)	W1XAL	49.67	6.04	20
Vatican City	HIJ	49.75	6.03	25
Moscow (U.S.S.R.)	RW96	49.75	6.03	100
Zeesen (Germany)	DJC	49.83	6.02	5-40
Rangoon (Burma)	XYO	49.94	6.01	10
Pretoria (South Africa)	ZRH	49.94	6.01	7
Moscow (U.S.S.R.)	RNE	50.00	6.00	20
Moscow (U.S.S.R.)	RIA	51.24	5.85	15
Delhi (No. 2) (India)	VUD ₂	60.49	4.96	10
Madras (India)	VUM ₂	60.98	4.92	10
Bombay (India)	VUB ₂	61.48	4.88	10
Calcutta (India)	VUC ₂	61.98	4.84	10
Amateurs	—	85.71	3.5α	—
		to	to	
		75.00	4.00	—
Amateurs	—	174.43	1.71	—
		to	to	
		150.00	2.00	—

tion which is laid down by the European Broadcasting authorities (Berne). If a receiver accepts a band of less than 10 kc/s., 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.

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 lie parallel for their whole length. It has a lower capacity. (See also *Coil*.)

P.W.E.—L

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.

SMOOTHING CHOKE.—A coil of wire having an iron core, used in the H.T. circuit to eliminate fluctuations in current and current intensity. (See also *Chokes* and *Low-frequency Chokes*.)

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 was first 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 it) water decomposes it, liberating hydrogen which, if the water is previously heated, catches fire.

SOFT VALVE.—A valve which is not completely evacuated, or which

SOFT VALVE — SOLDERING

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



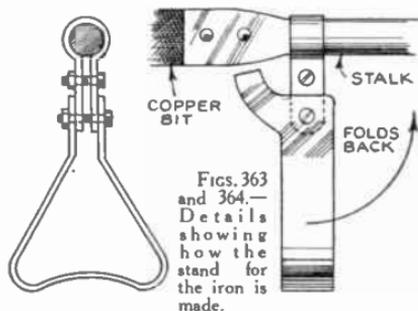
FIG. 361.—How to make a simple angle joint.



FIG. 362.—A wire to be attached at right angles to another should be looped together as shown.

necessary equipment and try jointing up scraps of tinfoil, 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



FIGS. 363 and 364.—Details showing how the stand for the iron is made.

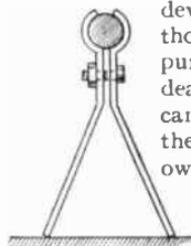


FIG. 365.—How to make a permanent fixing for the foot of the stand.

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

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,

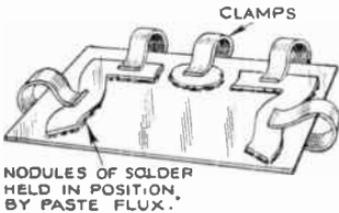


FIG. 367.—Strips held in position by spring clamps.

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

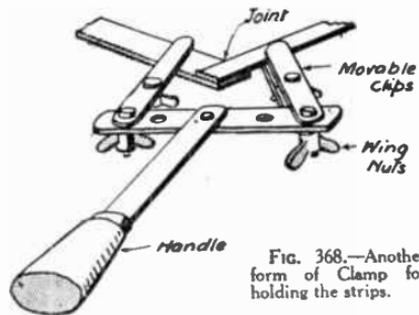


FIG. 368.—Another form of clamp for holding the strips.

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-

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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-

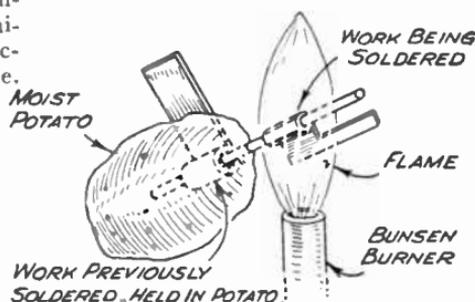


FIG. 369.—A typical case where a potato comes in useful.

tainer. 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.

When it is advisable for the particular job in hand—say, wiring up a wireless set—to employ a paste 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

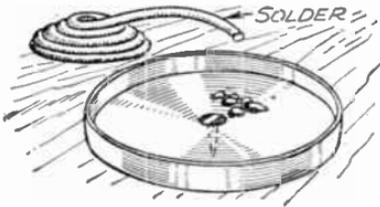


FIG. 370.—Coil of solder with a tin lid underneath to catch the drips of solder.

may be either looped round as shown in the sketch (Fig. 361), 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. 362.

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 (Figs. 363 and 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

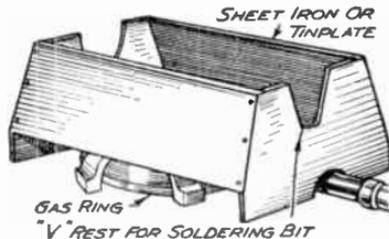


FIG. 371.—An easily-made Cowl that can be fitted over the gas ring.

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

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 tinplate, 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 tinplate 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, SPEED OF — SPECIFIC GRAVITY

SOUND, SPEED OF. — Sound waves travel 1,142 feet per second.

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.

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.

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.

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 the ratio of its weight to the weight of water it displaces when immersed therein. The ratio of the weight of the material to the weight of the same volume of water.

SPECIFIC RESISTANCE — STENODE

SPECIFIC RESISTANCE.—The resistance of a piece of material which is 1 cm. in length and 1 sq. cm. in cross section.

SPECTRUM.—The term applied to the complete range of light frequencies (known as the "visible" spectrum) and the complete range of sound frequencies (known as the "audible" spectrum). It is appreciated, of course, that in each spectrum there are frequencies which are not normally visible or audible. The complete range of the spectrum may be found under *Visible Spectrum* and *Audible Spectrum*.

SPEECH COIL.—The winding on a cone loudspeaker which carries the speech currents. It is usually of low resistance and is fed from the secondary of a transformer, the primary of which is joined in the anode circuit of the output valve. The speech coil is sometimes wound on a cylindrical former of insulating material, but is often made self-supporting by being doped with some non-hygroscopic material.

SPELTER.—A commercial name for zinc. It is also an abbreviation of the words "spelter-solder," which is a zinc substance for soldering brass.

SPREADER.—The rod or stick used for separating the wires of a two or more wire aerial. Where two wires are employed the spreader should be not less than 3 ft. long.

SQUEGGER.—The term applied to an effect which arises in a valve when oscillation reaches such a point that a form of saturation sets in. The valve then ceases to oscillate, and in some circuits will commence again, and so continue the cycle. The term is used to-day in super-heterodyne practice when a low-pitched howl arises in such a receiver due to the oscillator valve being operated under wrong conditions.

SQUELCH.—Another name (of American origin) for "Quiet A.V.C." (which see).

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.

STABILISER.—See *Neon*.

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 circuit. (See *Amplification*.)

STAINING.—See *Polishing*.

STALLOY.—An alloy of steel. This is a proprietary name for a special preparation of steel used for the cores of transformers, etc.

STAND-BI.—A nautical term, signifying the position of the tuner where waves of different lengths are received. The term is also employed to denote "wait."

STATIC.—Stationary electricity. It is the name also applied to atmospherics, and accumulations of electricity (atmospherics) on an aerial.

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. bypassing effect, and it is claimed that

STENODE — SWITCHES AND SWITCHING

this results in a degree of selectivity much higher than can be obtained even with a super het.

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 in the secondary.

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.

STEREOPHONY.—A term applied to the experiments which have taken place in an endeavour to obtain the illusion of depth in broadcast reception. As at present known, the sounds are picked up by a single microphone, which, of course, destroys all sense of "relief," and are relayed from a single point in the room. Experiments in stereophony have consisted of using two microphones arranged at each end of a studio, and relaying the sounds picked up by one from one station, and those from the other microphone from a different station. At the receiving end the two stations are received on separate receivers and two loudspeakers. Two loudspeakers arranged in different places will also give an effect of stereophony.

STOPPERS.—Devices used to prevent the flow of currents of some particular frequency. Thus, an anti-break-through choke (connected in series with the aerial lead-in) is used to "stop" the passage of medium-wave signals when the set is tuned to long waves. (See also *Grid Stopper*.)

STRAYS. — Another term for "Static," which see.

STROBOSCOPE.—A device for determining the speed of rotation of a disc, etc., by means of an interrupted light supply. In its simplest form it consists of a disc of paper or similar

material around the periphery of which are arranged an equal number of light and dark segments. When illuminated by a source of light interrupted regularly (for instance, an ordinary A.C. supply) the disc will appear to remain stationary at the correct speed. The formula for determining the number of segments is

$$\frac{120 \times f}{r}$$

where f is the frequency of the lighting supply and r the number of revolutions per minute. A neon lamp gives a more definite image.

SULPHATE OF COPPER.—Chalcanthite. The result of copper being acted upon by hot concentrated sulphuric acid. The crystallised salt is known as blue vitriol.

SULPHATING.—The action of the sulphuric acid upon the plates of the accumulator.

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 passed to the L.F. stages. (See also *Intermediate-frequency Transformer and Coils*.)

SUPER-REGENERATIVE. — See *Circuit and Armstrong Circuit*.

SUPERSONIC.—Above audibility. Frequencies over 20,000 cycles per sec.

SUPPRESSOR GRID.—The extra grid which is inserted between the anode and screening grid of a pentode valve. It is generally internally connected to the cathode and acts as a stabiliser by preventing the excessive electrons which are shot back from the anode from interfering with the normal grid-anode electron stream.

S.W.G.—An abbreviation for Standard Wire Gauge.

SWITCHES AND SWITCHING.—Devices for connecting one circuit with another or for breaking a circuit.

SWITCHES AND SWITCHING

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 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 transmitters.

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



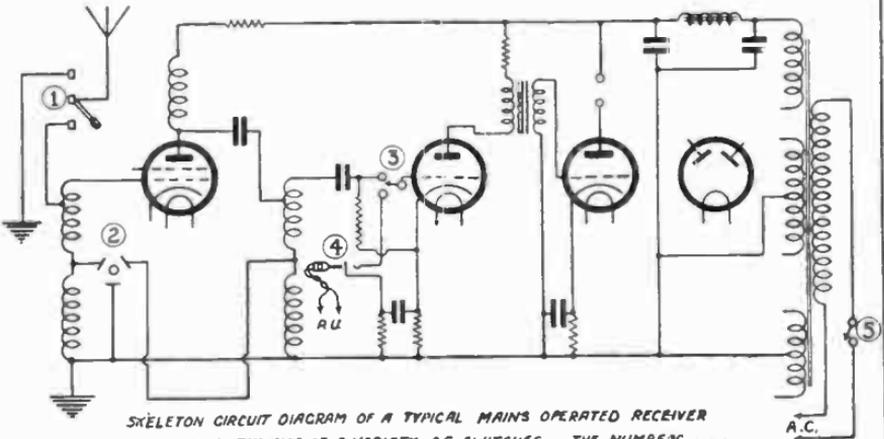
① KNIFE SWITCH
SINGLE POLE, DOUBLE THROW



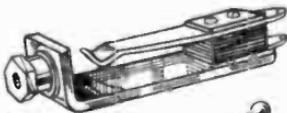
② THREE-POINT
SHORTING SWITCH



③ SINGLE POLE, CHANGE OVER SWITCH
EITHER TYPE IS SUITABLE



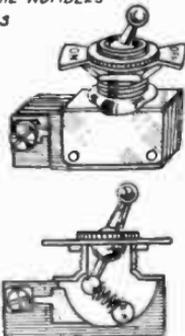
SKELTON CIRCUIT DIAGRAM OF A TYPICAL MAINS OPERATED RECEIVER
SHOWING THE USE OF A VARIETY OF SWITCHES THE NUMBERS
CORRESPOND WITH THOSE ON THE ILLUSTRATIONS



④ SINGLE OPEN CIRCUIT JACK
WITH PLUG



ANOTHER
SUITABLE JACK



⑤ "ON-OFF" O.M.B. SWITCH
FOR MAINS USE

FIG. 372.—Various Switches and how to use them.

SWITCHES AND SWITCHING

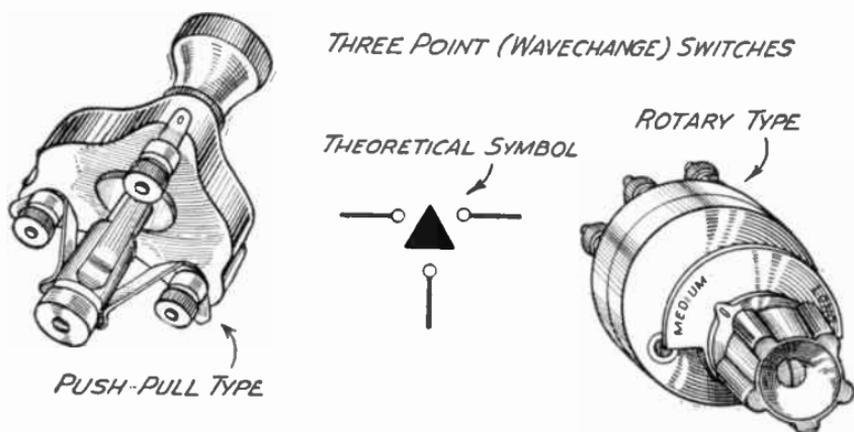


FIG. 373.—Theoretical and actual diagrams of a 3-point wave-change Switch.

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

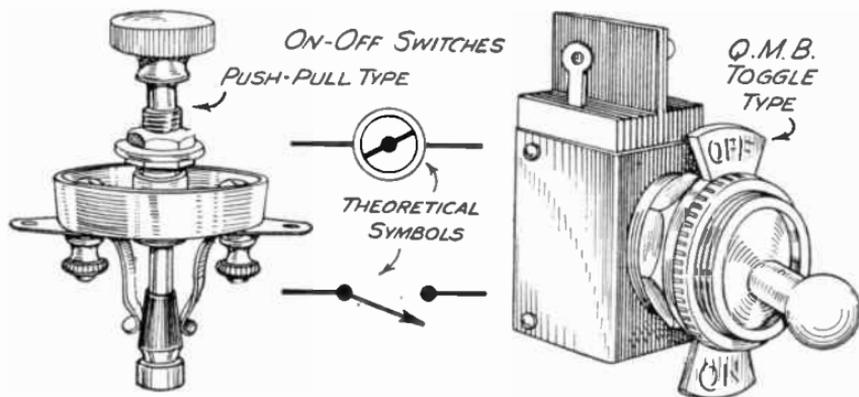


FIG. 374.—Theoretical and actual diagrams of an on-off Switch.

SWITCHES AND SWITCHING

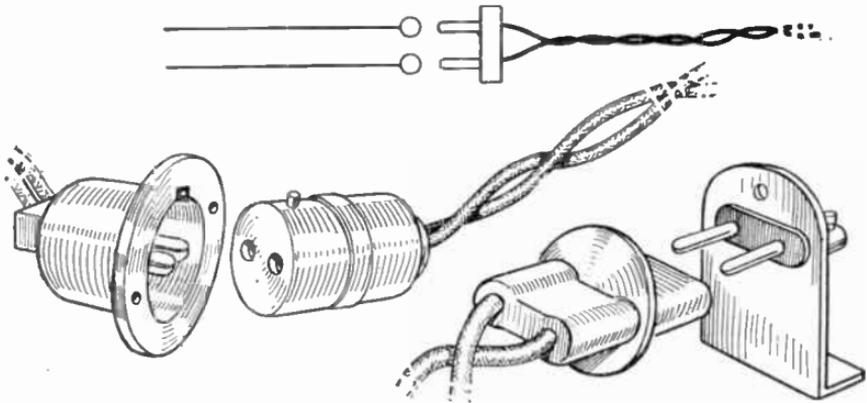


FIG. 375.—Theoretical and actual diagrams of a plug-in Connector.

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.

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

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 gramophone 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

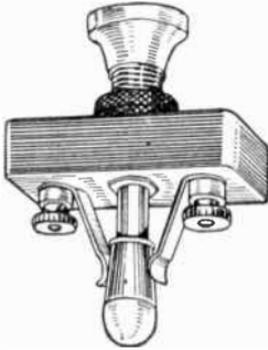


Fig. 376.—On-off Switch.



Fig. 378.—Snap Switch.

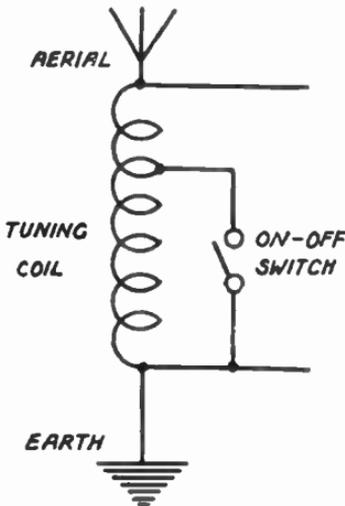


Fig. 377.—On-off Switch used for wave changing.

complete unit, comprising variable condenser and switch, is called an *extender*. The condenser is operated in the usual way, except that when

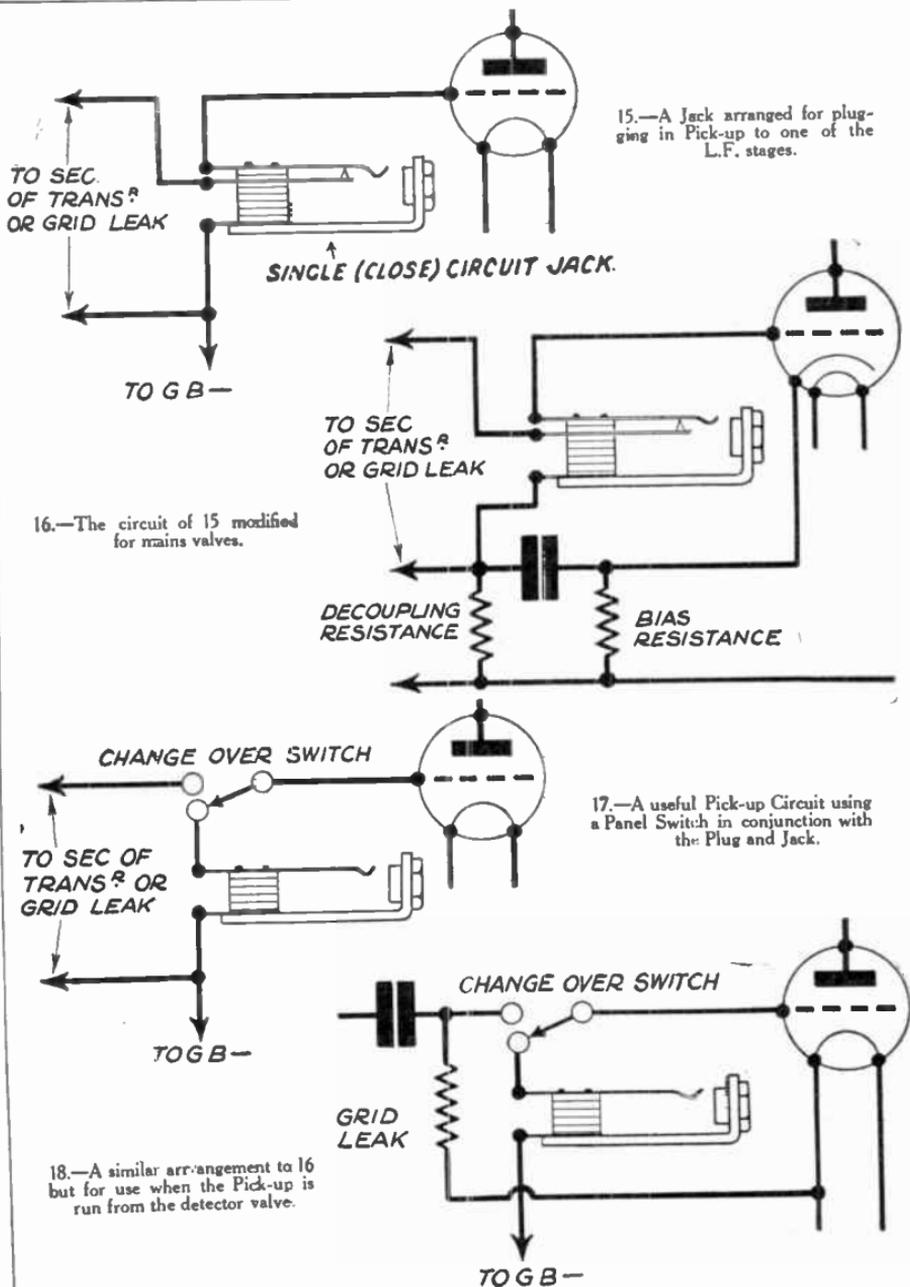


FIG. 379.—Various methods of Switching by means of Plugs and Jacks.

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.

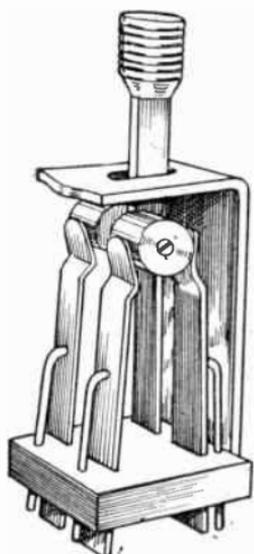


FIG. 380.—Anti-capacity Switch.

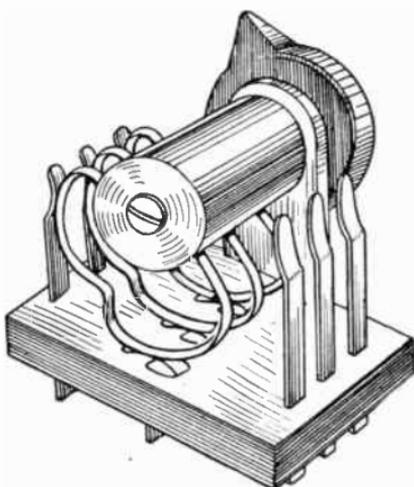
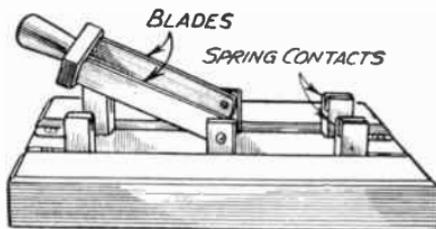
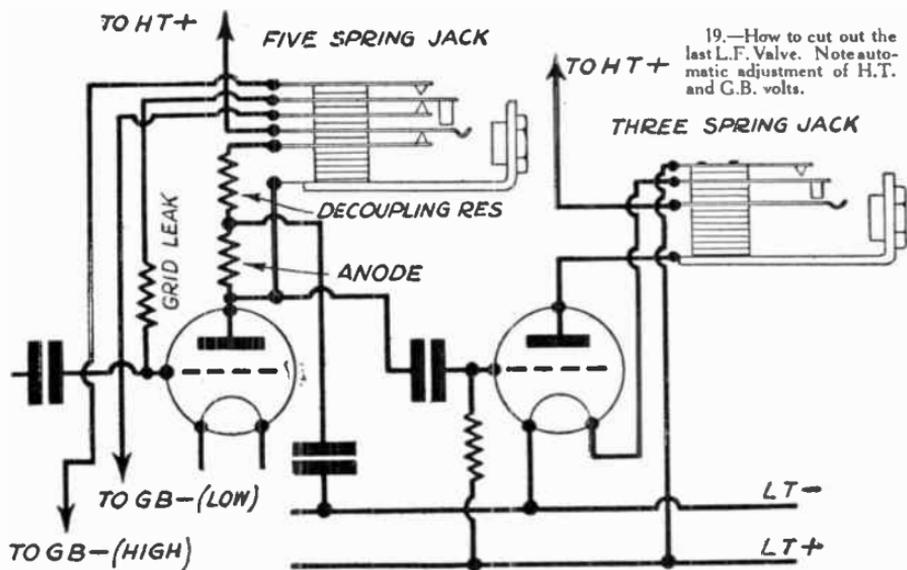


FIG. 382.—Another form of low-capacity Switch.

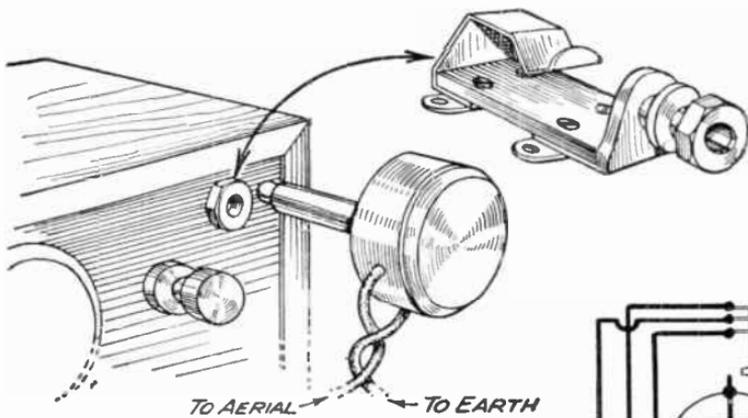


applied is so low this small resistance has a comparatively large effect, and reduces the current sufficiently to impair reception. What it means therefore is that the contacts must be of generous size, plated to prevent corrosion, and with springs just sufficiently strong to give a firm grip, but not so hard as to cause a scraping away of the contacts.

Two of the



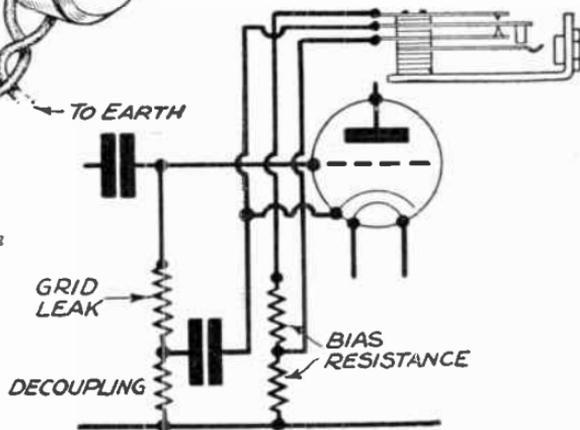
19.—How to cut out the last L.F. Valve. Note automatic adjustment of H.T. and G.B. volts.



21.—A portable set may be quickly attached to an outside aerial by using a Plug and Jack. Inset: details of the Jack.

20.—How to modify 18 when using mains valves.

FIG. 383.—Other methods of switching by Plugs and Jacks.



SWITCHES AND SWITCHING

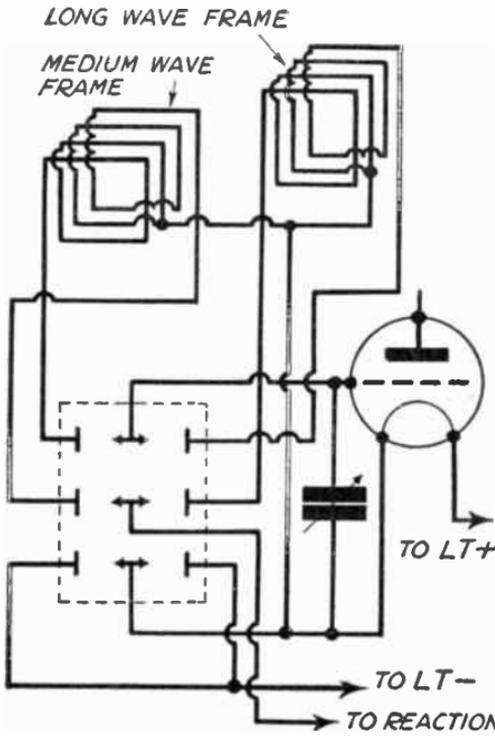


Fig. 384.—Three-pole change-over Switch used for wave changing with Frame Aerials.

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 into 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,

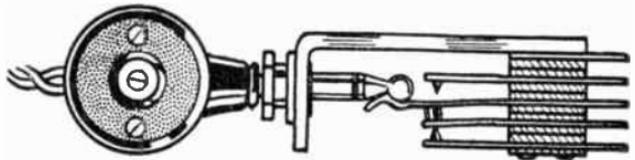


Fig. 385.—Typical Plug and Jack.

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.

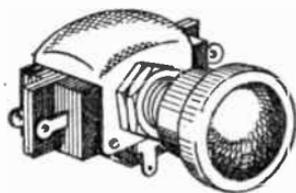


FIG. 387.—Rotary Switch.

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

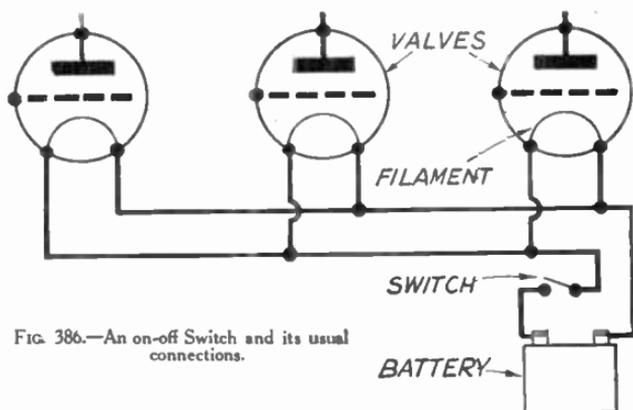


FIG. 386.—An on-off Switch and its usual connections.

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

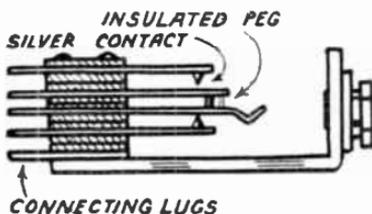


FIG. 388.—Contact points of a Jack.

SWITCHES AND SWITCHING — TANTALUM

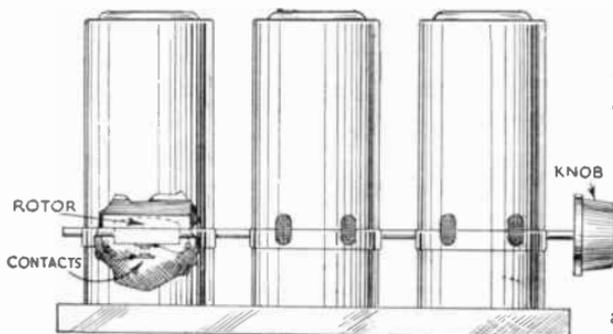


FIG. 389.—Three-gang Tuning Coil with self-contained Switch.

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. (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.

SYNCHRONOUS MOTOR.—Speed of Rotor = R.P.M. = $\frac{2f60}{n}$, where f = frequency, n = no. of teeth on rotor.

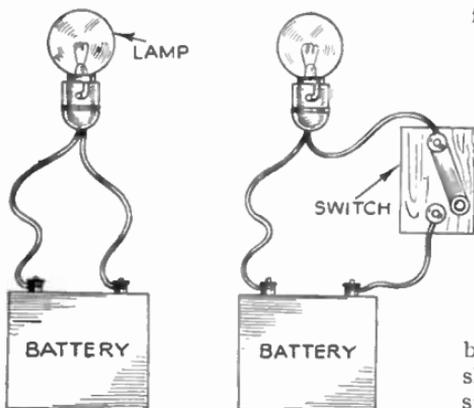


FIG. 390.—How the on-off Switch functions.

SYNTHESIS. — The building up of bodies by the direct union of their elements.

SYNTONY.—Two tuned circuits are said to be in syntony when they are tuned to the same frequency. Thus a transmitter and receiver are in syntony when the latter is correctly tuned to the former. The

word is also used to denote a balance of tone in respect to loudspeaker reproduction. (See also *Resonance*.)

SYSTO-FLEX.—An insulated tubing used

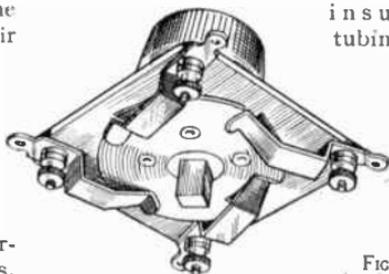


FIG. 391.—Another form of Rotary Switch.

for carrying wires in a wireless receiver. It consists of a plaited cotton fabric which is insulated.

T

T CODE.—See abbreviations, p. vii.

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.

TANK.—The term applied to the band-setting condenser used in a short-wave tuner in which band-spread tuning is employed.

TANTALUM.—A pentad metal-

TANTALUM — TAPE MACHINE

lic element. Symbol—Ta. The metal is obtained by heating the fluotantate 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 $11 \times 5 \times \frac{1}{8}$ 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, $2\frac{1}{2} \times \frac{3}{4}$ in., are cut from mild steel, drilled to take a $\frac{1}{8}$ -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

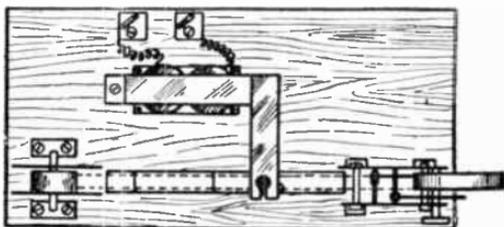


FIG. 392.—Plan view of the Tape Machine.

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 $1 \times \frac{1}{4}$ -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

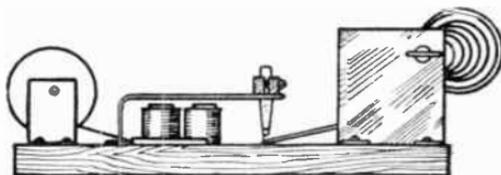


FIG. 393.—Side view.

mild steel $1 \times 2\frac{1}{2}$ in., and drill two holes to take the bolts $1\frac{1}{4}$ 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 $4\frac{1}{2} \times \frac{1}{2}$ in., drilled at each end to take $\frac{1}{2}$ -in. wood screws. The brush holder

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.

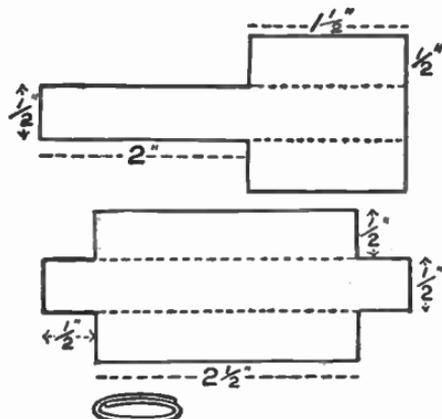


FIG. 394.—Details of the Guide Tubes through which the Tape passes.

(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-

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-

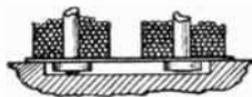


FIG. 396.—The method of mounting the Magnets.



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 $3\frac{1}{2} \times 5\frac{1}{2} \times \frac{1}{2}$ -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 $\frac{1}{4}$ -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 $1 \times \frac{1}{4}$ -in. bolt, which screws through a nut soldered



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

TAPE MACHINE — TAPPING

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.

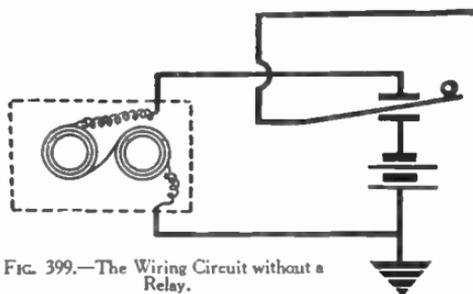


FIG. 399.—The Wiring Circuit without a Relay.

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

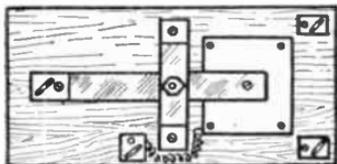


FIG. 401.—Plan view.

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

TAPPING — TELEPHONE TRANSFORMER



FIG. 402.—The Bridge which carries the Screw to adjust the tension of the Armature.

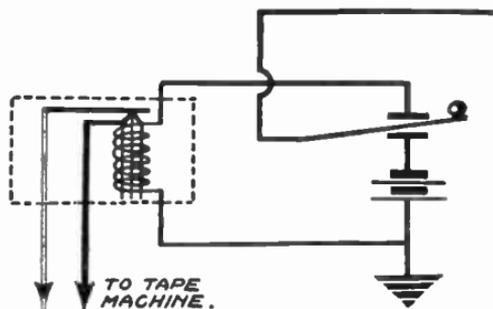


FIG. 403.—The Wiring Circuit showing how the Relay is connected.

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.

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 a sounder or buzzer (which see), or other device; and in the second category one may employ a lamp or similar device.

TELELOGOSCOPY.—The transmission, by television, of writing or written lines.

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.

TELEPHONE TRANSFORMER.—A transformer included in the

TELEPHONE TRANSFORMER — TESTING A RECEIVER

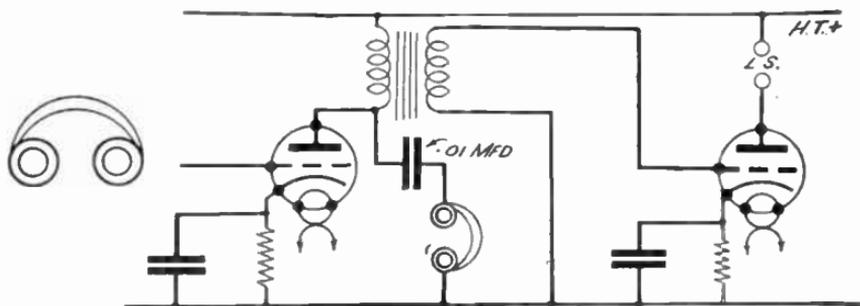


FIG. 404.—Theoretical illustration of Headphones and method of using phones with a mains set.

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.

TELETRON.—Another name for a cathode-ray tube.

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.

For fuller explanations of the high-definition systems see *Newnes Television and Short-wave Handbook* (uniform in style with the present volume), which also contains a summary of the Television Committee's Report. The television programmes are now transmitted on ultra-short waves of between 6 and 7 metres for both sound and vision, and of a definition of 405 lines interlaced, 50 frames per second. The following briefly explains modern high-definition and low-definition systems.

The Iconoscope. An instrument very similar in construction and principle to a cathode-ray tube. In place of the normal fluorescent screen, however, the end of the tube is covered with a mosaic of minute photo-electric cells, each of which charges and discharges under the effect of light so that the electron beam inside the tube is "modulated." It will be seen from this that the Iconoscope func-

tions as a transmitter, its operation being practically the reverse of that of the normal cathode-ray tube.

The Iconoscope is the invention of Dr. V. K. Zworykin, and is frequently described as the "electric eye" due to the fact that it automatically converts a light scene into its electrical equivalent, thereby providing a system of television transmission which is independent in any way upon mechanical devices. It is the basis of the Emitron camera.

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 characteristics of a metal, but bears so close a resemblance to selenium in its chemical properties that it is generally placed in the sulphur group.

TESTING A RECEIVER.—Assume that the receiver gives out no signals 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

TESTING A RECEIVER

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.

Now that leads have been checked over and found O.K., therefore there only remain 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 accumulator 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.

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.

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 valve, signals were heard quite O.K., then proceed as follows:

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 an R.C.C. unit. Substituting 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

TESTING A RECEIVER — TONE CONTROL

leak—and the other side of the resistance should be carefully touched to the $1\frac{1}{2}$ -volt socket. If a scratching sound can be heard in the phones then the primary is unbroken. If, however, nothing can be heard, try 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. Test the secondary similarly.

TETRODE.—A 4-electrode valve. The screen-grid valve is a tetrode, having filament, screening grid, control grid, and anode.

THEREMIN PRINCIPLE.—This is the principle upon which the production of electronic music is based. This name is derived from the musician Theremin. (See also *Electronic Music*.)

THERMION.—Another name for *Electron* (which see). (Also see *Valve*.)

THREE-ELECTRODE VALVE.—See *Valves Explained*.

THYRATRON.—A gas-filled triode, used for rectification, and in connection with television time-based generators. It is a registered trade-name owned by the B.T.-H. Co. Ltd.

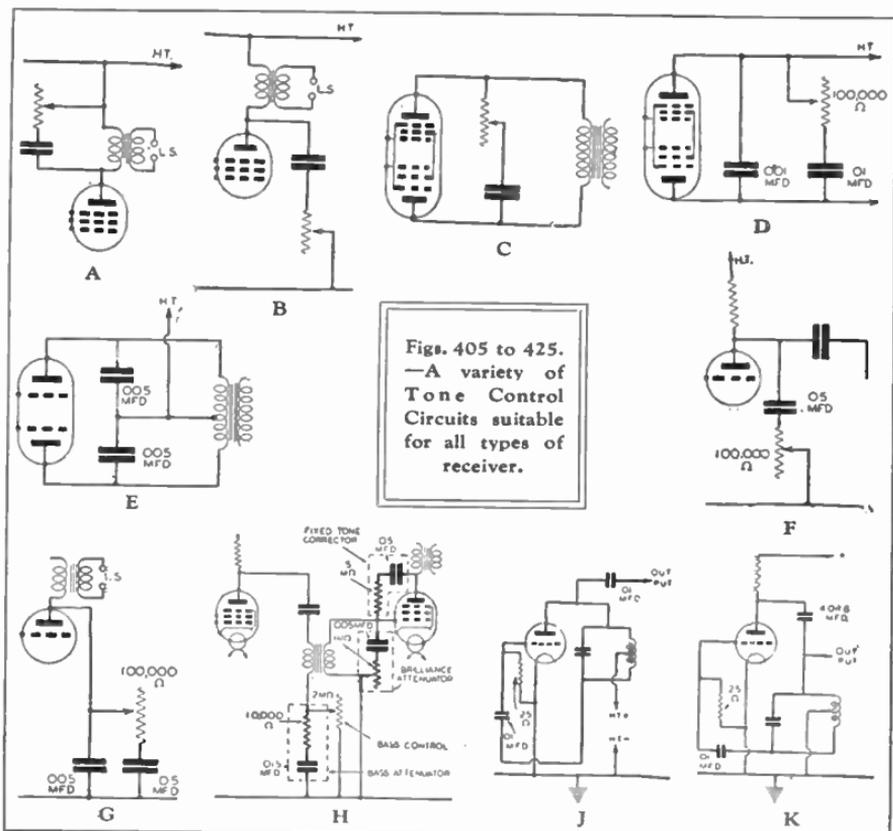
TIME BASE.—A circuit which employs valves as a means of providing a periodic voltage across a pair of deflector plates in a cathode-ray tube.

TIME SIGNAL.—The official Time Signal is that which is received from Greenwich Observatory. This is accurate to $\frac{1}{20}$ th sec., and Greenwich Mean Time is denoted by the *last* of the six pips. With the Big Ben time signal, the *first* of the strokes indicates the hour.

TONE CONTROL. — Practically every modern receiver contains a tone control, and apart from the value of this device to modify the balance of reproduction it often proves of use in removing background noises when a long-distance station is being received. The pentode output valve, the Class B stage, and the Q.P.P. arrangement all

need some form of tone correction in order to give a pleasing tone to the reproduction. Dealing first with the pentode, it may be stated that this gives over-emphasis to the higher notes, with the result that the tone sounds too shrill. Consequently we need a high-note cut-off to balance the reproduction, but as certain types of orchestral music need more cut-off than speech, for instance, the control should be variable so that it may be adjusted according to the item being received. The usual tone control for this type of valve is shown in Fig. A (p. 340), and it will be seen to consist merely of a fixed condenser in series with a variable resistance, both being joined across the output circuit. In this connection it should be remembered that the H.T. positive side of the speaker or output transformer is at earth potential in relation to the anode, and accordingly it is quite in order to join the tone control components between the anode and earth as shown in Fig. B (p. 340).

The Q.P.P. arrangement utilises either a double pentode or two separate pentodes in a push-pull circuit and accordingly a similar type of tone corrector may be employed. This should be joined across the two anodes, which is, of course, across the output circuit, as shown in Fig. C (p. 340). The resistor may be fixed or variable. In some cases it may be found that it is desirable to connect a fixed condenser permanently across this type of output stage and use the tone control arrangement already referred to as an addition. In Fig. D (p. 340), therefore, I show this arrangement, and values suitable for the pentode tone corrector may be stated to be as follows. For the fixed condenser some value between .001 and .05 mfd. is generally suitable, and for the resistor from 20,000 to 100,000 ohms. The shunt condenser in Fig. D (p. 340) should not gener-



ally be greater than .001 mfd.

In the Class B circuit such a comprehensive tone control is not needed, and generally the tone is sufficiently well balanced if a fixed condenser shunts each anode. A value of .001 mfd. up to .005 mfd. will generally be found satisfactory, and they should be placed as shown in Fig. E (above). The use of resistors on the input side is sometimes recommended with the Class B arrangement, but, generally speaking, if the L.F. circuits are properly designed, a condenser filter alone is adequate.

Many modern receivers are being provided with a tone control across the first L.F. stage. This usually takes the form of a condenser and resistance arrangement (similar to that used in the pentode circuit),

joined between the anode of the L.F. valve and earth. The general principle is shown in Fig. F (above), where it is used in conjunction with the standard resistance-capacity circuit. Suitable values will depend upon the valve and the R.C. components, and again, up to .05 mfd. and up to 100,000 ohms are generally suitable. A more comprehensive arrangement for use in this stage is seen in Fig. G (above), where, in addition to the usual resistance and condenser a fixed condenser is permanently joined between anode and earth. This follows on the lines of Fig. D (above), and a suitable value for the additional condenser is .005 mfd.

All of the circuits so far described merely control the high notes, or, in other words, the brilliance, but a cir-

TONE CONTROL — TRANSFORMER

cuit of great interest is seen in Fig. H (p. 340), which is the arrangement employed in an H.M.V. receiver. In this, provision is made for bass attenuation, brilliance attenuation and, in addition, a fixed tone corrector is employed. As will be seen, the bass attenuator consists of a fixed resistor and condenser in series between the anode of the penultimate stage and earth, and shunted across these two components is a variable resistor. The brilliance attenuation is effected by a fixed condenser and resistor across the grid circuit of the output valve, and the resistor is of the variable type to effect the degree of brilliance attenuation desired.

The fixed tone corrector in this circuit is a fixed condenser and resistor coupled between the grid and anode of the output valve. The separate circuits are indicated by varying line thickness in Fig. H (p. 340), and the values used by H.M.V. are given.

In addition to the usual arrangements shown, it is possible to employ chokes and other components in special circuits, and in this connection it should be remembered that there is a special tone control choke consisting of a tapped winding with a total inductance of 3 henries. This inductance naturally varies according to the current flowing through it, and to preserve the maximum value it should be so arranged in circuit that no D.C. flows. This may easily be done by using the normal filter circuit arrangement. In this choke tappings have been provided to give inductance values of 0.5, 1, 1.5, 2, and 2.5 henries, and the resonant frequency of the choke with various values of condenser are shown in the accompanying table.

Suitable circuit arrangements are shown in Figs. J and K (p. 340), and it should be noted that when the condenser is in parallel with the choke the circuit is of the rejector type, and

Capacity. Mfd.	Frequency. Cycles
0.1	500
0.07	600
0.052	700
0.04	800
0.031	900
0.025	1,000
0.011	1,500
0.0063	2,000
0.0041	2,500
0.0028	3,000
0.0021	3,500
0.0016	4,000
0.00125	4,500
0.001	5,000

when it is in series with the choke the circuit is of the acceptor type. For the benefit of those to whom these terms are not clear it may be explained that a rejector circuit provides maximum voltage at the resonant frequency, whilst the acceptor gives minimum voltage at the resonant frequency. Thus to eliminate needle scratch, for instance, an acceptor circuit would be needed, and 4,000 cycles is generally regarded as the frequency of needle and surface noise, which means that an acceptor circuit made up from the complete choke winding and a .0016 mfd. condenser would be needed.

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. Obsolete.

TRANSCEIVER. — A combined transmitter and receiver.

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

TRANSFORMER — TRANSFORMER WINDINGS

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. L.F. transformers generally have a step-up ratio of from 1 to 1 to 1 to 8; the most usual ratio is 1 to 5. Particulars of an L.F. transformer having a ratio of 1 to 5 are as follow:

Primary winding—3,500 turns of 40 S.W.G. S.S.C. copper wire (1 oz.).

Secondary winding—17,500 turns of 47 S.W.G. enamelled copper wire (1½ oz.). (See Fig. 226c.)

Bobbin— $\frac{3}{8}$ in. external diameter tube; $\frac{3}{8}$ in. internal diameter; 1½ in. long; flanges 1½ in. diameter, $\frac{1}{8}$ in. thick.

The iron core should be built up of narrow strips or laminations of stalloy iron. The magnetic circuit is closed by similar strips on either side of the windings, parallel to the core. These two strips are yoked together by shorter strips at right angles. Each strip should be enamelled. Fifteen strips will be required for the core, eight strips each for the two sides, and 16 yoke strips, $\frac{5}{16}$ in. wide.

TRANSFORMER COUPLING.—See *Low-frequency Couplings*.

TRANSFORMER RATIOS.—The usual ratio of primary turns to secondary turns is spoken of as the transformation ratio; thus a transformer with 100 primary turns and 1,000 secondary turns would have a

transformation ratio of 100 to 1,000 or 1 to 10.

$$\frac{\text{Primary turns}}{\text{Secondary turns}} = \frac{\text{Primary E.M.F.}}{\text{Secondary E.M.F.}}$$
$$= \frac{\text{Transformation}}{\text{Ratio}}$$

(See also *Low-frequency Couplings*.)

TRANSFORMER WINDINGS.—

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 3½ 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 3½ 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.

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 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.

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, H.T., 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.

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*.)

TRANSIENTS.—Sudden climaxes in music exemplified by cymbal clashes, final chords, etc. Other effects heard on the radio which come within the description of transients are pistol shots, slamming doors, etc. Sudden effects such as these require that the grid circuits of the broadcast receiver shall be designed to enable the sudden current change to be reproduced, and therefore, generally speaking, a condenser should not be included in this part of the circuit if maximum response on transients is required.

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.

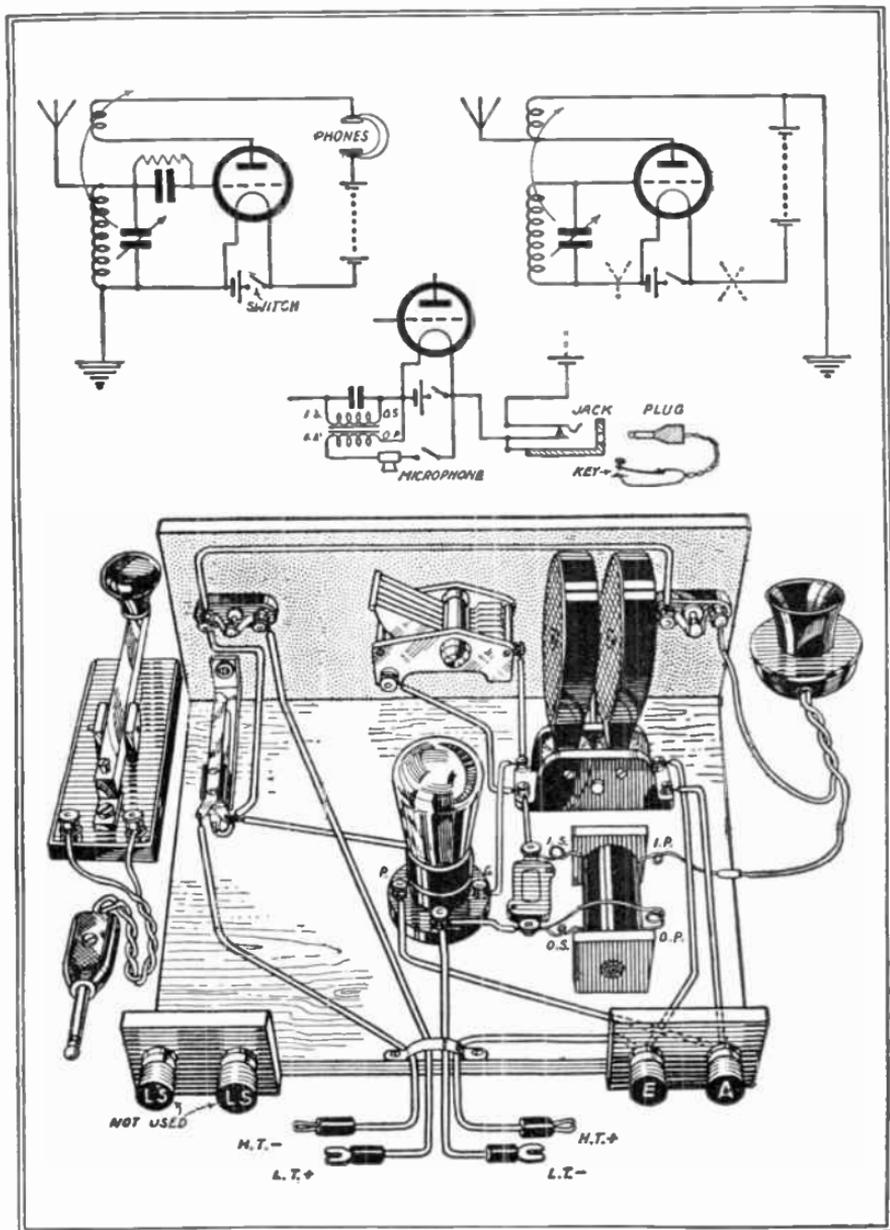
This circuit is the basic arrangement of *all* transmitters, and it is only necessary now to insert a key for the transmission of Morse signals, or a microphone for the transmission of speech or music. The most efficient way of breaking the circuit is to disconnect the wire linking the batteries, and 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,



Figs. 426 and 427.—A I-Valve Transmitter, with circuit showing how it differs from a I-Valve Receiver.

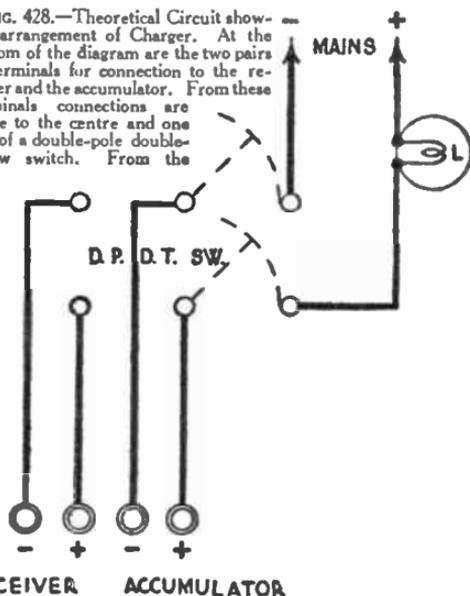
TRANSMITTER — TRICKLE CHARGER

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.

TRANSPORTABLE SETS.—This term is applied to receivers which

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



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

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.

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-

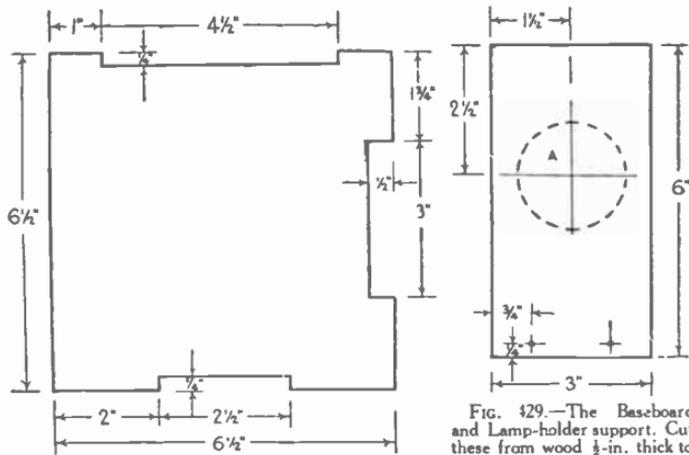


FIG. 429.—The Baseboard and Lamp-holder support. Cut these from wood $\frac{1}{2}$ -in. thick to the dimensions given in the diagram. The position of the lamp-holder is shown at A.

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

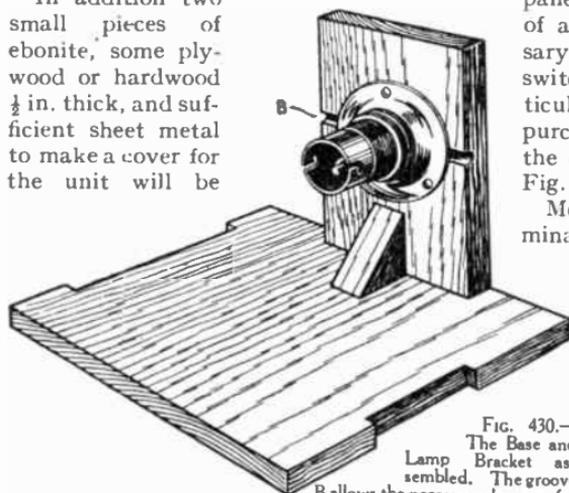


FIG. 430.—
The Base and
Lamp Bracket as-
sembled. The groove
B allows the necessary clearance for
the flex leads to the back of the lamp-holder.

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

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 x 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

TRICKLE CHARGER FOR D.C. MAINS

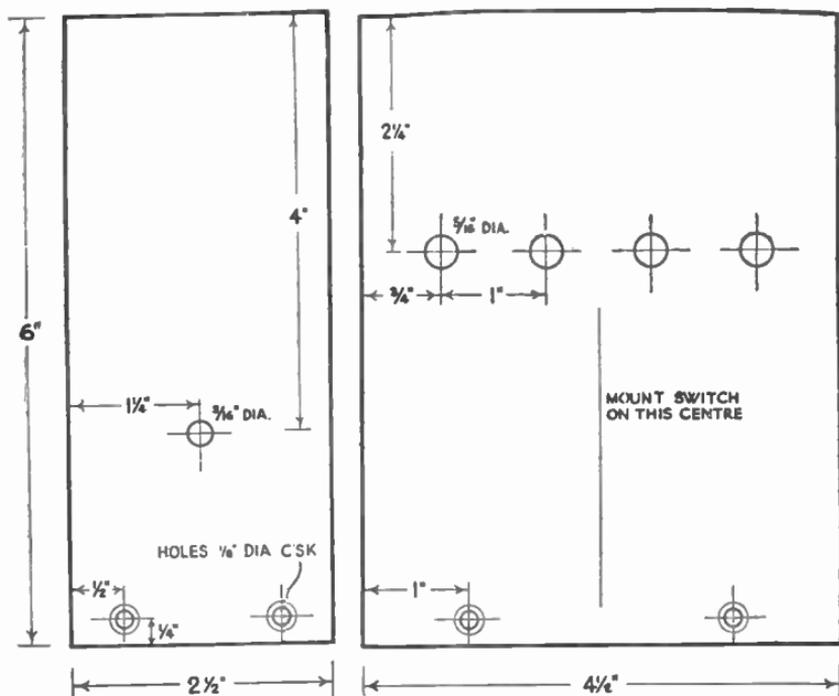


FIG. 431.—The two small Ebonite Panels, Cut from a 7 × 6-in. panel and drill as shown, the four holes in the larger piece being of suitable size for large insulated terminals. In addition the necessary mounting holes for the switch must be made on the centre line shown on the panel.

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

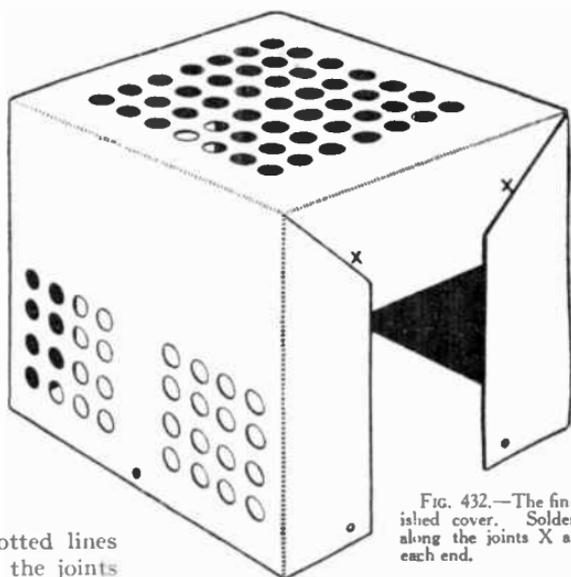


FIG. 432.—The finished cover. Solder along the joints X at each end.

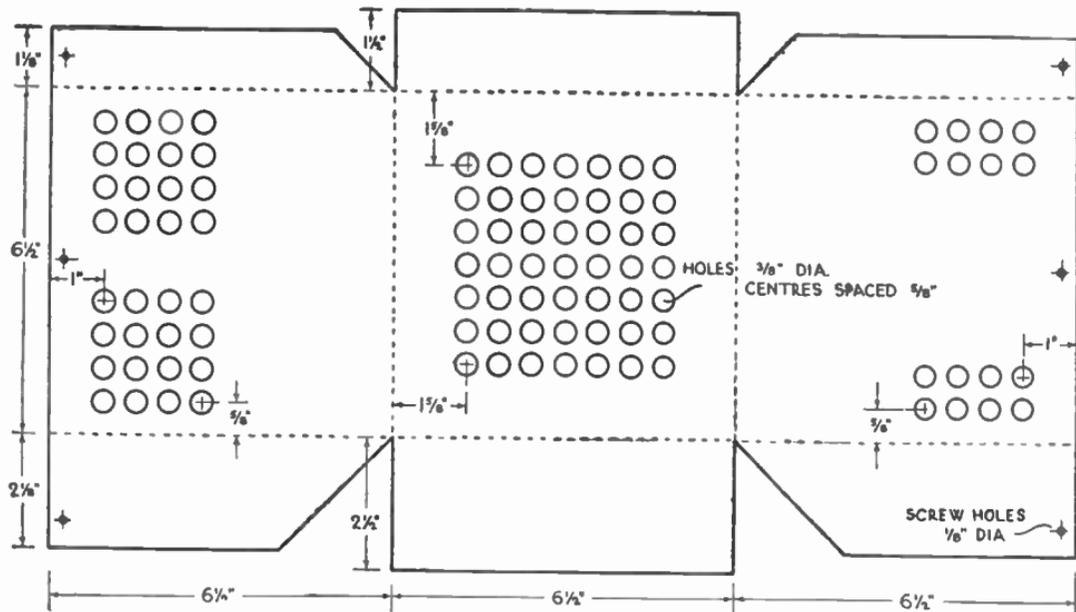


FIG. 433.—The Sheet-metal Cover. Cut out and drill as shown then bend along the dotted lines.

TRICKLE CHARGER — TUNING COILS

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.

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.

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.

This done, switch off and connect the accumulator and receiver.

TRIMMERS.—Small pre-set condensers fitted to ganged variable condensers and wired in parallel with each section. They are used to balance out the uneven capacities formed between the connecting wires.

TRIODE.—The 3- electrode valve.

TRIODE-PENTODE.—This is a frequency changer consisting of a triode and a pentode, the pentode section operating as a first detector and the triode as an oscillator. External mixing arrangements must be provided when this valve is used, as in the case of two separate valves.

TRITET.—Term used to describe a popular transmitting circuit employing a pentode valve, so connected to provide a triode-tetrode combination.

T.S.F.—The French abbreviation for wireless. The three words are "Télégraphie sans Fils" (telegraphy without wires).

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.

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*, *Iron-core Tuning Coils*, *Band-pass Tuning*, and *Permeability Tuning*.)

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-

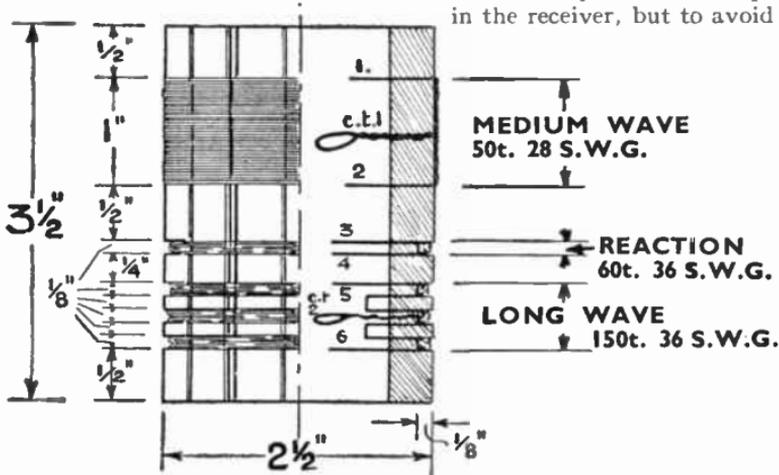


FIG. 434.—Constructional details of a Tuner made on an eight-ribbed 2½-in. diameter Ebonite Former. All turns are wound in the same direction.

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

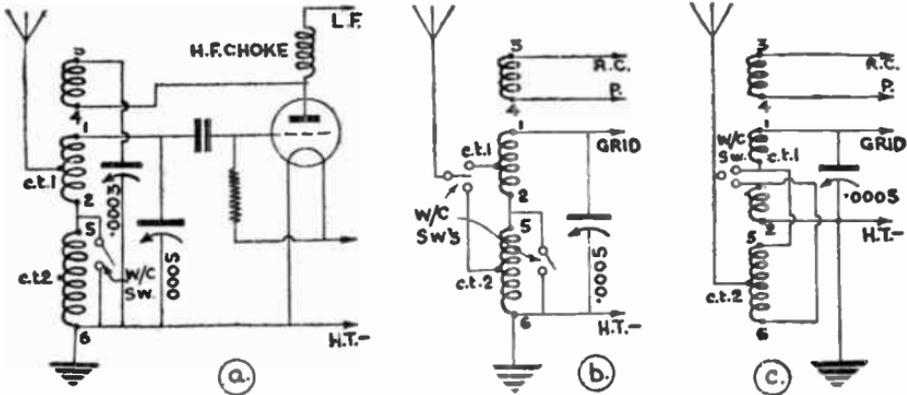


FIG. 435.—Three methods of connecting the Tuner shown in Fig. 434 into a Detector Circuit.

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 .0003-mfd. reaction condenser wired between one end of the reaction coil and earth. A H.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

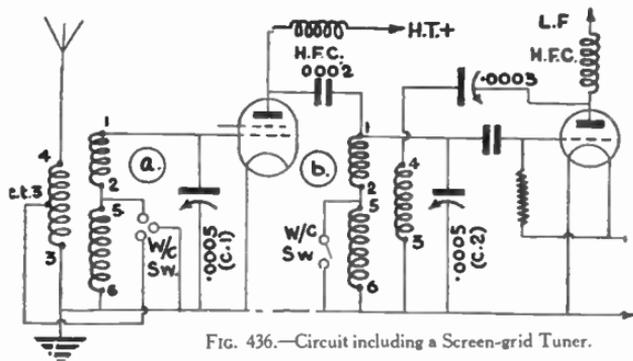


FIG. 436.—Circuit including a Screen-grid Tuner.

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 1½-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

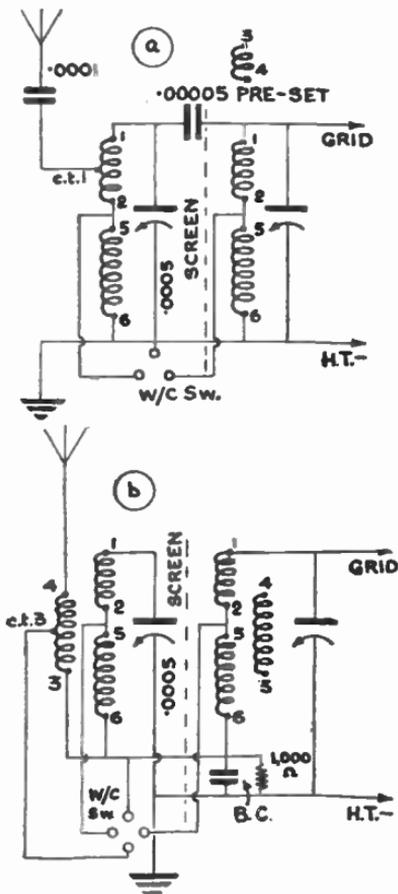


FIG. 437.—Band-pass-tuned Circuit, including a pair of small Tuners.

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
1¼ "	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

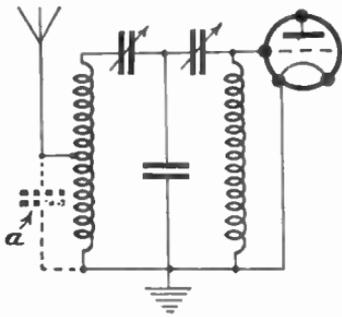


FIG. 438.—The Circuit arrangement of the Band-pass Scheme.

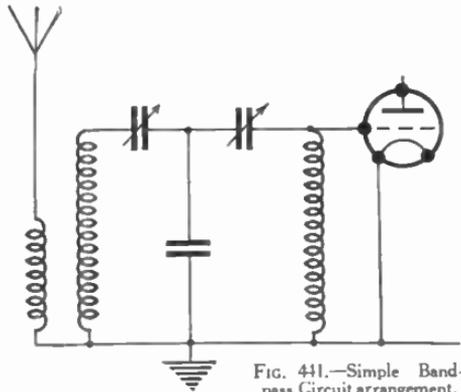


FIG. 441.—Simple Band-pass Circuit arrangement.

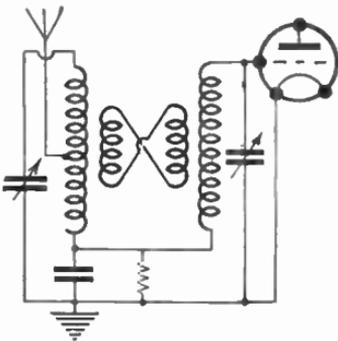


FIG. 439.—The Circuit of the "Link" Coupled Band-pass Tuner.

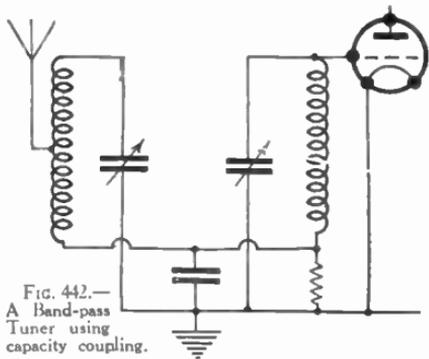


FIG. 442.—A Band-pass Tuner using capacity coupling.

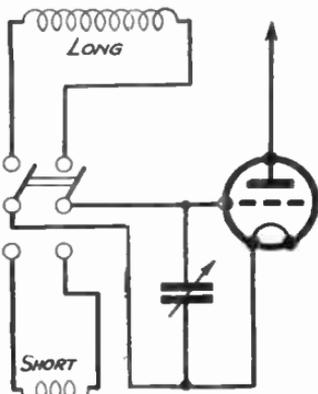


FIG. 440.—A simple method of fitting a Switch for wave-changing.

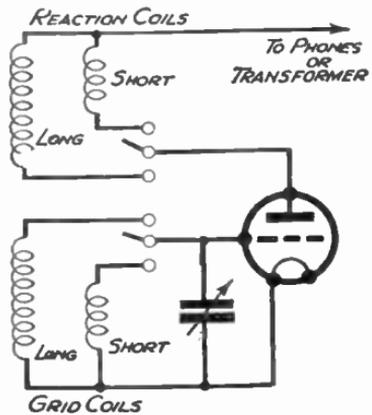


FIG. 443.—A simplified method of Switching without loss of efficiency.

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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-

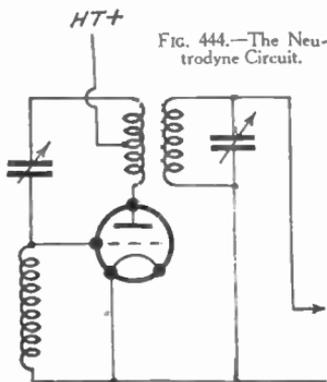


FIG. 444.—The Neurodyne Circuit.

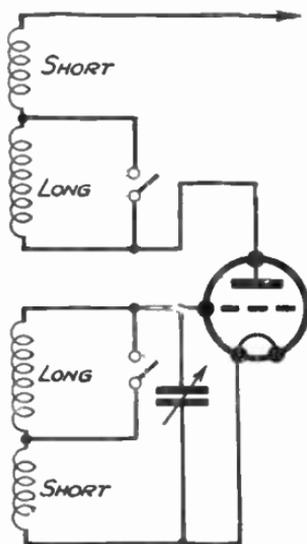


FIG. 445.—A Single-pole Single-throw Switch for wave-changing.

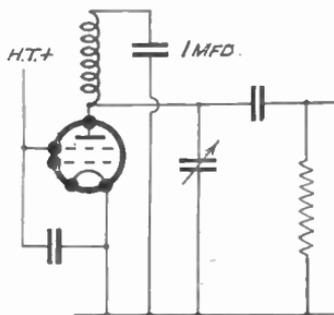


FIG. 446.—Another form of Tuned Anode Coupling.

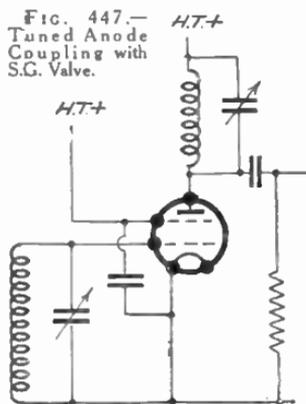


FIG. 447.—Tuned Anode Coupling with S.G. Valve.

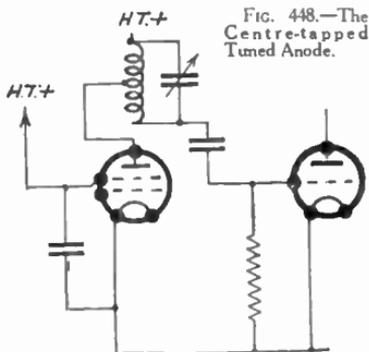


FIG. 448.—The Centre-tapped Tuned Anode.

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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 $\frac{1}{2}$ -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.

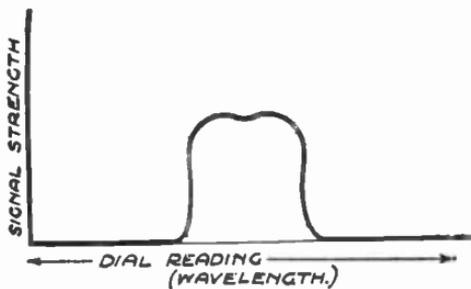


FIG. 449.—Band-pass Wave Form.

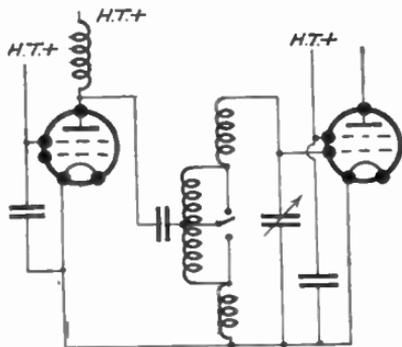


FIG. 452.—Wave-change Switching or Parallel-fed Tuned Grid Circuit.

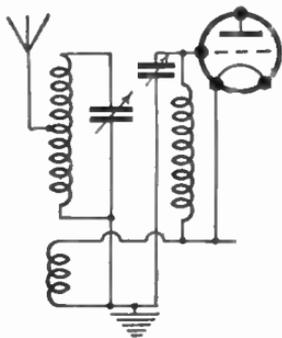


FIG. 450.—Inductive Band-pass Coupling.

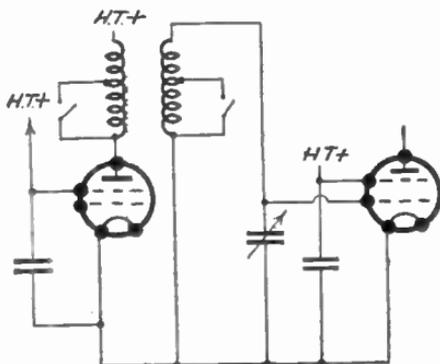


FIG. 453.—A H.F. Transformer with wave-switching.

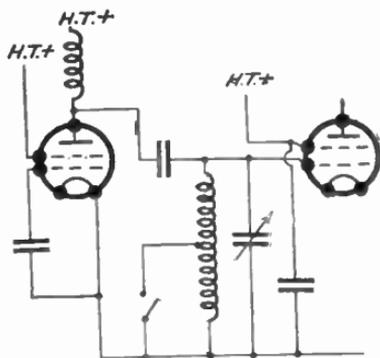


FIG. 451.—The Parallel-tuned Anode system.

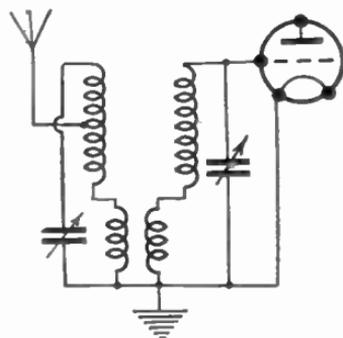


FIG. 454.—A Band-pass Tuner with common Coupling Coil.

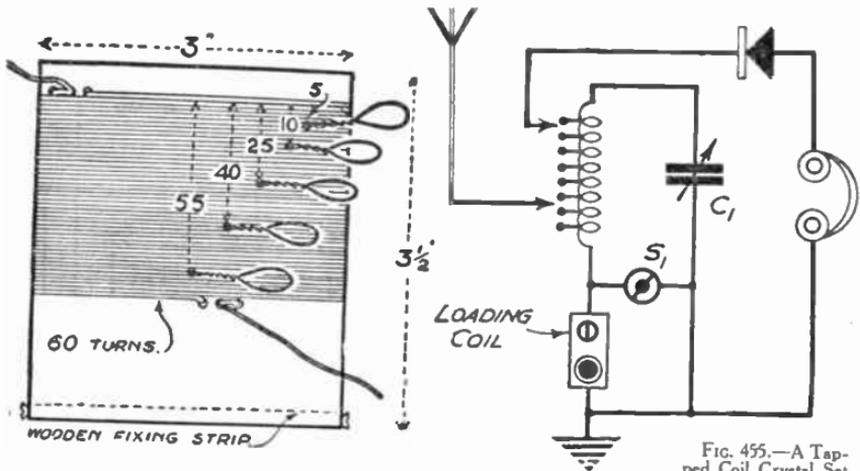


FIG. 455.—A Tapped Coil Crystal Set showing (left) details of the coil winding with 26 gauge D.C.C. wire.

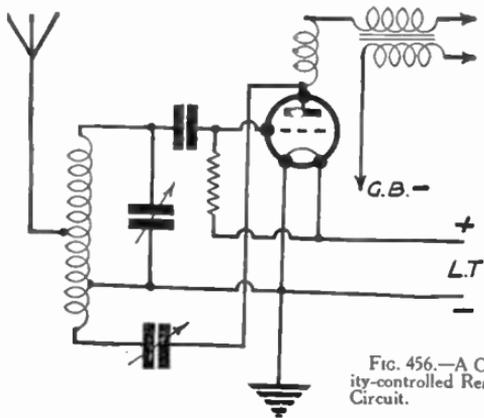


FIG. 456.—A Capacity-controlled Reaction Circuit.

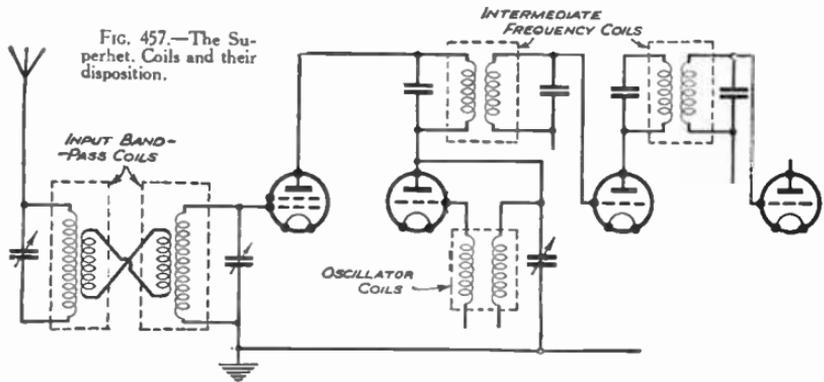


FIG. 457.—The Superhet. Coils and their disposition.

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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 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 un-screened 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 con-

cerned. 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 predetermined 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.

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 *Coils, Band-pass Tuning Circuit, Condenser, and Variable Condenser.*)

TWEETER — UNIT OF CONDUCTANCE

TWEETER.—A loudspeaker unit designed to reproduce only the high frequencies (usually above 3,000 cycles per second). (See *Woofers*.)

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.

U

ULTRA-SHORT WAVES.—The term given to those wavelengths between 1 and 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. 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 MAGNETIC POLE.—That pole which, if situated in a vacuum at a distance of one centimetre from a similar pole, would give rise to a mechanical force of repulsion of one dyne. The total number of lines of force which pass through a unit magnetic pole = 4π . (See *Weber, Maxwell, and Gilbert*.)

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—VALVES EXPLAINED

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.—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.

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.

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 or metal vessels containing electrodes used in wireless receivers. (See *Valves.*)

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 sig-

nal 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 arranged that it is impossible to plug a valve into its holder in the wrong way. The actual disposition of the legs is shown in Figs. 458 to 462. This illustration also gives the actual measurements between the pins of the valve.

VALVES EXPLAINED.—In a modern valve 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 project 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.

The functioning of the valve is commenced by passing a low-tension current from an accumulator through the filament; this has the

VALVE-LEG SPACING DIAGRAMS

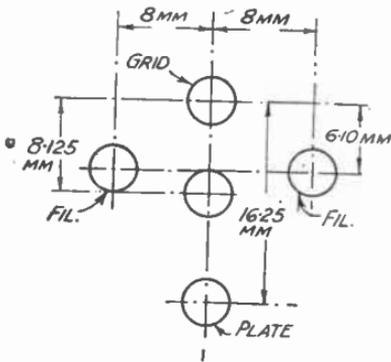


FIG. 458.—Valve-leg spacing for 4- and 5-pin valves. The diameter of the valve pins is 3.2 mm.

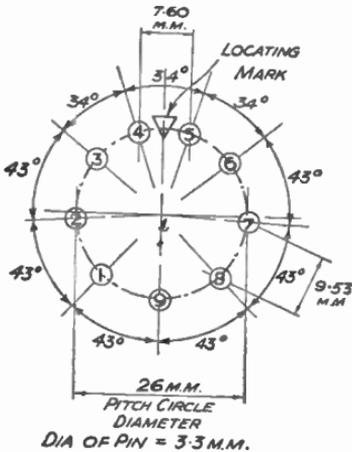
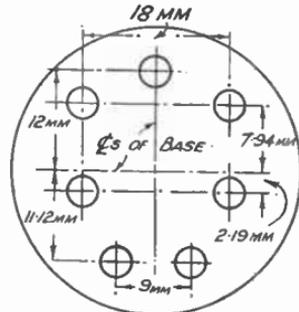
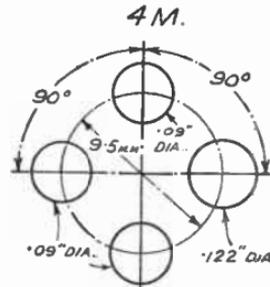
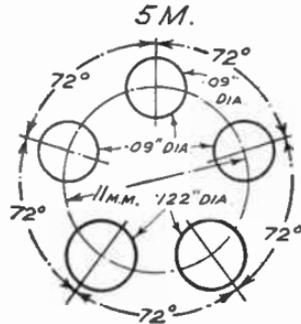


FIG. 460.—Valve-leg spacing for 9-pin valves.



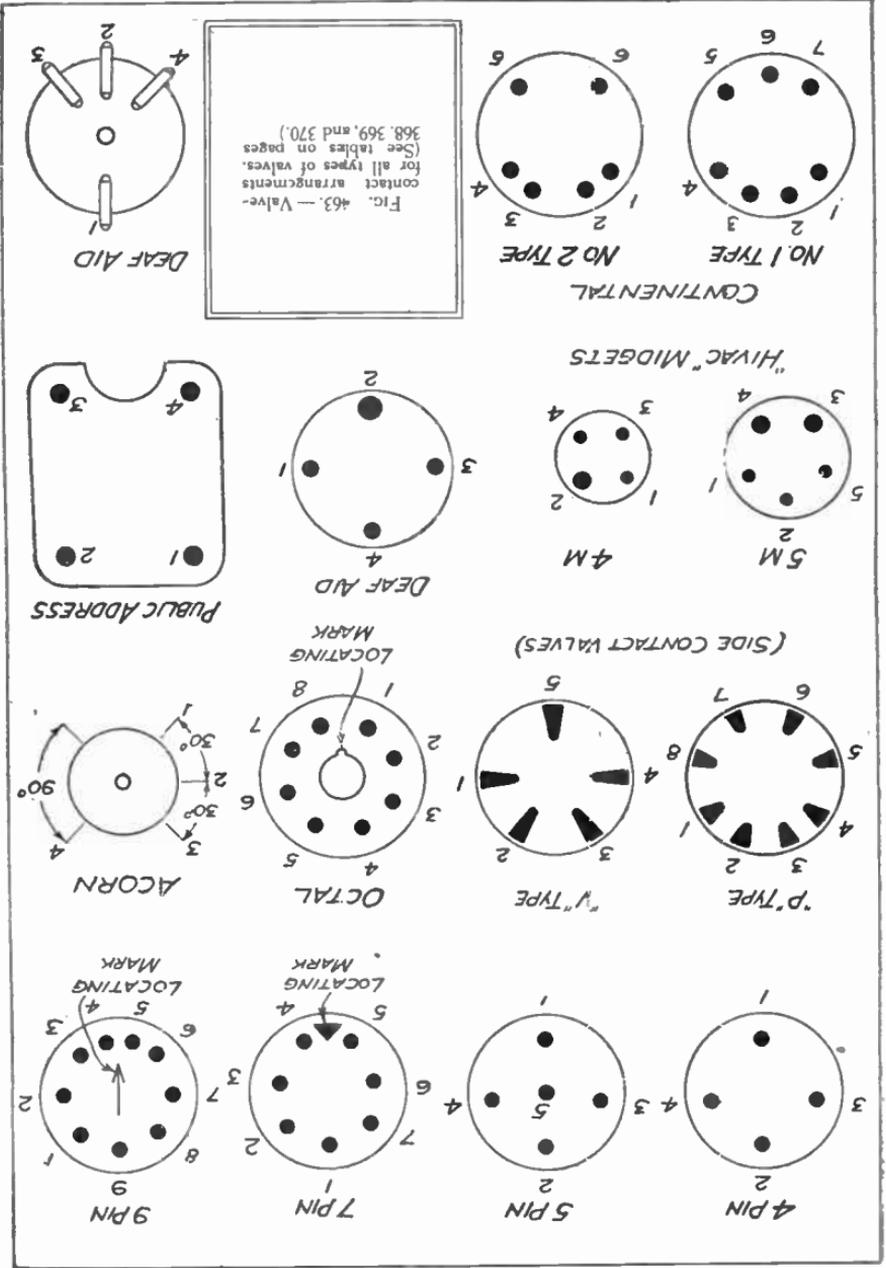
7 STANDARDS SPLIT PINS 1/8" DIA. APPROX.

FIG. 459.—Valv.-leg spacing for 7-pin valves.



FIGS. 461 and 462.—The two diagrams above show the valve-leg spacing of the Hivac midget valves (see table on page 369).

VALVES EXPLAINED



VALVE BASE CONNECTIONS FOR STANDARD (B.V.A.) VALVES

See page 369 for definitions of abbreviations used.

Valve Type	Base	Pin Connections									Top Cap	
		1	2	3	4	5	6	7	8	9		
Triode	D.H.	4	A	G	F	F	—	—	—	—	—	—
Triode	I.H.	5	A	G	H	H	—	—	—	—	—	—
Triode	I.H.	7	M	—	—	H	—	—	—	—	—	—
Tetrode	D.H.	4	G ₂	G ₁	F	F	—	—	C	A	—	G
Tetrode	I.H.	5	G ₂	G ₁	H	F	—	—	—	—	—	A
H.F. Pentode	D.H.	7	M	G ₁	G ₃	F	—	—	—	G ₂	—	A
H.F. Pentode	I.H.	5	G ₂	G ₁	H	H	C, G ₃	—	—	—	—	A
H.F. Pentode	I.H.	7	M	G ₁	G ₃	H	—	—	C	G ₂	—	A
H.F. Pentode	I.H.	7	M	A	G ₃	H	—	—	C	G ₂	—	A
Output Pentode	D.H.	4	A	G ₁	F	F	—	—	—	—	—	G ₁
Output Pentode	D.H.	5	A	G ₁	F	F	G ₂	—	—	—	—	G ₂
Output Pentode	I.H.	5	A	G ₁	H	H	C	—	—	—	—	G ₂
Heptode	D.H.	7	A ₀	G ₀	G ₂	F	—	—	C	A	—	—
Heptode	I.H.	7	A ₀	G ₀	G ₂	F	—	—	—	A	—	G ₁
Octode	D.H.	7	G ₂	G ₁	G ₃ , G ₅	F	—	—	C	A	—	G ₁
Octode	I.H.	7	G ₂	G ₁	G ₃ , G ₅	F	—	—	C, M, G ₆	A	—	G ₄
Class B Output	D.H.	7	G ₂	G ₁	A ₁	F	—	—	—	A ₂	—	—
Double-diode	D.H.	4	D ₁	D ₂	F	F	—	—	—	—	—	—
Double-diode	I.H.	5	D ₁	D ₂	H	F	—	—	—	—	—	—
Double-diode-triode	D.H.	5	A	D ₂	F, M	F	—	—	—	—	—	—
Double-diode-triode	I.H.	7	D ₁	M	D ₂	H	—	—	C	A	—	G
Triple-diode-triode	I.H.	9	D ₂	D ₃	—	H	—	—	C	—	—	G
Single-diode-tetrode	I.H.	7	—	G ₁	G ₂	H	—	—	C, M	A	—	G
Triode-pentode	D.H.	9	G ₂	A ₁	G ₃	F	—	—	—	A ₀	—	A
Triode-pentode	I.H.	9	G ₂	A ₁	G ₃	H	—	—	—	A ₀	—	G ₁
Triode-hexode	D.H.	7	A ₀	G ₀	G ₂	F	—	—	M	A	—	G ₁
Triode-hexode	I.H.	7	A ₀	G ₀	G ₂	H	—	—	C	A	—	G ₁
Double-pentode	D.H.	7	G ₁ ²	G ₁ ¹	A ₁	F	—	—	G ₂ ¹ , G ₂ ²	A ₂	—	—
Double-pentode	D.H.	9	G ₁ ¹	A ₁	G ₂ ¹	F	—	—	—	G ₂ ²	—	G ₁ ²
Double-diode-H.F. Pentode	I.H.	9	G ₂	A	—	H	—	—	—	D ₁	—	—
Double-diode Output Pentode	I.H.	7	D ₁	A	D ₂	H	—	—	C, G ₃	D ₁	A ₂ †	G ₁
Rectifier, Half-wave	D.H.	4	A	—	F	F	—	—	C	G ₂	—	G ₁
Rectifier, Half-wave	I.H.	5	A	—	H	F	—	—	—	—	—	—
Rectifier, Full-wave	D.H.	4	A	A	F	F	—	—	—	—	—	—
Rectifier, Full-wave	I.H.	4	A	A	H	H	—	—	—	—	—	—
Rectifier, Full-wave	I.H.	5	A	A	H	H	—	—	C	—	—	—
Rectifier, Full-wave	I.H.	7	H.C.T.	A ₁	C ₁	H	—	—	—	—	—	—
Barettor	.	4	—	—	F	F	—	—	C ₂	A ₂	—	—

VALVES EXPLAINED

VALVES EXPLAINED

Abbreviations relative to Table on page 368.

I.H.—Indirectly heated; D.H.—Directly heated. M.—Metallising. F.—Filament. H.—Heater. C, C ₁ , etc.—Cathodes.	A, A ₁ , etc.—Anodes (Ao—Oscillator anode). G or G ₁ —Control grid (Go—Oscillator control grid) G ₂ —Screening grid. G ₃ —Suppressor grid. D, D ₁ , etc.—Diodes (anodes).
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VALVE BASE CONNECTIONS FOR HIVAC MIDGET VALVES

See Figs. 461 and 462.

Type	Base	Pin Connections					
		1	2	3	4	5	Top Cap
Tetrode (S.G.)	1	A	G	F	F	—	—
Triode	1	G ₂	G ₁	F	F	—	A
Output Pentode	2	A	G ₁	F	F	G ₂	—

VALVE BASE CONNECTIONS FOR AMERICAN (OCTAL) VALVES

See Fig. 463.

Valve Type	Base	Pin Connections								
		1	2	3	4	5	6	7	8	Top Cap
Triode I.H.	Oct.	M	H	A	—	G	—	H	C	—
Triode I.H.	Oct.	M	H	—	A	—	—	H	C	G
H.F. Pentode I.H.	Oct.	M	H	A	G ₂	G ₃	—	H	C	G ₁
Output Pentode I.H.	Oct.	M	H	A	G ₂	G ₁	—	H	C	—
Heptode I.H.	Oct.	M	H	A	G ₃ , G ₅	Go (G ₁)	Ao (G ₂)	H	C	G ₄
Double-diode I.H.	Oct.	M	H	D ₂	C ₂	D ₁	—	H	C ₁	—
Double-diode-triode I.H.	Oct.	M	H	A	D ₁	D ₂	—	H	C	G
Rectifier, Full-wave I.H.	Oct.	M	H	—	A	—	A	—	H, C	—
Rectifier, Full-wave I.H.	Oct.	—	H	H	A ₂	C ₂	A ₁	—	H, C ₁	—
Rectifier, Full-wave I.H.	Oct.	M	H	A	—	A	—	H	C	—
Rectifier, Full-wave, Gaseous	Oct.	M	—	A	—	A	—	—	C	—

VALVE BASE CONNECTIONS FOR ACORN AND DEAF-AID VALVES

See Fig. 463.

Type	Base	Pin Connections						
		1	2	3	4	5	Top	Bottom
ACORN								
Triode	1	H	C	H	G	A	—	—
H.F. Pentode	1	H	C	H	S	SG	A	G
DEAF AID								
Triode (D.H.)	2	A	C	F	F	—	—	—
Triode (I.H.)	2	A	G	H	H	—	G	—
Triode (Mullard)	3	A	G	F	F	—	—	—
PUBLIC ADDRESS								
Triode	4	A	F	G	F	—	—	—

VALVES EXPLAINED

VALVE BASE CONNECTIONS FOR CONTINENTAL VALVES

See Fig. 463.

Type	Base	Pin Connections								Top Cap
		1	2	3	4	5	6	7		
H.F. Pentode	1	G ₂	H	H	C	A	G ₃	—	—	G ₁
H.F. Pentode	2	G ₂	H	H	C	A	M	G ₃	—	G ₁
Triode	2	—	H	H	C	A	M	G ₁	—	—
Double-diode	2	G ₂	H	H	C	D ₁	—	—	—	D ₂
Frequency Changer	2	G ₂	H	H	C	A	A ₀	G ₀	—	G ₁
Output Pentode	1	G ₂	H	H	C	A	G ₁ , G ₃	—	—	—
Output Pentode	2	G ₂	H	H	C	A	G ₃	G ₁	—	—
Rectifier	1	C ₁	H	H	C ₂	A ₂	A ₁	—	—	—
Rectifier	2	C ₁	H	H	C ₂	A ₂	—	A ₁	—	—

MULLARD UNIVERSAL SIDE-CONTACT VALVES

See Fig. 463.

Valve Type	Base	Contact Connections								Top Cap
		1	2	3	4	5	6	7	8	
Triode	P	M	H	H	C	—	—	—	A	G
H.F. Pentode	P	M	H	H	C	G ₃	—	G ₂	A	G ₁
Output Pentode	P	—	H	H	C, G ₃	—	—	G ₂	A	G ₁
Octode	P	M	H	H	C, G ₆	G ₂	G ₁	G ₃ , G ₅	A	G ₄
Double-diode	V	D ₂	H	H	C, M	D ₁	—	—	—	—
Double-diode (alternative)	V	M	H	H	C	D ₁	—	—	—	D ₂
Rectifier, Half-wave	P	—	H	H	C	—	—	—	A	—
Rectifier, Voltage Doubling	P	C ₁	H	H	C ₂	A ₁	—	—	—	—
Visual Tuning Indicator (TV ₄)	P	—	H	H	C	—	G	Target	A	—

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 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 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 special wire, and, as before stated, is between the filament and the anode. To this the incoming 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

VALVES EXPLAINED

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

to interpret the wireless signals. 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 broadcasting 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).

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

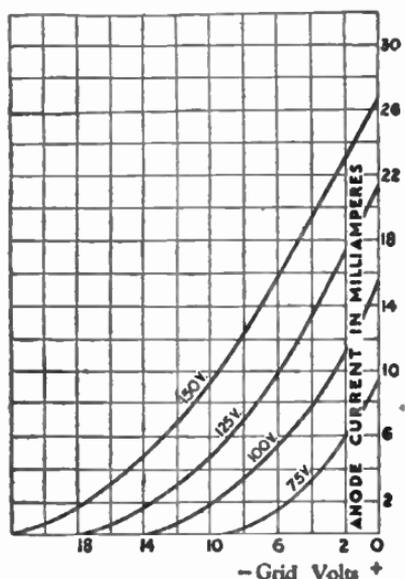


FIG. 464.—Characteristic Curve of a Low-impedance Medium-slope Valve.

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 economically as possible. The grid serves

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

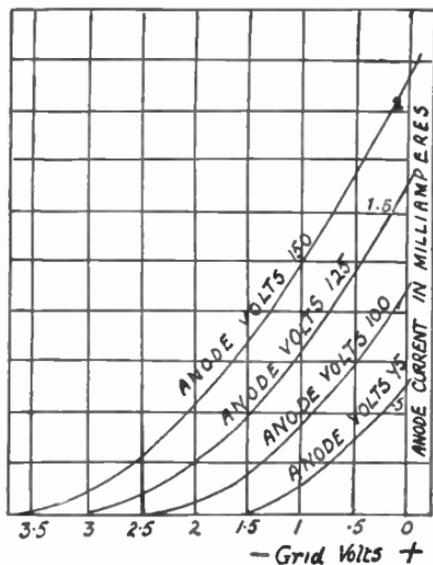


FIG. 465.—Characteristic Curve of a very High Impedance Valve.

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-

plification factor of 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

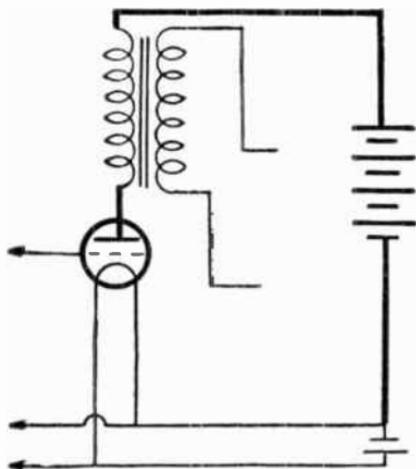


FIG. 466.—Matching is making the impedance of the anode roughly equal to the valve impedance. The Anode Circuit is shown by the heavy black line.

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

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

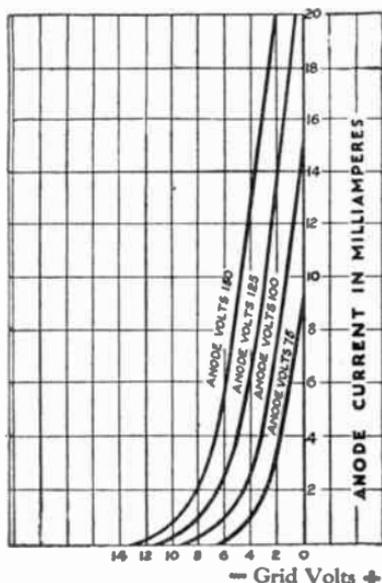


FIG. 467.—A Steep Slope Valve.

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

VALVE OSCILLATOR — 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 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. 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 oscillator is used for transmission and for super-heterodyne receivers.

VALVE VOLTMETER.—Used for measuring the voltage of alternating or high-frequency currents, and consists of a valve connected on the anode-bend-detection system. A milliammeter is wired in the anode circuit of the valve and the reading of this is taken as a measure of the A.C. voltage applied between the grid and cathode. The meter must, of course, be calibrated if it is to be used for accurate work, such as determining the efficiency of coils or the output of a receiver.

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 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 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 extremely 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 Lihti works on a wavelength of 1,807 metres; thus the difference in wavelengths is 128 metres; the frequency of the first-named station is 155 kcs.,

VARIABLE CONDENSER—VARIABLE-MU PENTODE

and the frequency of the latter 166 kcs., being a difference of 11 kcs. Thus at the very top of the long-wave dial 128 metres separation is equal to 11 kcs. separation. Belfast has a wavelength of 307.1 metres, and Ukhta a wavelength of 309.9 metres, the difference being 2.8 metres. The frequency of the former station is 977 kcs., and the latter station 968 kcs., a difference of 9 kcs. It will be remembered that at the top of the dial 128 metres was equal to 11 kcs., but it will be observed that at the lower end of the short-wave dial the same number of kilocycles is only worth 2.8 metres. Before leaving this subject, the reader will doubtless be surprised to hear that the separation between London National and Toulouse is twice as great as that between Droitwich and Radio Paris.

The straight-line frequency type is arranged so that each degree on the dial is equivalent to a definite frequency difference, and, therefore, a 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, 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 advan-

tage for ganging, as the shape of the vanes permits discrepancies of the coil matching to be overcome. It is incorrect to imagine that a trimming 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 throwing 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 vanes will result in ganging being preserved throughout the whole length, provided, of course, the trimmers have been adjusted to equalise odd capacities.

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.

VARIABLE-MU PENTODE.—A

VARIABLE-MU PENTODE — VOLT

valve possessing similar characteristics to the variable-mu screened-grid valve, but possessing an extra grid which increases its efficiency as an H.F. amplifier.

VARIABLE-MU S.G. VALVE.—Screened-grid valve having variable impedance. (See also *Valve*.)

VARIOCOUPLER.—A variometer

VARIOMETER.—Two coils, one rotatable within the other.

VELOCITY MODULATION.—A method of modulating the output current of a television transmitter by means of which the scanning spot moves quickly over the dark portions of the picture to be televised and slowly over the bright parts of the picture. Also known as variable tube scanning.

VELOCITY OF ETHER WAVES.

—The velocity of ether waves is 186,000 miles per second. This is equal to 300,000,000 metres per second. (See also *Sound Waves* and *Light Waves*.)

VELOCITY OF LIGHT.—The

same as the speed of ether waves, 186,000 miles per second.

VERI.—Abbreviation for verification of a transmission.

VIDEO.—Television term signifying picture or vision, as distinct from sound (audio).

VISIBLE SPECTRUM.—This extends from infra-red, through red, orange, yellow, green, blue, and violet to ultra-violet.

VISUAL TUNING INDICATORS.

—A device wired into a circuit to enable the correct resonance point to be seen. This arrangement has been rendered necessary by the employment of A.V.C. When the receiver is exactly tuned to a station the A.V.C. comes into effect and controls the H.F. amplification, and thus as the tuning circuit is detuned, the

A.V.C. effect will not be so great, and the H.F. amplification increases. Distortion due to side-band amplification, and increased background noises thereby result, and it becomes necessary to provide some indication when resonance is reached. There are many forms of indicator, some of which take the form of a light which

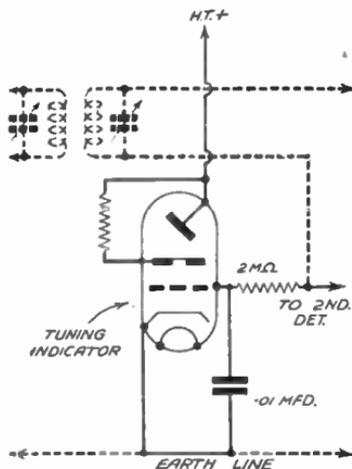


FIG. 460.—Connections for cathode-ray tuning indicator.

varies with input signal strength, and some in the form of a meter. The cathode-ray tuning indicator consists of a valve having cathode, heater, target anode, and space-charge grid. It is wired to the 2nd detector in a superhet. and the emission is directed on to a fluorescent disc which it causes to glow with a green colour. The degree of fluorescence and the shape of the glow depend upon the strength of the electron stream which in turn is dependent upon the signal arriving at the 2nd detector stage.

VOLT, THE.—The volt is the unit of electromotive force or pressure.

It is the practical unit of potential difference, being that potential difference which produces a current of one ampere when applied to a conductor the resistance of which is one

VOLT — VOLTMETER

ohm. It is equal to 10^8 C.G.S. electromagnetic units, the symbol being V.

The international volt is the potential difference which will produce a current of one international ampere when steadily applied to a conductor the resistance of which is one international ohm.

Other units are the *millivolt* (which

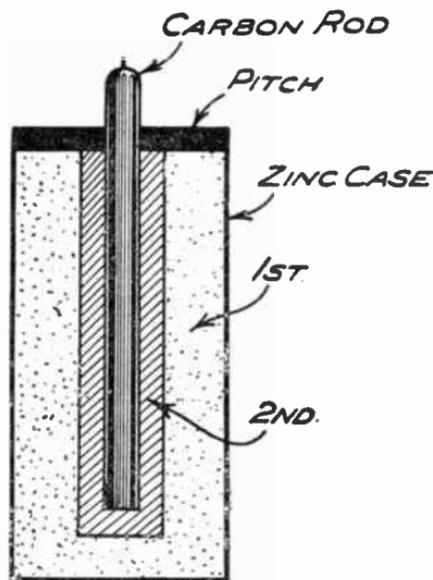


FIG. 470.—Section of a Dry Cell.

equals one-thousandth of a volt), the *microvolt* (one-millionth of a volt), and the *kilovolt*, which equals 1,000 volts.

VOLTA EFFECT.—When two dissimilar metals are in contact with one another (in air) one becomes positive and the other negative.

VOLT-AMPERE.—The product of R.M.S. volts and R.M.S. amperes. Symbol V.A.

VOLTAGE DOUBLER.—The term applied to a rectifying circuit wherein a metal oxide rectifier is employed. The rectifier is connected, together with fixed condensers, to provide a

bridge circuit, and this results in a step-up in voltage.

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 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 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 milliampere is one-thousandth part of an ampere.

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. (See Fig. 227B.)

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.

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 testing

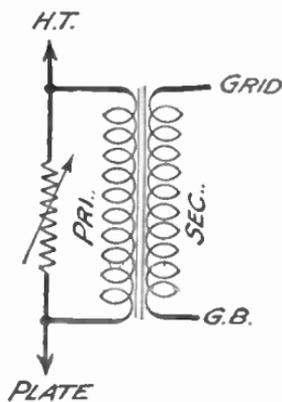


FIG. 471.—A simple form of Control in conjunction with the L.F. transformer.

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

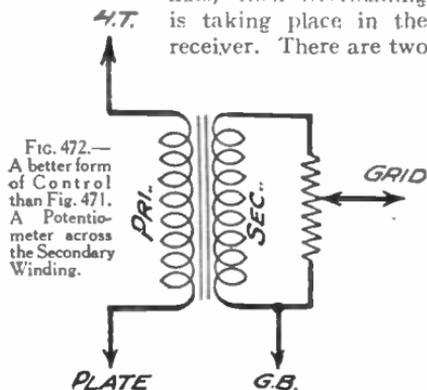


FIG. 472.—A better form of Control than Fig. 471. A Potentiometer across the Secondary Winding.

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.

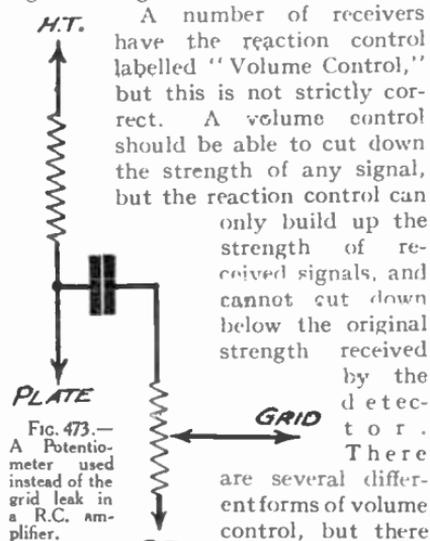


FIG. 473.—A Potentiometer used instead of the grid leak in a R.C. amplifier.

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. 471 and 472. In Fig. 471 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

VOLUME CONTROL

to the flattening of the curve. The value of the resistance in Fig. 471 should be about 100,000 ohms—no 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. 472, and this arrangement is shown in Fig. 473. 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

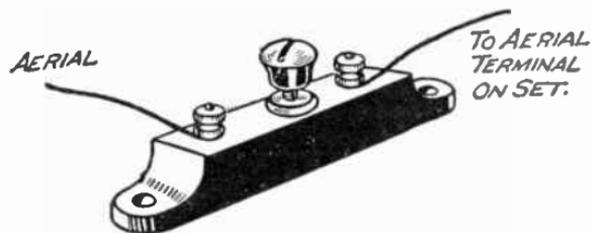


FIG. 474.—The series Aerial Condenser.

In Fig. 472 a high-resistance potentiometer is connected across the sec-

a poor contact between the resistance element and the moving arm.

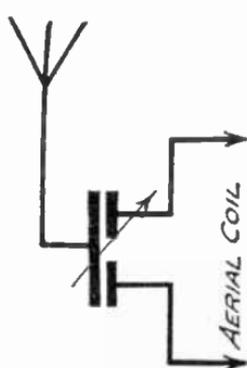


FIG. 475.—A Differential Condenser in the Aerial Circuit.

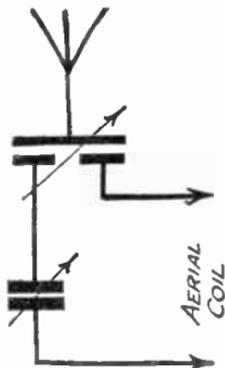


FIG. 476.—An improved form of the arrangement shown by Fig. 475.

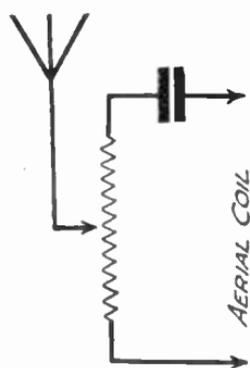


FIG. 477.—A Resistance instead of a differential Condenser in the Aerial Circuit.

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. 471 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. 472 arrangement. The potentiometer should have a value of 1 or 2 megohms. To ensure noiseless adjustment a fairly

This is the best method of I F. volume control.

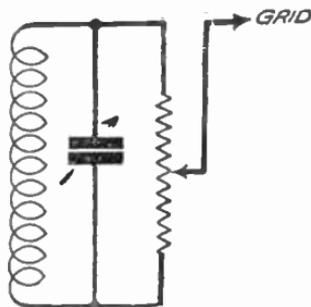


FIG. 478.—A Potentiometer across the Grid Coil.

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. 474), 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. 475—this arrangement not affecting the selectivity as does Fig. 474. 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. 476. 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. 477 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. 478, 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. 476.

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. (See also *Automatic Volume Control* and *Quiet Automatic Volume Control*.)

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 Electrical Unit of Power; the rate of work represented by a current of 1 ampere under a pressure of 1 volt. 746 watts = 1 h.p. It is the product of volts and amps.

WATT-HOUR.—A commercial unit of electrical work. It is the work done

WAVEBAND, AMATEUR — WAVEMETER

in 1 hour by a current of 1 amp. flowing between two points having a difference of potential of 1 volt.

WAVEBAND, AMATEUR.—It has been internationally agreed to allot the following bands of frequencies for amateur use. These are popularly referred to as the 5-, 10-, 20-, 40-, 80-, and 160-metre bands.

Frequency in Megacycles.	Equivalent Wavelengths in Metres (approx.).
56·000 to 60·000	5·357 to 5·000
28·000 to 32·000	10·714 to 10·000
14·000 to 14·400	21·428 to 20·833
7·000 to 7·300	42·857 to 41·095
3·500 to 4·000	85·714 to 75·000
1·715 to 2·000	174·635 to 150·000

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 173 and 882·3 metres, and there is then a gap until 1,060 metres. The gap is reserved for commercial stations, ships, etc. The long wavelengths, as they are called, extend from 1,060 to 1,973·5 metres.

WAVE FREQUENCY.—See *Frequency*.

WAVELENGTH. — The distance

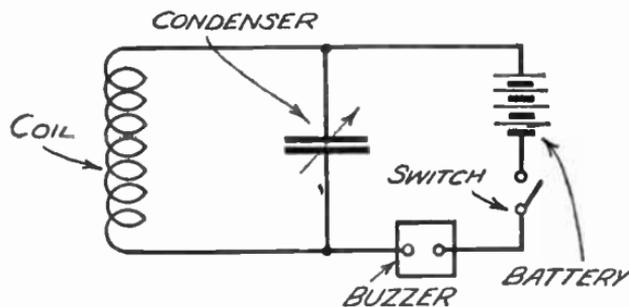


FIG. 479.—A Buzzer Wavemeter.

from the crest of one oscillation to the crest of the next. This distance is measured in metres. (See *Aerial, Natural Wavelength of*.)

WAVELENGTH OF TUNED CIRCUIT.—Formula for the wavelength of a tuned oscillatory circuit is: $1884.96\sqrt{LC}$, where L=inductance in microhenrys and C = capacity in microfarads.

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. 479) 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" trans-

WAVEMETER

mitting 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 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 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.

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 recalibration 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. 480 will make the construction quite clear.

Mounting the Components. Fig. 481 gives a birds'-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

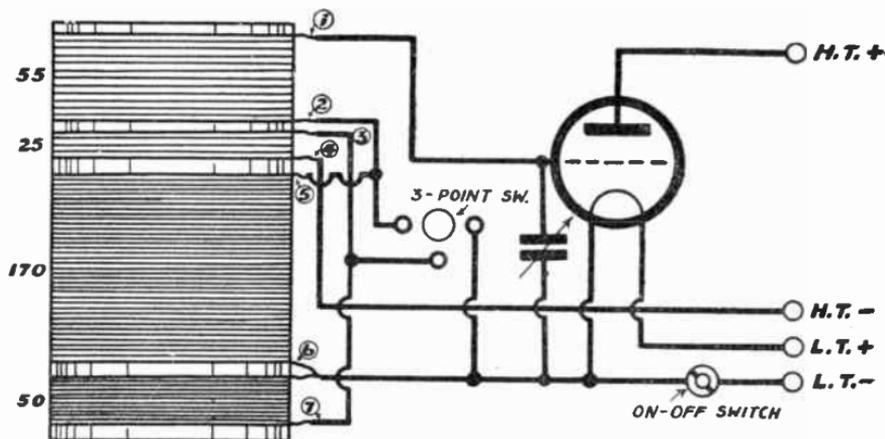


FIG. 480.—Diagram of coil connections for the Heterodyne Wavemeter shown in Fig. 481.

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.

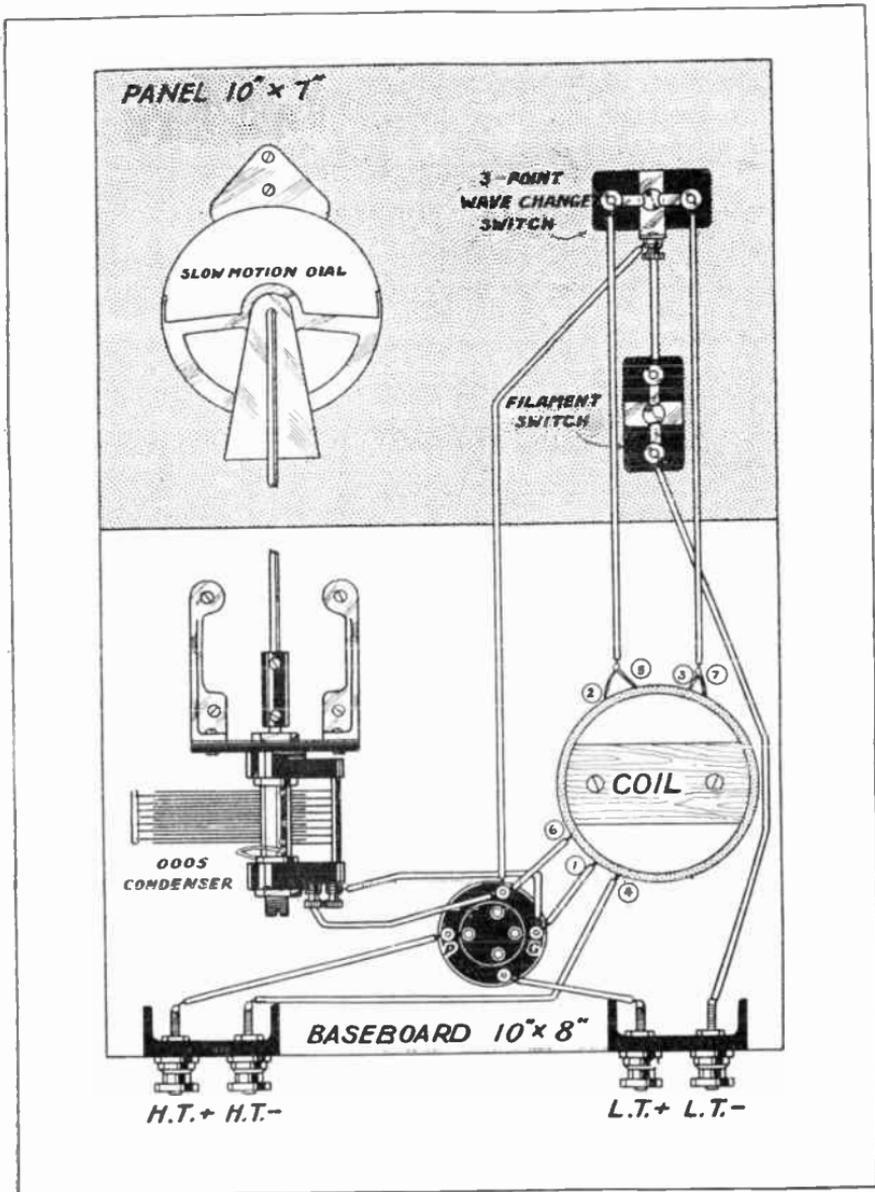


FIG. 481.—Wiring diagram for the Heterodyne Wavemeter.

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 the meter has previously been set, this having been done by means of the graph. Assume it was 350 metres, perhaps 120° on the wavemeter dial. 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 several points to be observed in calibrating and using the meter. The endeavour should be to keep the operating conditions the same. Do not, for instance, stand the meter on a wooden table one day and on another place it on an iron mantelshelf. 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. If there is any difficulty in getting it to do so it means that insufficient H.T. is being used or the value is unsuitable. If desired, an earth connection can be made to the meter; if you do so, the connection must remain, to secure uniformity of readings.

Finally, it is essential that the meter should oscillate. If it fails to do so, then the meter will be useless for all test purposes, as it will be impossible to obtain a note from it for heterodyning.

When calibrating a set you 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 dial.
- 1 pair of 2½ 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 2½ × 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.

WEBER.—The unit of pole strength named after the German physicist Weber (1795-1878). North and South poles are called positive and negative

poles respectively. A pole strength of m webers will repel a unit pole 1 cm. away in air, with a force of m dynes. (See *Ampere, Unit Magnetic Pole, Gilbert, and Maxwell.*)

WET BATTERY.—A battery in which the electrolyte is in liquid form.

WHEATSTONE BRIDGE.—A device for measuring the value of a

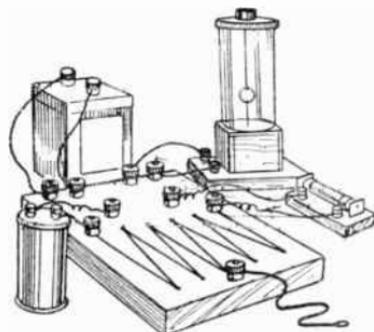


FIG. 482.—The Wheatstone Bridge and its associated apparatus.

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 chemist, and therefore is very useful to have.

It consists of a board 12 × 8 in. of very dry oak.

Mount nine brass terminals upon it in the positions shown in Fig. 483. At 20, 40, 60, 80, are brass pins driven into the base 1½ 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.

The zigzag line is a length of bare Eureka resistance wire of 22 gauge.

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, $\frac{1}{10}$ 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

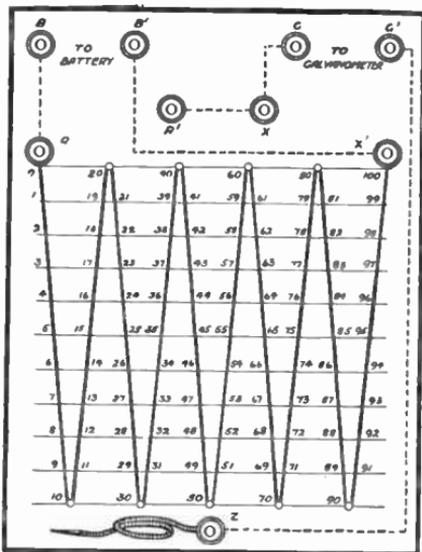


FIG. 483.—A detailed sketch of the Wheatstone Bridge, showing its construction.

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:

$$\frac{100 - N}{N} \times R = X,$$

where N = the number on the board,

R = the standard resistance,

X = the unknown resistance.

$$\text{Then } \frac{100 - 25}{25} \times 5 = X$$

$$\frac{75}{25} \times 5 = X,$$

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 — WOW

and collecting combs are also arranged close to the brushes. Charges are produced by induction, and are conveyed to a Leyden jar.

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. (S.W.G.)	Dia. (inches)	No. (S.W.G.)	Dia. (inches)
4/0	.400	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	.024	50	.0010

WIRELESS CLUBS.—See *Directory of Radio Societies.*

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 following list of diameters and corresponding sizes of wood screws that will fit them will be found handy: $\frac{1}{16}$ -in. diam., No. 00; $\frac{3}{32}$ -in. diam., No. 2; $\frac{1}{8}$ -in. diam., No. 5; $\frac{5}{32}$ -in. diam., No. 7; and $\frac{3}{16}$ -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., et c.	Dia- meter.	Size	Dia- meter.
1	.066	51	.067	—	—
2	.080	40	.084	—	—
3	.094	41	.096	—	—
4	.108	35	.110	—	—
5	.122	30	.128	$\frac{1}{16}$	.125
6	.136	28	.140	—	—
7	.150	23	.154	$\frac{3}{32}$	.156
8	.164	18	.169	—	—
9	.178	14	.182	$\frac{1}{8}$	.187
10	.192	9	.196	—	—
11	.206	4	.208	$\frac{7}{32}$	.218
12	.220	I	.222	—	—
13	.234	B	.236	—	—
14	.248	E	.250	$\frac{1}{4}$	.250
15	.262	H	.266	—	—
16	.276	K	.281	$\frac{5}{16}$	.281
17	.290	M	.295	—	—
18	.304	O	.316	$\frac{3}{8}$	.312
19	.318	P	.323	—	—
20	.332	R	.339	$\frac{7}{16}$	.343
21	.346	S	.348	—	—
22	.360	T	.358	—	—
23	.374	U	.368	$\frac{1}{2}$	.375
24	.388	V	.377	—	—
25	.402	X	.397	—	—
26	.416	Z	.413	$\frac{9}{16}$	.406
27	.430		.421	—	—
28	.444		.437	$\frac{5}{8}$	.437
29	.458		.453	—	—
30	.472		.468	$\frac{11}{16}$	.468
31	.486		.484	—	—
32	.500		.500	$\frac{3}{4}$	.500
			.515	$\frac{15}{16}$	.500

All dimensions in parts of an inch.

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, 1 part of cadmium, and 2 parts of lead. It melts at about 60° Centigrade. (See also *Crystals.*)

WOOFER.—A speaker unit designed to reproduce the lower frequencies. (See *Tweeter.*)

WOW.—Effect of change in pitch

WOOD SCREW PROPORTIONS — ZINCITE

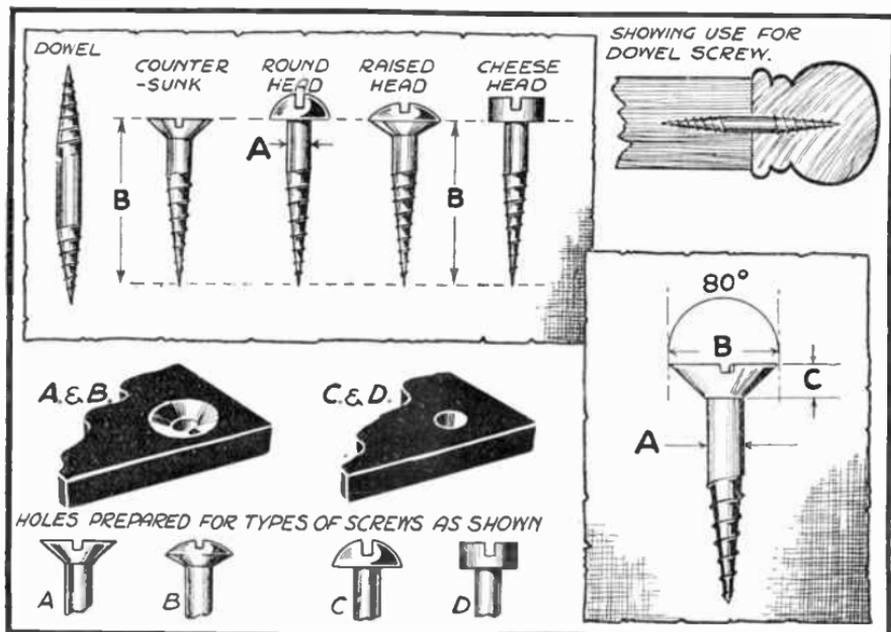


FIG. 484.—Wood Screw proportions and types.

STANDARD WOOD SCREWS

No. of Screw Gauge	Dia- meter. Dec.	A In. Approx. Fraction.	B In.	C In.	Slot.	
					Width.	Depth.
0	.05784	1/16	1/8	1/4	1/8	1/16
1	.07100	1/8	1/4	3/8	1/4	1/8
2	.08416	3/16	1/2	5/8	3/8	1/4
3	.09732	1/4	3/4	7/8	1/2	3/8
4	.11048	5/16	7/8	1 1/8	5/8	1/2
5	.12364	3/8	1 1/8	1 1/4	3/4	5/8
6	.13680	1/2	1 1/4	1 3/4	7/8	3/4
7	.14996	5/8	1 3/4	2 1/8	1 1/8	7/8
8	.16312	3/4	2 1/8	2 3/4	1 3/8	1 1/8
9	.17628	7/8	2 3/4	3 1/8	1 5/8	1 3/8
10	.18944	1 1/8	3 1/8	3 3/4	2 1/8	1 5/8
11	.20260	1 1/4	3 3/8	4 1/8	2 3/8	1 7/8
12	.21576	1 3/8	4 1/8	4 3/4	2 5/8	2 1/8
13	.22892	1 1/2	4 3/8	5 1/8	3 1/8	2 3/8
14	.24208	1 5/8	5 1/8	5 3/4	3 3/8	2 5/8
15	.25524	1 7/8	5 3/8	6 1/8	3 5/8	2 7/8
16	.26840	2 1/8	6 1/8	6 3/4	4 1/8	3 1/8
17	.28156	2 1/4	6 3/8	7 1/8	4 3/8	3 3/8
18	.29472	2 3/8	7 1/8	7 3/4	4 5/8	3 5/8
19	.30788	2 1/2	7 3/8	8 1/8	5 1/8	3 7/8
20	.32104	2 5/8	8 1/8	8 3/4	5 3/8	4 1/8
21	.33420	2 3/4	8 3/8	9 1/8	5 5/8	4 3/8
22	.34736	2 7/8	9 1/8	9 3/4	6 1/8	4 5/8
23	.36052	3 1/8	9 3/8	10 1/8	6 3/8	4 7/8
24	.37368	3 1/4	10 1/8	10 3/4	6 5/8	5 1/8

due to variation in speed in recording or reproducing machine.

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*.)

X'MITTER. — Abbreviation for Transmitter.

X'MITTING. — Abbreviation for Transmitting.

Z

ZINCITE.—A crystal formed from oxide of zinc. Used in conjunction with bornite or copper pyrites. (See also *Crystals*.)

IMPORTANT DATES IN WIRELESS HISTORY

IMPORTANT DATES IN WIRELESS HISTORY

JANUARY

- Jan. 1, 1893. Professor Hertz died.
 Jan. 7, 1927. Transatlantic service opened.
 Jan. 8, 1923. First outside broadcast, "The Magic Flute" (Mozart), from Covent Garden.
 Jan. 17, 1706. Benjamin Franklin born.
 Jan. 20, 1904. First Press message across the Atlantic.
 Jan. 21, 1914. First presidential address to Wireless Society of London.
 Jan. 22, 1775. André Marie Ampère born.
 Jan. 22, 1901. Station at Lizard opened.
 Jan. 27, 1912. Aranjuez station opened by King Alphonso XII.
 Jan. 31, 1926. Rugby telegraph station opened.

FEBRUARY

- Feb. 1, 1937. Penmon (Anglesey) transmitting station opened.
 Feb. 2, 1896. Marconi came to England.
 Feb. 2, 1923. Cardiff station opened.
 Feb. 3, 1870. Government take possession of British telegraphy system.
 Feb. 4, 1925. Oliver Heaviside died.
 Feb. 8, 1925. First amateur telegraphy between Australia and England.
 Feb. 9, 1938. Atlantic bridge by television.
 Feb. 11, 1847. Thomas Alva Edison born.
 Feb. 11, 1901. Wireless communication established between Niton and the Lizard; 196 miles.
 Feb. 14, 1922. Writtle (2MT) transmitter opened.
 Feb. 15, 1834. Sir W. Preece born.
 Feb. 16, 1923. First broadcast play.
 Feb. 17, 1923. First charity appeal by wireless.
 Feb. 18, 1900. First German commercial wireless telegraph station opened on Borkum Island.
 Feb. 19, 1745. Alessandro Volta born.
 Feb. 22, 1857. Professor H. R. Hertz born.
 Feb. 26, 1900. "Four Sevens" tuning patent taken out by Marconi.
 Feb. 27, 1922. First Annual Radio Conference held in Washington.
 Feb. 28, 1900. Communication up to 60 miles between s.s. *Kaiser Wilhelm der Grosse* and Borkum Island.

MARCH

- Mar. 1, 1901. Wireless service inaugurated in the Hawaiian Islands.
 Mar. 1, 1925. First amateur wireless telegraphy between Gt. Britain and New Zealand.
 Mar. 3, 1847. Dr. Alexander Graham Bell born.
 Mar. 3, 1899. First use of wireless in life-saving at sea.
 Mar. 3, 1923. Glasgow station opened.
 Mar. 5, 1827. Alessandro Volta died.
 Mar. 9, 1930. First dual transmission from Brookmans Park.
 Mar. 13, 1932. First programme from Broadcasting House.
 Mar. 16, 1787. Georg Simon Ohm born.
 Mar. 20, 1777. Sir Isaac Newton died.
 Mar. 23, 1906. First high-power directional aerial used at Clifden.
 Mar. 27, 1899. Communication established between Wimereux and South Foreland Light-house.
 Mar. 30, 1930. B.B.C. commence television broadcasts.

APRIL

- April 2, 1872. Samuel Morse died.
 April 7, 1927. First television demonstration by American Telephone and Telegraph Co.
 April 8, 1918. Cairo Wavelength Fixing Conference concluded.
 April 13, 1924. First broadcast from St. Martin-in-the-Fields, conducted by the Rev. Dick Sheppard.
 April 15, 1912. s.s. *Titanic* struck iceberg, and sank. Radio used to summon assistance.
 April 17, 1790. Benjamin Franklin died.
 April 23, 1924. First broadcast by King George V and King Edward VIII (then Prince of Wales) at opening of Wembley Exhibition.
 April 24, 1903. Cie. Française Maritime et Coloniale de T.S.F. formed.
 April 25, 1900. Marconi International Marine Communication Co., Ltd., incorporated.
 April 25, 1874. H.E. Marchese Marconi, G.C.V.O., LL.D., born.
 April 27, 1791. Samuel Morse born.
 April 29, 1932. First demonstration of U.S. ultra-short-wave television by Baird.

MAY

- May 1, 1922. Poldhu station closed.
 May 1, 1923. First broadcast from Savoy Hill.
 May 2, 1925. First broadcast by King George V, at the Royal Academy Banquet.
 May 13, 1897. Communication established over eight miles.
 May 21, 1901. First British ship, s.s. *Lake Champlain*, equipped with wireless telegraphy.
 May 30, 1927. Baird television by wire between London and Glasgow.

JUNE

- June 1, 1916. Wireless first adopted by New York Police.
 June 2, 1866. Marconi's first British patent granted, No. 12039, for Hertzian Wave telegraphy.
 June 3, 1898. Lord Kelvin sent first paid radio telegram from the Needles station.
 June 10, 1836. André Marie Ampère died.
 June 12, 1851. Sir Oliver Lodge born.
 June 25, 1902. First magnetic detection, installed in Italian cruiser *Carlo Alberto*.
 June 26, 1824. Lord Kelvin born.

JULY

- July 4, 1937. Washford transmitting station opened.
 July 5, 1912. International Radiotelegraph Convention signed in London.
 July 5, 1913. London Wireless Club inaugurated (the nucleus of the Wireless Society of London and the Radio Society of Great Britain).
 July 17, 1897. Communication up to 10 miles between Spezia and Italian cruiser *San Martin*.
 July 20, 1897. Wireless Telegraph and Signal Co., incorporated (from which the present Marconiphone Co. is directly descended).
 July 20, 1898. Events at Kingstown Regatta reported by Radiotelegraphy.
 July 20, 1937. H.E. Marchese Marconi, G.C.V.O., died.
 July 21, 1925. First transmission from Chelmsford, 5XX, B.B.C. high-power experimental station.

IMPORTANT DATES IN WIRELESS HISTORY

JULY—(contd.)

- July 24, 1903. Agreement by British Admiralty for the use of Marconi system in the Navy.
 July 27, 1896. First demonstration of directional wireless, using reflectors.
 July 27, 1915. Communication established between San Francisco and Japan via Honolulu.
 July 27, 1925. Daventry 5XX officially opened.
 July 28, 1916. Regulation published making wireless telegraphy compulsory on British vessels of 3,000 tons and over.

AUGUST

- Aug. 1, 1922. Dr. A. Graham Bell died.
 Aug. 2, 1928. First demonstration of Telegoscopy by Baird.
 Aug. 3, 1898. Communication established between the Royal Yacht *Osborne* and Ladywood Cottage, Osborne.
 Aug. 4, 1903. First International Conference on wireless telegraphy held in Berlin.
 Aug. 4, 1914. War declared on Germany and all private radiotelegraphy suspended.
 Aug. 13, 1888. John Logie Baird born.
 Aug. 15, 1904. Wireless Telegraph Act of Great Britain passed.
 Aug. 15, 1924. Hull relay station opened.
 Aug. 18, 1921. Leafeld (Oxford) station opened by P.M.G.
 Aug. 19, 1920. Communication established between an aeroplane in flight to Paris, and a telephone subscriber in London.

SEPTEMBER

- Sept. 3, 1939. Television transmissions suspended owing to declaration of war with Germany.
 Sept. 9, 1737. Luigi Galvani born.
 Sept. 12, 1923. Sir E. Rutherford's address to the British Association at Liverpool simultaneously broadcast from all B.B.C. stations.
 Sept. 16, 1929. First Regional station, Brookmans Park, opened.
 Sept. 22, 1791. Michael Faraday born.
 Sept. 22, 1918. First messages transmitted by wireless to Australia.
 Sept. 28, 1837. Morse patented his telegraph.
 Sept. 29, 1909. British coast stations taken over by P.M.G.
 Sept. 30, 1922. First Radio Exhibition at Horticultural Hall.

OCTOBER

- Oct. 1, 1922. First all-British wireless exhibition opened.
 Oct. 3, 1906. Triode patented by Lee de Forest.
 Oct. 7, 1934. Dr. Wittich station opened.
 Oct. 8, 1908. Russian Company of Wireless Telegraphs and Telephones formed.
 Oct. 10, 1923. Aberdeen station opened.
 Oct. 12, 1936. Burghead transmitting station opened.

- Oct. 15, 1901. First fan aerials erected for experiments between Poldhu and Newfoundland.
 Oct. 17, 1907. Transatlantic stations at Clifden and Glace Bay open for public service.
 Oct. 17, 1923. Bourne Heath station opened.
 Oct. 18, 1931. T. A. ... died.
 Oct. 19, 1937. ... transmitting station opened.
 Oct. 19, 1937. J ... herford died.
 Oct. 24, 1924. ... station opened.
 Oct. 25, 1926. ... and-Canada Beam station opened.
 Oct. 26, 190 ... of T.S.F. of Brussels formed.
 Oct. 26, 1 ... telephonic communication effected
 Eiffel ... Arlington, U.S.A., and the

NOVEMBER

- Nov. ... Marconi Wireless Telegraph Company ... Canada formed.
 Nov. ... first wireless land station in Belgium ... at La Panne.
 Nov. 14, 1924. London (2LO), first British broadcasting station, commenced.
 Nov. 15, 1832. Morse code first made public.
 Nov. 15, 1899. Communication up to 36 miles between the Needles station and s.s. *St. Paul*.
 Nov. 15, 1922. First programmes broadcast from the London, Birmingham, and Manchester stations.
 Nov. 16, 1904. First Fleming valve patent granted No. 24850.
 Nov. 22, 1899. Marconi's Wireless Telegraph Company of America formed.
 Nov. 22, 1922. Wireless Society of London changed its title to the Wireless Society of Great Britain.
 Nov. 25, 1642. Sir Isaac Newton born.
 Nov. 29, 1849. Dr. J. A. Fleming born.

DECEMBER

- Dec. 1, 1900. Wireless officially adopted by London Fire Brigade.
 Dec. 6, 1897. Communication established up to 18 miles between a steamer and the Needles.
 Dec. 9, 1932. Empire Broadcasting from Daventry began.
 Dec. 12, 1896. Sir W. Preece lectured on Marconi's invention at Toynbee Hall.
 Dec. 12, 1901. Signals received at St. John's, Newfoundland, from Poldhu, a distance of 1,800 miles.
 Dec. 15, 1922. British Broadcasting Company, Ltd., registered.
 Dec. 17, 1902. First wireless message transmitted across the Atlantic.
 Dec. 18, 1921. Demonstration of duplex radiotelephony between London and Amsterdam.
 Dec. 18, 1902. Messages despatched by Senator Marconi and Earl Minto to King Edward VII and King Victor of Italy.
 Dec. 24, 1910. Cia Nacional de T.S.H. formed.
 Dec. 24, 1923. Newcastle station opened.